CladFire Project: Methodology

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Overview

The Grenfell Tower fire resulted in 72 deaths, and precipitated a building safety crisis within the United Kingdom. For many buildings, remedial works were deemed as being required to achieve an adequate level of safety. However, identifying which buildings should be remediated – and to what extent – is a highly subjective process.

To provide a framework for such assessments, government sponsored the creation of a Publicly Available Standard (PAS 9980 [1]). PAS 9980 sets out a process whereby the fire risk associated with external cladding systems can be assessed. There are three key parts of the analysis:

1) Fire performance risk factors. These relate to the materials and products used in the external wall system and their configuration in relation to one-another.
2) Façade configuration risk factors. These relate to factors such as the extent of cladding systems, and the locations of openings into the building.
3) Fire strategy risk factors. These relate to wider building considerations such as the presence or extent of detection and the locations of escape routes.

For many engineers, assessing items 2) and 3) is a relatively straightforward exercise. This is because information relating to fire strategy, and the location and extent of combustible cladding ought to be readily available – or can be obtained through investigation. However, assessing item 1) is more challenging as the assessor requires detailed knowledge of the cladding materials and products and how they may (as an assembly) react in a fire.

Assessors may obtain such information from a variety of sources such as reaction-to-fire testing or large-scale fire tests (e.g. BS 8414 [2] [3]). However, such supporting information may not be readily available for existing buildings, or may be prohibitively expensive and/or time-consuming to generate.

The Grenfell Tower Inquiry Phase 2 report [4] highlighted the need for practitioners to have access to a body of information – "such as data from tests on product and materials". The Inquiry recommended that the construction regulator sponsor development of such a "library".

Engineers at Design Fire Consultants Ltd and researchers at The University of Edinburgh's Edinburgh Fire Research Centre (EFRC) have worked together to:

- Undertake a series of tests on a wide array of candidate ventilated rainscreen cladding assemblies;
- Analyse and present the results; and
- Show how these data may be used in support of an external wall assessment.

This report represents the first output from this project.

1. Aims and objectives

The project's aim is to generate a publicly available dataset that can be used by practitioners in support of external wall assessments.

To achieve this aim, the objectives of the project are as follows:

1. To design and fabricate a test assembly that allows different combinations of cladding and insulation materials and products to be tested in combination, in a ventilated rainscreen configuration.
2. To capture data to allow the potential hazards of combinations of products to be quantified.
3. To present the data in such a way that a suitably competent professional may use it in support of an external wall assessment.
4. To make the data freely and publicly available so that practitioners may make use of it and signpost practitioners to examples of how such data might be used.

This first report is intended to present the method by which the test data was generated. Full data sets are available online at the project's database website, which is freely and publicly accessible at https://claddingdata.dfc.co.uk.

2. Limitations of this work

The scope of this project is to investigate the fire hazards presented by different combinations of rainscreen cladding and insulation materials and products.

While the overall aim is to generate a dataset that has utility for fire safety practitioners, it must be acknowledged that the degree to which any test within this project may be compared against a real building is clearly limited. Indeed, the test results do not – and cannot – be precisely representative of a real building. Furthermore, the data generated in this project do not constitute classification results, and no pass/fail criteria are provided.

The data is only useful to the degree which a suitably competent professional believes they provide relevant insights about the potential fire hazards presented by any cladding system.

While the intent of this work is to provide information that may support competently performed external wall assessments, it is readily acknowledged that the data presented in this study will always be limited. In particular they are limited by the specific products that were tested and the scale at which they were tested. Readers must judge for themselves whether the data presented (in its context with other data) is relevant and useful for their particular circumstance, and the extent to which this is the case.

2.1. Disclaimer

3. Specifying the test

To achieve the project aims, it was necessary to undertake fire testing within a laboratory setting.

The key objectives for the test were as follows:

1. The test should be able to accommodate a range of cladding and insulation materials and products of different thicknesses;
2. The test should allow differentiation between the source fire (i.e. ignition source) and the fire on or within the assembly;
3. The test should yield both quantitative and qualitative data for use by practitioners;
4. The test should expose edges of products that may otherwise involve encapsulation of combustible materials within non-combustible facers;
5. The test should be relatively easy to execute by the operator, thereby allowing a large number of tests to be performed in a relatively short amount of time;
6. The test should be comparatively inexpensive to perform;
7. The test should give reproducible and repeatable results.

4. Methodology

This section describes the testing apparatus, testing procedure, and the methods for data processing.

4.1. Apparatus

The overall apparatus was as shown in Figure 1.

4.1.1. Panel geometry

The geometry for the cladding and the insulation within the test assemblies was selected as being 1.2 m high, and 0.5 m wide.

- The 1.2 m height was selected because the typical size of panelised insulations and board products is 1.2 m wide which allows materials to be easily obtained and reduces the time to prepare samples. In addition, the 1.2 m height was sufficient to ensure that the top of each panel was relatively remote from the ignition source.
- The 0.5 m width was selected as the maximum size that could be accommodated in the facilities available at the University of Edinburgh's fire laboratory.

4.1.2. Cavity width

Although the ventilated cavity width could be a parameter of study, it was decided to fix the cavity widths for this experimental programme. To select the cavity width to be used, a sensitivity study was performed varying cavity width with an OSB "cladding" and mineral wool (MW) insulation "backing insulation". Based on this work, a 50 mm cavity width was chosen for the experimental programme, as this was felt to offer a balance between a relatively narrow cavity and sufficient clearance to allow visualisation within the cavity. The sensitivity study on cavity width is provided in the subsequent "results and analysis" report.

4.1.3. Ignition source

Three line burners with 1 mm diameter holes spaced at 25 mm centres were selected as the ignition sources. The location of these line burners in relation to exemplar insulation and cladding is illustrated in Figure 2. A wire mesh was placed in front of the assembly to minimise the impact of any cross-flow in the lab.

The insulation burner was intended to:

- Subject the exposed edge of the insulation to direct flame impingement;
- Be offset from the point of direct flame impingement to minimise the degree to which dripping material might obstruct the flow of propane from the holes;
- Be oriented to allow the flame to be present in the cavity and over the surface of the product within the cavity.

The cladding burners were intended to:

- Subject the exposed edge and the front surface of the cladding to direct flame impingement;
- Be offset from the point of direct flame impingement to minimise the degree to which dripping material might obstruct the flow of propane from the holes;
- Be oriented to allow the flame to be present in the cavity and over the surface of the product within the cavity.

4.1.4. Debris tray

A debris tray was provided 100 mm below the specimens to collect any falling material.

4.1.5. Instrumentation

Instrumentation was provided to allow the measurement of total heat release by oxygen consumption calorimetry. The cladding and the insulation were mounted on separate supporting frames which were placed on independent mass balances to allow the measurement of mass loss rate of each individual component. The debris tray was also placed on a mass balance to measure the mass of falling debris.

Cameras were located both in front of the assembly (to provide an overview), and to the side of the assembly (to allow the cavity to be viewed).

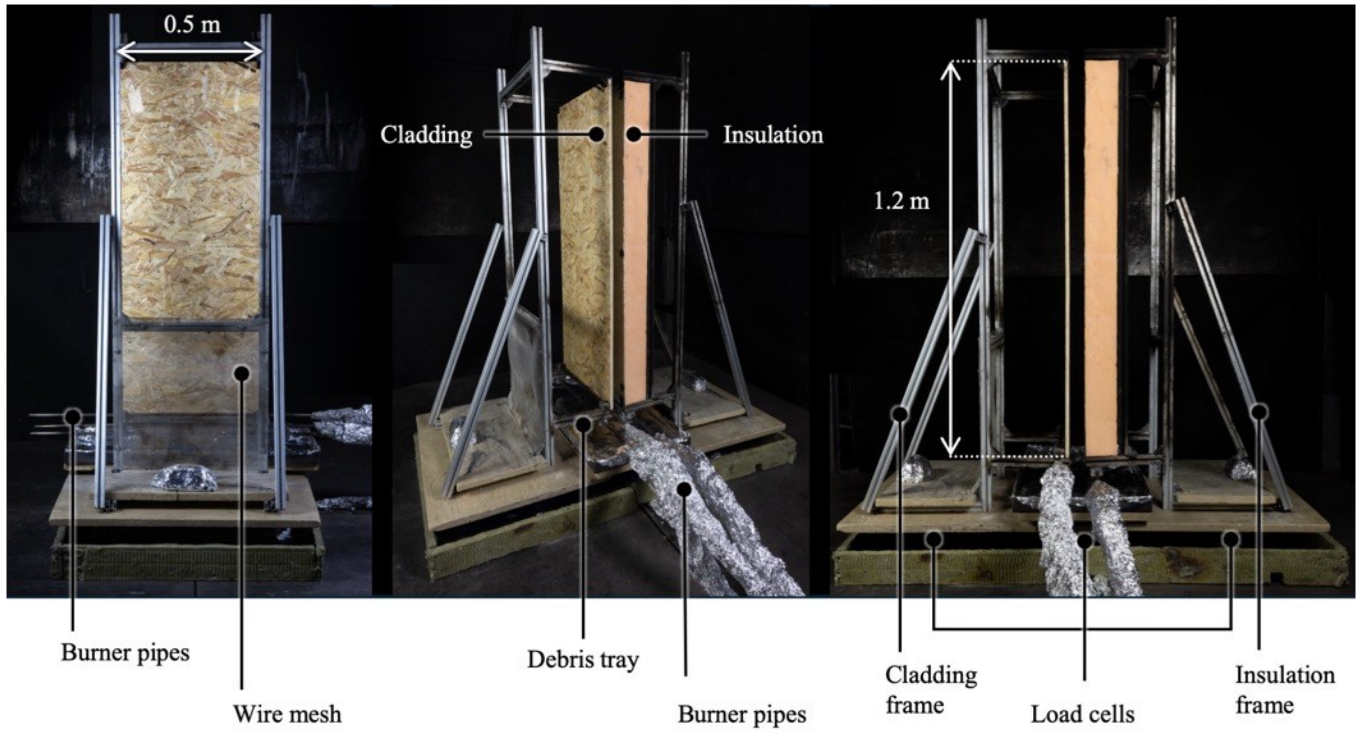


Figure 1. Photographs of constructed test assembly.

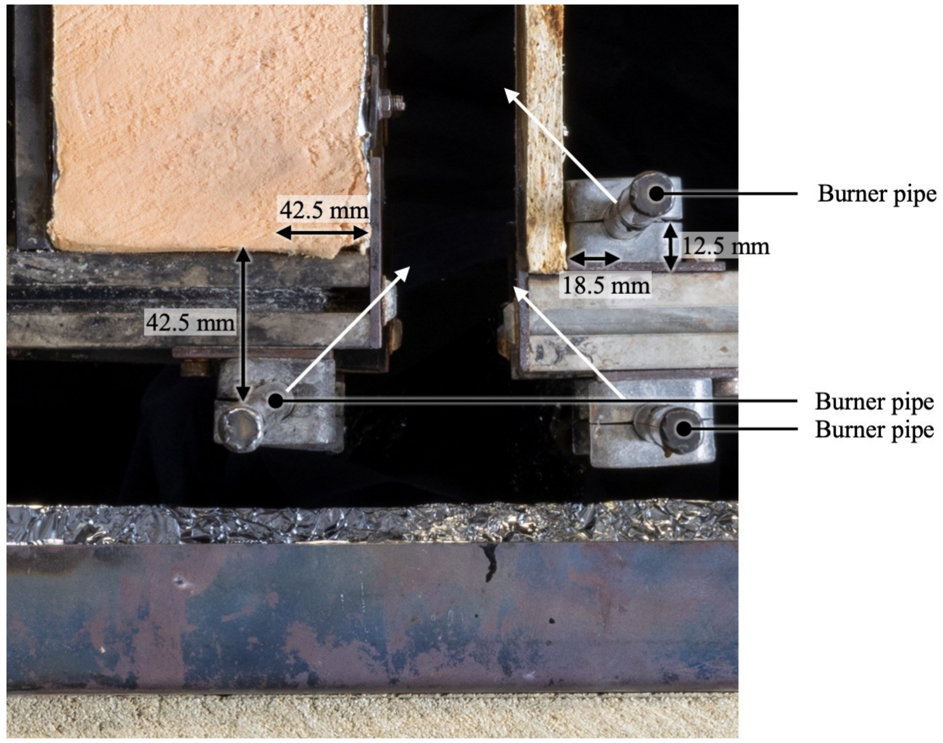


Figure 2. Detailing of line burner locations – white arrows show the indicative direction of propane on exiting the pipe. Note that the aluminium supports are present only at the panel edges.

4.1.6. Fixing details

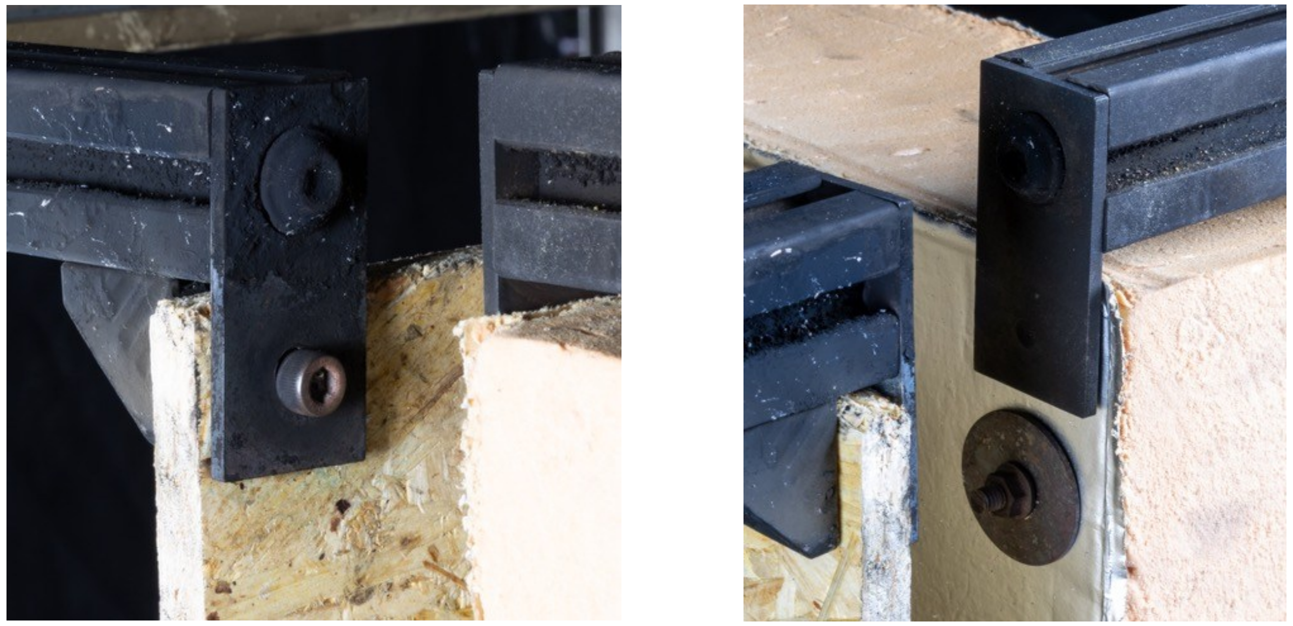
The cladding and insulation panels were supported by aluminium extrusions from below. An edge detail was provided to prevent each product from falling into the cavity, as shown in Figure 3.

The top of each insulation panel was held by a similar edge detail to prevent it from falling into the cavity. Illustrations of these fixing details can be seen in Figure 4.

The top corners of each cladding panel were also held by a bolt. The bolt was provided to prevent deformations at the bottom of the panels from causing the panel to fall into the cavity.

a) Cladding b) Insulation

Figure 3. Detailing of joint fixings, base.



a) Cladding b) Insulation

Figure 4. Detailing of joint fixings, top.

4.2. Test procedure

The test procedure was as follows:

1. The panels were positioned within the apparatus.
2. Gas flow to the burners was turned on, and the burners were ignited using a blowtorch.
3. The test was observed.
4. The test was terminated when one of the following two criteria were met:
    a. 30 minutes elapsed from ignition;
    b. The fire developed in such a way as to endanger the equipment (e.g. debris dropped into the region around either of the balances, or became larger than the capacity of the extraction system to remove combustion products). Where tests were terminated prior to 30 minutes, they are not included within the dataset.

4.3. Data processing

All data was interpolated to ensure a consistent timestep of 1 s for all datapoints.

Heat release rates (HRR) were calculated using O_2 consumption calorimetry as per Janssens [5]. Data was corrected to account for the time delays within the apparatus. Heat release data were then smoothed using a 20-point moving average (i.e. a 20 s moving average).

Mass data was processed into mass loss rate (MLR) by differentiation, and was then smoothed using a 100-point moving average (i.e. a 100 s moving average).

Video data was collated into a single file alongside a visualisation of the unsmoothed HRR data.

4.3.1. Data synthesis

The test data was also processed to create the following quantitative metrics:

- Peak heat release rate (kW);
- Time to peak heat release rate (mins);
- Peak rate of change of heat release rate (kW/s);
- Time to peak rate of change of heat release rate (mins);
- Total heat release (MJ);
- Residual heat release rate, averaged over the final minute of each test (MJ).

To generate these metrics, the baseline heat release rate of the burner (8.5 kW) was subtracted from the total heat release data. In addition, any values that were ± 3 kW of the baseline heat release were not used as this threshold eliminated the noise in the baseline being mistaken for a signal from the experiment.

5. Data Presentation

An objective for this project is to make the data publicly available so that practitioners may use the data in support of external wall assessments.

The data has been made available via the following website: https://claddingdata.dfc.co.uk.

For each test the following data is available for download in the form of a .csv file.

- General test information is as follows:
  - Test number;
  - File name;
  - Test name;
  - Cladding type;
  - Cladding thickness (mm);
  - Insulation type;
  - Insulation thickness (mm);
  - Cavity width (mm);
  - Repetition number;
  - Mass flow rate of propane (g/s);
  - Description of the test;
  - Experimental notes;
  - A permalink to an embedded video of the test;
  - Bulk density of the cladding (kg/m^3);
  - Bulk density of the insulation (kg/m^3);
  - Cladding material ID (UQ);
  - Insulation material ID (UQ);
  - Cladding gross heat of combustion (MJ/kg);
  - Insulation gross heat of combustion (MJ/kg);
  - Various unused fields.
- Key metrics are:
  - Peak heat release rate (kW);
  - Time to peak heat release rate (min);
  - Peak rate of change of heat release rate (kW/s);
  - Time to peak rate of change of heat release rate (min);
  - Total heat release (MJ);
  - Residual heat release rate (kW).
- Time series are provided for:
  - Test time (s);
  - Test time (min);
  - Heat release rate (kW) (unsmooted);
  - Heat release rate (kW) (smoothed);
  - Mass from rainscreen cladding scale (kg);
  - Mass from insultation scale (kg);
  - Mass from debris (drip) tray scale (kg);
  - Total mass (kg);
  - Mass loss rate (smoothed) of rainscreen cladding scale (g/s);
  - Mass loss rate (smoothed) of insulation scale (g/s);
  - Mass loss rate (smoothed) of debris (drip) tray scale (g/s);
  - Mass loss rate (smoothed) of total mass data (g/s).

Alongside the .csv file, the following visual or qualitative data are also available:

- An .mp4 file containing:
  - View from Camera 1;
  - View from Camera 2;
  - Animated plot of the heat release rate (unsmoothed) – note that this includes the baseline heat release from the burners.
- Images (from the videos) of:
  - The assembly prior to the test;
  - The assembly 10 s after ignition;
  - The assembly at peak heat release rate;
  - The assembly immediately prior to test termination.

Interactive plots are also provided that allow users to select tests and view the HRR plots within the online browser facility.

6. Conclusion

This report has presented the test and data acquisition/processing methodology. The manner in which data from the project has been processed has been described and the format of reporting has been explained.

The subsequent *CladFire Project: Results and Analysis* report will detail the results and analysis.

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7. References

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