Please note the contents of these documents contain detailed descriptions and diagrams of Grenfell Tower. This could be upsetting for some.

This version of the document has therefore been created with any photographs of fire damage or the interior of the Tower removed to minimise the amount of potentially upsetting or distressing information within it. A copy of the original documents with photographs can be provided on request.

Please take care when reading or circulating these documents.

The Grenfell Health & Wellbeing Service is a free and confidential local NHS service for children and adults affected by Grenfell. To talk to someone, you can get in touch by phone on 020 8637 6279 or by e-mail Grenfell.wellbeingservice@nhs.net.

This document and its contents have been prepared for the Ministry of Housing, Communities, and Local Government. For further information, please contact GrenfellTowerSite@communities.gov.uk

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ATKINS
Member of the SNC-Lavalin Group

Grenfell Tower

Update on design works

Ministry of Housing, Communities and Local Government

05 May 2021

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Document history

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Rev 3.0	Addendum added	[redacted]				05 May 2021

Contents

Executive Summary

This report has been prepared for the Ministry of Housing, Communities and Local Government (MHCLG) to summarise the work associated with the proposed temporary works at Grenfell Tower, and the main residual risks at this time.

Enhancement of propping system

An enhanced propping system – Stage 3 propping – has been designed to provide a robust support system within the structure to replace the current temporary works provision which the designer has confirmed is at the end of its design life. This new temporary works system is now in the final stages of checking and review by the designer and the Independent Checker; it has been further reviewed by MHCLG's Technical Advisor.

It has been confirmed by the designer that the Stage 3 propping system may start from the 4th floor level but that if deconstruction were not to start immediately following its installation then additional propping would need to be introduced between basement level and 4th floor level to mitigate the risks of leaving the building propped for an extended length of time.

As Technical Advisor, Atkins undertook a proof-of-concept design prior to the designer undertaking a full analysis and design. This work also supported the feasibility of carrying out the Stage 3 propping work from the 4th floor level and with the same caveat described above in relation to the deconstruction works.

Considerations relating to start of deconstruction works

Given the levels of damage to the primary structure it is not seen as practicable to remediate all or part of the damaged structure to bring it back in to use. As such it is expected that the superstructure, i.e. that part of the building above ground floor, will have to be deconstructed.

There is an on-going risk with retaining the structure in its current condition and even upon the installation of further propping a residual risk will remain due to the damaged nature of the structure. To address the risk of leaving the damaged structure propped in the medium-term, the need to fully prop the structure from basement to roof has been recommended by the Temporary Works Designer to provide an enhanced level of robustness and this recommendation is supported by the Independent Checker and Technical Advisor to the MHCLG.

The current programme indicates that the propping from 4th floor level to roof will be complete by May 2022. Therefore, in the absence of a decision on the future of the Grenfell Tower, as Technical Advisor, we would advise that the additional propping from basement to 4th floor level is also completed within this timeframe. Consequently, installation of the propping from basement to 4th floor level would have to occur simultaneously with the installation of the propping from 4th floor level to roof. This would require instructing the propping from the basement to 4th floor level no later than July 2021.

There is a residual risk with retaining the structure, irrespective of the temporary works measures put in-place, and as such deconstruction at the earliest opportunity remains the recommended course of action.

Ongoing risk associated with long-term propping of the structure

Completed in 1974, the structure is approximately 46 years old. Whilst the design life is not known, the building is likely in the latter part of its design life, if that has not already passed.

The age of the structure combined with the structural damage due to the fire has a detrimental effect on the long-term resilience of the structure. Putting this in terms of risk, the longer the building is left in-place, the risk of the structure's condition deteriorating to an unacceptable level, and the risks to the site operatives having to go inside the building, increases.

From an engineering perspective, deconstruction of the building at the earliest possible opportunity is the best means to mitigate these risks.

1. Introduction

This Report provides a summary of the current state of the design work being carried out on Grenfell Tower with respect to the recommended provision of additional temporary works as a means of mitigating the on-going risk of retaining this badly damaged structure until a decision is taken on deconstruction of the Tower.

1.1. Terminology

The terminology of propping stages and structure as used in this Report is defined for clarity:

- **Stage 1** propping refers to the props installed immediately following the fire to allow emergency service access
- **Stage 2** propping refers to the propping installed soon after Stage 1 to provide further stability and robustness to the Stage 1 propping scheme
- **Stage 3** propping refers to the replacement propping proposal currently being developed to provide enhanced support to the structure in the short-term whilst the future of the Tower is decided. The Stage 3 propping is the main subject of this Report.
- **Primary Structure** is that part of a building that provides the structural strength, stiffness, and stability. In contrast **Secondary Structure** such as infill wall panels, cladding, windows, etc do not contribute to the building's strength, stiffness, or stability. **Temporary works** relates to items such as props or scaffolding that are designed to be temporary in nature and in the case of propping, provides support to the primary structure.

1.2. Damage to structure

Whilst highting specific areas of structural damage is not the purpose of this Report, the photographs included in Appendix A are provided to illustrate the structural damage within Grenfell Tower and highlight the reason for the need to consider further temporary works measures at this time.

2. Current state of work

This section addresses the current work to develop a Stage 3 propping solution, which is nearing completion.

2.1. Overview

The design work currently underway is to provide an enhance level of robustness to Grenfell Tower until a decision is taken as to deconstruction of the Tower.

The Stage 1 and 2 propping schemes installed in the immediate aftermath of the fire were designed with the short-term goal of stabilising the structure. This propping was not designed as a long-term solution and it has been confirmed by the designer that the design life of these temporary works ends in 2021.

In order to address this issue, and to increase the level of support being provided to the structure, a third stage of propping is proposed.

The Stage 3 propping scheme proposes that a greater coverage of propping be installed at all Levels from 4th floor level to roof to replace the Stage 1 and 2 propping in the short-term. However, if on completion of the Stage 3 propping installation deconstruction could not start immediately, then further propping would need to be in place from basement to 4th floor level to mitigate the risks of propping the structure for a longer period of time.

2.2. Roles and responsibilities

Cantillon, Michael Barclay Partnership (MBP), and Atkins are the three main consultants involved in this stage of the work with further input from sub-consultants, the RSK Group and Plowman Craven Monitoring.

Cantillon are the designers of the temporary works generally and each stage of the propping works specifically; Michael Barclay Partnership are the independent checkers, and Atkins are the Technical Advisor to the MHCLG.

Whilst Cantillon are solely responsible for the design of the temporary works (including their internal checking processes), MBP and Atkins have carried out separate independent analysis to verify Cantillon's work.

Condition surveys, on-site investigation, and laboratory testing services are being provided by the RSK Group. The output from RSK's testing works such as the determination of reinforcement strength post-fire, are used in the analysis and design work noted above.

Plowman Craven Monitoring have installed various static and real-time monitoring systems throughout the building and carry out a monitoring and reporting role. The provision of monitoring provides a warning system should unexpected movements be detected.

2.3. Design and delivery process

Cantillon have carried out a detailed design for the propping system from 4th floor to roof and have also addressed the need for supplemental propping to be installed from 4th floor down to basement. This design work goes beyond simply designing the props and addresses the strength of the damaged primary structure such that the structure as a whole is considered.

As independent checker, MBP have carried out a detailed analysis equivalent to that required of a full design as an independent verification of Cantillon's work. This analysis work, whilst based on the propping proposal by Cantillon, is independent in that it has been carried out without reference to Cantillon's analysis model or design basis and has utilised different software.

Atkins as Technical Advisor have carried out a series of analysis studies in order to assess Cantillon's design methodology and analysis findings. As with MBP, Atkins work is standalone and is not based on, or reliant upon, Cantillon's analysis and design approach.

This three-level checking process – Cantillon's internal checking, MBP's full independent design, and Atkins independent validation checks – provide a level of rigorousness appropriate to the work on Grenfell Tower. In all three cases finite element analyses of varying levels of complexity have been undertaken to capture the effects of fire damage on the strength and stiffness of the structure and the interaction with the propping system in order to transfer loads through the height of the building.

With respect to the analysis and design process adopted by Cantillon, their work is based on current codes of practice, the Eurocodes, with load and material factors of safety applied, and this is documented in their Basis of Design report. Additionally, the processing of material test results from the structure is nearing completion, which will validate the material properties used in the analysis and design process. Cantillon have designed to the appropriate codes of practice, incorporated relevant guidance/research and used appropriate factors of safety.

In structural engineering the term *utilisation factor* may be used to describe how much excess capacity a particular member may have, e.g. a utilisation factor of 0.9 means that 90% of the capacity is used with only 10% remaining as a margin. Due to complexity of all structures, including Grenfell Tower, different parts of a structure will have different levels of utilisation. The various parts of the Grenfell Tower structure will be utilised to different degrees depending on their level of fire damage and as such it is not possible to give a single meaningful figure for utilisation. However, Cantillon have reported that all members have been shown to have adequate resistance, and that the proposed propping will provide adequate support to the damaged structure. Atkins review of Cantillon's work is in the final stages.

2.4. Findings to-date

Throughout the design process Atkins as Technical Advisor has met with Cantillon and MBP to review and question the design process and the methodology being adopted.

There is a broad consensus on the design process and methodology being followed by Cantillon with a number of minor clarifications still to be closed out.

Cantillon have stated that they have completed their Stage 3 propping design and confirmed that they believe it may begin at the 4th floor level and that further propping from 4th floor level to basement would be required if the structure is not to be deconstructed immediately following the installation of the Stage 3 propping installation.

Cantillon's conclusions are consistent with Atkins proof-of-concept study findings and MBP have also supported Cantillon's assessment. Both Atkins and MBP agree with Cantillon that the Stage 3 propping may begin at the 4th floor level and if the Stage 3 propping is to be left in place for any length of time following its installation that extending the propping to basement is strongly recommended as a mitigation. MBP are currently finalising their independent check on the Stage 3 propping solution such that they may issue a formal check certificate for the work.

As described above, the Stage 3 propping will be installed up to roof level (at 24th floor), however, the props will not be tightened up to the 24th floor slab soffit, as it has been demonstrated that the slab can be self-supporting in its damaged state. The reason for this is to avoid any thermal prop loads being 'jacked' into the lower level slabs from the stiffer roof slab. However, having the props in place ensures that the slab could be supported if further deterioration were to occur, even with the props terminating at 4th floor level. The condition of the 24th floor slab soffit will be subject to regular inspections and consideration will be given to applying a protective coating to the exposed rebar once the soffit has dried out sufficiently.

Cantillon are currently updating their final calculation package in order to address the issues raised and will also incorporate the results of the recent on-site testing when they become available. Cantillon report that this will be available before 25 December 2020.

2.5. Remaining items to be addressed

As noted in Section 2.4, the majority of the design work by Cantillon has been reviewed and commented upon in the weekly review meetings that have taken place over the course of the design process.

Cantillon are currently in the process of carrying out a final update to their Basis of Design, design calculations, and addressing the findings from site investigation works.

Once this work is complete, an update to this Report shall be provided to report on the conservative assumptions made in carrying out the design, the outcome of the sensitivity analyses carried out by Cantillon, and to give an indication of the factor-of-safety associated with the design solution.

3. Residual risks

Based on the investigation work carried out to-date and with respect to the current state of the structure and the proposals for modification of the temporary works, two key residual risks are identified below.

3.1. Ongoing risk associated with long-term propping of the structure

Completed in 1974, the structure is approximately 46 years old. Whilst the design life is not known, the building is likely in the latter part of its design life, if that has not already passed.

The age of the structure combined with the structural damage due to the fire has a detrimental effect on the long-term resilience of the structure. Putting this in terms of risk, the longer the building is left in-place, the risk of the structure's condition deteriorating to an unacceptable level, and the risks to the site operatives having to go inside the building, increases.

From an engineering perspective, deconstruction of the building at the earliest possible opportunity is the best means to mitigate these risks.

3.2. Considerations relating to start of deconstruction works

Given the levels of damage to the primary structure it is not seen as practicable to remediate all or part of the damaged structure to bring it back in to use. As such it is expected that the superstructure, i.e. that part of the building above ground floor, will have to be deconstructed.

There is an on-going risk with retaining the structure in its current condition and even upon the installation of further propping a residual risk will remain due to the damaged nature of the structure.

If the building were to rely on the propping being left in place for an extended duration, i.e. that deconstruction works were delayed, this would change the approach to the temporary works solution.

To address the risk of leaving the damaged structure propped in the medium to long-term, measures would have to be taken by the Temporary Works Designer to provide an enhanced level of robustness in any temporary works solution to address the risks associated with retaining the structure.

This has been addressed by Cantillon where propping to Basement Level has been adopted as the means by which increased robustness is provided.

There is a residual risk with retaining the structure, irrespective of the temporary works measures put in-place, and as such deconstruction at the earliest opportunity is the recommended course of action.

3.3. Structural deterioration

Further deterioration of the structure is considered to be a risk and as a mitigation measure, the recommendation of providing additional monitoring with in the structure has been accepted. Such systems will act as both an early warning for unexpected building movement and shall be used to monitor the structure as the Stage 3 propping is installed.

4. Addendum

4.1. Temporary works design life

Whilst the temporary works designer has stated that the temporary works system is at the end of its design life, Atkins view is that a slightly later completion date of a few months for the installation of the Stage 3 propping will not make a material difference. Clearly, this would need to be confirmed with the successful Principal Contractor on their appointment.

Appendices

Appendix A. Photographs of damage

The photographs in this Appendix are indicative of the damage to the primary structure.

Figure A.1 – 13th Floor, Flat 5: Spalling of corner column

Figure A.2 – 13th Floor, Flat 5: Spalling of corner column from outside (photograph courtesy of the MPS)

N.B. Figure A.2 has been supplied by the MPS; not for circulation beyond the MHCLG without MPS permission

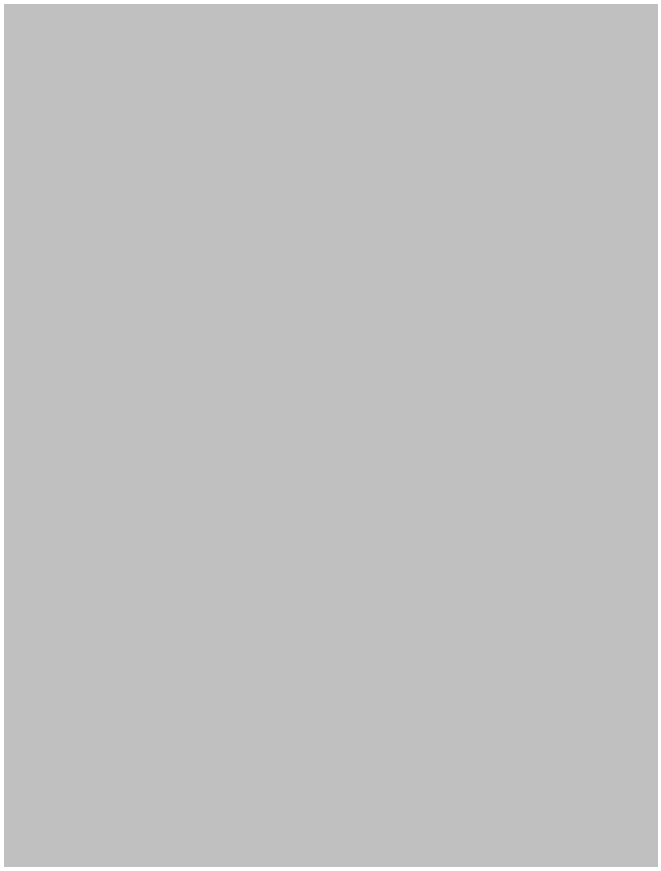

Figure A.3 – 13th Floor, Flat 5: Propping around corner column

Figure A.4 – 24th Floor (roof) soffit, Flat 2: Cover layer of concrete lost and bars debonded from slab

Figure A.5 – 23nd Floor soffit, Flat 2: Concrete has spalled to the depth of the inner layer of reinforcement; bars debonded from slab

Figure A.6 – 17th Floor soffit, Flat 3: Note the kink in the reinforcement bars due to one side of the slab falling away; note also the apparently intact piece of soffit on the left of the image has delaminated from the body of the slab above

Figure A.7 – 14th Floor soffit, Flat 5: An example of a slab that has undergone significant deflection; note also the extent of the loss of concrete from the slab soffit

Figure A.8 – 14th Floor soffit, Flat 5: A second photograph from this flat showing that adjacent reinforcing bars have debonded and fallen away from the slab; in some instances they have been tied to the still bonded reinforcing bar for the safety of the site operatives

Figure A.9 – 8th Floor soffit, Flat 6: Significant structural damage local to a corner column; depth of spalling is to the inner layer of reinforcement with other bars debonding

Figure A.10 – 8th Floor soffit, Flat 6: A second photograph from a different area within the same flat illustrating the local nature of damage in some flats

[redacted]
Atkins Limited
Nova North
11 Bressenden Place
Westminster
London
SW1E 5BY

[redacted]