MODERN DESIGN METHODS FOR EXTERNAL FIRE SPREAD

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Requirement B4(1) of the Building Regulations 2010 (as amended) primarily addresses two hazards: building-to-building fire spread and upward storey-to-storey fire spread. Current design methods for these hazards are limited and often lead to significant implications for building design. This proposal outlines an approach to developing two new design tools, one for each hazard. The approach would quantify the probability of failure that the English regulatory system implicitly deems acceptable for each hazard in inert enclosures, which would then be used as benchmarks to design buildings with inert or combustible enclosures. The tools would provide a means of demonstrating acceptable risk levels for both hazards, informing the specification of measures such as spandrel height and suppression system reliability. This is particularly relevant for combustible enclosures, which can increase the risk posed by both hazards. The tools would be limited to buildings with Euroclass A1/A2 external wall systems. The same development framework would be used for both tools (Figure 1).

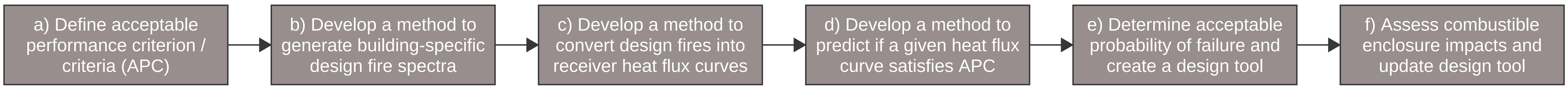

Figure 1: Overview of the framework for developing both design tools

WP1: BUILDING-TO-BUILDING FIRE SPREAD

WP1a)

The building should have an adequately low probability of subjecting a neighbouring building to an incident heat flux (IHF) exposure equivalent to 12.6 kW/m^2 for 10 minutes. This is based upon BR 187 [1].

WP1b)

Make modifications as required to OFR's SFEPRAPY tool [2].

WP1c)

Discretise the emitter and determine the time-temperature history for each element. Discretise the receiver and calculate the time history of IHF for each element. See Figure 2 (left: illustrative emitter discretisation, right: 3-D view of emitter and receiver).

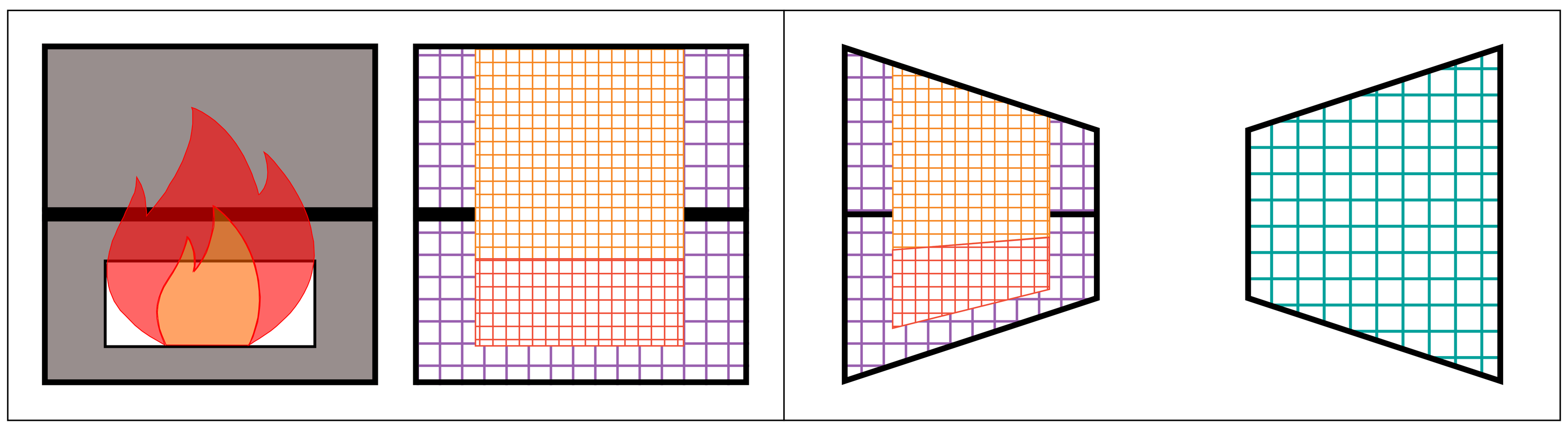

Figure 2: Illustrating the discretisation of an emitter into protected, unprotected and external elements and a neighbouring building's elevation into receiver elements.

WP1d)

Calibrate a sample to have a mean piloted ignition time of 10 minutes when exposed to a constant IHF of 12.6 kW/m^2. Create a machine learning classification model to predict if piloted ignition occurs for an identical sample exposed to a user-specified IHF curve. Train and validate the model using two sets of IHF curves - specifically, via H-TRIS testing and a range of analytically derived parameters. See Figures 3 and 4.

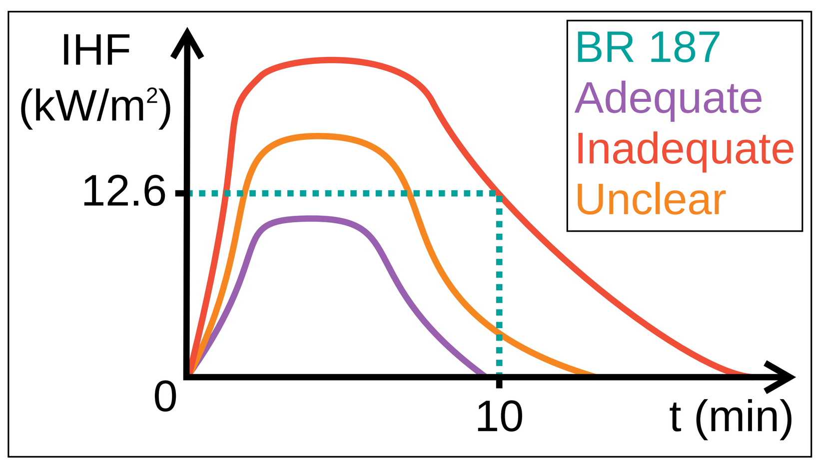

Figure 3: Illustrating the need for a comparative method for IHF curves

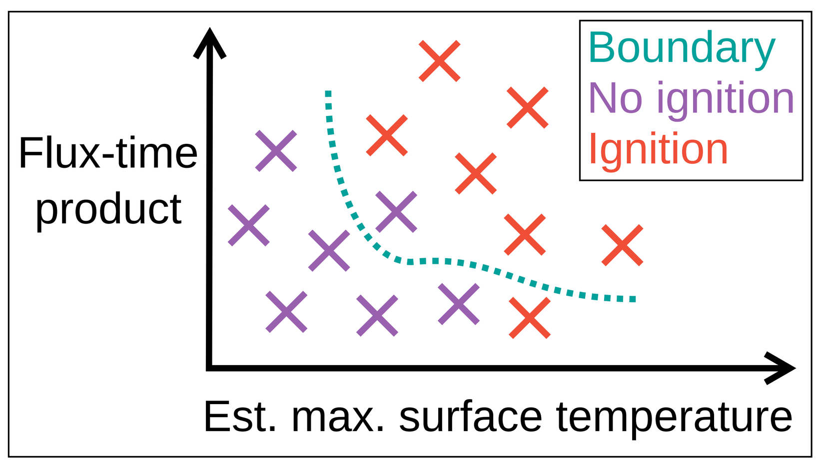

Figure 4: Illustrative contextualisation of the classification model concept

WP1e)

Develop a probabilistic methodology to quantify the implicitly acceptable probability of failure, considering a range of designs deemed adequate by the English regulatory system. Use this probability as a benchmark for a design tool that takes a range of building-specific parameters and assesses if the design proposal satisfies the APC.

WP1f)

Quantify the impact of combustible enclosures on factors influencing risk, e.g., higher temperatures and more external flaming. Update the tool as required.

WP2: STOREY-TO-STOREY FIRE SPREAD

WP2a)

The building should have an adequately low probability of upward storey-to-storey fire spread occurring within 15 minutes of ignition. For higher consequence buildings, a delay time greater than 15 minutes may be appropriate. The delay time of 15 minutes is based upon the findings of Fire Note 8 [3].

WP2b)

Same as WP1b).

WP2c)

Same as WP1c), except make the emitter exclusively comprise external elements and make the receiver the external wall on the storey above the compartment of fire origin.

WP2d)

Create a sample by positioning a cotton pad behind a glass panel with no recognised fire resistance. Calibrate the sample such that piloted ignition of the cotton pad occurs after an average of 15 minutes' exposure to the IHF curve induced 1 m above the top of the opening in a BS 8414 test [4]. Create a machine learning classification model to predict if piloted ignition of the cotton pad occurs within 15 minutes for an identical sample exposed to a user-specified IHF curve. Train and validate the model using the same approach as for WP1d), i.e., H-TRIS + derived parameters. See Figures 5 and 6.

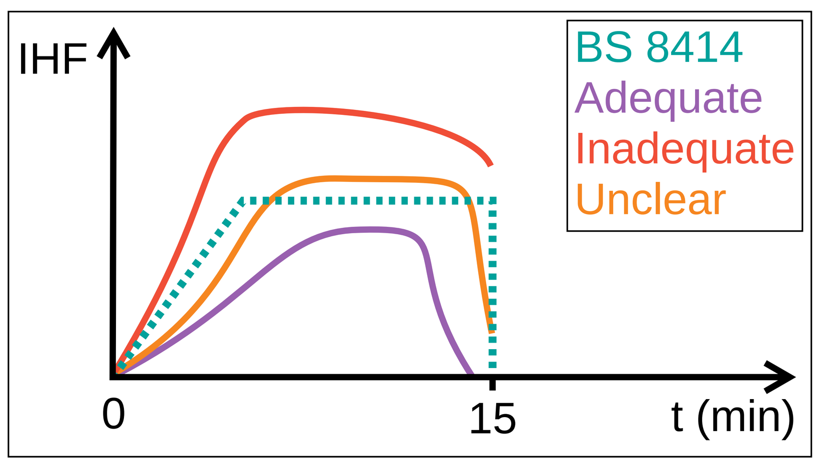

Figure 5: Benchmark IHF curves against the first 15 minutes of BS 8414 at 1 m

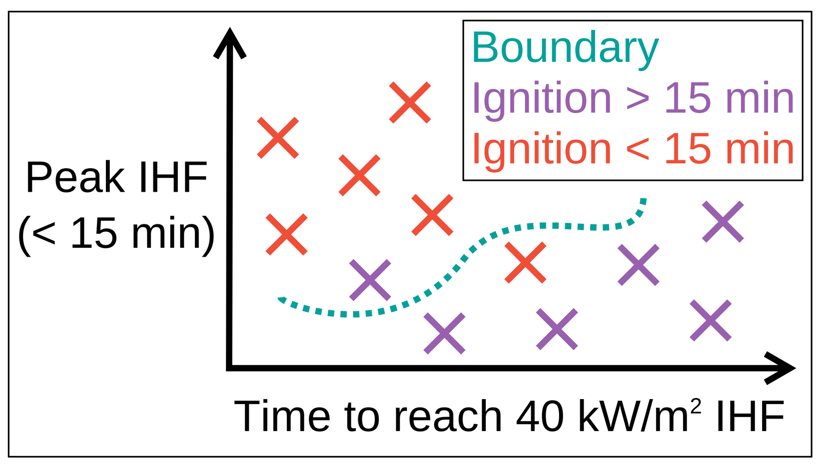

Figure 6: Illustrating the use of H-TRIS / derived parameters for model training

WP2e) - WP2f)

Same as WP1e) - WP1f).

REFERENCES

[1] R. Chitty, 'BR 187 External fire spread. Building separation and boundary distances.', 2nd ed. Watford: BRE Bookshop, 2014.

[2] I. Fu, I. Rickard, D. Hopkin, and M. Spearpoint, 'Application of python programming language in structural fire engineering - Monte Carlo simulation', presented at the Interflam 2019, Royal Holloway, 2019.

[3] G. J. Langdon-Thomas and M. Law, 'Fire and the external wall', Joint Fire Research Organisation, Boreham Wood, England, Fire Research Note 8, 1966.

[4] BSI, 'BS 8414-1:2020 Fire performance of external cladding systems. Part 1: Test methods for non-loadbearing external cladding systems fixed to, and supported by, a masonry substrate', BSI, London, 2020.