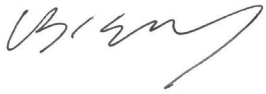
THE UNIVERSITY of EDINBURGH
School of Engineering

Grenfell Tower Inquiry
Phase 2 – BRE Reconstruction Report

Professor Luke Bisby

Signed: 

Dated: 10th May 2022

Contents

1.0 Additional Instructions

1. Further to Cathy Kennedy's letter of 20th October 2021, I am writing with respect to the additional Phase 2 Instructions contained therein.

2. In my Phase 2 instructions for the Grenfell Tower Inquiry (the Inquiry), I was asked to provide a report on my final conclusions on the relative contributions of the cladding design and materials to the fire spread at Grenfell Tower, taking account of the findings made in the Phase 1 report.

3. In the Chairman's Phase 1 report, Chapter 22, a postscript at paragraphs 22.41-22.42 refers to the disclosure to the Inquiry by the Metropolitan Police Service (MPS) of a report dated 24 May 2019, prepared by the BRE and containing its description and analysis of a large-scale reconstruction of the fire in Flat 16 of Grenfell Tower, and the conclusions it had drawn from it.[1] I understand that this report was received after Chapter 22 of the Chairman's Phase 1 Report had been drafted.

4. I have been instructed to prepare this short report explaining whether the BRE reconstruction causes me to alter or refine the evidence I gave at Phase 1. The purpose of this report is to assist the Chairman and the Panel in considering whether the reconstruction itself, and the conclusions drawn from it, have a bearing on the questions addressed in Chapter 22 of the Phase 1 report.

5. The opinions I express herein represent my true and professional opinion on the matters to which they refer. I have had regard to the evidence that is material to my discipline (including the oral testimony), and I can confirm that I have discharged my overriding duty to the Inquiry.

6. In my *Phase 1 (Supplemental) Expert Report*[2] and oral testimony to the Inquiry at Phase 1[3, 4], I provided an assessment of matters related to the initiation, growth, and spread of the Grenfell Tower fire.

7. During Phase 2 of the Inquiry I have prepared four expert reports (to date), namely:

8. *Materials Testing Report 1*

9. *Phase 2 Experiments, Work Package 1 – Regimes of Burning*

10. *Phase 2 Experiments, Work Package 2 – System Interactions*

11. *Phase 2 – Regulatory Testing and the Path to Grenfell*

12. My comments in the current report should be considered alongside my prior reports and evidence (as noted in Paragraphs 6 through 11 above).

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1 [MET00040237]
2 [LBYS0000001]
3 Expert Witness Presentations, 20th June 2018.
4 Expert Evidence, 21st November 2018.

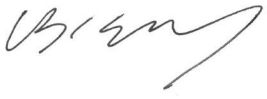
1.1 Statements

13. I confirm that I have no conflict of interest of any kind, other than any which I have already set out in this report or disclosed to the Inquiry. I do not consider that any interest which I have disclosed affects my suitability to give expert evidence to the Inquiry on any issue on which I have given evidence and I will advise the Inquiry if, between the date of this report and the Inquiry hearings, there is any change in circumstances which affects this statement.

14. I confirm that I have made clear which facts and matters referred to in this report are within my own knowledge and which are not. Those that are within my own knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinions on the matters to which they refer.

15. I confirm that I understand my duty to assist the Inquiry on matters within my expertise, and that I have complied with that duty. I also confirm that I am aware of the requirements of Part 35 and the supporting Practice Direction and the Guidance for the Instruction of Experts in Civil Claims 2014.

16. I reserve the right to alter my opinions and conclusions in light of any further evidence or relevant information of which I am currently unaware. I will immediately inform the Inquiry should such a situation arise.

Signed:  Dated: 10th May 2022

2.0 Chapter 22 of the Chairman's Phase 1 Report

17. Chapter 22 of the Chairman's Phase 1 report is concerned primarily with "The Escape of the Fire from Flat 16". It states that:

18. > "A key phase in the development of the fire was its escape from the kitchen of Flat 16 into the exterior cladding system… It is important to understand as far as possible the process by which the fire escaped, not least because at that point it developed from a relatively minor domestic kitchen fire to a major fire within the external cladding system."[5]

19. Chapter 22 also provides a summary of my expert evidence on this issue, alongside that of Prof Jose Torero and Dr Barbara Lane. I will not rehearse this evidence here, other than to note the Chairman's main conclusions on this matter as follows (emphasis added):

20. > "… the experts agreed that **the fire probably escaped from the kitchen of Flat 16 into the cladding in one or other of the two ways described by Professor Bisby**, and that of those **the more likely is that the deformation and collapse of the uPVC window jamb enabled it to bypass the window and enter the cavity around the column**."[6]

21. The above route for escape of the fire from Flat 16 is effectively a re-statement of Hypothesis B2 from my *Phase 1 (Supplemental) Expert Report,* which I stated as follows:

22. > "The route of fire spread from inside the kitchen of Flat 16 to the external cladding was due to parts of the internal window surround and external cladding system being penetrated by the fire, thus allowing fire spread directly into the back of the cladding cavity from within the room of origin. This subsequently led to sustained burning of the cladding either within the cavity or on its external surface, or both."[7]

23. However, in Chapter 22 of his Phase 1 Report, the Chairman also concludes that:

24. > "The video evidence does show flames coming out of the window and impinging on the ACM panels directly above, so **it is possible that the mechanism described in Professor Bisby's Hypothesis B2 also played a significant role**."[8]

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5 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 517.
6 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 537.
7 [LBYS0000001/146]
8 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 538.

25. I believe that "B2" in Paragraph 24 above is a typographical error, and that this actually refers to Hypothesis B1 as stated in my *Phase 1 (Supplemental) Expert Report,* where it was stated as follows:[9]

26. "The route of fire spread from inside the kitchen of Flat 16 to the external cladding was due to **impingement of flames and hot gases from the kitchen fire within Flat 16 venting through an open window, the window infill panel within which the extract fan was mounted, or via the extract fan itself**. This subsequently ignited the external cladding adjacent to the kitchen window of Flat 16 and led to sustained burning of the external cladding."

27. It is noteworthy that Chapter 22 of the Chairman's Phase 1 Report also states that:[10]

28. "Ultimately, however, [the route of escape of the fire from Flat 16] is of little significance, because in both cases [i.e. my hypotheses B1 and B2] it was the proximity of combustible materials to the interior of the compartment that allowed the fire to spread."

29. The Postscript to Chapter 22 of the Chairman's Phase 1 Report notes that, after the chapter had been drafted, the Inquiry received from the MPS a report prepared by the BRE containing its description and analysis of a large-scale reconstruction of the fire in Flat 16, Grenfell Tower and the conclusions it had drawn from it:

30. "The reconstruction sought to reproduce as accurately as possible the configuration and contents of Flat 16 immediately before the fire and two storeys of the facade above, including the cladding."[11]

31. Finally, the Chairman's Phase 1 Report points out that, "basing itself solely on the results of that reconstruction",[12] the BRE reached the following conclusion regarding the escape of the fire from Flat 16:

32. "It appears from the reconstruction **most likely that fire spread to the cladding via the extractor fan and infill panel into which it was mounted, and then ignition of the exposed edge of the polyethylene core of the ACM**. The second most likely route evidenced by the reconstruction, and one which could have occurred if the polyethylene had not been the cladding component first ignited, is the route via the construction around the window (through the uPVC, insulation and gap between window frame and column)".[13]

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9 [LBYS0000001/144]
10 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 538.
11 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 539.
12 https://assets.grenfelltowerinquiry.org.uk/GTI%20-%20Phase%201%20full%20report%20-%20volume%204.pdf, pg. 539.
13 [MET00040237/3]

33. The BRE Reconstruction Report therefore appears to focus on effectively the same two fire spread mechanisms that I have stated as my hypotheses B1 and B2, albeit with an eventual preference for B1 over B2, rather than some combination thereof (which is my preferred way of thinking about these issues), and with a focus on flames venting from "the extractor fan and infill panel into which it was mounted". I note that this conclusion is stated as being based on the BRE/MPS reconstruction, rather than on a detailed analysis of assembled footage from the Grenfell Tower fire, the fire scene investigation, or other available sources of evidence.

34. I note that the BRE Reconstruction Report *also* concludes that:

35. "The initial fire development in the cladding was consistent with that observed during the [BS 8414 type] cladding tests (albeit limited in this case to two storeys as opposed to three) in that the polyethylene of the ACM appears to have been principally responsible for initial fire growth, circumventing any lines of fire protection (such as cavity barriers) and igniting other combustible components within the cladding (such as the insulation). Once well involved, burning droplets of polyethylene were observed which would have promoted downward fire spread if such an option were available (it was not in the case of the reconstruction). Once involved, the insulation also contributed to the ongoing developing fire."[14]

36. Notwithstanding my comments in the following section, the above conclusion is not inconsistent with my *Phase 1 (Supplemental) Expert Report*[15]. The BRE Reconstruction Report goes on:

37. "In the case of the reconstruction, fire spread back into the window in the upper floor appears to have been driven by ignition of the extract fan and infill panel in which it was mounted, followed shortly by failure of the glazing (noting that glazing to glazing fire spread is not precluded by Building Regulations or the guidance supporting them). However, this fire spread occurred under a condition where a strong fire plume (up the column) was impinging on the windows. A different mechanism, potentially involving the extractor fan/infill and/or the construction around the window, might have occurred where the plume dynamics were less severe (i.e. fire spreading laterally or downward across the façade of the Tower, rather than up a column as was the case above Flat 16)."[16]

38. Again, notwithstanding my comments in the following sections, the above statement is not inconsistent with my *Phase 1 (Supplemental) Expert Report*.[17]

[14] [MET00040237/4]
[15] [LBYS0000001]
[16] [MET00040237/5]
[17] [LBYS0000001]

3.0 My Phase 1 Oral Evidence to the Inquiry

39. During my oral evidence to the Inquiry on 21st November 2018[18] I made a number of statements relevant to the escape of the fire from Flat 16 and into the cladding. The following excerpts from my oral evidence are those that I consider most relevant to the additional instructions that I am addressing in the current report[19]:

40. "I have Professor Torero's analysis which suggests to me that the gas layer in the kitchen is between 200 and 300 degrees Celsius, most likely, and that we have flame impingement on whatever is going on inside the kitchen at that stage.

41. If we assume that the uPVC is physically absent, and if we assume along with the uPVC goes the 25-millimetre thick PIR which is adhered to the back of the uPVC, then we have EPDM weatherproofing membrane, which would provide negligible resistance to flame impingement and those type of gas temperatures and it would burn through quite rapidly, and then we're into the back of the cladding, and as Professor Torero said yesterday, at that point, with flame impingement and those types of gas temperatures, it's anyone's guess as to which material is the first ignited material within the cavity.

42. Outside the window, I have flames and hot gases exiting. I have impingement of those flames and hot gases directly above and potentially to the left, if I'm outside the building and looking at the building, of the window, and at some stage we see polyethylene melting and dripping and falling from that region to the left-hand side of the window as I'm looking at it from the outside.

43. I think where that leaves us is in a situation where, no matter how you look at this, you have some combination of those two heating mechanisms that are causing eventually the ignition of the cladding and the escalation of the fire spread up the building.

44. If you look at -- I was looking at this over the lunch break -- paragraph 713 in my report, I sort of finish this section on B1 and B2 -- it's immediately below the paragraph that you read previously, and I say:

45. '713. Indeed, it is probable that some combination of the fire spread routes suggested in hypotheses B1 and B2 conspired to cause the initial ignition and sustained burning of the external cladding.'

46. That's kind of where I end up with it.

47. I guess I would like to say also, with respect to this issue, that for me, it's almost a secondary issue. I can understand why you want to get to knowing more confidently which one it is, but at the end of the day, there's a number of mechanisms by which rainscreen cladding of this nature could be ignited on the outside of the building, and to focus too heavily on the specifics of what has happened in this particular fire scenario I think in a way diminishes the

[18] Expert Evidence, 21st November 2018.
[19] Phase 1, Day 78, 21 November 2018 at pages 133-135.

importance of recognising the clear risks that it presents under any scenario. So I wouldn't want to labour the point too much.

48. …If you really push me, I would say that fire spread through the uPVC is ahead by a nose."

49. I have already noted that the purpose of the current report is to explicitly consider whether the reconstruction itself, and the conclusions drawn from it, cause me to alter or revise my evidence on these matters (as summarised above). The short answer is "no".

4.0 The BRE Reconstruction Report[20]

50. I have reviewed the 24th May 2019 BRE Global Client Report entitled "Grenfell Tower Fire Investigation - Reconstruction (Issue 2)" prepared for the MPS by Dr David Crowder and Ciara Holland.

51. I note that I also attended the BRE reconstruction in person, and inspected the reconstruction rig both immediately before and immediately after the reconstruction was performed – during the reconstruction fire, observers were only permitted to watch a series of live video feeds broadcast into a conference room somewhat removed from the testing site at the BRE Campus, Watford.

52. The "aims and objectives" of the BRE reconstruction are stated as follows:

53. "[1] To recreate as closely as is reasonably practicable and scientifically possible the conditions of the fire so that the development and spread of the fire within Flat 16 and to the cladding could be observed.

54. [2] To test hypotheses that had been developed as a result of work carried out in other work packages, in particular the route(s) by which the cladding became involved in fire.

55. [3] To examine mechanisms of initial fire development of the cladding when exposed to (a best approximation of) the actual compartment fire that occurred (as opposed to the idealised wood crib fuel source used in 'standard' cladding tests and the cladding experiments).

56. [4] To examine the mechanism by which external (cladding) fire spread back through the construction of windows into other flats."[21]

57. When considering the above aims and objectives, it is important to recognise that a large-scale partial fire reconstruction can only ever provide a single data point in terms of the various possible fire growth and spread scenarios that may have actually occurred in the real fire event of interest (the Grenfell Tower fire in this case).

58. Such reconstructions are extraordinarily complex, and their outcomes are likely to be significantly influenced by a range of parameters that are difficult or impossible to reproducibly control. For instance: small differences in the type, amount, and distribution of fuel within the compartment; the ventilation conditions in terms of initial ventilation openings; the opening up of additional ventilation openings as a consequence of the fire (i.e. the timing and extent of window breakage); and the effects of wind. All of these parameters (and indeed others) have the potential to drastically alter the progression of a fire under the scenarios relevant to this report.

59. The conditions of the reconstruction may indeed "recreate as closely as is reasonably practicable… the conditions of the fire",[22] but they (self-evidently)

[20] [MET00040237]
[21] [MET00040237/4]
[22] [MET00040237/4]

cannot ever *exactly* recreate the conditions of the fire, or its development. The challenge is therefore in developing a sound technical basis to be able to make similarity judgements between the reconstruction fire and the real event.

60. Strictly speaking, a single large-scale reconstruction such as that described in the BRE Reconstruction Report can only show what *could* have happened – i.e. what is *possible*, under the conditions of the reconstruction. A reconstruction of this type cannot definitively show what *did* happen – i.e. what *actually occurred* at Grenfell Tower.

61. Professor Torero has provided a critique of the BRE Reconstruction Report, and the work that it presents, in his 4th January 2022 report to the Inquiry entitled "Phase 2 Grenfell Tower Inquiry: Adequacy of the Current Testing Regime".[23]

62. Prof Torero (rightly in my opinion) concludes his critique by stating that:

63. > "… the fire reconstruction conducted by BRE Global delivers a fire scenario that is inconsistent with the available evidence. Despite the scenario being different, the observations made and measurements collected do not contradict any of the statements presented in my Phase One report or the Chairman's Phase One report.

64. > Unfortunately, the lack of background analysis and clear objectives led to an attempt to reconstruct the Grenfell Tower fire that does not deliver any information beyond what was presented in my Phase One analysis."[24]

65. Only by properly interrogating, characterising, and quantifying the influence of innumerable relevant parameters can credible claims be made regarding the extent to which any reconstruction truly represents what *did* happen during the Grenfell Tower fire. And only by understanding the sensitivity of a reconstruction's outcomes to relevant input parameters can suitable confidence be ascribed to the realism and applicability of any observed outcomes.

66. I must therefore agree with Professor Torero's overall assessment, that in the absence of the above understanding and sensitivity analysis, "all that is being tested is one potential scenario of very many that are possible and therefore there is no guarantee that the data collected reflects the flat fire scenario of interest."[25]

[23] [JTOR00000006]
[24] [JTOR00000006/168]
[25] [JTOR00000006/164]

5.0 Revisiting My Phase 1 Evidence

67. As I have already stated, my Phase 1 evidence to the Inquiry on the matters relevant to the current report can be summarised as follows:

68. > "No matter how you look at this, you have some combination of those two heating mechanisms [i.e. B1 and B2] that are causing eventually the ignition of the cladding and the escalation of the fire spread up the building."

69. Nothing in the BRE Reconstruction Report, or from my own observations of the reconstruction fire and review of the resulting data, causes me to alter the above view. If anything, the BRE Reconstruction Report is confirmatory with respect to my Phase 1 evidence and in particular the following:

70. > "If you look at … paragraph 713 in my report, I sort of finish this section on B1 and B2 … and I say… 'it is probable that some combination of the fire spread routes suggested in hypotheses B1 and B2 conspired to cause the initial ignition and sustained burning of the external cladding.'

71. Nothing in the BRE Reconstruction Report causes me to alter this view; again, if anything, it is confirmatory with respect to my Phase 1 evidence where I concluded:

72. > "If you really push me, I would say that fire spread through the uPVC is ahead by a nose."

73. Nothing in the BRE Reconstruction Report causes me to alter this view, although I maintain the view that it would be incorrect to consider a strict dichotomy between my Phase 1 hypotheses B1 and B2; i.e. it is almost certainly the case that a combination of both routes conspired to eventuate in fire spread to the cladding.

74. In conclusion, in preparing this brief report I have explicitly considered whether the BRE reconstruction itself, or the conclusions drawn from it, cause me to alter or revise my evidence on matters related to the route of fire spread from inside the kitchen of Flat 16 to the external cladding.

75. The BRE reconstruction does not deliver any information beyond that which I presented during Phase 1; nor – in my opinion – does the information presented in the BRE Reconstruction Report contradict any of the statements made in my Phase 1 evidence, nor any of the statements made in the Chairman's Phase 1 report.