LONDON FIRE BRIGADE

Fire Engineering Group

Thematic Report - Modular Construction

September 2025

Contents

1 Summary

1.1 This thematic review highlights some of the key areas where, in London Fire Brigades (LFB) experience, building design teams have not sufficiently evidenced how proposed modular construction designs have satisfied the Building Regulations. LFB have produced this thematic report due to concerns that the impact of fire on poorly designed or constructed modular buildings isn't fully understood.

1.2 This document includes areas for consideration and highlights the potential need for additional, project specific analysis on structural elements and the global modular system. It also highlights a number of questions that design teams should be satisfying, as part of their design review process. This document does not constitute design guidance and should not be used as such

1.3 It is the view of LFB that there are key benefits to be attained by addressing the concerns highlighted. Such benefits could be:

a. Gaining an increased understanding of the fire performance of the global construction methodology to then inform the suitability of future projects at an early stage.

b. By understanding the fire related failure modes of modular buildings when compared with those of traditional construction, issues can be addressed and provide greater confidence in the use of this construction typology.

c. Ensuring a consistent and more robust methodology based, upon first principles, may enhance the standard across the fire safety industry and support approving authorities reviewing schemes through the provision of benchmarked standards of safety that can be referred to.

d. Improving the understanding of modern methods of construction by design teams and early consideration of the above factors may help progress buildings through the planning, design and Building Regulations Consultations stages (and any associated Building Safety Regulator Gateways), supporting the drive for safe, affordable housing. This would benefit those delivering new buildings and those Regulating the built environment.

1.4 Information on the structural performance (including fire) of the global modular system may be invaluable in the process of applying for, and obtaining, a building assessment certificate as part of any required safety case review under the Building Safety Regulator.

1.5 This report makes five recommendations for areas that would benefit from additional consideration and/or review from the sector, covering Design (see section 6), Structural considerations (see section 7), Testing (see section 8), Firefighting (see section 9) and General fire precautions (see section 10).

2 Introduction

2.1 There is a clear need to build more homes quickly, economically, safely and sustainably, by reducing the environmental impact wherever possible. With the skills shortages identified within the construction sector, there has been a drive to use more Modern Methods of Construction (MMC) and particularly off-site manufacture.

2.2 London Fire Brigade (LFB) supports the Government's and Mayoral ambition to build homes quickly and sustainably, reducing the environmental impact wherever possible, and recognise

the role that MMC can play in achieving this. LFB also share the Government's and the Mayor of London's commitment to building safety and ensuring Londoners are safe in their homes.

2.3 It is essential that MMC are appropriately scrutinised and demonstrate compliance with the functional requirements of the Building Regulations. Assurance is needed that fire performance of materials, elements, and complete systems have been fully considered, have been tested appropriately, and provide the level of safety that residents and firefighters should expect. It is however the LFB's experience that a number of projects utilising modern methods of construction have not fully recognised or addressed the need to demonstrate the performance of the design in regard to fire. This is coupled with ongoing concerns regarding the quality of construction which is relevant to both traditional and modern methods of construction.

2.4 There is a therefore concerns of the potential risks and unknown consequences of failure within these types of buildings which represents a potential risk to both occupants and attending firefighters in the event of a fire through structural failure and/or unexpected fire development or spread.

2.5 LFB also notes that there has been an inconsistent approach in terms of the level of detail provided in demonstrating compliance with the Building Regulations. This inconsistent approach is compounded by a lack of industry guidance against which design teams and regulators can use as a 'benchmark' of best practice. These key concerns are shared by the National Fire Chiefs Council who issued a position statement on Modern Methods of Construction in November 2022[1].

2.6 This thematic report focusses on one type of modern method of construction; category 1 pre manufacturing 3D primary structural systems (as defined in the MHLCG[2] MMC definition framework). This form of construction is often referred to as 'modular' or 'volumetric' and this report uses the term 'modular' for reference.

2.7 Modular buildings are those whereby prefabricated units are constructed off site before being stacked in a bespoke arrangement on site, usually to form columns of modules connected to one another through a series of rigid connections. Module stacks are then often linked to one or more traditionally built steel/concrete core(s) and/or podium decks. Modular buildings therefore lack key features which are present in buildings of traditional construction such as a uniform floor plate, whilst introducing new features such as perimeter floor channels within the floor deck/slab, an increased number of voids and additional, (side by side) structural elements.

3 Background

3.1 London Fire Brigade's main role when responding to Building Regulations consultations is considering future compliance with the Regulatory Reform (Fire Safety) Order and supporting the design development process so that future works should not be needed once the project is complete. To do this it is important to first understand the fundamental fire safety design principles of the projects. However, it is often found that crucial details are missing, especially regarding the specific structural elements of projects incorporating MMC. For instance, fire

[1] https://nfcc.org.uk/nfcc-publishes-modern-methods-of-construction-position-statement/. Currently under review
[2] MHCLG now DLUHC (Department for Levelling Up Housing and Communities)

strategies for projects utilising volumetric or modular construction methods often fail to acknowledge this approach is even being used or consider its impact on fire safety design.

3.2 Within both consultations themselves, and in design meetings attended by LFB on modular buildings, a common assumption has been that structural aspects fall solely under the purview of structural engineers, while fire-related matters are handled separately by fire engineers. When it is questioned why the construction methodology was not included, or even mentioned within the design documentation, the response is often that it did not impact the fire strategy. While this division of responsibility may not impact schemes using more traditional methods of construction, it may not hold true for MMC, especially when the fire performance of MMC structures is not yet well understood. There is a need for more considered "structural fire engineering," where a connection is established between the two disciplines to better understand the structural fire performance resulting from non-traditional construction techniques.

3.3 Despite potential consideration by structural engineers, fire engineers often overlook structural design information, indicating a reluctance to move beyond Building Regulations guidance (i.e. Approved Document B) and fully consider the design from a holistic fire safety perspective, with consideration of first principles when necessary. Indeed, a key learning outcome of a 2021 CROSS (Collaborating Reporting for Safer Structures UK) report[3] was to ensure that effective communication is had between stakeholder teams such as between the fire engineers and structural engineers "so that all aspects of the design are fully assessed". By adopting the recommendations provided within this document, it is anticipated that there would be increased efficiency in communication between stakeholders. This may aid in the understanding gathered from the consultation package and reduce the review period when any review is undertaken, particularly by the LFB. It would also serve to benefit approving authorities in their assessment of compliance with legislation i.e. The Building Regulations.

3.4 Building on this, a crucial aspect of evaluating MMC designs is the peer review process both within the design team, but also an independent review supporting the approving authorities. This peer review process is especially important where stakeholders lack the expertise to assess the design competently. Competence continues to be a concern within the fire industry (given the infancy of some modern methods of construction) and LFB continues to encounter a lack of detail in fire strategies that would specifically demonstrate the competence needed to assess and validate the suitability of MMC projects.

3.5 The Government recently commissioned Harlow consulting and Edinburgh Napier University to undertake volumetric modular research[4] and the HSE published a research report on the 'impact of permanent volumetric modular construction (PVMC) on building safety'[5] it is questioned if more should be done following the cases identified.

The MHCLG research paper identified a number of key findings including;

- There is a risk that 'deemed compliant' products may not have been subject to the right test conditions

[3] https://www.cross-safety.org/uk/safety-information/cross-safety-report/volumetric-modular-buildings-and-fire-1065
[4] MHCLG Research and Analysis 'Volumetric Modular Construction research; published 26 November 2024 (research finalised July 2022)
[5] HSE Research 'The impact of Permanent Volumetric Modular Construction (PVMC) on building safety' Report RR1203 (2024)

- The issues of fragmentation (and the need for commonality) and the critical risk of a working interface between offsite and onsite processes.
- Lack of research into post-occupation repair and maintenance issues
- Need for on-going research into materials behaviour/long-term structural integrity

3.6 While many of the above issues are equally applicable to other forms of construction, one of the relevant risks highlighted in the MHCLG report, identified as specific to modular construction, was the risk of disproportionate damage in the event of fire (or flooding) with modules being subsequently difficult to access to then replace or repair.

3.7 In terms of the HSE research document, this report appears to be based on limited case studies and stakeholder engagement. It is also unclear if any fire and rescue service opinions or data were accessed as part of this project. The report included reference to the MHCLG research and stated that 'There are potential risks cited in 'Research into risks in volumetric construction' for which no evidence has been found in this project. In these cases, it cannot be assumed that because in this project no evidence has been found, that the safety issues has not occurred or that the risk of it occurring is less than for those issues where evidence of an incident has not been found'. As with the MHCLG report, the HSE concludes that more work needs to be done in this area.

3.8 Sufficient consideration should also be given to business continuity and the impact of the fire on the ability of any building owner to rely on the current fire strategy to ensure the safety of occupants post fire. LFB recognise that modular connections, for example, may form very complex mechanisms to fail either partially or fully and/or accept a degree of movement when heated, it may be necessary to create a plan for a high degree of inspection and remedial works post fire over and above that which may be anticipated in a building of traditional construction.

4 Building Design Guidance

4.1 The Building Regulations approved documents provide guidance for common building situations. The Manual to the Building Regulations (2020) details that the approved documents may not provide appropriate guidance if the proposed building is unusual in terms of its design, setting, use, scale or technology. Inevitably, buildings that incorporate modern methods of construction are likely to exhibit one or more of these unusual aspects. Non-standard conditions defined in the manual also includes buildings with unusual occupancies and very large/tall buildings. Those with responsibility for meeting the requirements of the regulations need to consider for themselves whether following the guidance in the approved documents is likely to meet the requirements of the regulations in the particular circumstances of their case. It is our view that modular construction is a complex modern method of construction, and cannot therefore, by default, be assumed to be a common building situation.

4.2 In August 2022 the then DLUHC produced some clarification as part of a list of Frequently Asked Questions in regard to the use of Approved Document B[6]. In particular regards to 'Buildings with

[6] https://www.gov.uk/guidance/approved-document-b-fire-safety-frequently-asked-questions

alternative structural failure mechanisms' the following question was clarified with the below reference statement;

"*Can I apply the guidance in Approved Document B for buildings with an unusual structural design approach (e.g. volumetric modular construction) in meeting the requirements of the building regulations?*"

Designers should discuss and agree the design intent and the necessary evidence with the building control body (BCB) before starting building work.

4.3 At the time of writing this thematic review a technical review of Approved Document B remains underway with areas such as structural fire resistance being researched to confirm if the current guidance is sufficient or requires an update.

4.4 As set out in Approved Document B, the guidance is provided for common building situations. Tall, large, or complex buildings, where alternative structural failure mechanisms or unusual routes for internal fire spread might exist, are not common building situations and present additional considerations which designers should have regard to.

4.5 The designer should consider the type of construction, alongside factors influencing the consequences of fire spread and fire induced structural failure such as height, size, and use of the building, when considering whether it is appropriate to apply the provisions in Approved Document B.

4.6 Following the guidance in Approved Document B, including the minimum fire resistance periods and the standard test methods, may not be sufficient to meet the requirements of the building regulations, particularly in cases where the consequences of fire spread, and fire induced structural failure are more significant.

4.7 Where alternative methods of complying with the building regulation requirements are adopted, it is likely to require a detailed, evidence-based understanding of fire performance for the specific design demonstrating how each of the building regulation requirements will be addressed directly.

4.8 Whatever design method is applied, the functional requirements of the building regulations must be met for all building work. This applies to all those responsible for building work including the building owner, agents, designers, builders and installers.

4.9 MHCLG sponsored a publicly available standard; PAS8700:2005 Modern methods of construction for new-build residential properties – specification which came into effect on 30 April 2025. The PAS covers a number of areas including establishing a delivery team (with an emphasis on competence), testing and inspection and a section on systems, assemblies and components which includes fire protection and safety. Within the PAS there is specific reference to a number of areas that are raised within this report including (but not limited to);

a) the importance of considering the overall structural behaviour of the building as a whole,

b) need for structural load cases to includes assessing structural behaviour under accidental damage including implications of fire/heat damage and

c) need for structural load cases to include assessing the impact of structural deflection and misalignment on fire safety elements.

4.10 The PAS also highlights considerations for the development of the fire strategy which includes aspects including the need to outline specific complexities of the building and the chosen MMC. The guidance highlights the need for careful consideration around fire testing assumptions and where design teams need to include specific attention to aspects such as voids, connections and features such as encapsulation.

5 The Building Safety Act

5.1 As a key requirement of the Building Safety Act is to ensure the creation and collation of information about a building's safety, known as 'The Golden Thread', it can be said that such a process may require additional consideration for a high-risk/in scope modular building. This thematic review document highlights the potential need for additional, project specific analysis on structural elements and the global modular system. Where said information is not suitably and holistically collated and maintained, it may not be possible to provide sufficient evidence to demonstrate safety through the relevant gateways in construction or upon occupation, as part of the safety case report. LFB understand that there has already been at least one example where issues have been presented and information has not been sufficient to support the issuing of a Building Assessment Certificate

LFB Recommendations

6 Design approach

6.1 This document does not constitute design guidance and should not be used as such. Nevertheless, observations & recommendations are provided below to reflect the views of LFB on the approach to demonstrating the suitability of a modular design.

6.2 As now confirmed by the Government FAQs, the guidance within the Approved Document B is not necessarily appropriate to use for reference. It is our expectation that those with responsibility for meeting the requirements of the regulations should confirm how the building will be assessed with respect to meeting the functional requirements of Building Regulations – and which aspects (if any) of the guidance in Approved Document B are appropriate (and on what basis). LFB anticipate this should form part of the Qualitative Design Review (QDR) process. The QDR process should determine whether following the prescriptive recommendations/minimum requirements can provide sufficient evidence that compliance can be made with the Building Regulations. Where deemed necessary, following this review, the design may be required to acquire additional evidence to demonstrate the suitability of the design. Any further analysis should also follow a suitable framework such as that detailed within BS 7974.

6.3 The proposals should carefully consider and detail the 'standard or proof' and what accompanying evidence will be submitted for the scheme.

6.4 LFB would advocate that project specific analysis is carried out by the design team to enable full understanding of the performance of the structure when subject to heating and cooling as a result of a fire incident. Therefore, a design should not be justified based only/entirely upon analysis carried out for prior projects. While it may be appropriate to provide reference to other projects utilising a similar global modular system, LFB maintain the view that existing projects using a modular building design does not necessarily set a precedence for future projects due to their very bespoke nature. The design team should also ensure that the impact of any slight or

significant differences in modular design such as: structural loading, connection location, module spans, the use of materials and voids depths are suitably understood.

6.5 The design team should ensure that they have sufficient competence to work on a scheme utilising innovative construction products/techniques and should detail this as part of their report (suggested best practice for report writing in BS7974).

6.6 In reviewing the design, where the BCB competency is not available in house, the BCB should seek advice and guidance from a suitably competent third party to assist them in their approvals decision. In this case LFB would expect that the third party is independent of the design team. Where the scheme is particularly complex then an independent third-party peer review should, in the view of LFB, be undertaken regardless of in-house competence availability.

7 Structural Considerations

7.1 As part of the design development process with engagement with the client, it should be confirmed how it will be ensured that any linings (e.g. plasterboard or fireboard) provided and relied upon to protect the structural elements will be controlled, maintained and monitored throughout the lifetime of the building. As part of this process, consideration should be given to the requirement for contracts and leases to allow an enhanced level of control, maintenance and monitoring for this purpose. Whilst LFB also recognise that this is an important consideration for all buildings, regardless of construction typology, it is common that within the structural assessments of modular buildings that the linings play a critical role in preventing structural movement/failure.

7.2 Where significant reliance is placed on certain control measures, LFB may consider the use of an alterations notice under article 29 of the Regulatory Reform (Fire Safety) Order 2005. The correct function of any fire engineered solution is reliant on the existing structure, layout, services, fittings, equipment or the fire loading in or on the premises being maintained. Changes to the above matters are likely to result in the fire engineered solution ceasing to provide necessary protection for relevant persons and firefighters.

7.3 Where finite element software is used to assess the impact of fire on the structure, the analysis should be accompanied by a report detailing justification for all input parameters. This should also demonstrate how/why the software is validated for this purpose. Furthermore, it is recommended that a sensitivity analysis is carried out on key inputs which define the various structural elements as these may be different throughout the building, e.g. at varying height due to loads. It is an LFB expectation that, where recommended by Approved Document A, any 'systematic risk assessment' should include explicit consideration of the effects of accidental fire.

7.4 Where methods such as finite element analysis (FEA) are used for demonstrating a suitable modular structural design, sufficient evidence should be provided to the BCB to demonstrate that the analysis is appropriate in each specific case. LFB highlight that FEA should not be solely relied upon to understand the global system performance. This should therefore be used only as a tool, in conjunction with fire test data (standard and experimental data) to enhance the holistic understanding of the global modular structure in each case.

7.5 Any modular system proposal should be accompanied by accurate detail on the make-up of the module units, how they connect with one another and how they connect to other materials of

different properties (e.g., stair cores). Module connections may be complex in their design and performance therefore all connections should be well understood.

7.6 Whilst it is understood that it will be the role of the structural engineer to consider disproportionate collapse to meet requirement A3, LFB advocate that a suitably competent fire engineer is appointed on the project to, as part of the holistic review of the design, consider the impact of fire on the structure. Any assessment of the buildings structural performance should consider the following (noting this is not an exhaustive list):

I. The performance of the fire protection from both sides of a wall or floor;
II. The reliance on each unit to maintain structural integrity for another unit during and after a fire;
III. Design and manufacturing tolerances, and any post installation work required to complete fire compartmentation;
IV. The impact of heating/cooling for structural components and the interaction between structural elements which may be subject to differing heating/cooling regimes (such as adjacent structural columns). Consideration should also be given to the effect of rapid cooling via firefighting intervention;
V. The extent of any voids between modules, how consistent or variable these are, and how these are provided with fire barriers at compartment lines;
VI. The effect of any penetrations (e.g. for services) and how these interact with compartmentation and voids;
VII. The make-up and materials utilised for vertical service penetrations e.g. shafts, particularly where these pass through modules and require a smooth/consistent surface
VIII. Ongoing maintenance requirements of any fire resisting protection;
IX. The interaction between elements of construction of different material properties such as concrete/steel with timber;
X. Any challenges for firefighting given the unique construction. Examples may include: An unpredictable layout of passive fire barriers, an enhanced reliance on fire resisting linings and voids, as mentioned in VI above, which could enable unseen fire/smoke spread.
XI. The allowance of unprotected openings. In our opinion given the unique nature of construction, reliance cannot be placed on allowances within guides such as for unprotected openings. These were not incorporated into guidance for traditional construction methods and cannot be assumed to be appropriate for modular design without significant analysis.

8 Testing

8.1 The design team should confirm whether any fire testing will be/has been carried out so far and any outcomes of such testing. Where testing is undertaken, the fire test rig should match the attributes of the proposals, and clear pass/fail criteria should be set based on the aim of each test.

8.2 Where the aim of the testing is to understand the behaviour of the structure, when subject to heating and cooling as a result of fire (in high-rise residential buildings, for example), it may be necessary to test individual connecting components, fire stopping and linings to the point of

failure. This will allow a greater understanding of the level of resilience and redundancy in the structure.

8.3 Whilst standard fire tests may be useful in understanding the local performance of structural elements and components, testing of the global structure may be beneficial in understanding the performance of the system, including complex and bespoke components such as connections. Whilst it is acknowledged that there is limited design guidance and testing standards available for modular design, a test standard such as LPS 1501 Fire test and performance requirements for innovative methods of building construction, may provide useful reference for design teams in carrying out a test for stacked and adjacent modules.

9 Firefighting

9.1 Added focus for assessment is required for any areas which may have the potential to impact firefighting (e.g., voids and the dangers associated with unseen fire spread). Accurate detail should be provided on the extent of any voids between modules, how consistent or variable these are, and where fire barriers are installed to restrict fire spread.

9.2 To ensure that a fire in the construction phase can be effectively fought by firefighting crews it should be confirmed that facilities for firefighting are constructed at appropriate intervals within the build stage and as early as possible during this phase. Notification of when works are to commence on site are requested such that local crews can undertake familiarisation visits.

9.3 Information for attending fire crews on the construction methodology of the building would be useful and should be provided within a premises information package[7] and BS 9999 Code of practice for fire safety in the design, management and use of buildings.

10 General Fire Precautions

10.1 Interaction with other risk-critical life safety systems should also be carefully considered through the design and construction of the building, especially smoke control systems where shafts require smooth and consistent internal surfaces and rely on minimal leakage and movement to maintain their effectiveness.

10.2 The complexity of modular construction may significantly restrict the appropriateness of any other design variations from Approved Document B that might otherwise be justified with a traditional construction methodology. The design team and BCB should apply an enhanced level of scrutiny over the compatibility of any such proposed variations.

10.3 Contingency measures should be planned to be implemented if one or more control measures are not available (e.g., through failure or maintenance), for even a short period of time. This may include the introduction of additional temporary control measures, or a restriction on occupation of parts of the building while the control measures are returned to their effective operation. These should be carefully considered by the Responsible Person as part of the fire risk assessment and supported by other competent parties (as appropriate).

10.4 Construction phase risks, specific to modular construction, should be understood and assessed prior to construction commencing as a project specific inspection programme will need to be

[7] further guidance on premises information boxes and packages can be found at: Fact sheet: Secure information box (regulation 4) - GOV.UK (www.gov.uk)

developed in conjunction with the BCB. This requires cooperation and coordination between the design team, those responsible for fire safety during the construction phase. Any relevant risk information should be made available to LFB to understanding of the site should an incident occur during this stage of the project.

10.5 Any modular build project should include an on-site and off-site quality assurance process for the installation of passive fire safety provisions. This may include frequent inspection from a third-party specialising in fire stopping specific to modular construction techniques. Furthermore, it should be ensured that all fire stopping products have been tested for use in accordance with each specific scenario. The inspection regime and oversight should be determined and developed during the design process and in conjunction with the BCB and any other approving authority (for example, the Building Safety Regulator)

10.6 Upon occupation, the LFB would expect that the fire risk assessment makes explicit reference to the construction typology, along with sufficient consideration given to the maintenance required in the particular case. To ensure that the fire safety risk can be effectively managed through the lifetime of the building, it is important that all structural and fire safety information is transferred to the responsible person through the Regulation 38 process. This will ensure that any future competent person, when conducting a review of the building, can easily request relevant information.