Bushfire Burnover Assessment

of the By Joost Greenhouse : February 2012

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Figure 8 Fire resistant door





Fire Crunch

Alternative Australian
Certified Building Solutions

Figure 10 House construction part 2

(*clockwise from top left*: Top truss of portal frame; Roof framing; Roof lining; Installation of straw bale wall insulation; Roof membrane and external wall cladding)

3.1 House Construction Details

The house consisted of a portal frame/truss construction which provided clear spans between external walls (see Figure 10). All the framing except for the roof battens were constructed from light gauge steel 90mm x 42mm by 1mm thick cold rolled channel sections (see Figure 12). The frame was constructed using screwed joints. In the walls and portal frame the joints were recessed so the screw head is flush with the surface of the frame (see Figure 12). The floor, wall and roof cavities were sized to accommodate 950x400x450mm straw bales. All exposed faces of the building except the roof were lined with a double layer of 10mm FireCrunch board fasters to the frame by self-drilling, countersunk screws(see Figure 14).. The first layer was screwed at 300mm centres along each stud. The second layer was also screwed at 300mm centres offset by 150mm. The double layer provided a lap over any joints and redundancy if the outer layer becomes deformed or cracks. Due to shortage of material only part of the back wall had a double layer, strips of board were used to cover all joins in the back wall. The roof was protected by ~150mm of soil. All external gaps and joints were sealed with Tremco "TremStop Pu" polyurethane sealant (http://www.tremco.com.au/docs/techsheets/TREMstop%20PU.pdf) (see Figure 13)

Figure 12 Light gauge steel channel sections used for framing.

Figure 13 Tremstop Pu sealant used to fill gaps

Figure 14 Self-drilling, countersunk head screws used to fasten external cladding

3.1.1 Floor System

The floor system (see Figure 15) was supported by three 500mm deep truss bearers each of which forms the base of a portal frame. The floor was suspended 0.5m off the ground on 9 steel stumps to provide a worst case bushfire scenario allowing entry of flame to the underfloor, although the preferred construction system would be slab on ground. For practicality Mega Anchor (http://www.mega-anchor.com.au) foundation/stumps were used to support the floor system. This had the advantage that they were easy to install into the test pad and could be removed at the end of the testing. Both the flooring and the underside lining are supported by joists that span between the bearers and are screwed to the side of the top and bottom chords of the bearers. The underside lining consists of a double layer of 10mm thick FireCrunch board the flooring is a single layer of 20mm FireCrunch board The floor cavity is filled with straw bales with a ~100mm air gap between the top of the straw and the flooring. The outside face of the bearers are also lined with a double layer of 10mm thick FireCrunch board

Note. A localized buckling failure occurred in the bearer at the stump support during construction and additional steel beams were installed under the house for stability (See Figure 32 and Figure 35).

Figure 15 Floor system

The pre and post fire front radiant heat is provided by a single row of burners set on the ground a small distance from the front of the house as shown in Figure 21. The timing of the test is matched to the weather conditions to ensure the heated air from the burners is blowing towards the house.

The flame immersion stage uses a grid of burners in front of the house (including some right next to the house) as shown in Figure 22. The flames spread under, over and around the house.

Figure 21 House during the radiant heat exposure phase

Figure 22 House during the flame immersion phase

6. INSTRUMENTATION

The house was instrumented with thermocouples, radiometers and air sampling equipment to record:

- The air temperatures outside, inside and within the building cavities and surfaces
- The radiant heat on the outside of the building as well as that transmitted through the door glazing.
- The air quality within the room

A number of the thermocouples were aligned at two locations on the front wall of the house to record how the temperatures varied both through the wall and vertically up the wall. These locations are referred to as Sect A and Sect B, representing sections though the house at approximately one third distance in from the side as shown in Figure 25.

As many of the locations for temperature measurement would not have been accessible when the house was completed, a number the thermocouples were installed during the week construction period. The thermocouple leads were placed into bundles (see Figure 26) so they could be moved out of the way of construction work. Slots or holes were made in the floor, wall or ceiling lining to allow the cables to pass through. Due to construction scheduling it was necessary to provide 2 access holes through the front wall for some of the front wall and roof thermocouples (circled in blue in Figure 25). Once the house was completed the cables were draped across the room and attached to the data logging instrumentation in the centre of the floor (see Figure 27).

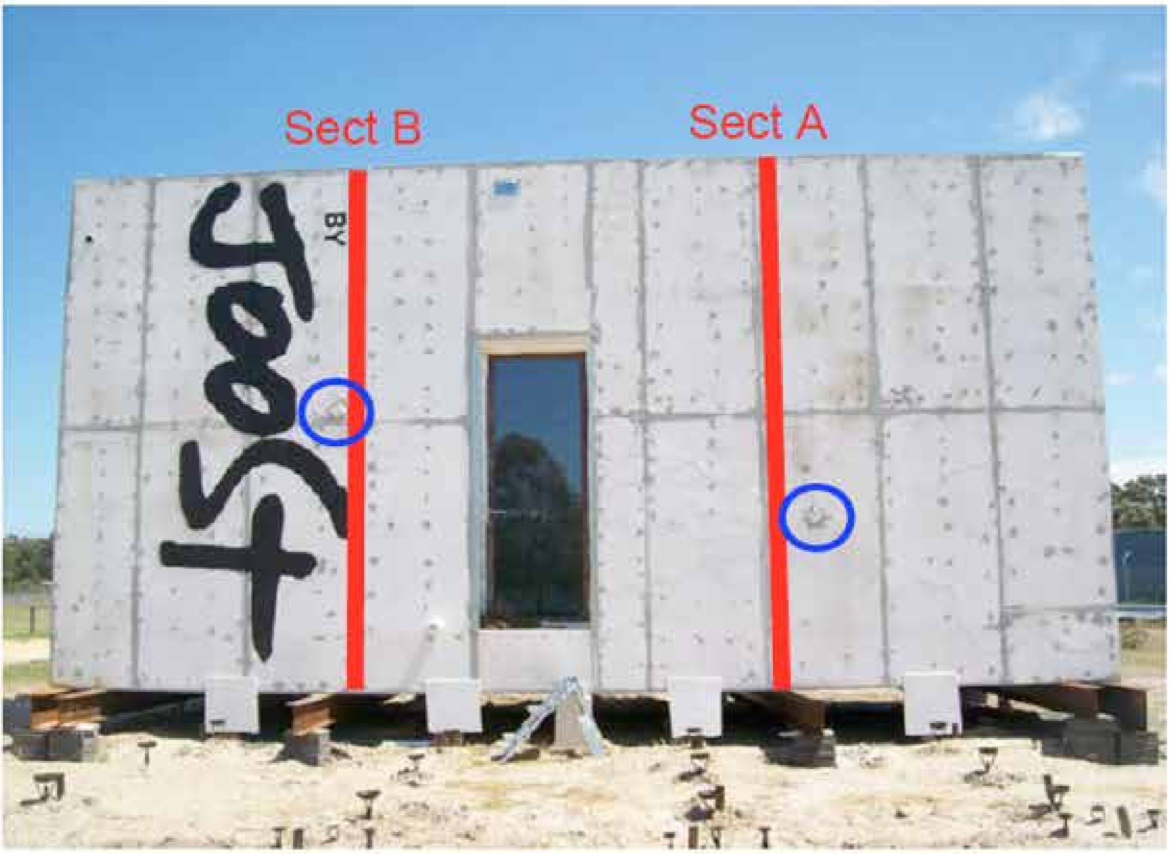


Figure 25 Locations of thermocouples in the front wall shown in red

(Access holes for external thermocouples circled in **blue**)

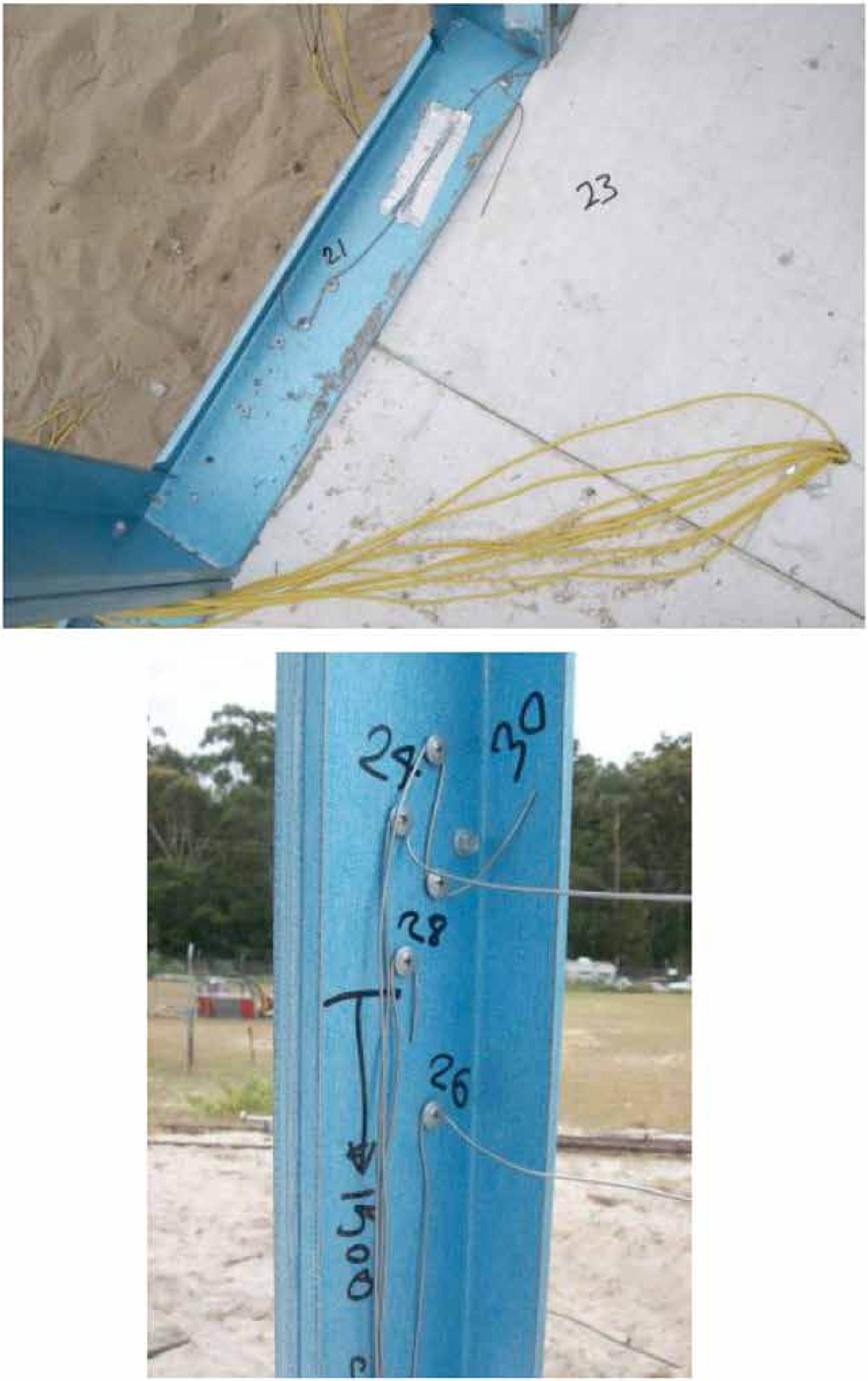


Figure 29 Examples of thermocouples used for measuring surface temperatures

(#21 bottom plate flange, # 28 stud web, #30 stud flange)

8.5 Air temperature on the outside of house

The air temperature on the outside of the house during the flame immersion phase is shown in Figure 39, Figure 41 and Figure 41.

The average air temperature across the front of the house was measured at 12 locations and was found to vary between 500-1000°C while peak temperatures varied between 700-1200 °C. The temperatures are symmetric about the vertical centreline of the front wall indicating the flame immersion was reasonably uniform. The variation in temperature closely matches the burn pattern on the cladding with exposure to an average temperature of less than 500 °C causing little discoloration to the cladding. The area around the door and the two sections where the majority of thermocouples were placed (Sect A and Sect B) were exposed to the highest temperatures with average values over 900 °C.

The average air temperature at the centre of the side walls varied between 500-600 °C while the peak temperature varied between 800-1000 °C.

The air temperatures on the underside of the house were measured at four locations, two near the front and two near the centre. The temperatures were reasonably uniform with average temperatures around 800-900 °C and peak temperatures around 1000 °C.

The temperatures on the back wall and top of the house were significantly lower with average values generally less than 200 °C and peak values less than 300 °C except for the lower back location where the values were a little higher.

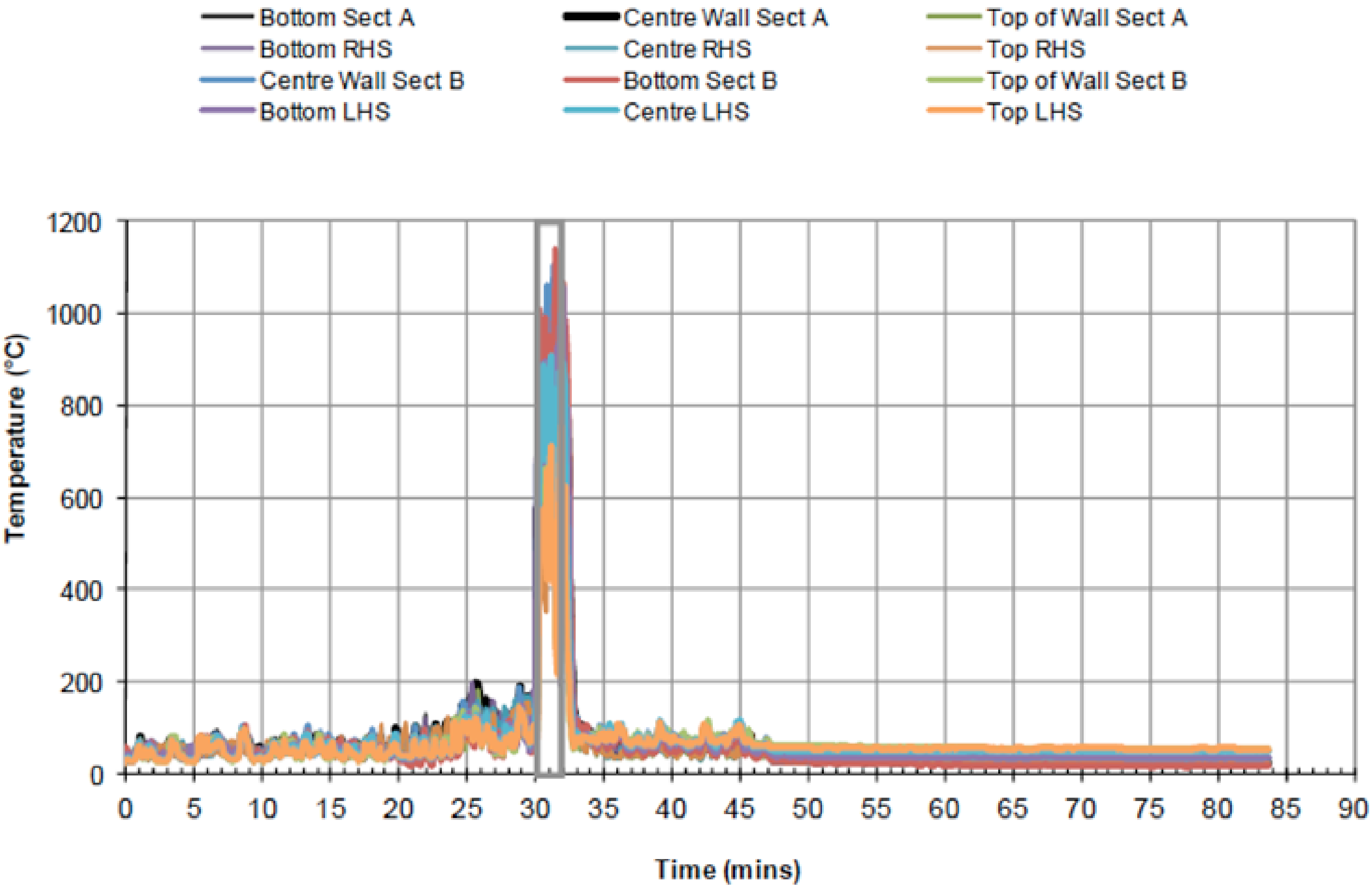


Figure 39 Temperatures on the front of the house

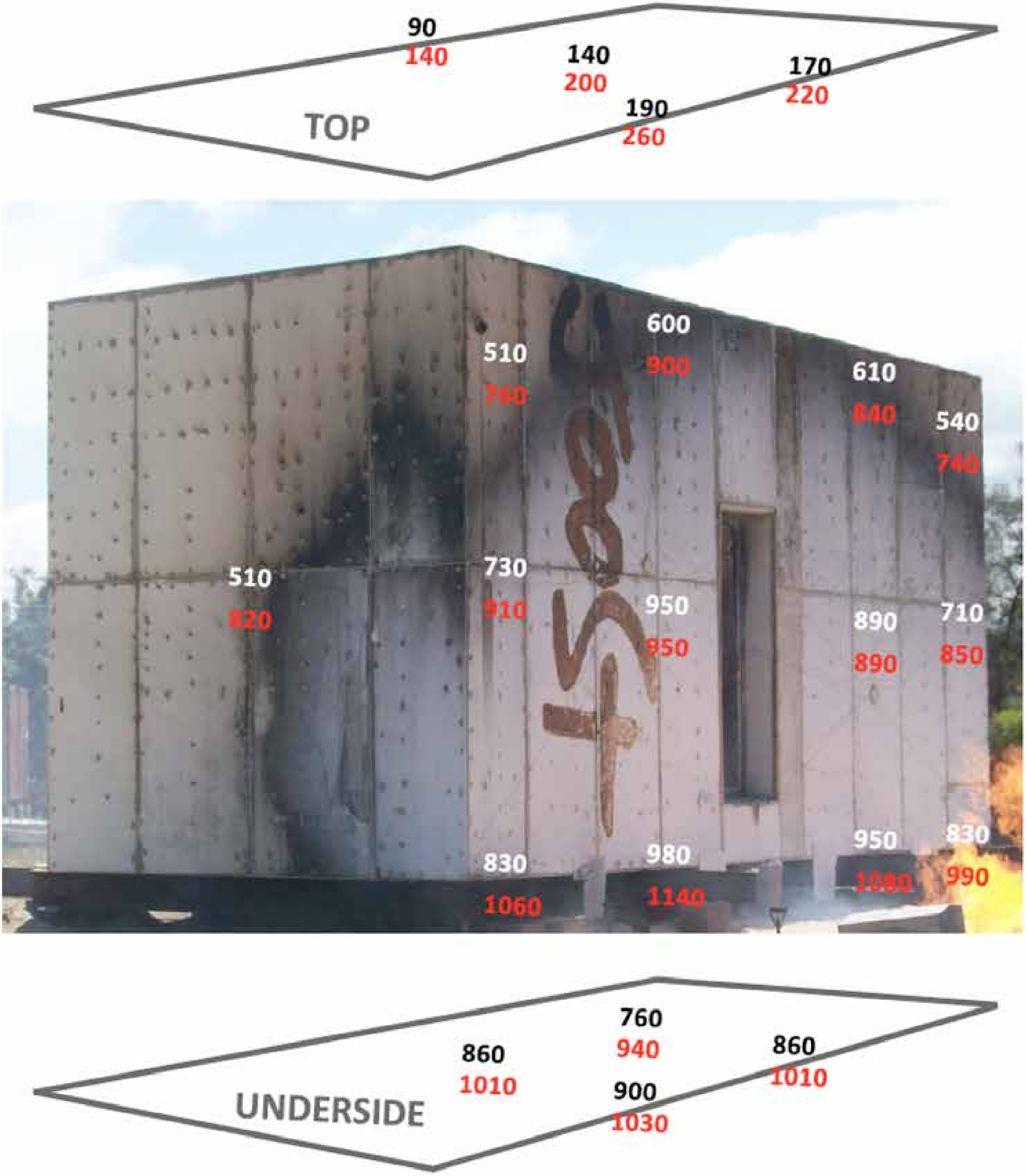


Figure 40 Average air temperatures (°C) on the outside front, side, top and bottom of the house during flame exposure.

(Numbers in red represent peak values)

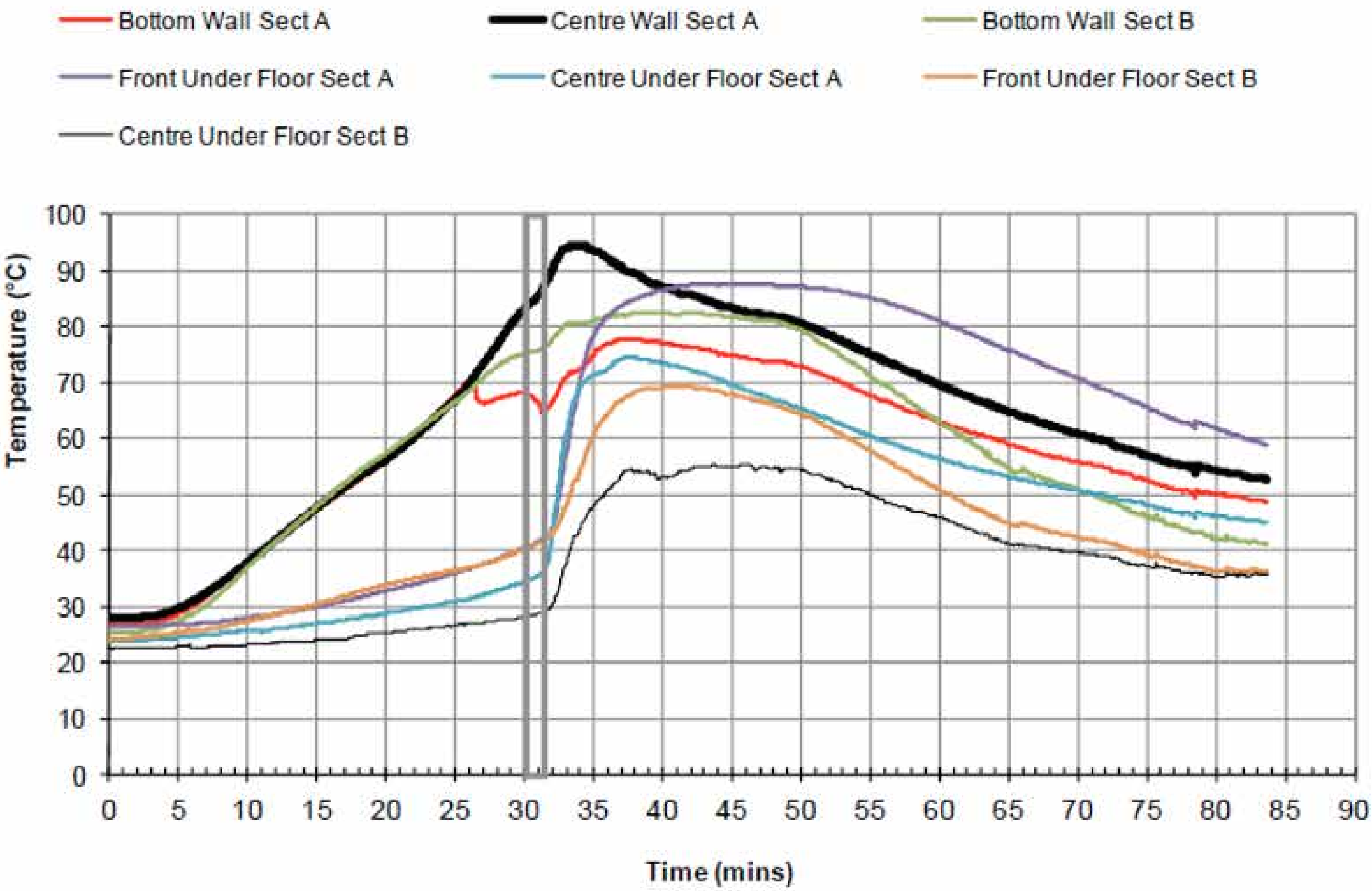


Figure 44 Temperatures on inside surface of external cladding

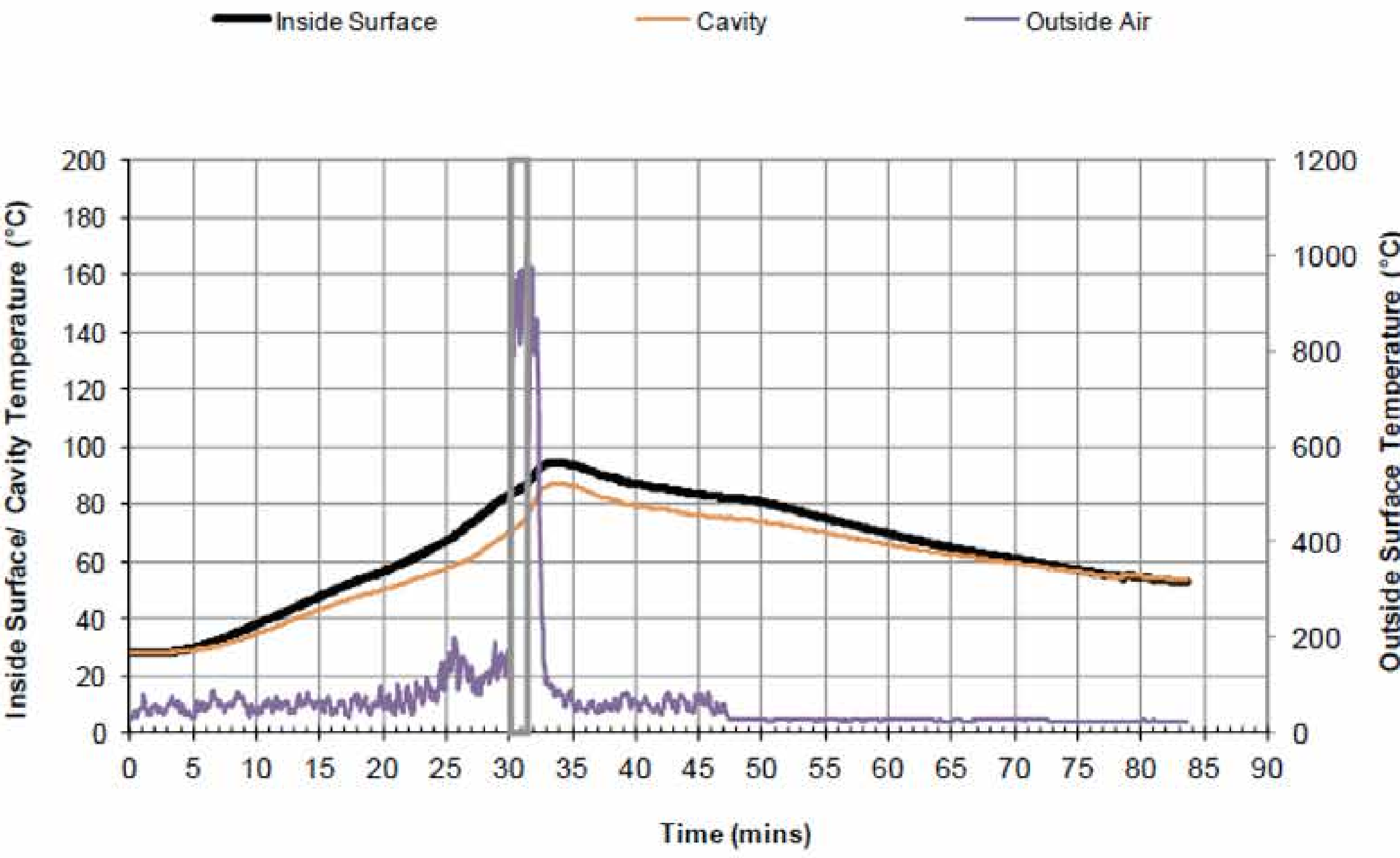


Figure 45 Temperatures on external wall cladding (Sect A)

Figure 49 Thermocouple placement on roof truss

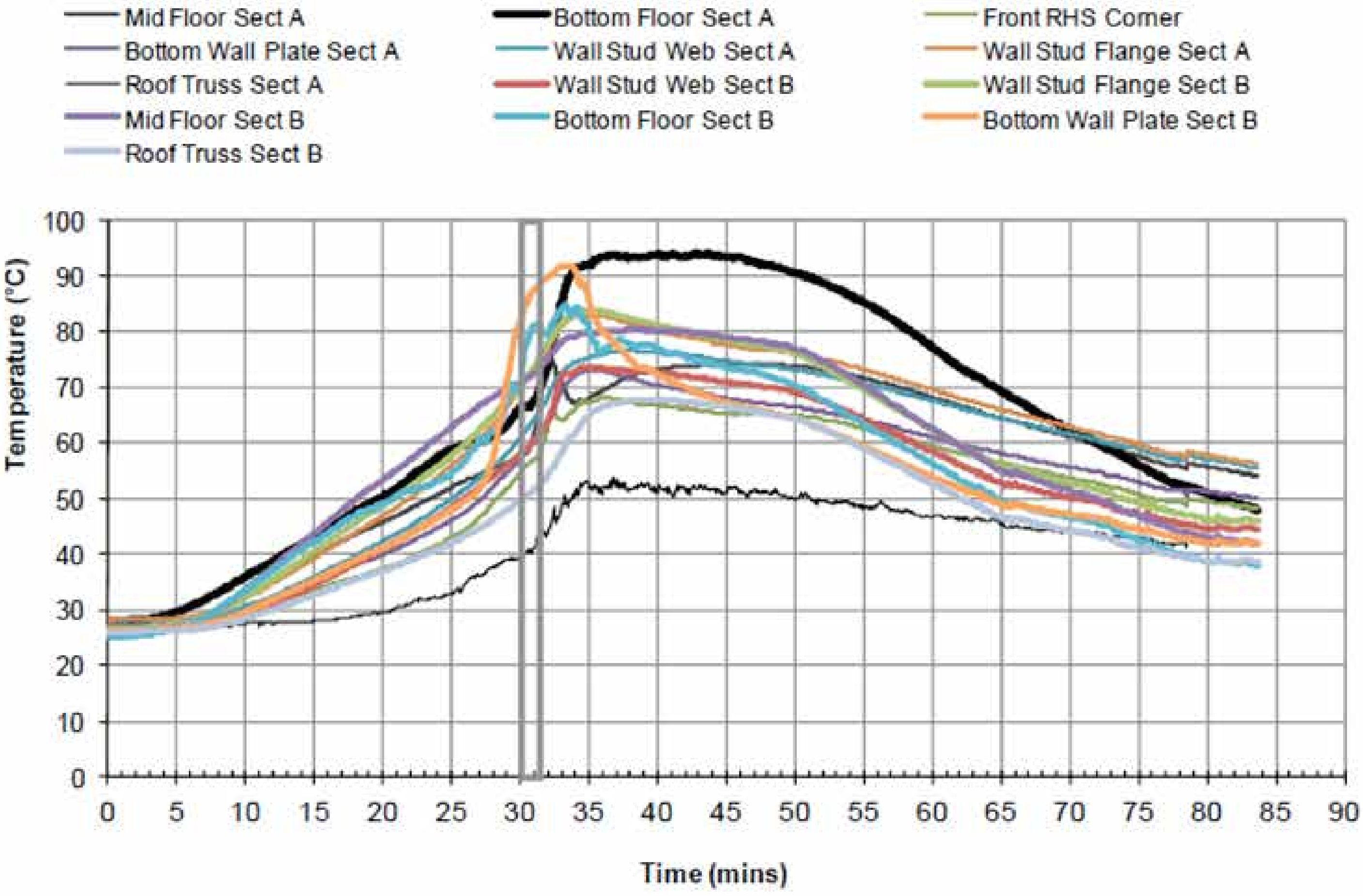


Figure 50 Temperatures on inside surface of external cladding

Figure 51 Frame after test (Bottom of wall Sect A)

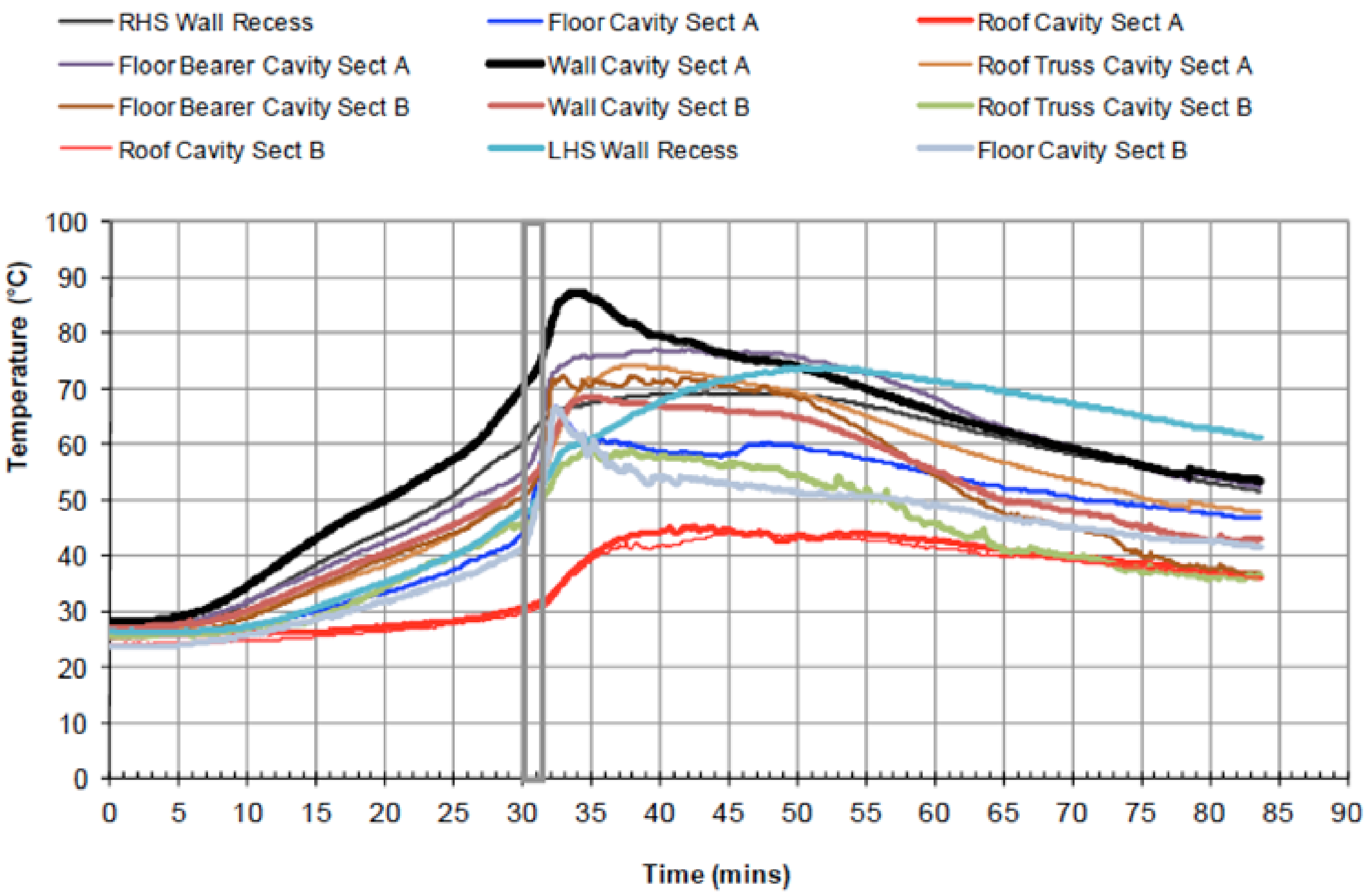


Figure 53 Cavity temperatures

8.9 Interior air temperature

8.9.1 Thermocouple locations

Thermocouples were installed on a stand in the centre of the room. The individual locations were:

- 0.5m above floor level
- 1.5m above floor level
- 2.5m above floor level

Note the ceiling height was 3m. The locations are shown in Figure 54.

8.9.2 Performance

A plots of the temperatures are shown in Figure 55

The following points are noted:

- The maximum rise in temperature was less than 40 °C. Within 0.5m of the floor the rise is less than 35 °C.

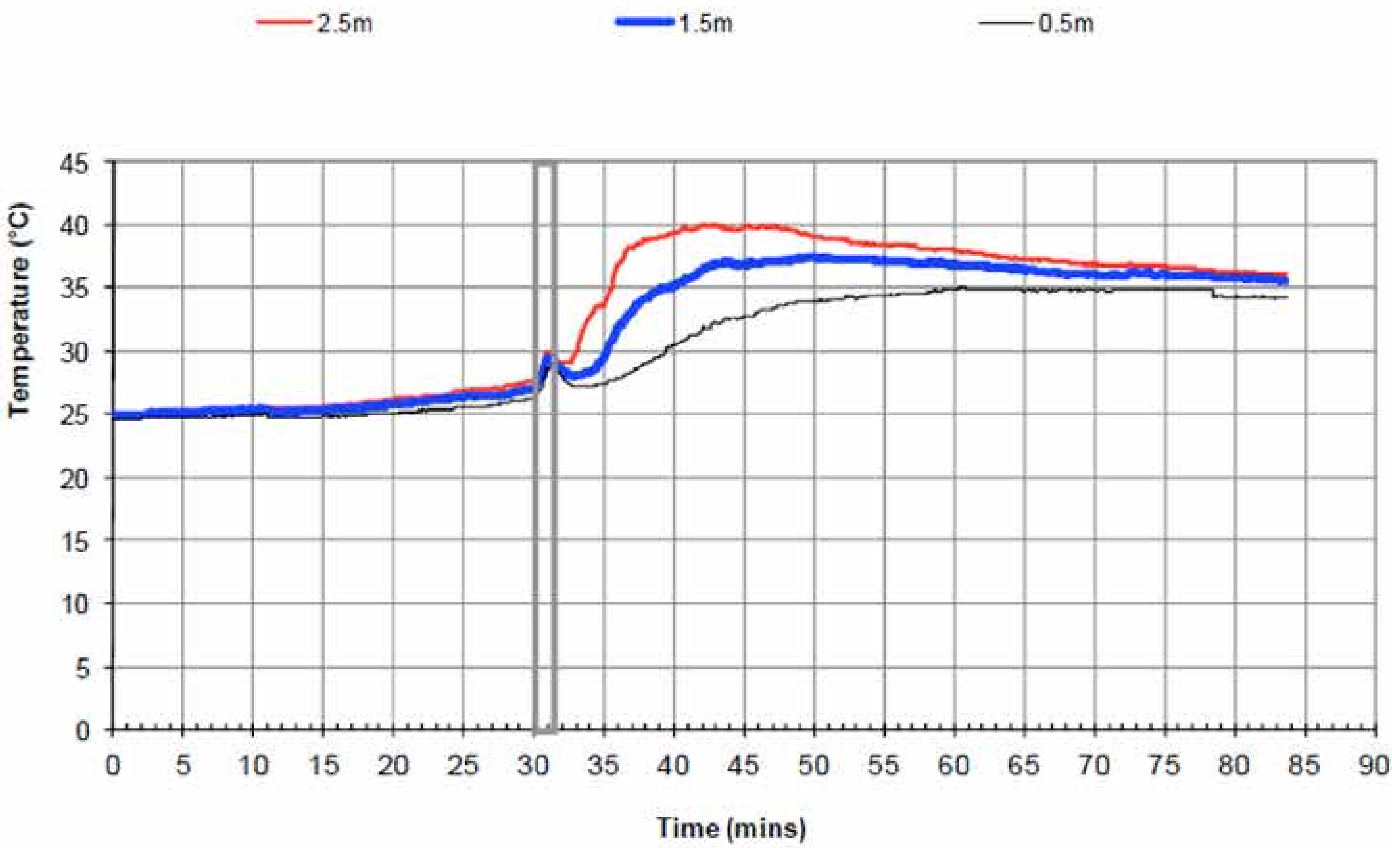


Figure 55 Indoor surface temperatures

Figure 56 Interior air after test

Figure 57 Typical thermocouple locations for measuring internal surface temperatures

(#66-top of wall, #68-ceiling)

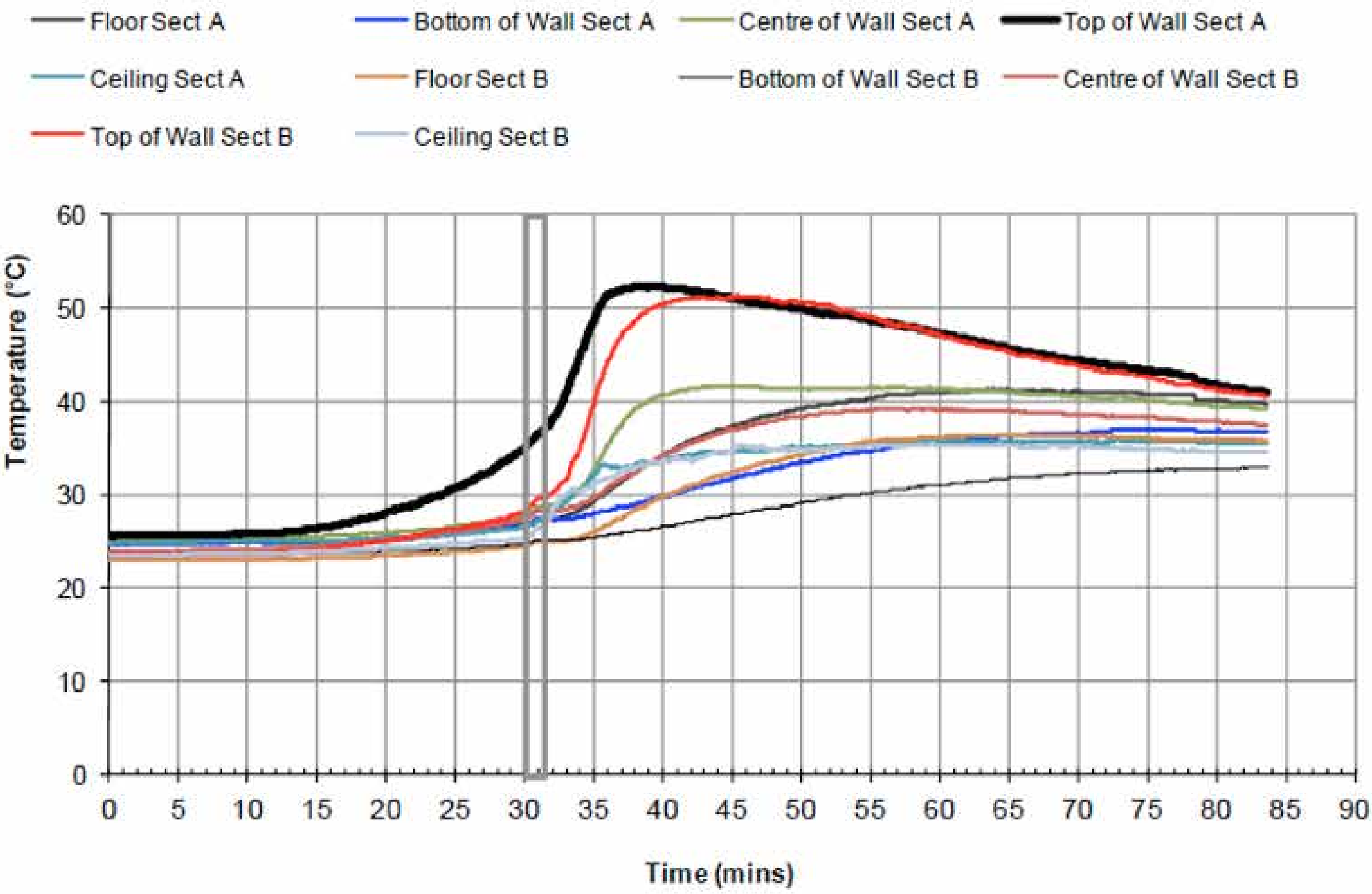


Figure 58 Internal surface temperatures

Figure 59 Interior of house after test

8.11 Door

8.11.1 Radiant heat through the glass

The radiant heat through the glass was measured using a radiometer set back 356mm from the inside centre of the door as shown in Figure 34. The plot of the radiant heat through the glass is given in Figure 60. This shows the peak to be less than $4kW/m^2$.

8.11.2 Thermocouple locations

Thermocouples were installed on both the inside and outside of the door (see Figure 61 and Figure 62). The individual locations were:

Inside

1. Top of Glass (on top left corner)
2. Bottom of Glass (on bottom left corner)
3. Centre Frame (on frame mid height hinge side)

4. Gap Hinge Side (air gap between door and frame mid height on hinge side)
5. Gap Handle Side (air gap between door and frame near handle)
6. Door Handle

Outside

7. Bottom of Glass (bottom right corner)
8. Mid Height of Glass (mid height on hinge side)
9. Mid Height of Frame (mid height on hinge side)
10. Air Top of Recess (air top of recess on hinge side)
11. Air Bottom of Recess (air bottom of recess on hinge side)

8.11.3 Performance

Plots of the temperatures are shown in Figure 63 and Figure 64.

The following points are noted:

- The outside glass temperature (green in Figure 63) increases at a faster rate than the air temperature reaching ~250 °C or approximately 100 °C higher than the air temperature just before the flame immersion phase.
- The outside glass, frame and air temperatures are ~900 °C during the flame immersion phase.
- The outside bottom glass temperature drops rapidly 15secs after the start of the flame immersion phase. This is likely due to the outside glass pane of the door failing and dislocating the thermocouple.
- The inside glass temperature reaches a maximum of ~130 °C, occurring more than a minute after the flame immersion phase began. During the flame immersion phase the temperature is less than 80 °C.
- The inside temperature of the steel door frame and the glass have a very similar temperature profile over the duration the test.
- The door handle temperature reaches a maximum temperature of ~60 °C, 3 minutes after the end of the flame immersion.
- The inside air temperature in the gap between the door and the frame increases rapidly on the hinge side towards the end of the flame immersion. This may be due to hot air entering the gap or to the thermocouple coming into contact with the door due to deformation of the door/frame. The air temperature in the gap on the handle side increases rapidly after the flame immersion phase to ~70 °C, 3 minutes after flame immersion then instantly jumps to ~120 °C. This is probably due to the thermocouple coming into contact with the door due to deformation of the door/frame. Both temperatures then follow the same decline as for the inside glass and frame of the door.
- At the end of the test (45minutes) the temperatures are in decline.

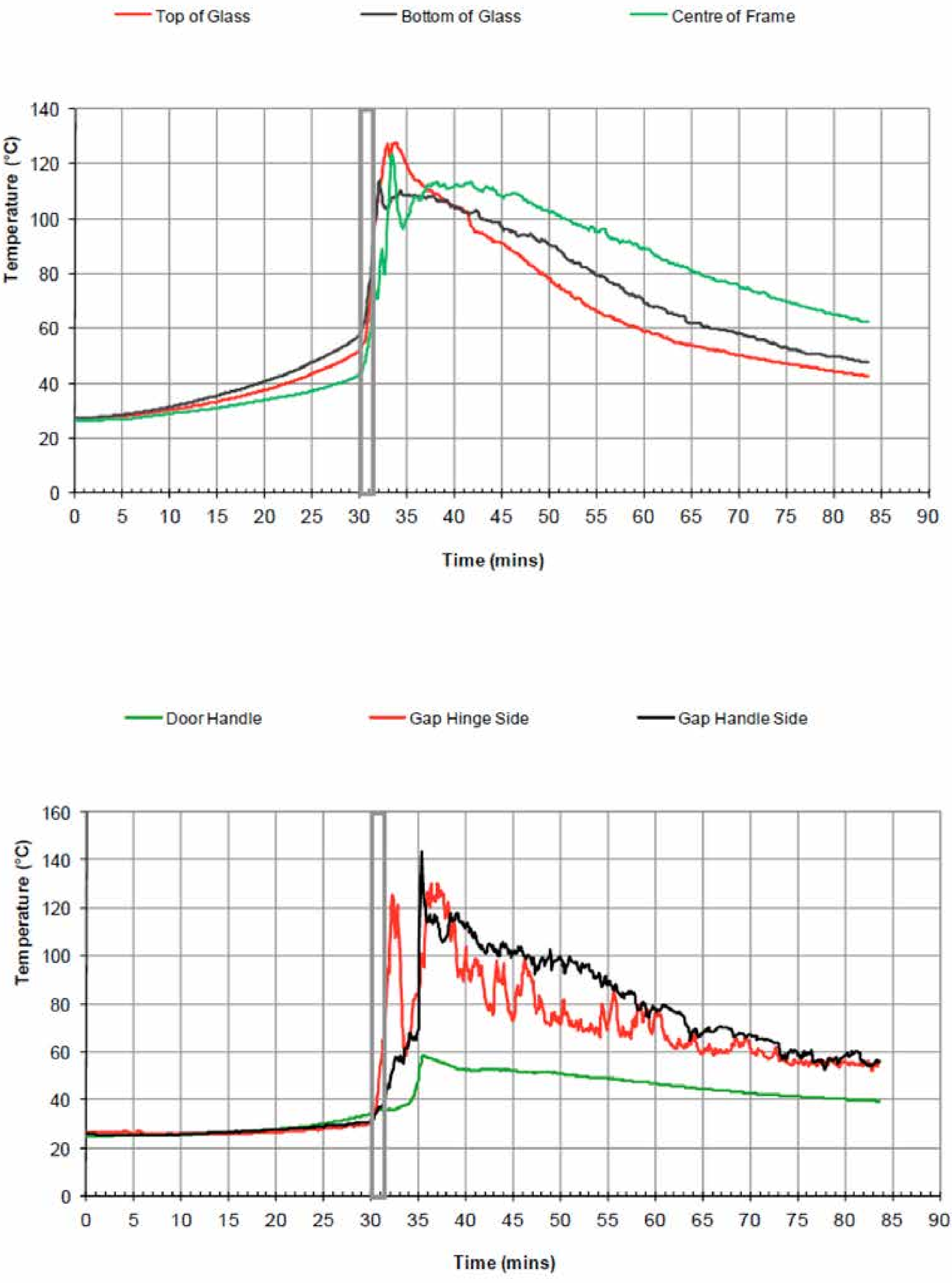
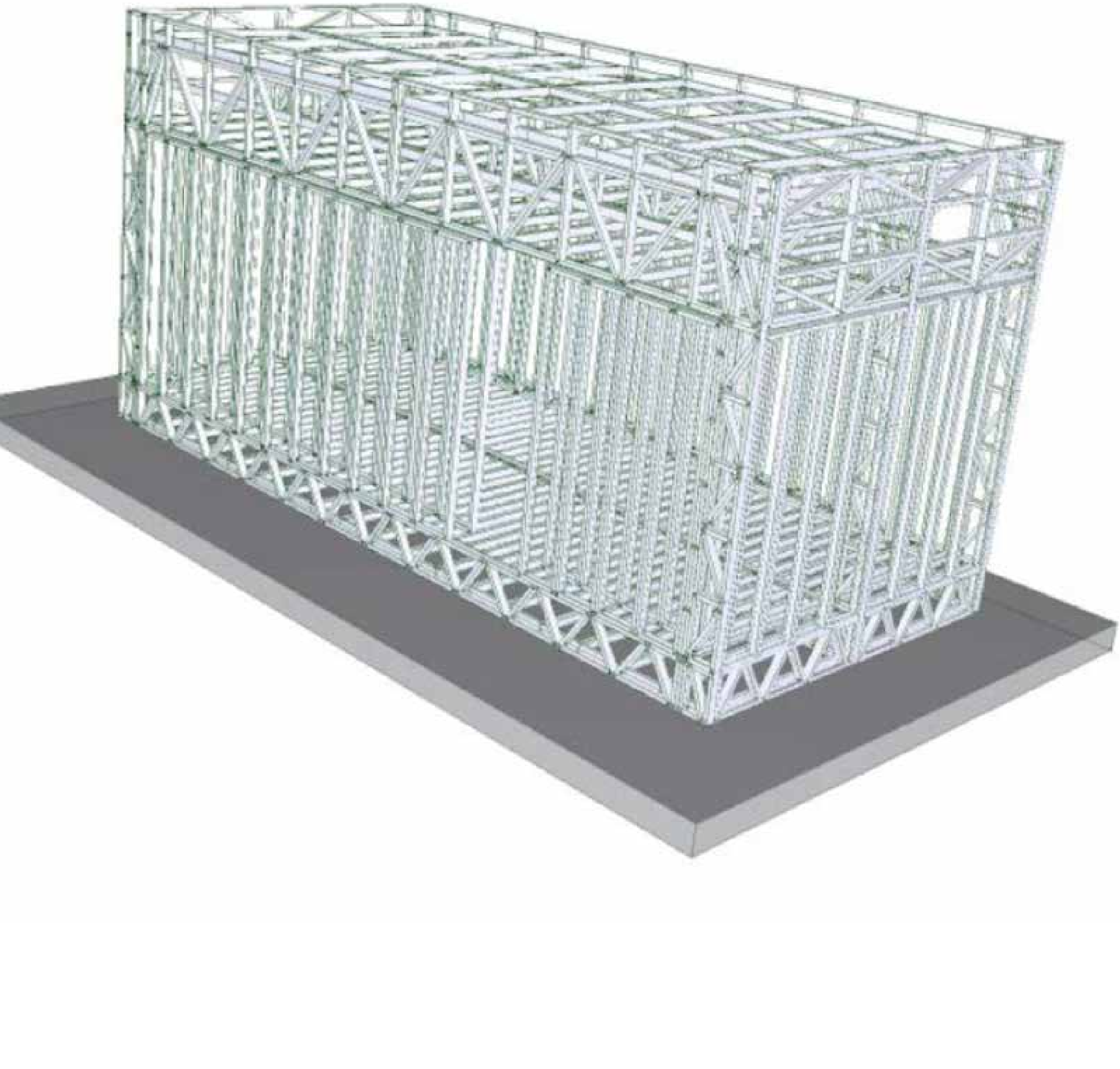


Figure 64 Temperatures on inside of the door



5.4 Burners

Burner nozzles used are mounted on 150 mm vertical stems off the manifolds. This allows the manifolds to be covered with sand to a depth of 50 to 100 mm for heat insulation. Brass jets, appropriately sized for each test, can be quickly screwed in as needed. For the purpose of flame shaping, each burner has a convex-down deflector approximately 150 mm in diameter mounted 150 mm above the jet, see Figure 24. For this experiment the burner nozzles delivered at approximately 16 MW/m of fire line, which was considered sufficient to create flame significantly taller than the house hence effectively immerse it, high gas flow rate will have produce a larger flame body but is unlikely to have resulted in a more severe direct exposure to the house with the excess heat energy being expressed well above the house.

The burners are ignited by pilot flames that are lit prior to the start of the test.

Figure 24 Gas delivery from main grid burners

5.5 Flow measurement

The great benefit of simulated bushfires is the capability of accurately controlling the rate of fuel delivery. The simulator is fitted with nitrogen-regulated supply pressure for propane delivery, and calibrated jet sizes.