Solutions for mid-rise wood construction: full-scale standard fire test for exterior wall assembly using lightweight wood frame construction with gypsum sheathing: Test EXTW-1: report to Research Consortium for Wood and Wood-Hybrid Mid-Rise Buildings

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REPORT TO RESEARCH CONSORTIUM FOR WOOD AND WOOD-HYBRID MID-RISE BUILDINGS

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(TEST EXTW-1)

E. Gibbs, B.C. Taber, G.D. Lougheed, J.Z. Su and N. Bénichou

1 INTRODUCTION

The acceptable solutions provided in the 2010 National Building Code (NBC) Division B [1] limits the use of combustible (wood) construction based on building height. For example, for Group C (Residential), Group D (Business and Personal Services) and Group E (Mercantile) occupancies, combustible construction can be used up to 4 storeys, and up to 2 storeys for Group A – Division 2 (Assembly) occupancies. In addition to the building height limitation, there are also building area limitations in the 2010 NBC for the use of combustible construction for these occupancies. For buildings that exceed the height and area requirements for combustible construction, the prescriptive requirements in the 2010 NBC require that noncombustible construction be used for the primary structural elements.

The prescriptive construction requirements for fire safety and protection of buildings, which are dependent upon the building size and occupancy type, are provided in Subsection 3.2.2 of the 2010 NBC. This includes the identification of the buildings for which noncombustible construction is required. The intent of the prescriptive requirements for noncombustible construction as they relate to the NBC fire safety/fire protection of building objectives is "*to limit the probability that combustible construction materials within a storey of a building will be involved in a fire, which could lead to the growth of fire, which could lead to the spread of fire within the storey during the time required to achieve occupant safety and for emergency responders to perform their duties, which could lead to harm to persons/damage to the building*".

The 2010 NBC defines noncombustible construction as "*that type of construction in which a degree of fire safety is attained by use of noncombustible construction materials for structural members and other building assemblies*" [1]. Article 3.1.5.1 requires that a building or part of a building required to be of noncombustible construction be constructed using noncombustible materials. The intent of this requirement, as it relates to the NBC fire safety/fire protection of building objectives, is "*to limit the probability that construction materials will contribute to the growth and spread of fire, which would lead to harm to persons/damage to the building*".

The NBC does permit, as exceptions, an extensive use of combustible materials in buildings otherwise required to have their primary structural elements to be of noncombustible construction. The allowed materials and associated limitations are primarily provided in Articles 3.1.5.2 to 3.1.5.21. Generally, the combustible elements permitted relate to interior finishes, gypsum board, combustible roofing materials, combustible plumbing fixtures, cabling, protected insulation, flooring, combustible glazing, combustible cladding systems, non-loadbearing framing elements in partitions, stairs in dwellings, and trim and millwork, among others.

Divisions B of the NBC (the “acceptable solutions” portion of the Code) generally does not permit combustible materials to be used for the primary structural elements in buildings required to be of noncombustible construction. In the Scoping Study [2] for mid-rise and hybrid buildings, it was suggested that an alternative solution using wood construction may be developed to meet the intent of the prescriptive “noncombustibility” requirement for mid-rise (and taller) buildings. As one approach, encapsulation materials could be used to protect the combustible (wood) structural materials for a period of time in order to delay the effects of the fire on the combustible structural elements, including delay of ignition. In delaying ignition, any effects of the combustion of the combustible structural elements on the fire severity can be delayed. In some cases, and depending upon the amount of encapsulating material used (e.g. number of layers), ignition of the elements might be avoided completely. This scenario would primarily depend upon the fire event and the actual fire performance of the encapsulating materials used. A research project, Wood and Wood-Hybrid Midrise Buildings, was undertaken to develop information to be used as the basis for alternative/acceptable solutions for mid-rise construction using wood structural elements.

In Article 3.1.5.5, the NBC allows the use of combustible components for non-loadbearing exterior walls to be used in a building required to be of noncombustible construction provided:

a) the building is
    i. not more than 3 storeys in height, or
    ii. sprinklered throughout,
b) the interior surfaces of the wall assembly are protected by a thermal barrier conforming to Sentence 3.1.5.12.(3), and
c) the wall assembly satisfies the criteria of Sentence 3.1.5.5.(3) and 3.1.5.5.(4) when subjected to testing in conformance with CAN/ULC-S134 *Fire Test of Exterior Wall Assemblies* [3].

Since the introduction of the requirements for the use of combustible components for non-loadbearing exterior walls in noncombustible construction, a number of proprietary cladding systems have been developed that meet the requirements in the NBC when tested using CAN/ULC-S134. However, one assumption in this testing is that the non-loadbearing exterior wall assemblies will be used in conjunction with an exterior wall system constructed using noncombustible structural elements either as infill or panel type walls between structural elements or attached directly to a loadbearing noncombustible structural system (see Appendix Note A-3.1.5.5.(1) of the 2010 NBC).

During the development of the CAN/ULC-S134 test method, three assemblies using lightweight wood frame construction met the criteria in the 2010 NBC for non-loadbearing exterior walls [4, 5]:

1. Assembly 3.1. - Vinyl siding on gypsum sheathing on glass-fibre-insulated untreated (non-fire-retardant-treated) wood frame wall;
2. Assembly 3.3. - 12.7 mm fire-retardant-treated plywood on untreated (non-fire-retardant-treated) wood studs, with phenolic foam insulation in cavities; and
3. Assembly 3.4. - Aluminum sheet (0.75 mm) on fire-retardant-treated wood studs, with phenolic foam insulation in cavities.

The results of the original three tests can currently provide the basis for developing generic alternative solutions for exterior wall assemblies for use in mid-rise buildings using lightweight wood frame construction. However, generic alternative solutions based on these tests would be limited by the materials tested, including the insulation types used in the original tests.

One of the tasks in the project, Wood and Wood-Hybrid Midrise Buildings, was to develop further information and data for use in developing generic exterior wall systems for use in mid-rise buildings using either lightweight wood frame or cross-laminated timber as the structural elements. This report describes a standard full-scale exterior wall fire test conducted on March 6, 2012 on an insulated lightweight wood frame wall assembly protected using gypsum sheathing. The test was conducted in accordance with CAN/ULC-S134-13 [3].

2 TEST FACILITY

The test was conducted using the exterior wall fire test apparatus as described in CAN/ULC-S134 (see Figure 1 and Figure 2) located in the Burn Hall of the NRC Fire Laboratory, Almonte, Ontario.

The burn room portion of the apparatus consisted of a reinforced concrete floor, concrete block walls and a precast concrete panel ceiling. The walls and ceiling were covered on the room side with 25 mm thick ceramic fibre insulation. The floor was covered with 57 mm thick fired clay paving stones. The inside dimensions of the burn room were 5.95 m wide, 4.4 m deep and 2.75 m high.

The fuel source in the burn room consisted of four 3.8 m long linear propane burners spaced equally along the width of the room and designed to provide a fire exposure equivalent to uniformly-distributed wood cribs of kiln-dried pine (with pieces 38 mm x 89 mm), having a total mass of approximately 675 kg. The burners were mounted 0.6 m above the surface of the paving stones.

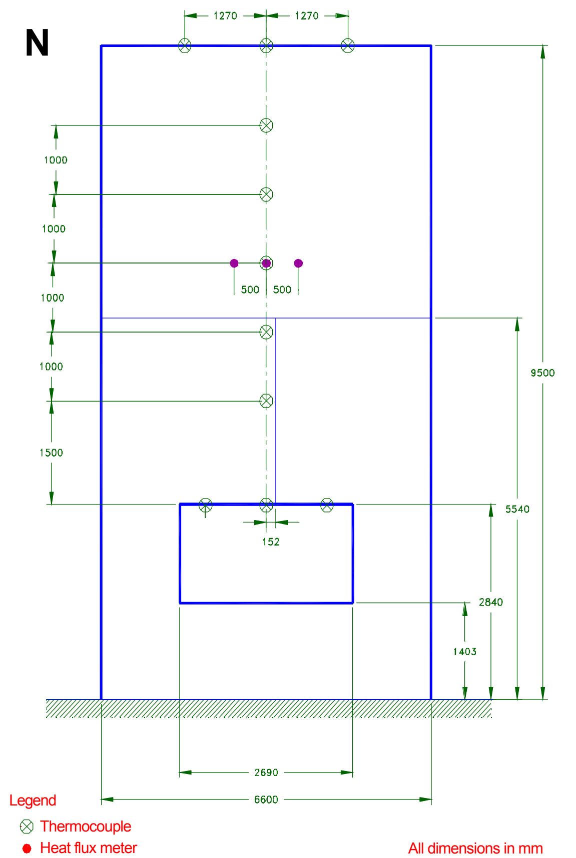

Figure 1. Test Facility (front view).

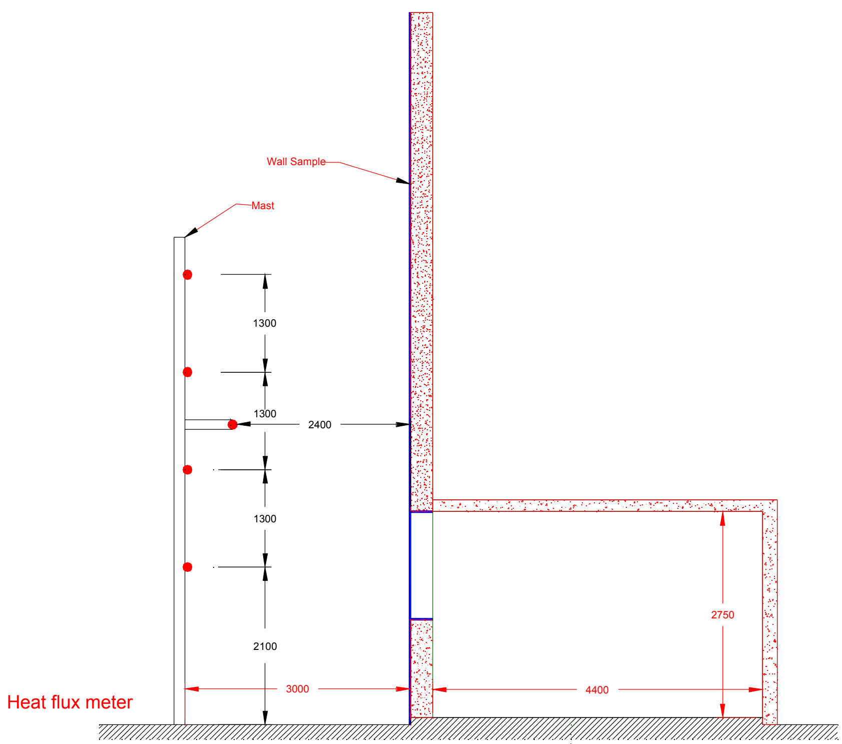

Figure 2. Test Facility (side view).

3 DESCRIPTION OF TEST WALL ASSEMBLY

The wall assembly simulated platform construction using lightweight wood frame assemblies. The wall assembly was installed over 15.9 mm thick Type X gypsum board that formed part of the test facility. Drawings for the wall assembly are shown in Figure 3 and a photograph of the wall assembly under construction is shown in Figure 4.

Wall sections were constructed using 2 x 6 studs spaced at 400 mm on center (o.c.). The studs were 38 mm x 140 mm x 2286 mm long. The wall sections included a single base plate and a double top plate constructed using 38 mm x 140 mm x 2400 mm lumber. The height of the wall sections were approximately 2413 mm. In the test assembly, this is the spacing between the top of the simulated floor (untreated plywood) and the bottom of the wood I-joist sections used in the simulated floor (Figure 3). This simulated a nominal floor-to-ceiling height of 2.4 m, assuming that a single layer of 12.7 mm thick gypsum board is used for the ceiling.

Floor sections were simulated using 38 mm x 286 mm rim board mounted such that the exterior face of the rim board was in the same vertical plane as the exterior face of the wood stud wall sections. Short pieces of 286 mm wood I-joists spaced 400 mm o.c. were used in the space between the rim board and the 15.9 mm thick gypsum board fastened to the test facility. 15.9 mm thick plywood was mounted between the top of the rim board and the base plate of the wall section to simulate a subfloor.

Gypsum sheathing (12.7 mm x 1.2 m x 2.4 m panels) was used as the exterior surface of the wall assembly. The gypsum sheathing complied with CAN/CSA-A82-27-M91 [6]. The material was combustible, had a surface flame-spread rating of 20, and a smoke developed classification of 0. The gypsum sheathing was attached using 32 mm long coarse thread drywall screws at 200 mm spacing.

The wall sections and floor sections for the test assembly were constructed on the floor of the test facility. This included the attachment of the gypsum sheathing to the wall and floor sections. This was done so that a spray-applied polyurethane foam (SPF) insulation could be applied from the interior side of the wall assembly, as is done in normal construction practice.

The cavity spaces formed by the wood studs in the wall sections, as well as the spaces between the wood I-joist pieces used as spacers in the floor sections, were filled using a medium density SPF insulation. The SPF was applied on site to fill the 140 mm depth of the cavity. However, the actual finished depth varied and there possibly was a small airspace between the insulation and the 15.9 mm Type X gypsum board on the test facility in some areas.

SPF was used for this test assembly as it is widely used to provide insulation in lightweight wood frame exterior walls in combustible construction. A medium density SPF insulation was selected based on cone calorimeter tests that showed that it had a higher potential heat output than a light density SPF [7].

Although medium density SPF insulation was used in the test assembly, it was assumed that, if the assembly using a medium density SPF insulation met the requirements in

3.1.5.5. of the 2010 NBC for exterior wall systems, exterior wall assemblies insulated using light density SPF insulation or non-combustible mineral fibre insulation would also meet the requirements.

The wall and floor sections were lifted into place using a crane and fastened to the test facility using metal angle sections fastened to the studs at the sides of the test assembly sections. Metal angle sections were also located at the center at the top of the wall sections and were used to attach the top plate of the wall section to the test facility.

The bottom wall section included an opening that was the same size as the window opening in the test facility. Standard framing for windows was used with double studs used on either side of the window opening and a double header using 38 mm x 235 mm lumber was installed above the window opening (Figure 3).

Metal flashing (approximately 25 mm by 25 mm) was located at the outer edge of the window opening. The flashing was fastened to the assembly inside the window opening. The edges of the wall assembly at the window opening and the metal flashing were covered with 25 mm thick ceramic fibre insulation. The metal flashing and ceramic fibre insulation are typically used for CAN/ULC-S134 test assemblies to limit flame penetration at the edges of the test wall assembly.

The full test specimen was 9.9 m high and approximately 5.0 m wide, with a window opening 2.5 m wide and 1.45 m high. The wall assembly extended 7 m above the window opening in the test facility. It conformed to the height and width requirements in CAN/ULC-S134 [3].

A horizontal joint between gypsum sheathing panels was located 3.0 m above the window opening. This complies with the requirement in CAN/ULC-S134 [3] that a horizontal joint is located 2.7 ± 0.3 m above the window opening in the wall assembly.

Since the wall assembly was installed on the test facility in sections, there were horizontal joints located at each of the simulated floors. 2.4 m gypsum sheathing panels were used on the wall section with the base of the panel at the mid-height of the base plate and the top at the mid-height of the top plate. Gypsum sheathing was attached to the floor section forming horizontal joints at the mid-height of the top plate of the wall section below the floor section and the mid-height of bottom plate of the wall section above it. In total, there were five horizontal joints located above the window opening at the heights of 0.6 m, 3.0 m, 3.4 m, 5.8 m and 6.2 m.

The test assembly had a vertical joint above the window on the centerline of the assembly. It also had vertical joints 1.2 m to either side of the centerline of the assembly.

The test assembly simulated a structural exterior wall system. However, no loads were applied to the wall. The objective of the test was to evaluate the performance of the assembly for exterior fire spread. If, in practice, the exterior wall assembly required a fire-resistance rating as well, it would need to be evaluated using CAN/ULC-S101 [8].

The construction materials of the test wall assembly proceeding outward from the concrete block wall of the test facility were as follows:

1. 15.9 mm thick Type X gypsum board;

2. Lightweight wood frame wall assembly insulated with medium density SPF insulation; and,
3. 12.7 mm thick gypsum sheathing.

An exterior cladding system was not included in the test assembly. It was assumed that a noncombustible exterior cladding would provide additional protection for the wall assembly and, therefore, if the wall assembly met the requirements in Article 3.1.5.5. of the 2010 NBC without an exterior cladding, it would also meet the requirements with a noncombustible cladding.

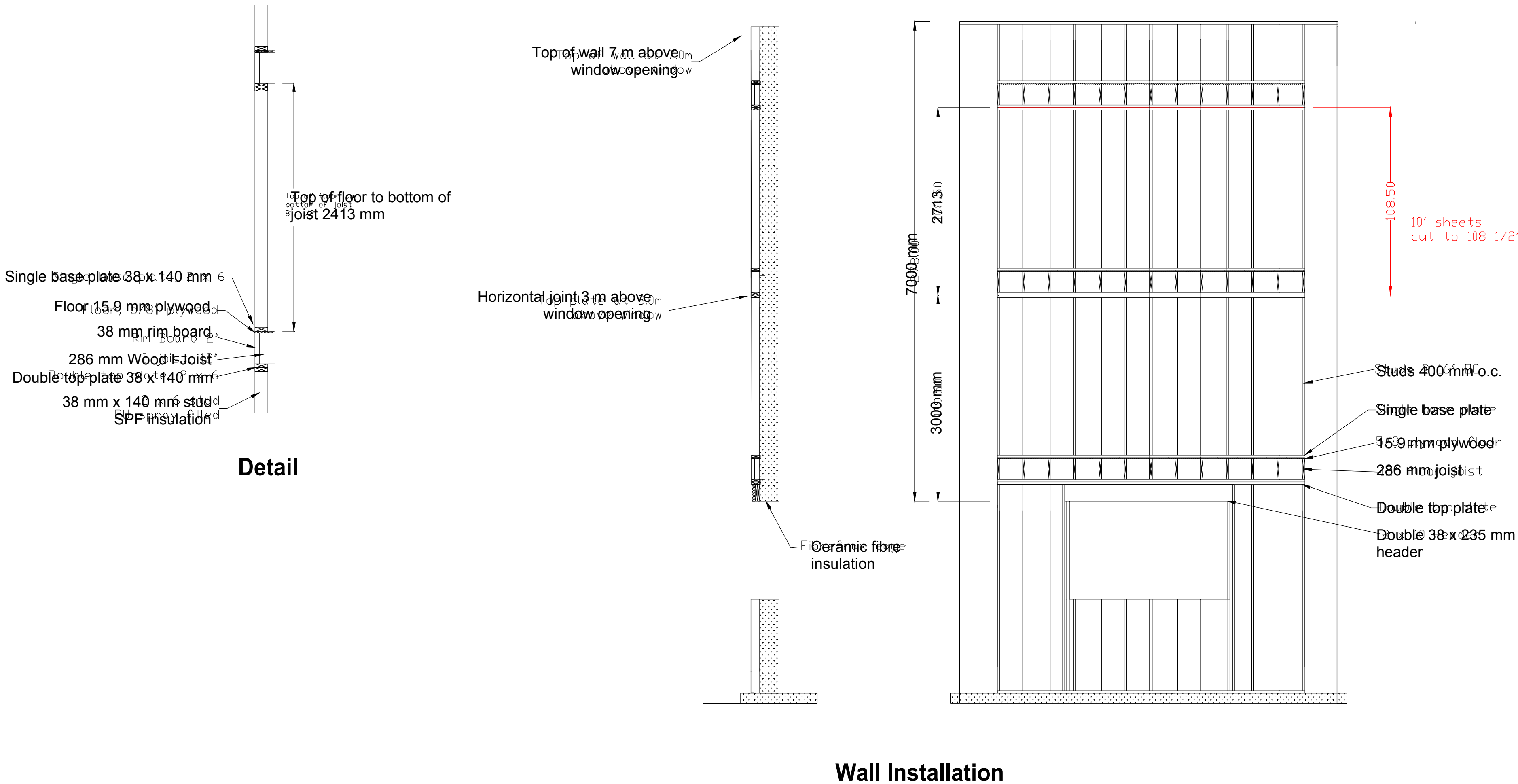

Figure 3. Construction Detail.

Figure 4. Segment of Wall System under Construction.

4 INSTRUMENTATION

Room Temperatures – The burn room air temperature was monitored by six Type K thermocouples, enclosed in 6 mm (outside diameter) Inconel sheaths. The thermocouples were introduced through the side walls with the measuring tips 0.6 m from the inner surface of the wall. All room thermocouples were located on the vertical centre lines of the side walls.

Window Opening Temperatures – The temperature of the flames issuing from the window opening was measured with three Type K, bare-beaded thermocouples installed 0.15 m below the top of the window opening, on the vertical centre line of the window opening and 0.4 m from the sides of the window opening (see Figure 1).

Wall Temperatures – The wall temperatures were monitored using Type K bare-beaded thermocouples on the vertical centre line of the wall. They were located at five levels above the top of the window at 1.0 m intervals, starting at 1.5 m above the window opening (see Figure 1). Three thermocouples were used at each level, one on the exterior surface of the wall assembly, the second at the mid-depth in the insulated cavity and the third on the surface of the 15.9 mm Type X gypsum board in the cavity.

The temperature of the fire plume at the top of the test assembly was monitored by three Type K bare-beaded thermocouples located 0.1 m out from the exterior surface of the wall, one on the centre line of the wall, and the other two and the other two at a distance of 1.3 m to either side of the centre line of the wall (see Figure 1).

Heat Flow – The total heat flux to the wall above the window was monitored by three water-cooled heat flux meters (Medtherm Corp. Series 64) installed in the test wall, 3.5 m above the top of the window, one on the centre line of the wall and one on each side, 0.5 m from the centre line (see Figure 1).

Radiant heat emitting from the fire was also monitored by heat flux meters (Medtherm Corp. Series 64) installed on a mast (Figure 2), placed 3.0 m from the test wall opposite to the centre line of the wall. The heat flux meters were located at distances of 2.1 m, 3.4 m, 4.7 m and 6.0 m above the level of the burn room floor. An additional heat flux meter was installed on the mast at the 4.0 m height and 2.4 m from the face of the wall.

Propane – The propane gas flow rate to the burners was monitored with a mass flow meter.

Visual Records – Video records of the front and side views were made during the test and digital photos were taken before, during and after the test.

Data Acquisition – All thermocouples, as well as the heat flux meters, were connected to a data acquisition system and readings were recorded at 5 s intervals.

5 ATMOSPHERIC CONDITIONS

At the time of the test, the ambient temperature in the Burn Hall was 6°C and the relative humidity was 53%.

6 TEST PROCEDURE

The test procedure was in accordance with CAN/ULC-S134 [3]. The pilot burners were lit prior to the commencement of the test. Gas flow to the burners was manually adjusted to follow the prescribed heat input required by the standard.

7 VISUAL OBSERVATIONS

(min:sec)

0:00	Ignition of burners
2:48	Flames are exiting the room
3:10	Flames are reaching 1.0 m
4:16	Flames are reaching 1.5 to 2.0 m
4:58	Gypsum sheathing paper is starting to burn
5:20	Paper has flashed behind the window flame plume
5:00	Steady state for gas flow
5:56	Flame height is 2.0 to 2.5 m
6:16	Dense black smoke is produced
6:56	Flames are steady at 2.0 to 2.5 m
8:50	Paper is burned to a height of 2.5 m
9:15	Ceramic fibre insulation on the upper windowsill is beginning to sag, no significant damage to the wall
10:00	Flames are intermittently reaching 3.0 m
13:41	No evidence of foam burning, except smoke; damage to wall is minimal
18:40	No change
21:15	Cracks are visible in the gypsum sheathing at 1.0 m near centerline

21:30 Crackling sounds are heard
22:55 Inverted "V" extends to 3.5 m, cracks are more visible
23:55 Red embers are seen in the wall cavity at the first seam near the centerline
25:00 Gas is turned off
25:45 Crackling is still heard
26:04 Smoke is emanating from the cracks in the gypsum sheathing
33:45 Small flames are observed left of centerline at 1.0 m height
35:50 There is a small fire inside the cavity near the 1.0 m height
44:39 Yellow smoke from the bottom left of the wall
45:15 The gypsum sheathing is bulging where cracks have formed
56:27 The fire in the cavity has crept up to 1.5 m
56:50 Smoke still coming out of the bottom left of the wall; the gypsum sheathing at this location is cool to the touch
61:45 Fire is observed in a fissure right of centerline at approx.1.5 m height
63:36 A small fist sized piece falls out left of centerline at 1.5 m height
65:00 Intermittent flames is seen where the gypsum sheathing fell out, charred foam and glowing embers are present at this location
73:13 Smoke is coming out on the right edge of the wall assembly at 0.5 m height
75:44 Smoke is now emanating from both edges of the assembly at 3.5 m
81:59 Another piece of gypsum sheathing falls off exposing more foam and a wood stud
83:10 Several pieces of gypsum sheathing are falling off right of centerline
90:45 Data Off

8 RESULTS

Room Temperatures – The average gas temperature in the burn room (average of six thermocouples) was as shown in Figure 5.

Window Opening Temperatures – The average temperature of the fire gases emerging from the window opening was as shown in Figure 5.

Wall Temperatures – The temperatures recorded on the outer surface of the test assembly are shown in Figure 6. The temperatures made a sharp rise over the first 5 minutes to reach steady state and a peak temperature of 634°C at 1.5 m above the window opening, 560°C at 2.5 m above the window opening, 387°C at 3.5 m above the window opening, 286°C at 4.5 m above the window opening and 236°C at 5.5 m above the window opening.

Once the propane was turned off at 25 min, there was a gradual decay in the measured temperatures at all heights. With the fall-off of gypsum sheathing at approximately 60 min, there was an increase in fire size resulting in a gradual increase in temperatures on the surface of the gypsum sheathing. However, for more than 30 min, the fire was contained within the wall cavity. It was very small and could have been easily suppressed.

The temperatures recorded by the thermocouples within the test assembly are shown in Figure 7. This figure shows significant rises in temperature at the 1.5 m and 2.5 m locations. The peak temperature during the propane fire exposure was 359°C at 1.5 m above the window opening, 182°C at 2.5 m above the window opening, 99°C at 3.5 m above the window opening, 93°C at 4.5 m above the window opening and 91°C at 5.5 m above the window opening.

The temperatures at the 2.5 m height and above gradually decayed after the propane burner was shut off at 25 min. The temperature measured at the 1.5 m height decreased after the burner was shut off. However, it reached a steady temperature due to the small fire contained within the wall cavity. This temperature began to increase again at approximately 60 min as the fire grew after some of the gypsum sheathing fell off.

Temperatures recorded by the thermocouples behind the wall assembly, on the surface of the 15.9 mm thick gypsum board in the wall cavity, are shown in Figure 8. The temperature increase at this location was limited until approximately 40 min after the start of the test. This indicates that the fire in the wall cavity did not penetrate through the SPF insulation until well after the propane burner was shut off.

The fire plume temperatures measured at the top of the wall are shown in Figure 9. The temperatures at the top of the wall reached a maximum of 167°C. The temperatures decayed after the propane was shut off. There was minimal or no increase in temperature at the top of the wall with the small fire that occurred after the portion of gypsum sheathing fell off.

Heat Flux – The total heat flux to the wall, as measured 3.5 m above the top of the window, is shown in Figure 10. The data shown in this figure has been smoothed using the procedure of a running average over one minute.

The heat flux values at all three locations showed a steady rise in exposure over the first 5 minutes followed by various uneven peaks. The maximum one-minute averaged values recorded at the 3 locations were 22.5 kW/m^2 at the centre location, 14.7 kW/m^2 at the north location and 15.6 kW/m^2 at the south location.

The heat flux values decayed after the propane was shut off at 25 min. There was a low heat flux (< 3 kW/m^2) measured by the device located at the center of the wall assembly after 60 min.

The heat flux values measured by the heat flux meters installed on the mast are shown in Figure 11. The heat flux at the 2.1 m height reached 19.3 kW/m^2, at the 3.4 m height it reached 14.9 kW/m^2, at the 4.7 m height it reached 5.9 kW/m^2 and at the 6.0 m height it reached 3.3 kW/m^2. The heat flux at 2.4 m from the wall at the 4.0 m level reached 10.7 kW/m^2.

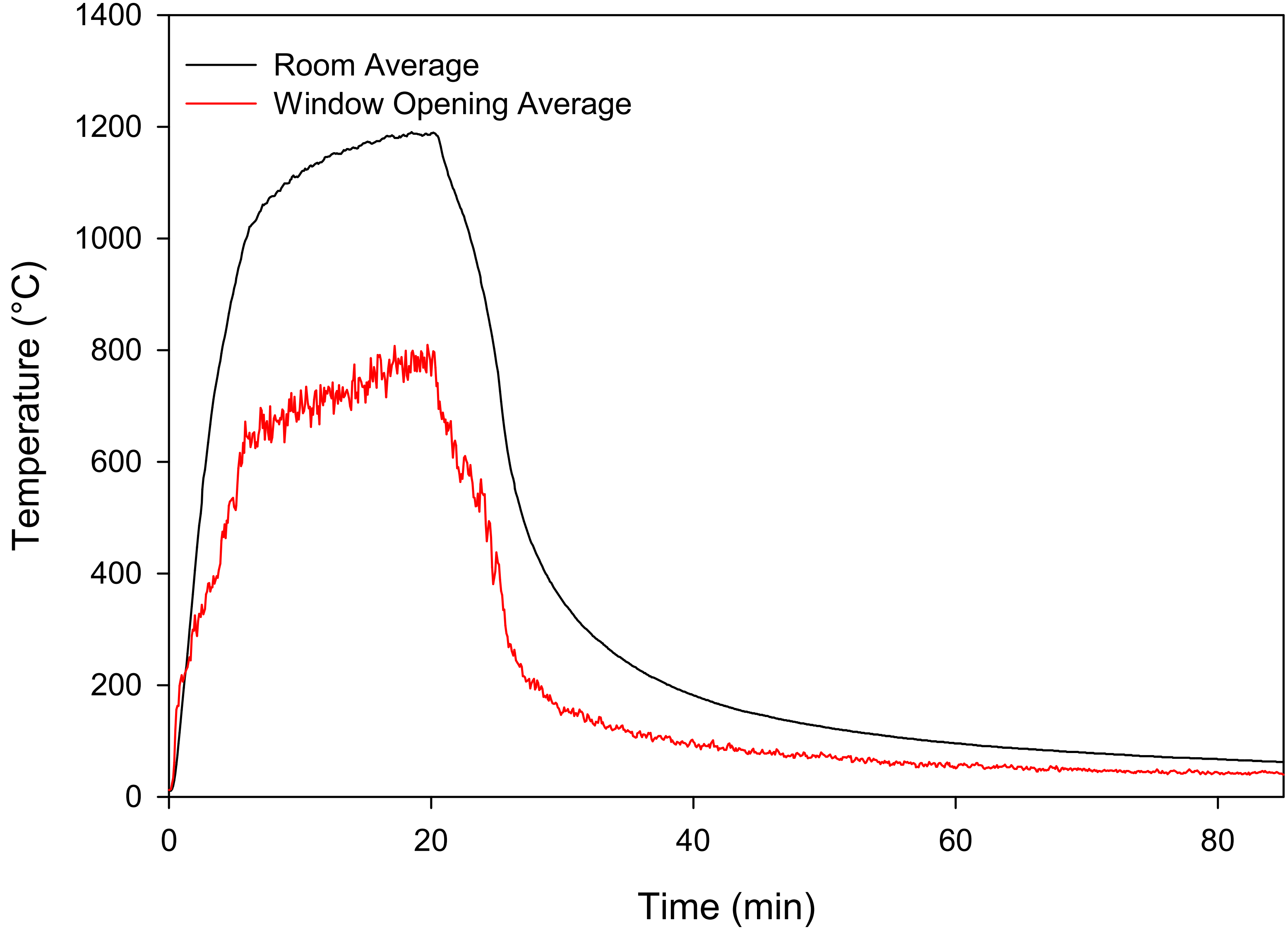

Figure 5. Average Room and Window Opening Temperatures.

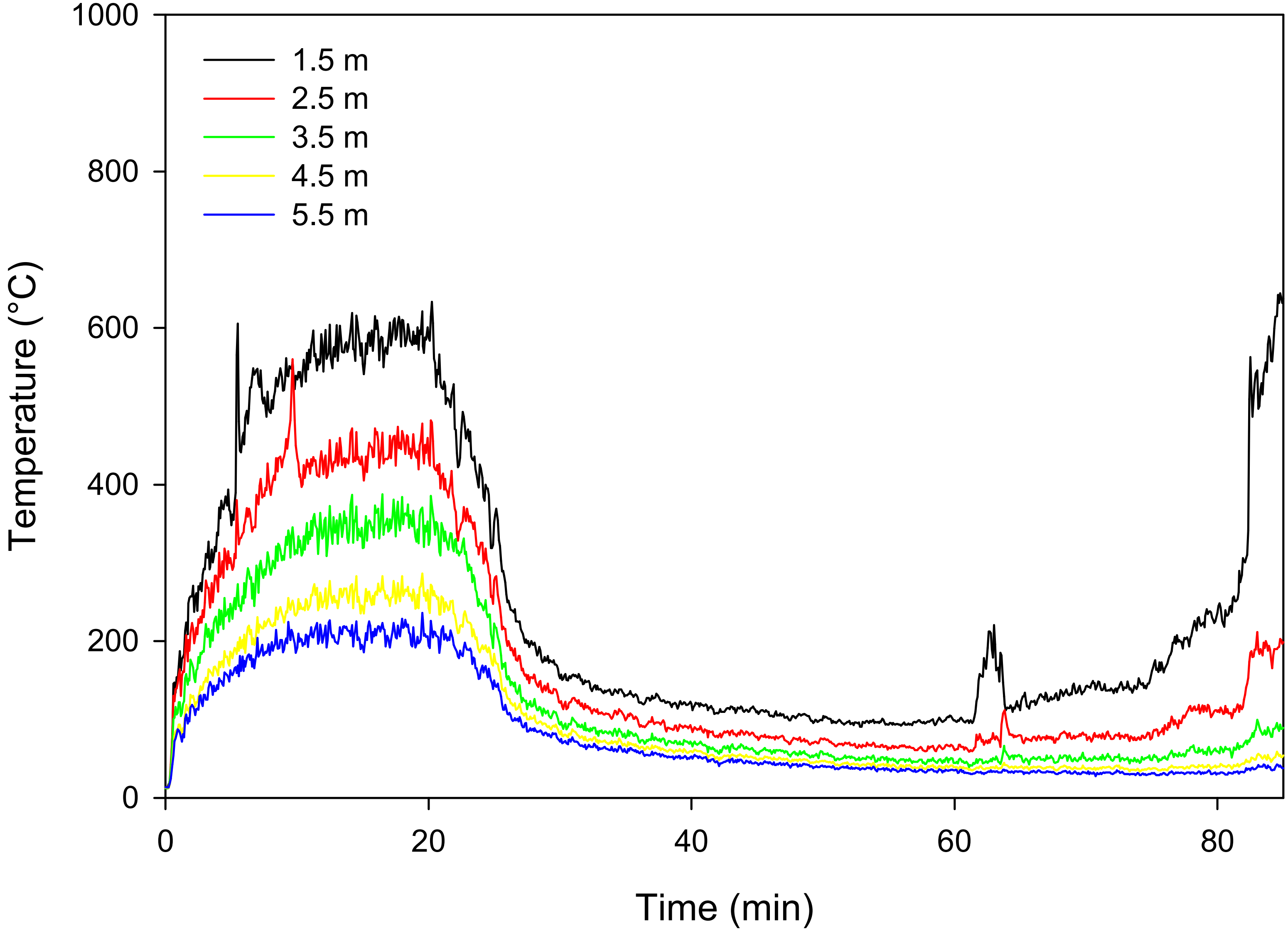

Figure 6. Temperatures on Surface of Wall.

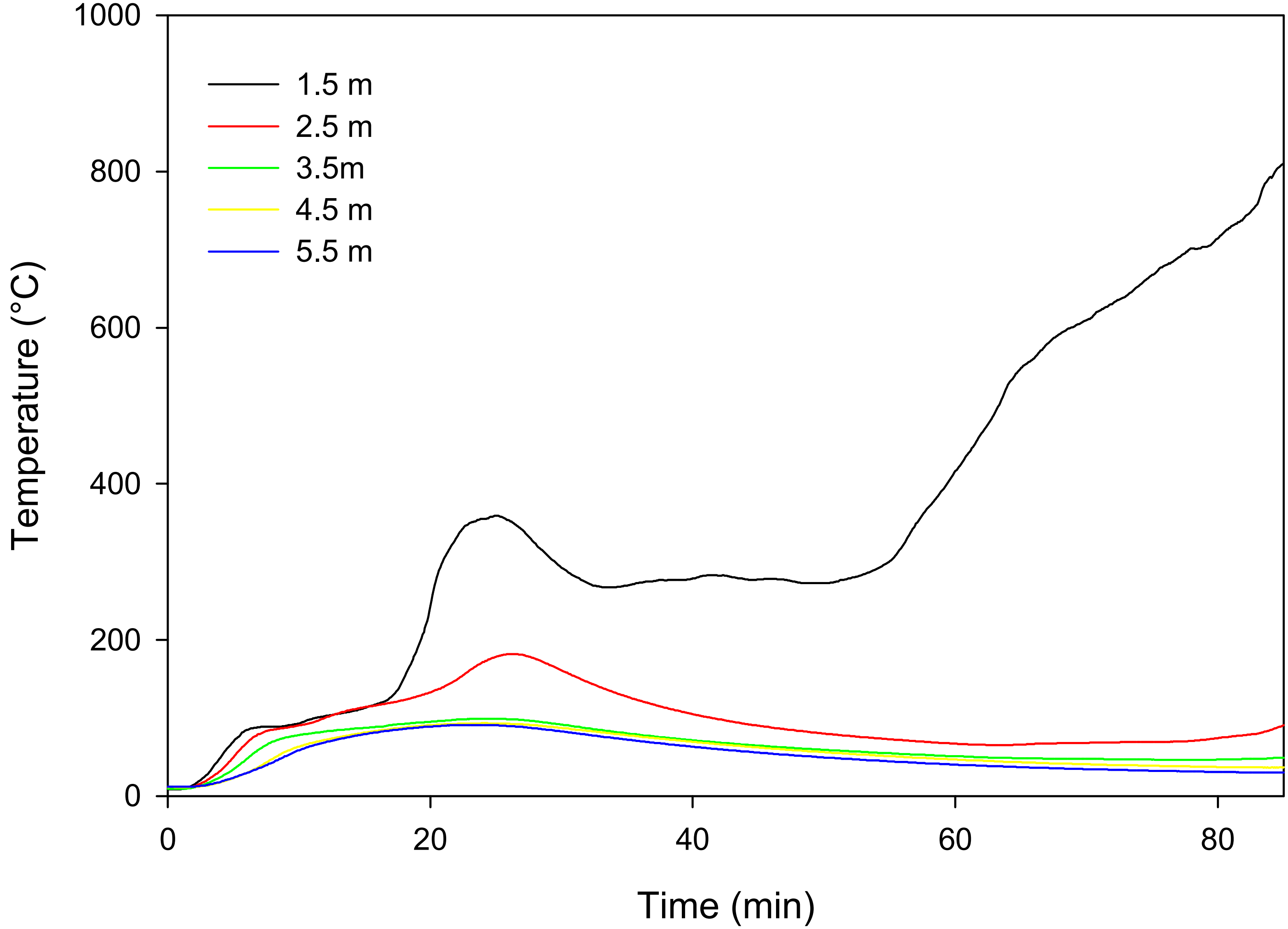

Figure 7. Temperatures inside the Wall Cavity.

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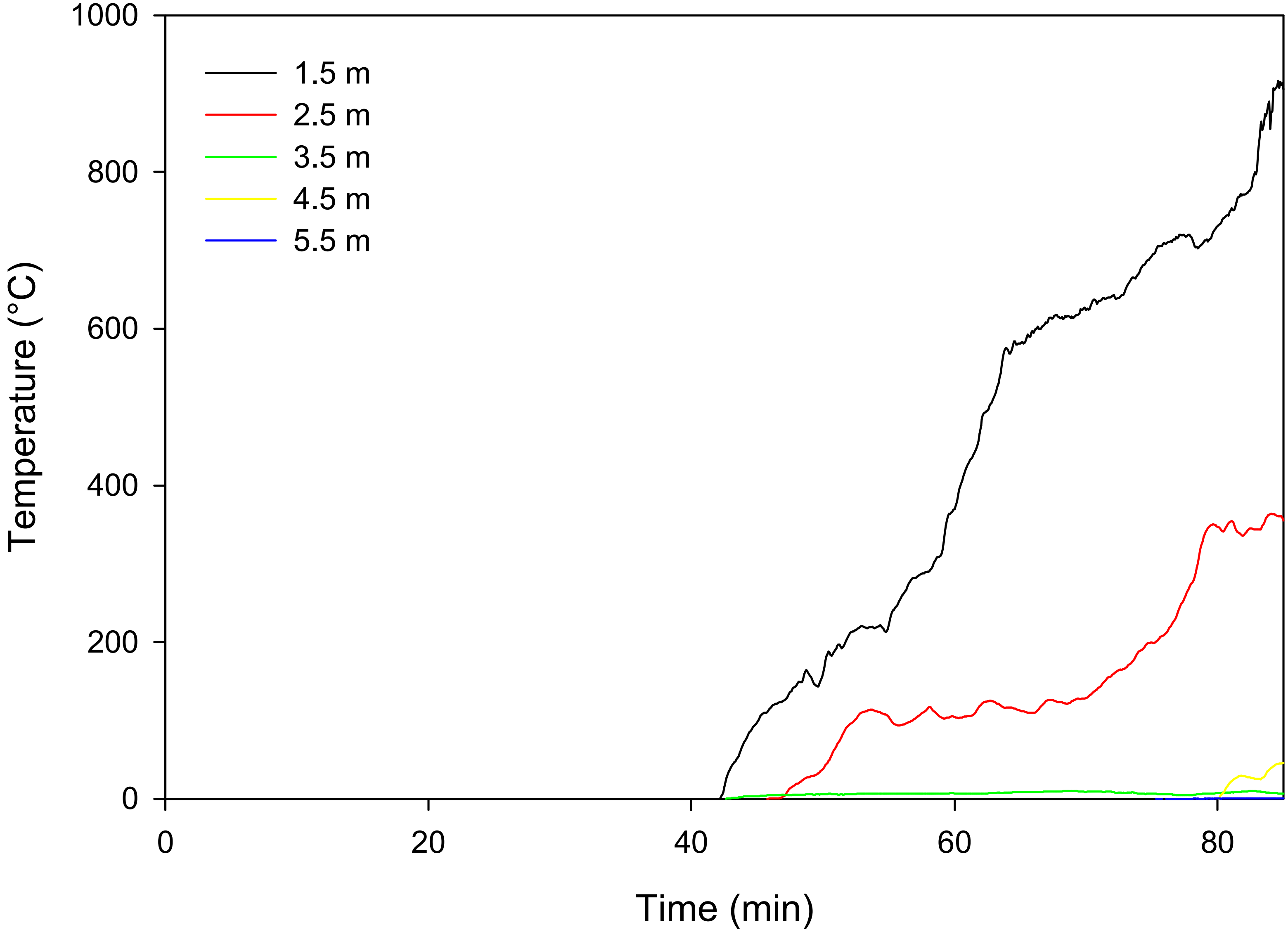

Figure 8. Temperatures on Surface of 15.9 mm Type X Gypsum Board.

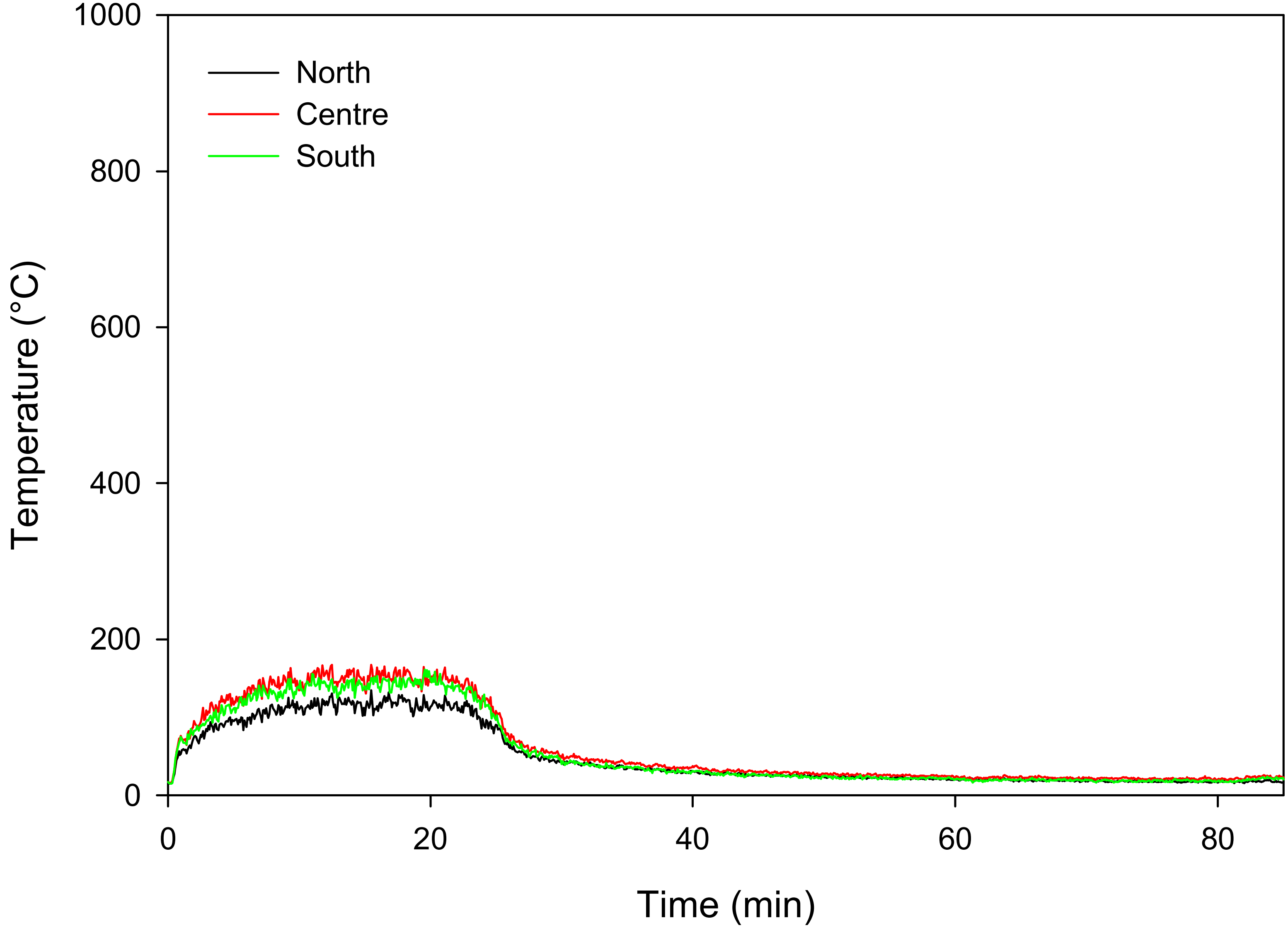

Figure 9 . Temperatures at Top of Wall.

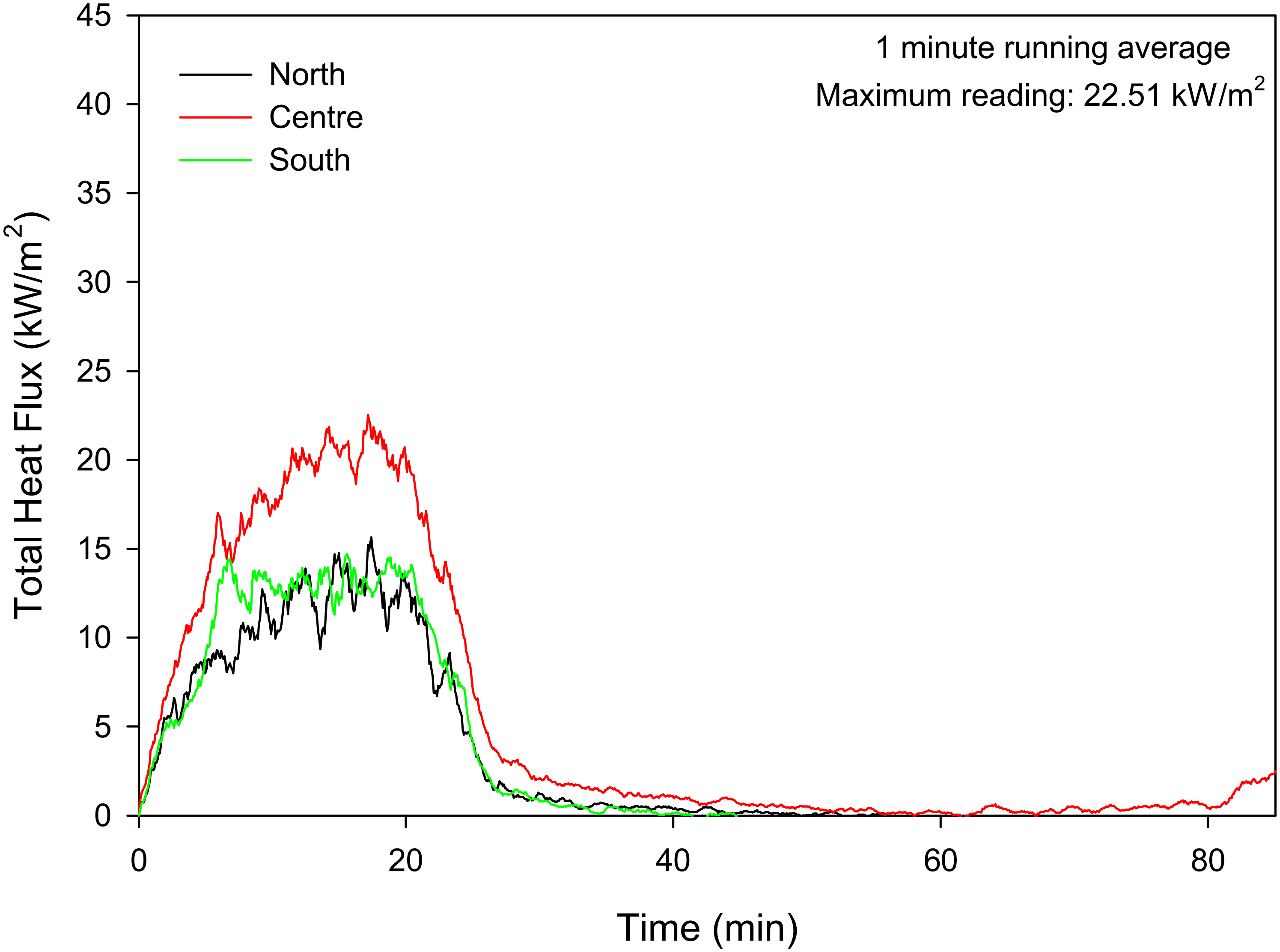

Figure 10. Heat Flux on Wall.

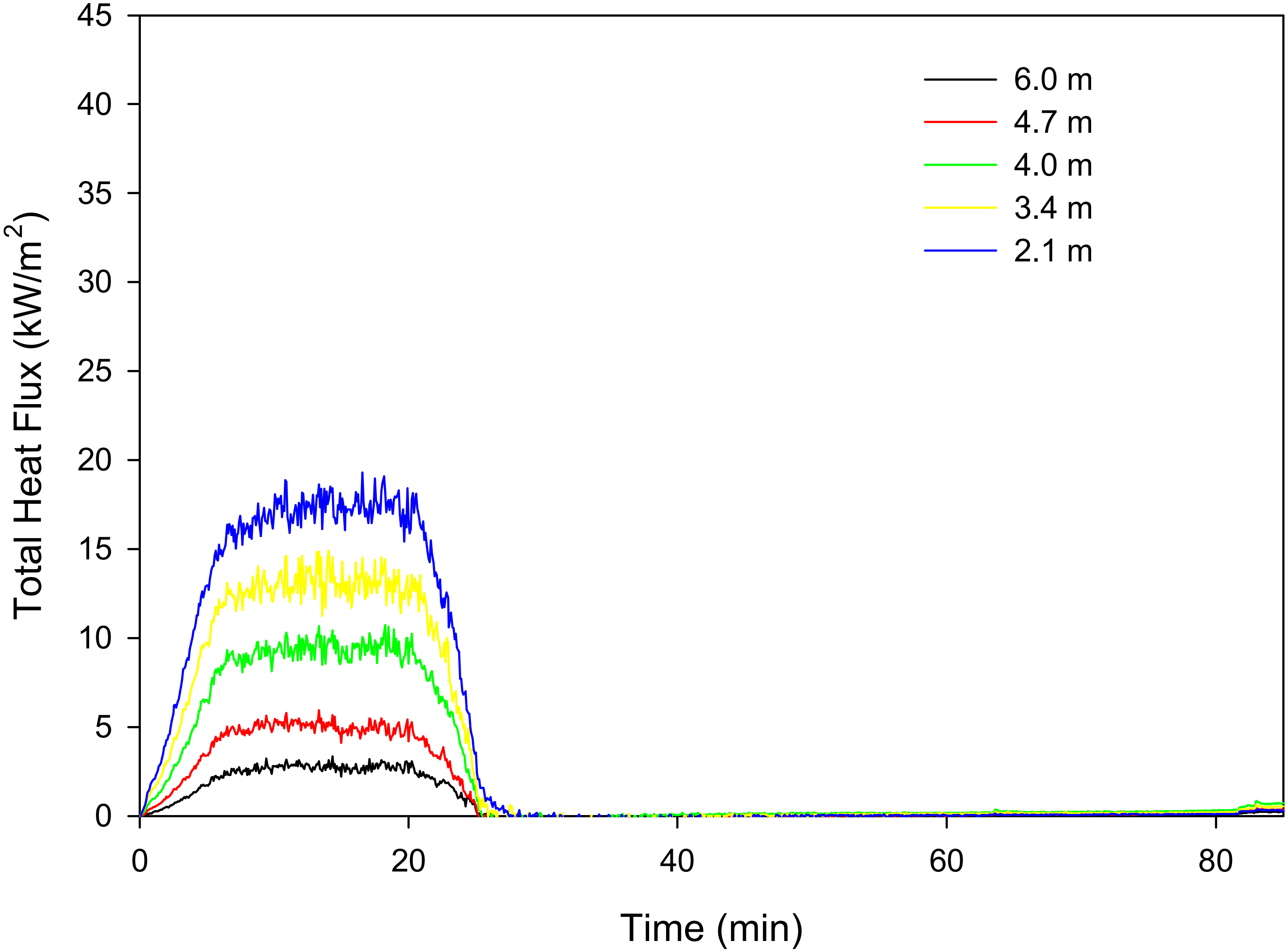

Figure 11. Heat Flux at Mast.

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9 PERFORMANCE OF THE WALL ASSEMBLY

A) Flame Spread over Exterior Face

The only observable events in the test were the paper flashing and the small flames at centerline near the end of the test. After the gas was shut off at 25 minutes, the wall was observed for another 60 minutes at the request of the client. (Since its first publication in 1992, CAN/ULC-S134 has required that the assembly continue to be observed until all fires self-extinguish. However, in most cases, the fires that remain after the propane is shut off are very small and pose a limited hazard. In the 2013 edition of the test standard, which was used as the basis for these tests, the test is observed for a maximum of 60 min after the ignition of the burners. During this 60 min, the test assembly must meet the requirements in the 2010 NBC for limiting the maximum flame height and 1-min averaged heat flux at the 3.5 m height.)

Other than a few cracks, the gypsum sheathing stayed intact until a piece fell off at 63 minutes (from ignition). At that point the small fires within the wall grew to larger sizes and resumed their upward progression. The flames did not spread beyond 3.0 m above the window opening, which is less than the 5 m limit specified in the 2010 NBC.

B) Incremental Radiant Heat Flow to the Wall above the Window Opening

The maximum one-minute averaged value of the total heat flux on the test wall at 3.5 m above the top of the window opening was 22.5 kW/m^2. This is less than the 35 kW/m^2 specified in Sentence 3.1.5.5.(3) of the 2010 NBC [1]. For comparison, the value for a noncombustible wall (Marinite) is 16 kW/m^2. (Note: Marinite is a thermal structural board insulation, which is a formed from calcium silicate with inert fillers and reinforcing agents. This material was used to provide the noncombustible wall, which was used for calibration and reference purposes in the initial test series used to develop the test method [5]).

C) Incremental Radiant Heat Flow at Target Mast

The average values of heat flux at the target mast over the 15 min period of steady gas supply, as compared to a noncombustible wall (Marinite), were:

Table 1. Average Values of Heat Flux at Target Mast.

Distance from Test Assembly (m)	Height Above Burn Room Floor (m)	Heat Flux (kW/m^2)	
		Lightweight Wood Frame Wall Assembly	Noncombustible Wall Assembly (Marinite)
3.0	2.1	16.6	15.9
3.0	3.4	12.7	11.2
2.4	4.0	9.1	8.2
3.0	4.7	4.9	4.7
3.0	6.0	2.6	2.1

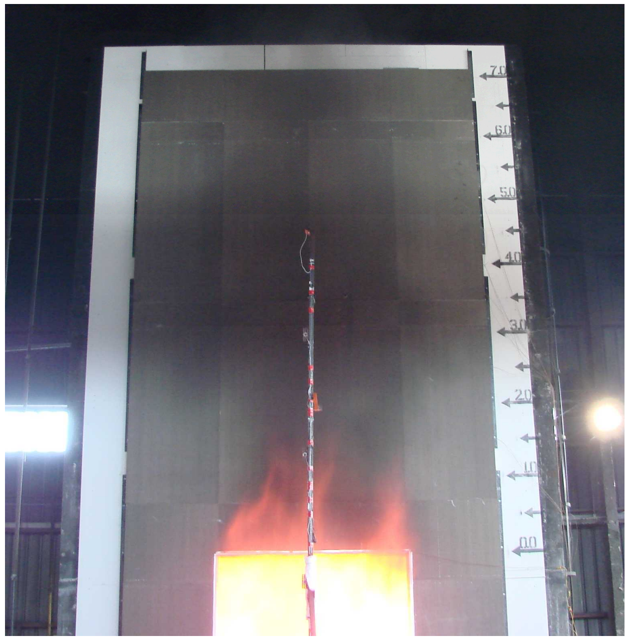
D) <u>Damage to the Wall Assembly</u>

Figure 12 shows the wall assembly at two different times during the fire exposure.

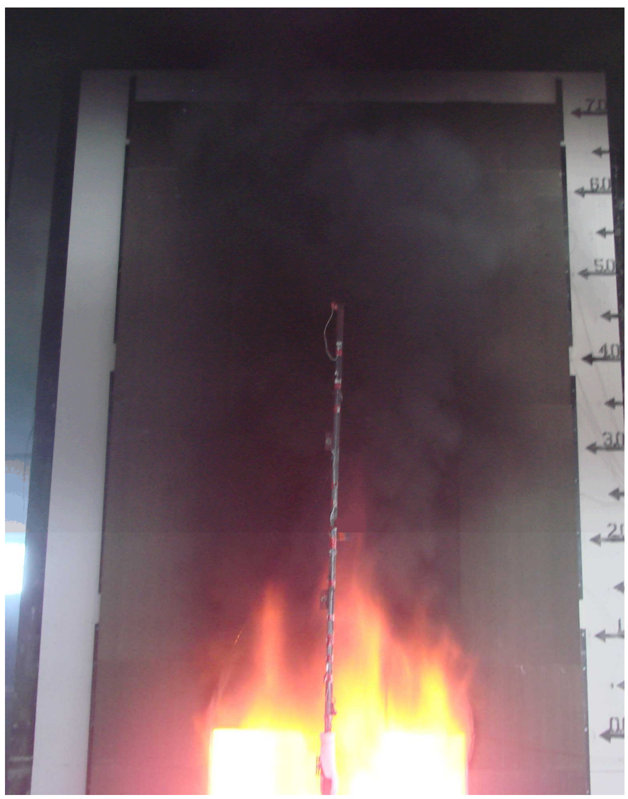
Figure 13 shows the extent of the damage to the wall assembly after the test.

The primary area of damage was limited to the lower portion of the first wall section above the window opening. This is the area where the gypsum sheathing fell off 60 min after the start of the test. The stud located at the center of the assembly and the two adjacent studs were heavily charred at their base. However, much of this damage occurred as a result of the fire involvement after 60 min.

There was some loss of SPF insulation in the damaged area of the wall. However, outside this area the insulation was not affected by the fire.



(a) 4 Minutes After Ignition.



(b) 11 Minutes After Ignition.

Figure 12. Wall Assembly During the Fire Exposure.

Figure 13. Wall Assembly after Fire Exposure.

10 REMARKS

1. The test facility and test method, as described in this report, conform to the requirements of Article 3.1.5.5 of the 2010 NBC [1]. The test was conducted in accordance with CAN/ULC-S134-13 [3].
2. The extent of damage to the test wall assembly was limited to an area above the window opening to a height of 3.5 m during the fire exposure, mostly in the form of burnt gypsum sheathing paper facing. There were a few fissures in the gypsum sheathing on both sides of the centerline below 1.5 m.
3. During the fire exposure there were flames to 3.0 m above the window opening. This is less than the 5 m limit for flame spread distance specified in Sentence 3.1.5.5.(2) and defined in Appendix A (A-3.1.5.5.(2)) of the 2010 NBC [1].
4. The maximum one-minute averaged value of the total heat flux on the test wall assembly, at 3.5 m above the top of the window opening during the fire exposure was 22.5 kW/m^2. This is less than the 35 kW/m^2 specified in Sentence 3.1.5.5.(3) of the 2010 NBC [1].
5. A small fire continued to burn inside the wall cavity after the propane was shut-off at 25 min. This fire was limited to the lower section of the first wall section above the window opening. There was limited propagation of this fire until after some of the gypsum sheathing fell off at 63 min. There was limited fire growth after 60 min. However, the fire remained relatively small and was easily suppressed once the test was concluded.
6. There was limited damage to the SPF insulation in the cavity. Most of the damage was limited to central section of the first wall section above the window opening. There was no fire damage to the insulation in the second wall section above the window opening.

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