Grenfell Tower – fire safety investigation: The fire protection measures in place on the night of the fire, and conclusions as to:

the extent to which they failed to control the spread of fire and smoke; the extent to which they contributed to the speed at which the fire spread.

Phase 1 Report - Section 5

The observed events of 14th June 2017

REPORT OF

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Fire Safety Engineering

24th October 2018

Specialist Field: Fire Safety Engineering

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On behalf of : Grenfell Tower Inquiry

On instructions of : Cathy Kennedy, Solicitor, Grenfell Tower Inquiry

Subject Matter To examine the circumstances surrounding the fire at

Grenfell Tower on 14th June 2017

Inspection Date(s): 6th October, 1st November, 7-9th November 2017

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5 The observed events of 14th June 2017

- 5.1.1 The events that unfolded at Grenfell Tower on 14 June 2017 rapidly became unprecedented.
- Rather than a fire within one internal compartment, a major fire in the building envelope occurred and this itself was on multiple storeys and across multiple compartments. Additionally, there were very many post-flashover fires internally, in multiple compartments, on multiple storeys.
- 5.1.3 The building envelope itself was therefore a major hazard on the night of the fire. The active and passive fire protection measures within the Grenfell Tower were required to mitigate an extraordinary event, and as a result the consequences were catastrophic.
- 5.1.4 It is important to understand the scale and location of the external and the internal fires, as context to all the analysis presented in my Report. I am instructed to identify the active and passive fire protection measures within Grenfell Tower on 14th June 2017, and the extent to which they failed to control the spread of fire and smoke; and contributed to the speed at which the fire spread.
- 5.1.5 In this section I present through photographs, the scale of the fire, the direction it spread around the building envelope, the speed at which it spread, and the observed internal fires. This is to create a timeline of observed events, to act as a framework for my work. Note in Section 13 of my report I provide a detailed explanation, based on an assessment of formal evidence, of critical times throughout the whole fire event.
- 5.1.6 This timeline is partially based on the timed London Fire Brigade (LFB) decision log (LFB00000003). This log is based on "hard data drawn from London Fire Brigade mobilising and information recording systems, from the time of the first call at 00:54hrs until 20:00hrs on the 14/06/17." Note, the following meanings for terms from the LFB log referenced throughout this section:
 - a) "pump" refers to a fire fighting appliance (i.e. fire engine), which has a water pump for fire fighting operations;
 - b) "aerial appliance" refers to fire fighting appliance (i.e. high reach appliance) used for high-rise fires. Aerial appliances have ladders or platforms to assist with fire fighting and rescue operations for tall buildings;
 - c) "make pumps..." these are requests from the LFB to change the number of appliances in attendance at the site.

For example, "Make pumps 6" is a request to increase the total number of pumping appliances on site to 6.

- I have reviewed the following additional evidence with regards to observed events on the 14th June 2017:
 - LFB oral evidence [25th June 02 Oct 2018] and LFB operational response log 00.50hrs -02.00hrs (LFB00001914).
 - Samples of CCTV footage and helicopter video footage (NFPA13/NPAS44 provided by the Inquiry); references provided where relied upon within this report.
 - Samples of body worn video footage of Inspector Thatcher (INQ0000151).
 - IWS videos (IWS00000036 through IWS00000040; IWS00000046 through IWS00000051; IWS00000053 through IWS00000057; IWS00000059, IWS00000072, IWS00000073).
 - Luke Bisby's Videos 1 through 5, attached to his supplemental report.
 - I have subsequently received and reviewed the LFB Short Incident Log Report (MET00013830), which is the original evidence upon which the LFB decision log (LFB00000003) is based. The LFB decision log appears to be a concise and accurate reflection of the LFB Short Incident Log Report, therefore there has been no need to update the relevant references in this section.
- 5.1.8 Using this new evidence, I have updated my observed times for fire spread to the exterior of the building and for fire spread above the compartment floor line at Level 5.
- 5.1.9 The timeline of observed events, presented here, demonstrates how the very principles of the defend in place strategy upon which the stay put regime relies, as I explained in Section 3, were very quickly overcome and rendered entirely inadequate for the fire that took place.
- 5.1.10 The sequence of events presented here is external or viewed from outside the building. This is crucial context in understanding the impact within the building, where many of the residents and a large number of fire fighters had to remain. Those interior conditions were not visible from the outside on the night of the fire, but are fundamental to explain the resulting loss of life, and to explain how the active and passive protection measures performed.
- 5.1.11 I have set out in Figure 5.1 the references for the building columns and building elevations, to aid understanding of location for the reader, within the series of photos presented here.

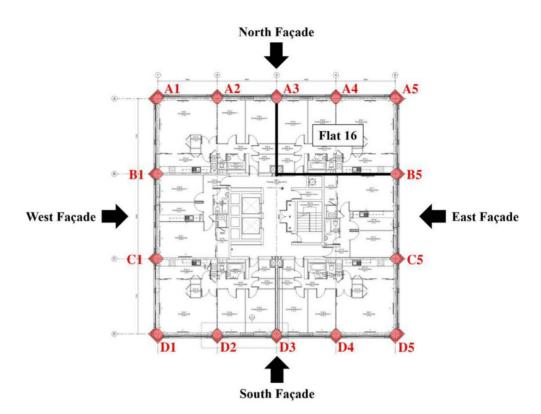


Figure 5.1: References for Grenfell Tower columns and building envelope, shown on level 4 plan (SEA00010474)

- 5.1.12 In this report, I have from time to time relied on images to identify critical times during the night of 14th June 2017. Where available, I have given the time that an image was taken. Where I have been provided with details of adjustments that need to be made to the timing of an image, I have adjusted the time in my report.
- 5.1.13 Whilst much work has been done to verify the accuracy of the timings of various sources of evidence (e.g. CCTV footage from inside the Grenfell Tower, videos and photographs taken by the public and thermal camera images captured by the first responders to the fire in Flat 16), work is continuing. Therefore, all timings cited in this report should be treated as provisional and subject to further work.
- 5.1.14 In particular, screenshot images from YouTube videos are used in some cases to illustrate the timeline of events on 14 June 2017. The estimated times for the YouTube screenshots are based on my visual analysis of the fire development in the YouTube videos compared to the timestamped Metropolitan Police Service (MPS) evidence provided to me.
- 5.1.15 All times referenced in this section are on 14th June 2017.
- 5.1.16 All YouTube videos referenced herein are from the same username and are titled "footage of Grenfell Tower on fire X minutes in".

5.2 Summary of external fire spread

- A fire started in Flat 16 on Level 4 of Grenfell Tower on 14 June 2017, and subsequently spread to the building envelope by 01:08. Previously, the earliest evidence I had of fire spread to the exterior building envelope was at 01:14 (MET00012593). I have now reviewed further evidence, including earlier video footage (IWS00000051) which shows fire spread to the exterior building envelope by 01:08. A screenshot of this video footage is shown in Figure 5.5.
- 5.2.2 The vertical fire spread was primarily along column lines. The lateral fire spread was primarily along the cladding above and below window lines, and along the new polystyrene sandwich panel infill between windows, and was aided by some of the construction materials surrounding the windows and some of the construction materials surrounding the cavity formed between the new and old infill panels. I explain this in detail in Section 9 and Section 10 of my report.

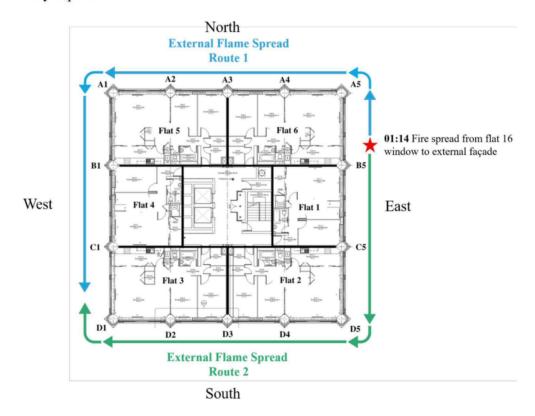


Figure 5.2: External flame spread routes around Grenfell Tower (SEA00010474)

5.2.3 Once the fire spread to the building envelope adjacent to column B5, it spread in two lateral directions around the building – towards the North and South of the building. The fire eventually spread to the building envelope on all elevations, fully enveloping the building perimeter at approximately 04:03.

5.3	Fire spread from Flat 16 to building envelope
5.3.1	On 14 June 2017, a fire began in the kitchen of Flat 16 on Level 4 of Grenfell Tower.
5.3.2	At 00:54:29 the first call to the incident by LFB is recorded (LFB00000003)
5.3.3	At 00:55:01 the autodialler connected to the smoke control system is recorded as contacting Tunstall, the remote monitoring company (THL00000002).
5.3.4	At 00:55:14 LFB assigns three pump appliances to the incident.
5.3.5	At 00:57:44, the LFB Control received the second 999 call, which was from a remote monitoring company, Tunstall Response (LFB00001914).
5.3.6	At 00:59:12 a fourth pump appliance is assigned by Peter May when he manually changed the ITC record from A1 to A1HR, identifying the incident as involving a high rise building (MET00015882).
5.3.7	Figure 5.3 is a photograph of the fire in the Flat 16 kitchen window before 01:02. It is the earliest photograph of the fire that I have seen. (MET000083344)

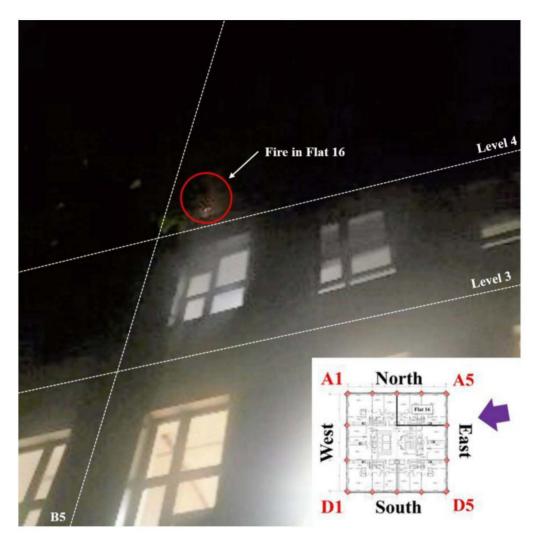


Figure 5.3: Fire in Flat 16 on Level 4 at unknown time before 01:02 on 14 June 2017 (MET000083344) (SEA00010474)

5.3.8 Figure 5.4 is a photograph of the fire in the Flat 16 kitchen window at 01:02. (MET00012593)

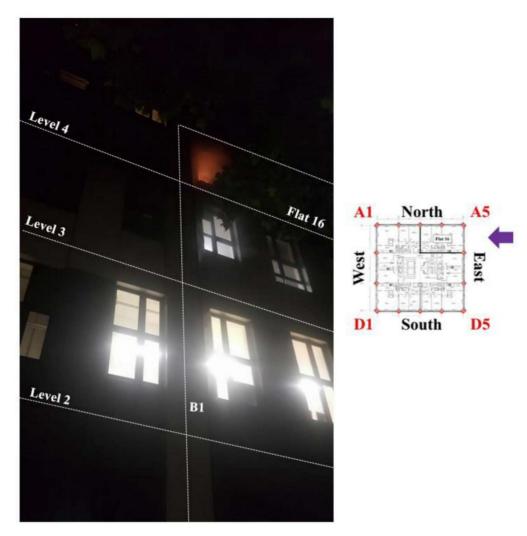


Figure 5.4: Fire in Flat 16 on Level 4 at 01:02 on 14 June 2017 (MET00012593) (SEA00010474)

5.4 External fire spread around building perimeter

5.4.1 Figure 5.5 shows external flaming outside the window of the kitchen in Flat 16 at 01:08. This is the earliest evidence I have seen of external flaming based on the photographs and videos I have reviewed to date.

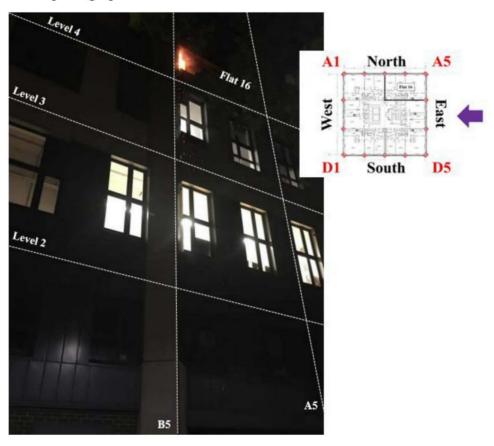


Figure 5.5: Fire on East elevation of the building envelope at 01:08 on 14 June 2017 (IWS00000051) (SEA00010474)

5.4.2 Figure 5.6 is a screenshot from new video evidence that shows fire spread above the compartment floor line at Level 5 by 01:13 (IWS00000050). Previously, the earliest evidence I had of fire spread above the Level 5 floor compartment line was at 01:15.

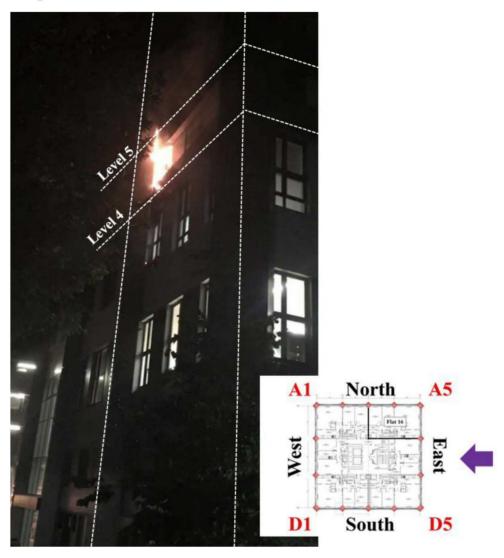


Figure 5.6: Fire on East elevation of building envelope spread to Level 5 at 01:13 (IWS00000050) (SEA00010474)

5.4.3 Flames then spread at Level 4 to column B5 on the East elevation of the building envelope by 01:14, as shown in Figure 5.6.

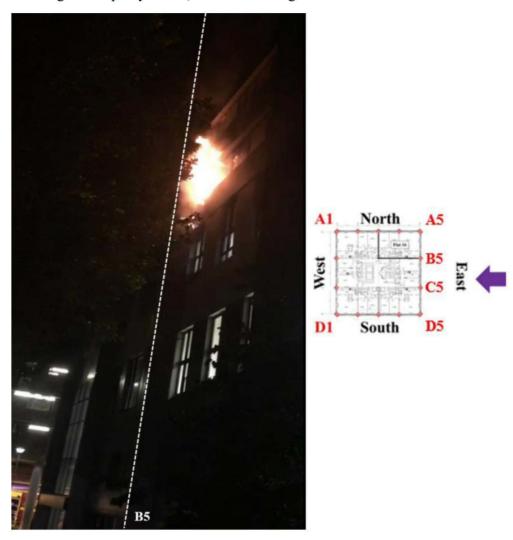


Figure 5.7: Fire on East elevation of building envelope spread to Level 5 at 01:14 (IWS00000050) (SEA00010474)

LFB made the first request for a high reach (aerial) appliance at 01:14 (LFB00000003). A high reach appliance was not part of the standard response protocol for Grenfell Tower (MET00012492).

Figure 5.8 shows the East elevation of the building envelope at 01:15:47, which shows no firefighting water being applied to the building. In comparison, the East elevation of the building envelope at 01:15:50 is shown with external firefighting water being applied to the building. This is the first confirmed time of external firefighting I am aware of, based on the photographs and videos I have reviewed to date. Some firefighter witness statements suggest that water was applied to the building before 01:15:50, but I have not been able to confirm this through photographic and video evidence. Refer to Section 17 of my report for my analysis of the external firefighting achieved by LFB on 14th June 2017.

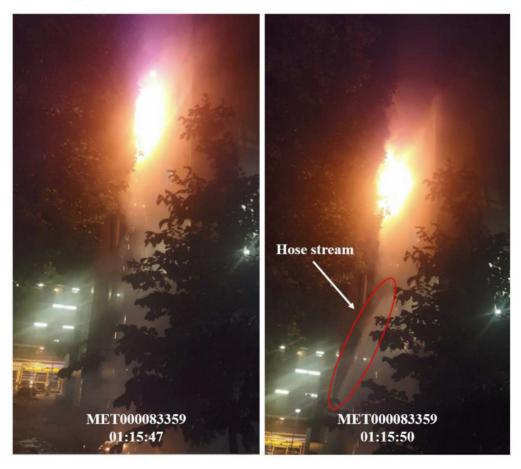


Figure 5.8: First observed fighting hose stream on East elevation of building envelope at 01:15 on 14 June 2017 (MET000083359)

5.4.6 Figure 5.9 shows that burning debris started to fall off the building by 01:15.



Figure 5.9: Burning debris observed on East elevation of building envelope at 01:15 on 14 June 2017 (MET00006834)

- 5.4.7 LFB then made the call for "Make pumps eight" at 01:19 (LFB00000003).
- 5.4.8 The fire had spread vertically along the line of column B5, reaching approximately Level 11 (32m above Ground level) by 01:21, as shown in Figure 5.10. LFB continued to actively fight the building envelope fire from the ground at this time.

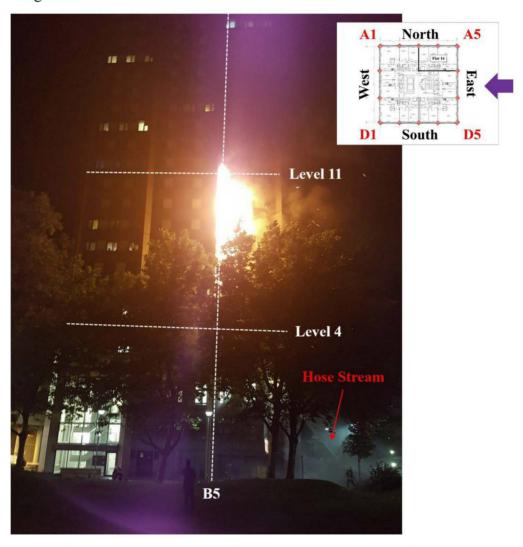


Figure 5.10: Fire on East elevation of the building envelope at 01:21 on 14 June 2017 (MET00006591) (SEA00010474)

5.4.9 The fire spread vertically along the line of column B5, reaching approximately Level 13 (37m above Ground level) by 01:22, as shown in Figure 5.11.

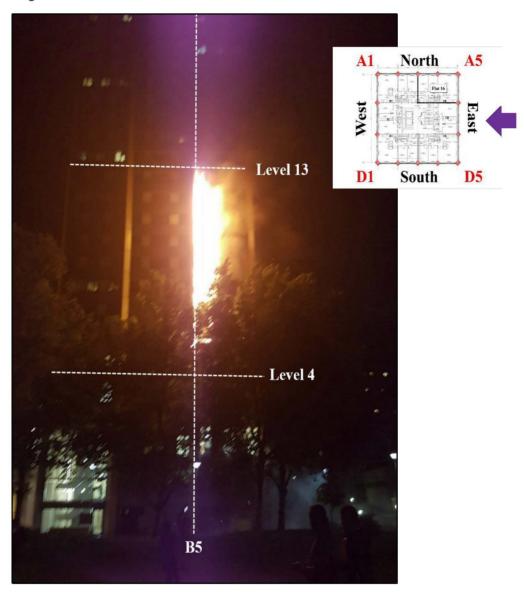


Figure 5.11: Fire on East elevation of the building envelope at 01:22 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.10 LFB then made the call to "Make pumps ten" at 01:24 (LFB00000003).
- 5.4.11 The fire spread from Level 4 to Level 23 along column B5, spanning a height of over 50 m by 01:26, as shown in Figure 5.12. In approximately 12 minutes, the fire spread up 19 storeys on the outside of the building.
- 5.4.12 Significant burning debris continued to fall off the building. Falling debris was a significant hazard for those occupants who decided to evacuate the building, and not stay put; and also for emergency responders (LFB, Ambulance, and MPS) throughout the fire. Please refer to Section 5.5 for additional photographs of falling debris and the impact debris had on emergency operations.

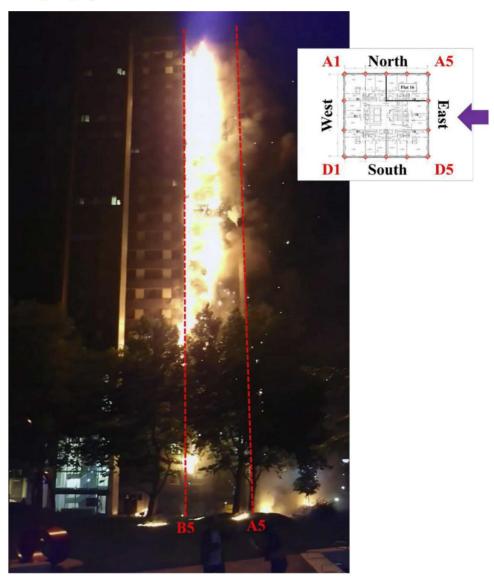


Figure 5.12: Fire on East elevation of the building envelope on 14 June 2017, estimated time 01:26 (SEA00010474)¹

¹ https://www.youtube.com/watch?v=6AYUZ5Snxzo

- 5.4.13 LFB then make the call to "Make pumps 15, Aerials X2" at 01:27 (LFB00000003).
- 5.4.14 Very quickly after that, LFB make a further call to "Make pumps 20, fire rescue units X2" at 01:29 (LFB00000003). This is 21 minutes after the fire spread to the building envelope.
- 5.4.15 By 01:29, the fire has spread vertically to the top of the building along Column B5, as shown in Figure 5.13. At this stage, the fire was also spreading horizontally across the building envelope, from Column B5 to Column A5.

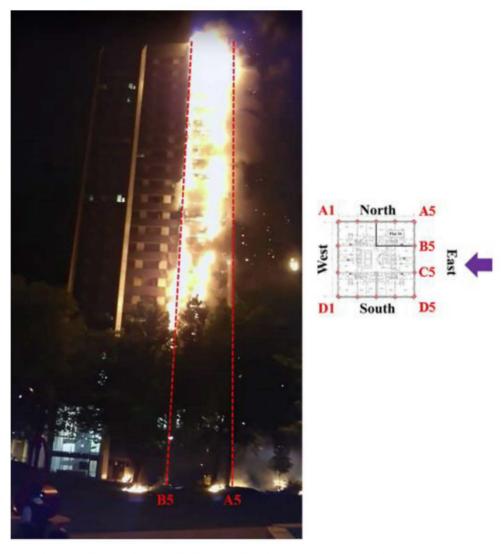


Figure 5.13: Fire on East elevation of the building envelope on 14 June 2017, estimated time 01:29 (SEA00010474)²

² https://www.youtube.com/watch?v=AKTsQxbvXiU&t=18

- **5.4.16** At 01:31 LFB decide to "Make pumps 25" (LFB00000003).
- 5.4.17 By 01:36 the fire was spreading in two lateral directions on the East elevation of the building envelope, as shown in Figure 5.14. The fire spread from column B5 towards A5 (northeast corner of the building) and from column B5 towards C5 (southeast corner of the building).

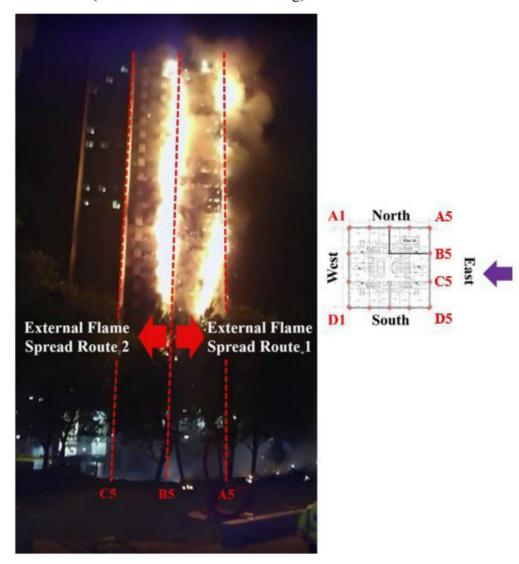


Figure 5.14: Fire on East elevation of the building envelope on 14 June 2017, estimated time 01:36 (SEA00010474)³

³ https://www.youtube.com/watch?v=bBCnQvxNaDg

5.4.18 These two distinct external flame spread routes are shown in Figure 5.15.

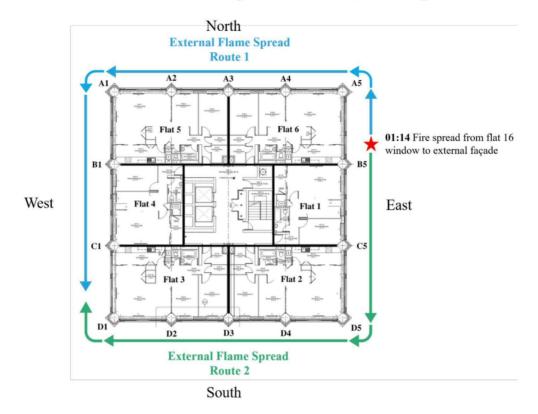


Figure 5.15: External flame spread routes around Grenfell Tower (SEA00010474)

- 5.4.19 The following photographs are presented in chronological order to show how these two flame spread routes developed.
- 5.4.20 Section 5.4.24 shows the progression of External Flame Spread Route 1 and Section 5.4.42 shows the progression of External Flame Spread Route 2.
- 5.4.21 In addition to photographic evidence, a timeline of events from the MPS and LFB are presented throughout both sections.
- 5.4.22 Observations of the external flame spread routes converging on the West elevation of the building are presented in Section 5.4.63.
- 5.4.23 In most of the photographic and video evidence of external fire spread after 02:08 that I have reviewed, I observed a consistent diagonal pattern of fire spread along both External Flame Spread Route 1 and 2, as shown in Figure 5.16. I observed this diagonal pattern of fire spread on all elevations of Grenfell Tower for photographic evidence refer to Figure 5.21 (North elevation), Figure 5.28 (East elevation), Figure 5.35 (South elevation) and Figure 5.38 (West elevation). In Section 10 of my report I describe this diagonal pattern of flame spread with regards to the routes for external vertical and horizontal fire spread on the building envelope.

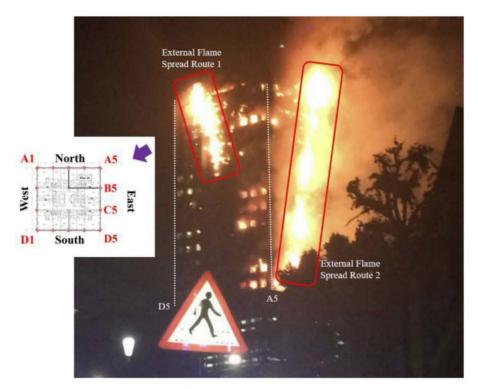


Figure 5.16: Diagonal pattern for External Flame Spread Routes 1 and 2 at 02:08 on $14^{\rm th}$ June 2017 (MET0001253) (SEA00010474)

5.4.24 External Flame Spread Route 1

- 5.4.25 This section describes the progression of External Flame Spread Route 1 (direction of column B5 to A5).
- 5.4.26 Figure 5.17 and Figure 5.18 show fire spread to column A5 (northeast corner of the building) at 01:36 and 01:38, respectively.

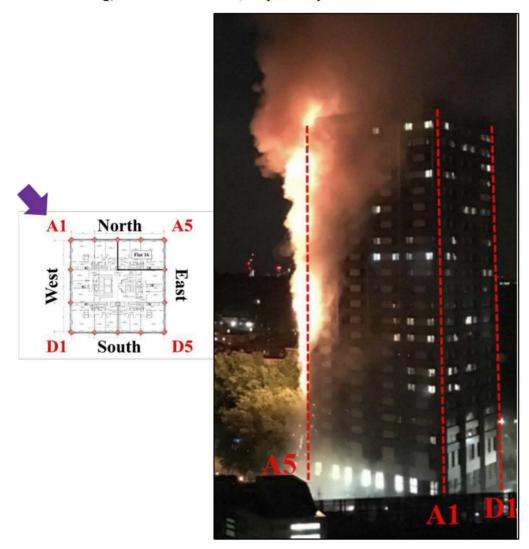


Figure 5.17: Fire spread along column A1 (northeast corner of building) at 01:36 on 14 June 2017 (MET00012593) (SEA00010474)

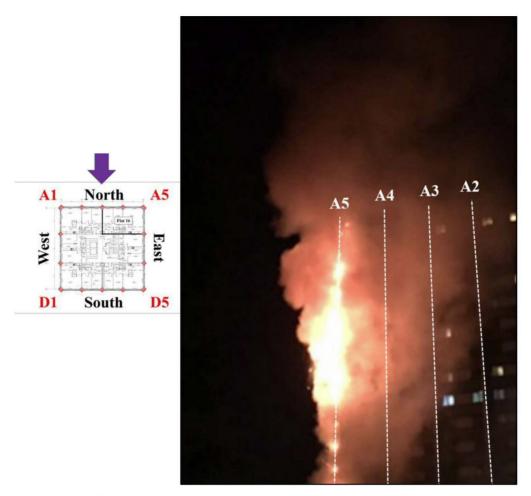


Figure 5.18: Fire spread along column A1 (northeast corner of building) at 01:38 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.27 According to Metropolitan Police Service, the fire spread from the East elevation to the North elevation of the building envelope by 01:42; refer to Figure 5.19 (MET0000802).



Figure 5.19: Fire spread from East elevation to North elevation of building envelope at 01:42 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.28 LFB then "Make pumps 40" at 02:04 (LFB00000003).
- 5.4.29 At 02:06, the LFB declared the fire a "major incident" (LFB00000003).
- 5.4.30 The fire continued to spread laterally on the North elevation of the building envelope, from column A5 (northeast corner of the building) towards column A1 (northwest corner of the building), along the lines of the windows, as shown in Figure 5.20, which is at 02:10.
- 5.4.31 At this time, both the East and North building envelopes of the building were involved in external fire, and multiple internal fires can be observed.

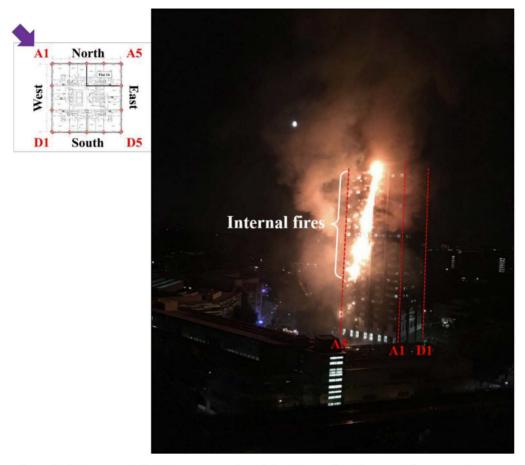


Figure 5.20: Internal fires burning on North building elevation and fire spread on North elevation of building envelope at 02:10 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.32 At 02:30, it was reported that the East elevation of the building envelope was fully involved in fire (MET00012593).
- 5.4.33 Multiple internal fires were burning simultaneously at 02:34, as shown in Figure 5.21.

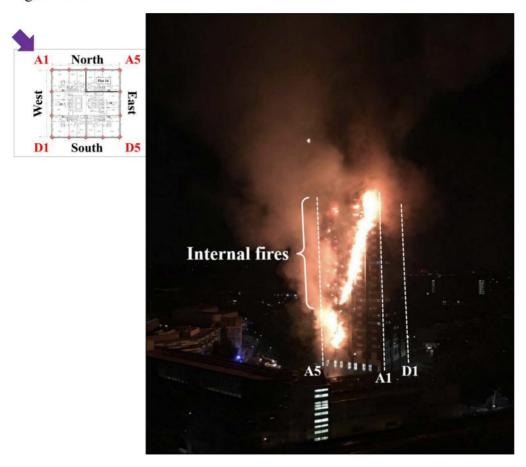


Figure 5.21: Internal fires burning on North elevation and fire spread on the North elevation of the building envelope at 02:34 on 14 June 2017 (MET00012593) (SEA00010474)

- While the precise timing and wording of the orders given by the relevant commanders will be a matter for the Chairman to consider (as well as what advice was actually given by Control Room Operatives), the existing evidence indicates that at 02.35 Jo Smith instructed the control room officers to change advice from stay put to leave (Transcript of 11th/12th July 2018). The available evidence also indicates that at or about 02:47 Assistant Commander Roe, then the Incident Commander, also separately ordered that the advice be changed to leave (MET00005404).
- 5.4.35 At this time, the East, North, and South elevations of the building envelope were involved in fire (MET00012593).
- 5.4.36 The fire continued to spread laterally on the North elevation of the building envelope from column A5 towards column A1 (southwest corner of the building).

- 5.4.37 According to the Metropolitan Police Service, the fire spread from the North elevation to the West elevation of the building envelope, around column A1 (northwest corner of the building), at 02:51 (MET00012593).
- 5.4.38 The fire continued to spread laterally on the West elevation of the building envelope towards the Southeast corner of the building, as shown in Figure 5.22. This photograph also shows a firefighting jet was being applied to the North elevation of the building envelope at 03:08.

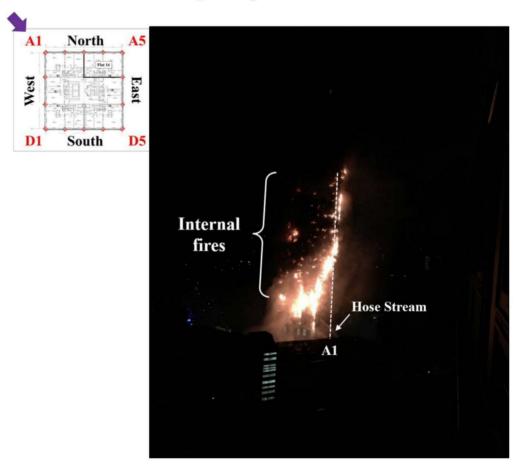


Figure 5.22: Internal fires burning on North elevation and fire spread on the North and West elevations of the building envelope at 03:08 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.39 The North elevation of the building envelope was reported to be fully involved in fire by 03:23. (MET00012593)

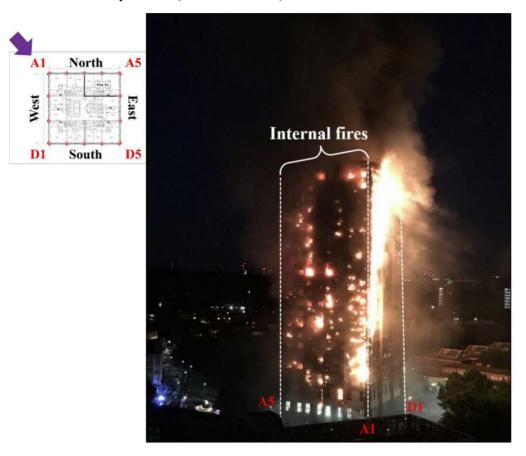


Figure 5.23: Internal fires burning on North elevation and fire spread on North elevation and West elevation of the building envelope at 03:23 on 14 June 2017 (MET00012593) (SEA00010474)

The fire continued to spread towards the Southwest corner of the building (column D1), and two (2) firefighting jets were applied to the building at 03:44, one on the East elevation of the building envelope and the other on the West elevation of the building envelope, as shown in Figure 5.24.

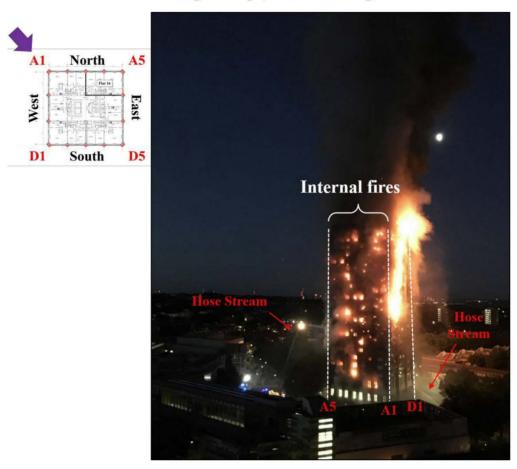


Figure 5.24: Internal fires burning on North building elevation and fire spread on West elevation of the building envelope at 03:44 on 14 June 2017 (MET00012593) (SEA00010474)

Refer to Section 5.4.63 for photographs and observations of the external flame spread routes converging on the West elevation of the building envelope.

5.4.42 External Flame Spread Route 2

- 5.4.43 This section describes the progression of External Flame Spread Route 2 (direction of column B5 to D5 on building East elevation i.e. East to South).
- 5.4.44 The fire spread laterally across the East elevation of the building envelope from column B5 to column C5 on Levels 17 to 23, as shown in Figure 5.25. Multiple internal fires can be seen in the building.

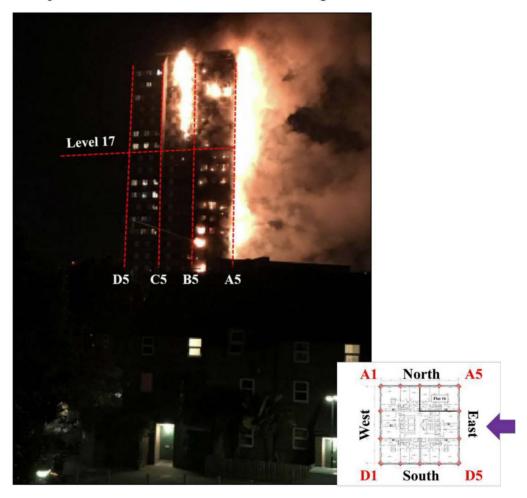


Figure 5.25: Fire spread on East elevation of the building envelope at 01:52 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.45 LFB "Make pumps 40" at 02:04 (LFB00000003).
- As shown in Figure 5.26 an LFB aerial appliance was active close to the East elevation of the building envelope at approximately 02:05.

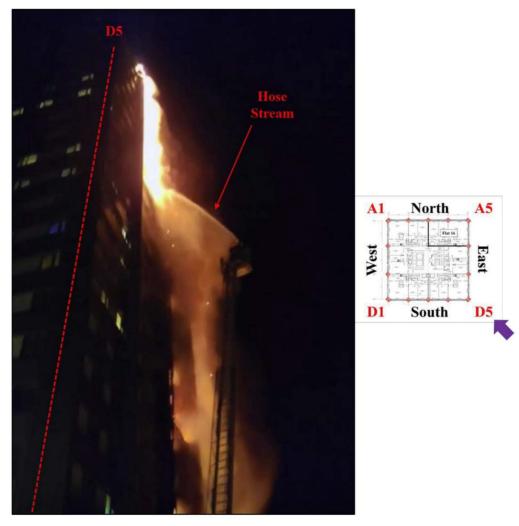


Figure 5.26: High reach (aerial) fire fighting jet on East elevation of building envelope, estimated time 02:05 (SEA00010474)⁴

- 5.4.47 As noted in Section 5.4.29, the LFB declared the fire a "major incident" at 02:06 (LFB00000003).
- 5.4.48 At this time, both the East and North elevations of the building envelope were involved in external fire (MET00012593)
- 5.4.49 The fire continued to spread laterally from column C5 to D5 on Levels 18 to 23, as shown in Figure 5.27. Multiple internal fires can be seen in the building in this photograph.

⁴ https://www.youtube.com/watch?v=z8wIbhf7NL4&t=53s

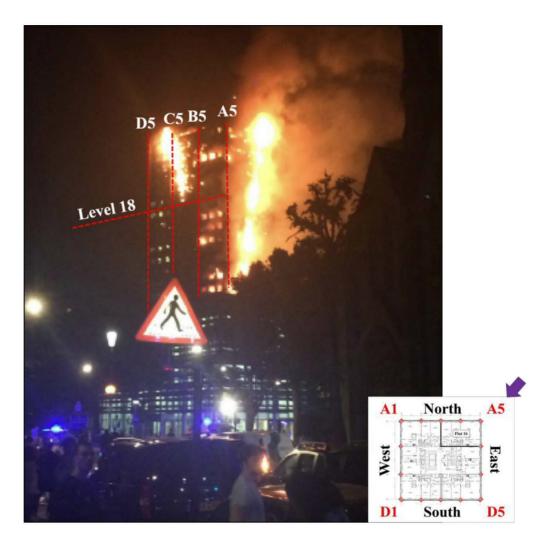


Figure 5.27: Fire spread on East elevation of the building envelope at 02:08 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.50 By 02:22 the fire reached column D5 (southeast corner of the building), as shown in Figure 5.28 and Figure 5.29. It also appears the fire spread downwards from level 18 to level 16 between 02:08 and 02:22, based on a comparison of Figure 5.27 and Figure 5.28.

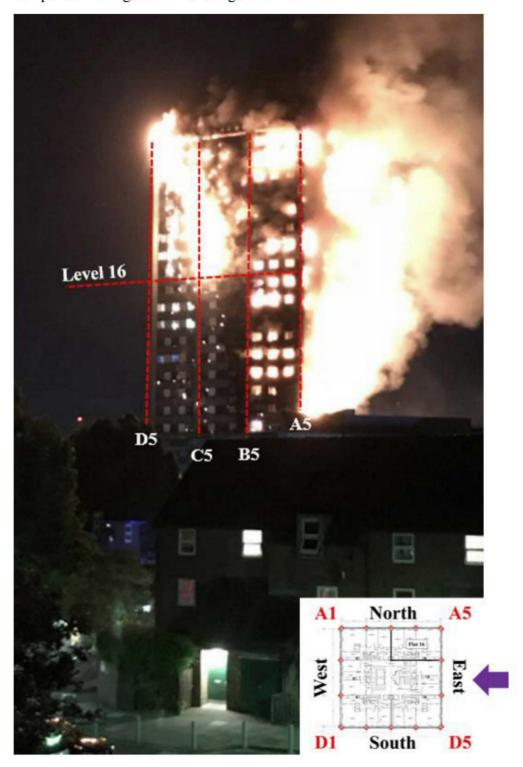


Figure 5.28: Fire spread on East elevation of the building envelope at 02:22 on 14 June 2017 (MET00012593) (SEA00010474)



Figure 5.29: Fire spread on East elevation of the building envelope at 02:24 on 14 June 2017 (MET00012593) (SEA00010474)

- According to the MPS, the fire spread to the South elevation of the building envelope at 02:25 (MET00012593).
- Figure 5.30 shows both flame spread routes at Grenfell Tower at 02:27 on 14th June 2017. External Flame Spread Route 1 is spreading from column A5 towards D5 on the East elevation of the building envelope, whereas External Flame Spread Route 2 is spreading from column A5 towards A1 on the North elevation of the building envelope.

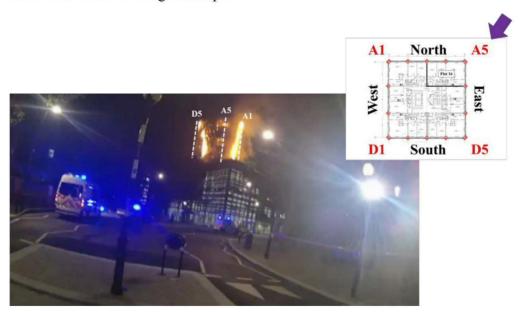


Figure 5.30: Two flame spread routes on East elevation and North elevation of the building envelope at 02:27 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.53 Figure 5.31 and Figure 5.32 show that the initial fire spread from the East elevation to the South elevation of the building envelope was at Level 23, around column D5 (southeast corner of the building).

5.4.54 At 02:30, it was reported that the East elevation of the building envelope was fully involved in fire (MET00012593).

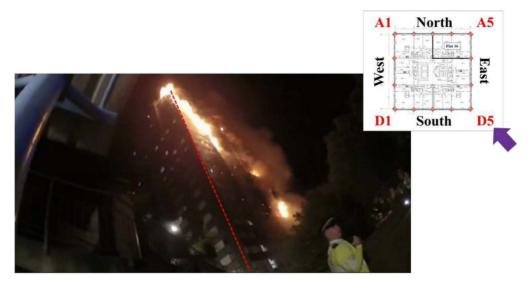


Figure 5.31: Fire spread around column D5 (southeast corner of building), from East elevation to South elevation of the building envelope at 02:33 on 14 June 2017 (MET00012593) (SEA00010474)



Figure 5.32: Fire spread on South elevation of the building envelope at 02:41 on 14 June 2017 (MET00012593) (SEA00010474)

- As noted in 5.4.34, LFB changed the stay put guidance at 02:35 (Jo Smith) and 02:47 (AC Roe) (MET00005404). At this time, the East, North, and South elevations of the building envelope were involved in fire and multiple internal fires were burning simultaneously, as shown in Figure 5.21.
- 5.4.56 The fire continued to spread laterally on the upper levels of the South elevation of the building envelope from the Southeast corner of the building (column D5) towards the Southwest corner of the building (column D1), as shown in Figure 5.32 and Figure 5.33.

5.4.57 Figure 5.33 shows a fire fighting jet being applied to the building envelope at the Southeast corner (column D5) of the building. Note, the fire fighters are staged on the walkway adjacent to Grenfell Tower.



Figure 5.33: Fire spread on South elevation of the building envelope at 02:48 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.58 Fire fighting crews continued to apply a fire fighting jet to the Southeast corner of the building, as shown in Figure 5.34 and Figure 5.35. An aerial appliance was used to deliver a fire fighting jet to the East elevation of the building envelope by 03:32.
- 5.4.59 The fire did not spread below Level 10 on Column D5 (southeast corner of the building).



Figure 5.34: Fire spread on East elevation and South elevation of the building envelope at 03:09 on 14 June 2017 (MET00012593) (SEA00010474)

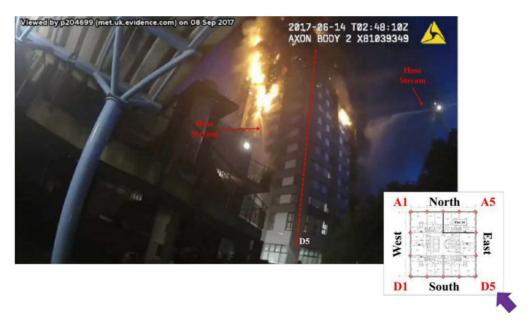


Figure 5.35: Fire spread on South elevation of building envelope at 03:48 on 14 June 2017 (MET00012593) (SEA00010474)

Figure 5.36 shows that the fire spread on the South elevation of the building envelope has reached the Southwest corner of the building (column D1) by 03:56.

The high rise (aerial) appliance was still being used to apply a fire fighting jet to the East elevation of the building envelope at 03:56; refer to Figure 5.36.



Figure 5.36: Fire spread on South elevation of the building envelope at 03:56 on 14 June 2017 (MET00012593) (SEA00010474)

- The South elevation of the building envelope was reported to be fully involved in fire at 04:09. (MET00012593)
- 5.4.63 Building enveloped by external fire
- As shown in Figure 5.15, there were two distinct external flame spread routes around Grenfell Tower.
- 5.4.65 In Sections 5.4.24 and 5.4.42 above, I have provided pictures to show the progression of External Flame Spread Route 1 and External Flame Spread Route 2, respectively.
- 5.4.66 In this section, I have presented evidence of the external flame spread routes converging on the West elevation of the building envelope.

5.4.67 As shown in Figure 5.37, External Flame Spread Route 1 and External Flame Spread Route 2 were approaching each other on the West elevation of the building envelope, between columns C1 and D1, at 03:48.



Figure 5.37: Internal fires burning on West building elevation and fire spreading from column C1 and D1 on the West elevation of the building envelope at 03:48 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.68 At approximately 04:03, these two flame fronts appear to effectively converge at the crown, near the southwest corner of the building; as shown in Figure 5.38.

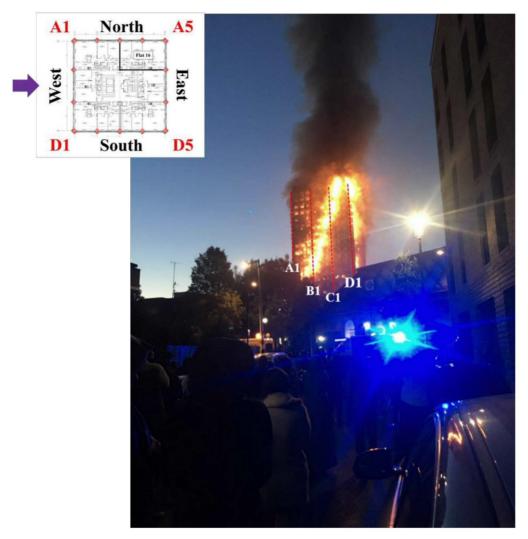


Figure 5.38: Fire spread on West elevation and South elevation of the building envelope at 04:03 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.69 The two flame fronts spread laterally towards each other between columns C1 and D1, fully enveloping the building's perimeter, as shown in Figure 5.39, Figure 5.40, Figure 5.41, and Figure 5.42.
- 5.4.70 On 14 June 2017, civil twilight was from 03:55 and sunrise was at 04:42. I have estimated the timings for some of the following images based on this daylight information and my visual observations of fire development, benchmarked to images with known times.
- **5.4.71** Figure 5.39 shows fire burning in and around the crown cladding construction.

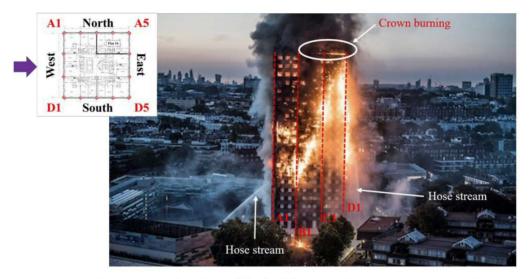


Figure 5.39: Fire on West elevation of the building envelope on 14 June 2017 (exact time between 04:03 and 04:42 unknown) (SEA00010474)⁵

⁵ http://www.telegraph.co.uk/news/2017/06/14/grenfell-tower-inferno-disaster-waiting-happen-concerns-raised/

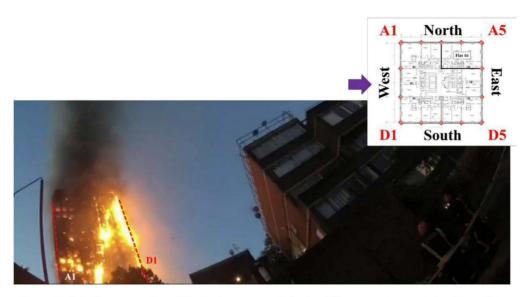


Figure 5.40: Fire spread on West elevation of the building envelope at 04:15 on 14 June 2017 (MET00012593) (SEA00010474)



Figure 5.41: External fire enclosed full perimeter of Grenfell Tower building envelope on West elevation on 14 June 2017 (unknown time) (SEA00010474)⁶

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 $^{^6 \, \}underline{\text{http://st1.photogallery.ind.sh/wp-content/uploads/indiacom/grenfell-tower-burnt-to-ashes-in-london-during-fire-201706-1497422586.jpg}$



Figure 5.42: Fire on West elevation of the building envelope at 04:19 on 14 June 2017 (MET00012593) (SEA00010474)

- 5.4.72 Figure 5.43, Figure 5.44, and Figure 5.45 show several internal fires burning while the building envelope on the West elevation continues to burn. These photographs are estimated to be between 04:03 and 04:42.
- 5.4.73 Figure 5.43 shows fire burning in and around the crown cladding construction.

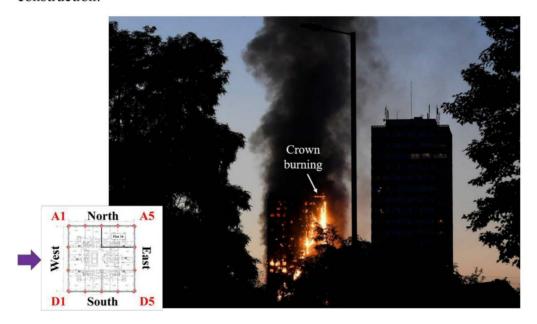


Figure 5.43: External fire West elevation of building envelope on 14 June 2017 (exact time between 04:03 and 04:42 unknown) (SEA00010474)⁷

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⁷ https://www.ibtimes.co.uk/grenfell-tower-fire-no-more-survivors-expected-flames-finally-extinguished-1626385



Figure 5.44: External fire West elevation of building envelope on 14 June 2017 (exact time between 04:03 and 04:42 unknown) (SEA00010474)⁸



Figure 5.45: External fire West elevation of building envelope on 14 June 2017 (exact time between 04:03 and 04:42 unknown own) (SEA00010474)⁹

5.4.74 Multiple internal fires were burning in other areas of the building. Figure 5.46 shows a high reach (aerial) appliance firefighting jet being applied to internal fires on the East elevation of the building envelope at 04:26.

 $^{^{8} \, \}underline{\text{https://www.ibtimes.co.uk/2017-pictures-year-devastating-fires-floods-landslides-earthquakes-other-disasters-1651182}$

⁹ http://www.newsweek.com/grenfell-tower-london-fire-grenfell-action-group-warning-625446



Figure 5.46: Internal fires on East building envelope at 04:26 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.75 Figure 5.47 shows fire spreading vertically down the West elevation of the building envelope along column B1.



Figure 5.47: Downward fire spread on West elevation of building envelope at 04:31 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.76 While the fire continued to spread on the West elevation of the building envelope, internal fires burned as well. Figure 5.48 shows internal fires burning on the North and West elevations while the West elevation of the building envelope continues to burn at 4:43. I observed three (3) fire fighter jets being applied in this photograph – one on each of the East, North, and West elevations.

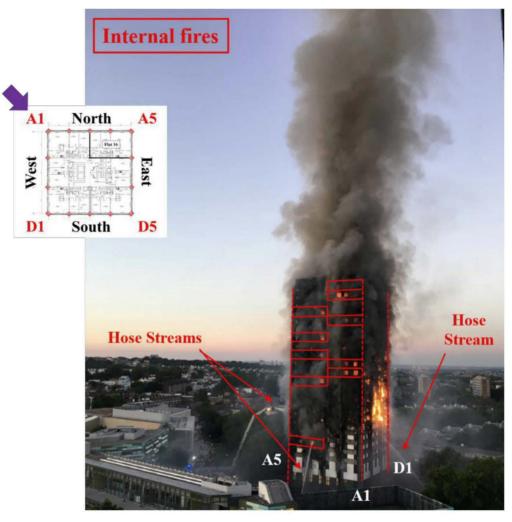


Figure 5.48 Internal fires burning on North and West elevations and fire spread on West elevation of the building envelope at 04:43 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.77 Figure 5.49 shows internal fires burning on the West building envelope while the West elevation of the building envelope continues to burn at 4:44.

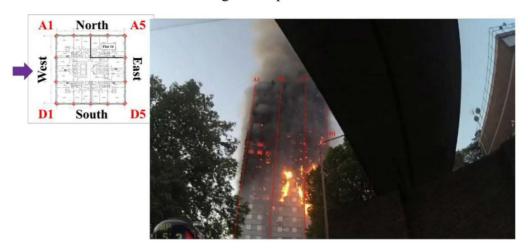


Figure 5.49: Fire spread on West elevation of building envelope at 04:44 on 14 June 2017 (MET00012593) (SEA00010474)

The West elevation of the building elevation was reported to be fully involved in fire at 04:47 (MET00012593).

5.4.79 Figure 5.50 and Figure 5.51 show internal fires on the East building elevation at unknown times. Based on Figure 5.51, at least two (2) fire fighter jets were being applied at this time – one on the North elevation and one on the East elevation.

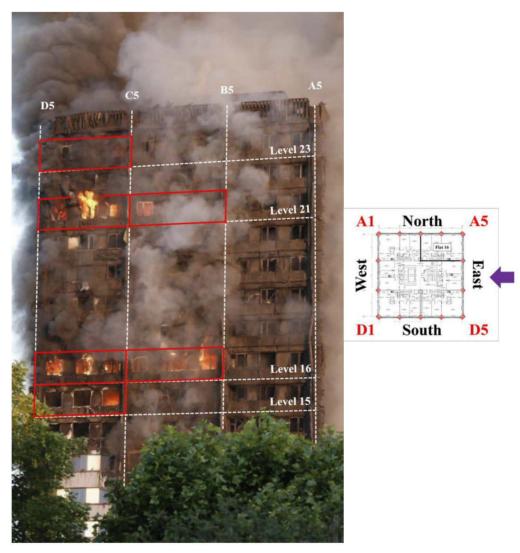


Figure 5.50: Internal fires on East elevation on 14 June 2017 (unknown time) $(SEA00010474)^{10}$

¹⁰ https://twitter.com/fire_event/status/874886358938079232

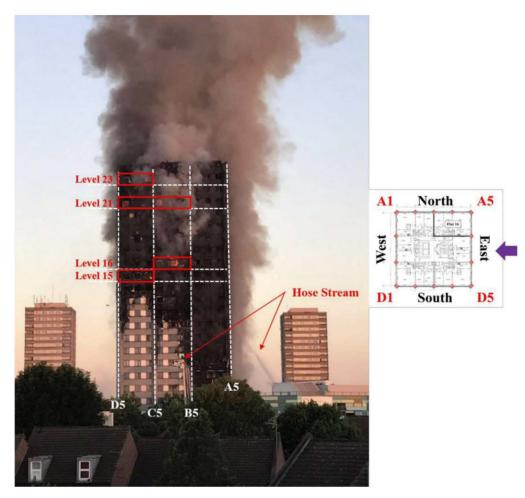


Figure 5.51: Internal fires observed on East elevation (unknown time) (MET00006799) (SEA00010474)

5.4.80 Figure 5.52 indicates there were at least two (2) fire fighter jets being applied to the building at 05:16 – one on the East elevation and one on the North elevation. Although it is not easily visible in Figure 5.52 and Figure 5.53, there does appear to be internal fires burning at this time, as indicated.

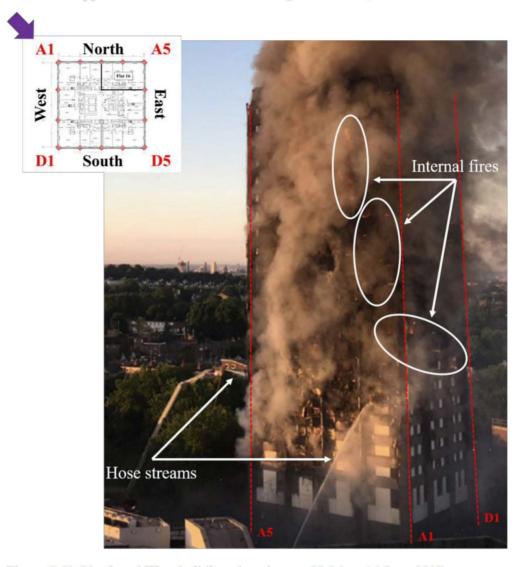


Figure 5.52: North and West building elevations at 05:16 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.81 Figure 5.53 indicates there were at least three (3) fire fighter jets being applied to the building at 05:39 – one on each the East, North and West elevations. Although it is not easily visible in these images, there does appear to be internal fires burning at this time, as indicated in Figure 5.53.

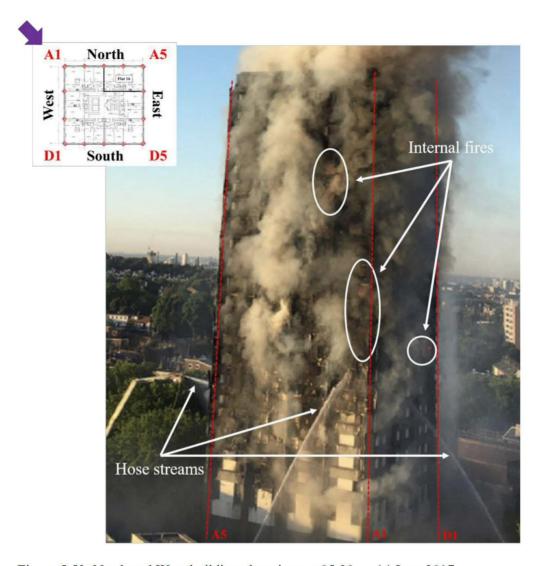


Figure 5.53: North and West building elevations at 05:39 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.82 Based on Figure 5.54, there was an internal fire in Flat 105 on Level 13 at 06:07 and at least two (2) fire fighter jets were being applied several floors below Flat 105 – one on the North and one on the West elevation.

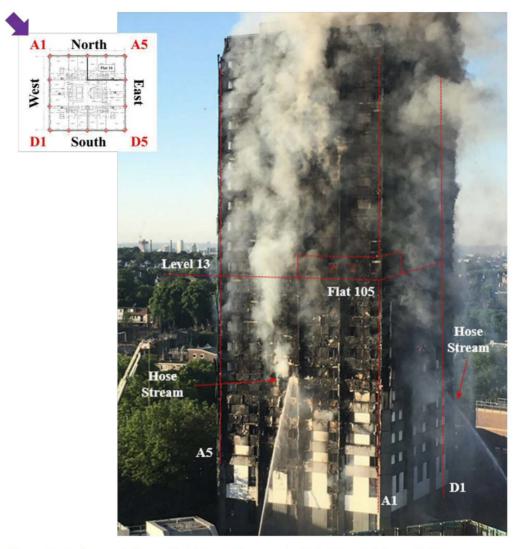


Figure 5.54: Internal fire in flat 105 on Level 13 at 06:07 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.83 Based on Figure 5.55, at least two (2) fire fighter jets were being applied at 07:55 – one on the North and one on the West elevation. Although it is not easily visible in these images, there does appear to be at least one internal fire burning at this time, as indicated in Figure 5.55.

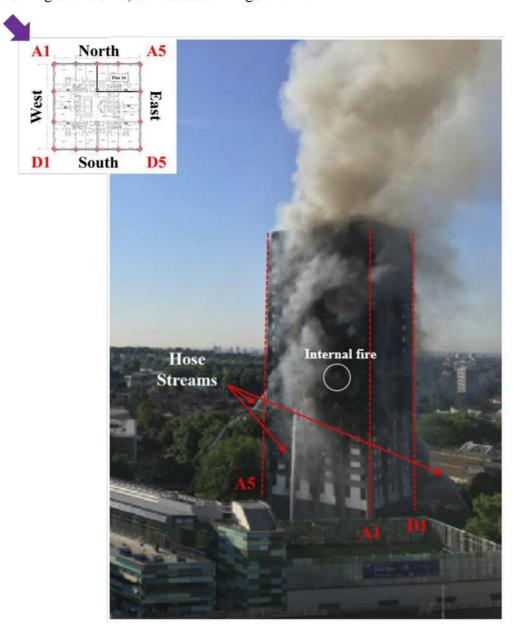


Figure 5.55: North and West building elevations at 07:55 on 14 June 2017 (MET00012593) (SEA00010474)

5.4.84 Figure 5.56 shows the North and West elevations of the building at 11:03. There are no visible internal fires on the North or South elevations in this photograph. However, this does not provide positive evidence that there were no internal fires at this time. I would expect that the majority of any fuel load available was consumed by this time; except for any gas acting as a fuel source.

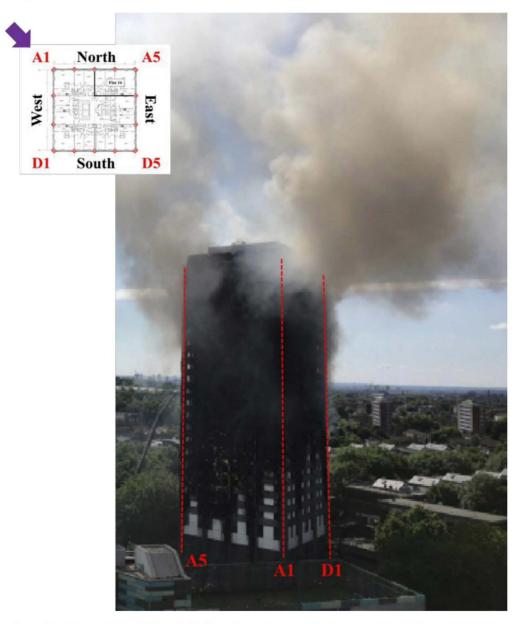


Figure 5.56: North and West building elevations at 11:03 on 14 June 2017 (MET00012593) (SEA00010474)

Based on Figure 5.57, there was an internal fire in Flat 104 on Level 13 at approximately 11:38. This is the time the photograph was posted to Twitter. Unlike other images posted by this person on Twitter, the time the image was taken was not indicated in the post. Therefore, I am relying on the time of the Twitter post only.



Figure 5.57: Internal fire in flat 104 (level 13) on building West elevation on 14 June 2017apparently at approximately 11:38 (SEA00010474)¹¹

5.4.86 At 19:55 the Incident Commander recorded "There is no longer any saveable life in the building" (LFB00000003).

¹¹ https://twitter.com/Natalie Oxford/media?lang=en

- 5.4.87 The LFB handed over active control of the site to the Major Incident Command at 20:00 (LFB00000003).
- **5.4.88** Figure 5.58 shows the North and West elevations of the building at 20:25. I cannot see any internal fires in this photograph.
- 5.4.89 However, I can see internal fires in multiple flats on the building's North and West elevations at 21:50 in Figure 5.59.
- 5.4.90 It is unclear what the source of fuel is from these photos.



Figure 5.58: North and West elevations of the building apparently at 20:25 on 14 June 2017 (SEA00010474)¹²

¹² https://twitter.com/Natalie Oxford/media?lang=en

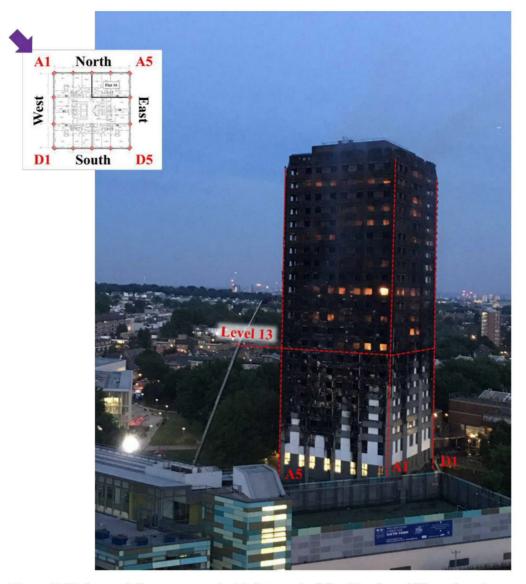


Figure 5.59: Internal fires apparent in 19 flats on building North and West elevations apparently at 21:50 on 14 June 2017 (SEA00010474)¹³

¹³ https://twitter.com/Natalie Oxford/media?lang=en

5.5 Falling Debris

5.5.1 A significant amount of debris fell off the building envelope of Grenfell Tower on 14th June 2017. A large amount of this debris was on fire, as shown in Figure 5.60 and Figure 5.61.



Figure 5.60: Burning debris falling of building¹⁴



Figure 5.61: Burning debris falling off building¹⁵

 $^{^{14} \, \}underline{\text{http://i2.cdn.cnn.com/cnnnext/dam/assets/170615184219-02-week-in-photos-0616-super-169.jpg}$

 $[\]frac{15}{http://i4.mirror.co.uk/incoming/article10620720.ece/ALTERNATES/s1200/Grenfell-Tower-fire-London-UK-14-Jun-2017.jpg$

- I observed burning debris falling off the East elevation of Grenfell Tower as early as 01:15; refer to Figure 5.9.
- 5.5.3 Figure 5.62, Figure 5.63, and Figure 5.64 also show burning debris falling off the East elevation of the building.

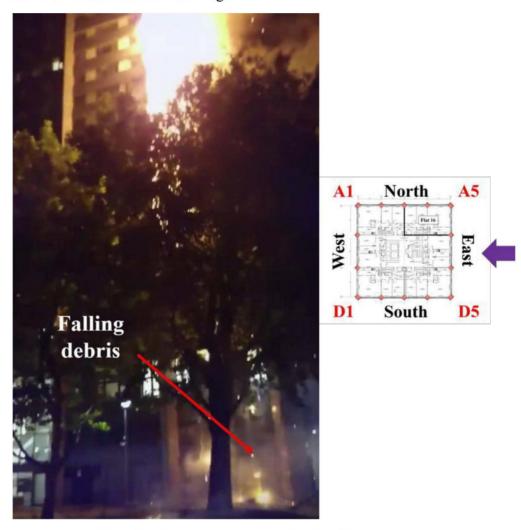


Figure 5.62: Falling debris on East elevation of the building envelope on 14 June 2017, estimated time 01:24 (SEA00010474)¹⁶

¹⁶ https://www.youtube.com/watch?v=lTNUvZkZcMc



Figure 5.63: Falling debris on East elevation of the building envelope on 14 June 2017, estimated time 01:26 (SEA00010474)¹⁷



Figure 5.64: Falling debris on East elevation of the building envelope on 14 June 2017, estimated time 01:26 (SEA00010474)¹⁸

- 5.5.4 Falling debris presented a significant hazard for people evacuating from the building and for the emergency personnel (LFB, Ambulance, and the MPS) working at ground level.
- 5.5.5 The impact of falling debris on operations was discussed in several witness statements from LFB firefighters, such as:
 - a) From the early stages of the fire, falling debris was a risk to firefighters and those evacuating (MET00007765, MET00007518, and MET00007520)

¹⁷ https://www.youtube.com/watch?v=6AYUZ5Snxzo

¹⁸ https://www.youtube.com/watch?v=6AYUZ5Snxzo

- b) Debris was as much of a risk to firefighters as fighting the fires (MET0007520).
- c) Turntable ladders (TL) and Aerial Ladder Platforms (ALP) were unable to get close enough to Grenfell Tower to operate effectively because of the debris (MET00007512 and MET00007782).
- d) Spotters were used to help fire fighters avoid larger chunks of debris (MET00007520).
- e) The entry/exit to the building had to be changed because of falling debris. (MET00007525).
- f) There was a need for fire fighters to put out burning debris on the ground around the building (MET00007512).
- g) Falling debris split and made a sizeable hole in fire-fighting hoses feeding the dry riser inlet (MET00005252).
- LFB requested long shields for escort duties at 03:05 (MET00012593). The long shields were used by firefighters to protect themselves and others (primarily evacuating residents) from falling debris. Figure 5.65, Figure 5.66, and Figure 5.67 show emergency personnel using the long shields while navigating the site and entering Grenfell Tower. Figure 5.66 shows fire fighters wearing breathing apparatus and carrying fire hoses into the building while other emergency personnel hold long shields over head to protect the firefighters.



Figure 5.65: Firefighters use long shields to protect themselves from falling debris as they enter Grenfell Tower 19

 $^{^{19} \, \}underline{\text{http://i.dailymail.co.uk/i/pix/2017/06/14/15/416A638900000578-4603658-image-a-23-1497451105686.jpg}$

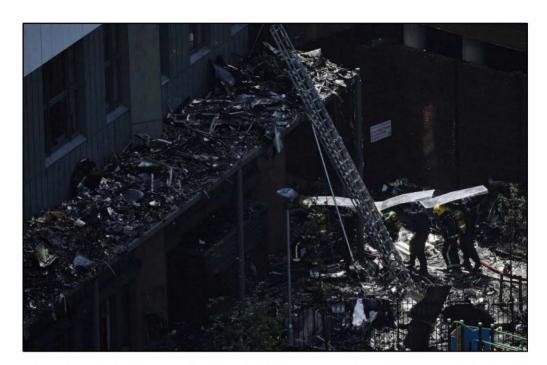


Figure 5.66: Firefighters using long shields to protect themselves from falling debris as they enter Grenfell Tower with Breathing Apparatus and fire fighting hose ²⁰



Figure 5.67: Firefighters using long shields to protect themselves from falling debris while working at fire scene at Grenfell Tower ²¹

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 $^{^{20} \, \}underline{\text{http://i1.wp.com/metrouk2.files.wordpress.com/2017/06/pri_43353181_1497442500-092-e1497447515348}$

 $^{^{21} \ \}underline{http://www.telegraph.co.uk/news/2017/07/08/grenfell-tower-firefighters-hampered-equipment-faults-\underline{delays/}}$

5.5.7 Figure 5.68 shows debris littered by the Southeast corner of Grenfell Tower, near the location of the building's main exit and the fire access road. This debris was an obstruction on the ground level and a damage hazard to the fire-fighting hoses.



Figure 5.68: Debris and firefighting hoses near Southeast corner of Grenfell Tower blocking access to building (MET00006773) (SEA00010474)

5.6 Summary of observed events on 14 June 2017

5.6.1 Table 5.1 summarises the observed events on 14 June 2017.

Table 5.1: Summary of observed events on 14 June 2017

Time	Event	Evidence
00:54	First call from incident (fire in Flat 16)	LFB00000003
00:55	Pre-determined attendance of 3 pumps assigned to the incident.	LFB00000003
00:55	Smoke control system autodialler sends signal to Tunstall a remote monitoring company and "fire service called".	THL00000002
00:57	Brigade Control receive the second 999 call in relation to Grenfell Tower, from a remote monitoring company, Tunstall Response.	LFB00001914
00:59	A fourth pump appliance is manually assigned to the incident by Peter May	MET00015882
01:08	First image of fire taking hold outside Flat 16 (East façade)	IWS00000051
01:14	First request for Aerial Appliance	LFB00000003
01:15	First confirmed external fire-fighting jet from ground observed	MET000083359
01:19	"Make pumps eight"	LFB00000003
01:24	"Make pumps ten"	LFB00000003
01:27	"Make pumps 15, Aerials X2"	LFB00000003
01:29	"Make pumps 20, fire rescue units X2"	LFB00000003
01:31	"Make pumps 25"	LFB00000003
01:42	North façade ignited	MET00012593
02:04	"Make pumps 40"	LFB00000003
02:05	Aerial appliance active close to East Building envelope	YouTube video ²²
02:06	LFB message from incident "CU8 from GM Welch this is a major incident"	LFB00000003
02:25	South façade ignited	MET00012593
02:30	East façade fully involved	MET00012593
02:35	Stay put advice begins to change	MET00007766; Jo Smith evidence, Transcript 12 July 2018 p.132
02:47	AC Roe records decision for FSG advice from control staff to "advise people to make efforts to leave the building"	MET00005404 LFB00000003
02:51	West façade ignited	MET00012593
03:23	North façade fully involved	MET00012593

²² https://www.youtube.com/watch?v=z8wIbhf7NL4&t=43s

Time	Event	Evidence
04:09	South façade fully involved	MET00012593
04:44	West façade fully involved	MET00012593
19:55	Incident Commander Ellis records "There is no longer any saveable life in the building"	LFB00000003
20:00	LFB hands over active control of the site to the Major Incident Command	LFB00000003

- 5.6.2 The cumulative fire damage to the external façade of Grenfell Tower from the events that unfolded on 14 June 2017 can be observed in Figure 5.69, Figure 5.70, Figure 5.71, and Figure 5.72.
- In Section 12 of my report, I present the significance of the building envelope fire and its impact on the conditions in the flats.
- In Section 13 of my report I provide a detailed comparison of these observed events, with the evacuation time of residents from the building, as well as the movement of the residents who evacuated their own flat, but did not get to evacuate Grenfell Tower, and so lost their life. I also compare these observed events with LFB command decisions and I provide an analysis of the number of fire fighters logged as entering and exiting the building.
- 5.6.5 In Section 14 of my report I present the significance of the building envelope fire and its impact on the conditions in the stair and lobbies.



Figure 5.69: East building envelope of Grenfell Tower, UAV image taken on 10/06/2017 (MET00012593) (SEA00010474)



Figure 5.70: North building envelope of Grenfell Tower, UAV image taken on 10/06/2017 (MET00012593) (SEA00010474)



Figure 5.71: West building envelope of Grenfell Tower, UAV image taken on 10/06/2017 (MET00012593) (SEA00010474)



Figure 5.72: South building envelope of Grenfell Tower, UAV image taken on 10/06/2017 (MET00012593) (SEA00010474)

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