Modern methods of construction: reflections on the current research agenda

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BUILDINGS & CITIES

Modern methods of construction: reflections on the current research agenda

SPECIAL COLLECTION: MODERN METHODS OF CONSTRUCTION: BEYOND PRODUCTIVITY IMPROVEMENT

EDITORIAL

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ABSTRACT

HIGHLIGHTS

Modern methods of construction (MMC) comprise a value-laden and highly flexible discourse. Nevertheless, the constituent narratives have long-lasting consequences for the material fabric of the built environment. Current policy sources can be seen to possess an embedded pro-innovation bias that offsets any appetite for evidence-based research, especially that which relates to the mistakes of the past. Many policy narratives in favour of MMC are further characterised by an exaggerated sense of hubris, with an in-built institutionalised preference for disruptive innovation. Liberalised economies are especially prone to technological optimism, with a tendency to cast regulation as a barrier to be overcome. The Grenfell Tower tragedy provides a stark reminder of the limitations of viewing regulation solely through the lens of innovation. Hence, it illustrates how the prevailing built environment research–policy consensus has failed the civil society which it purportedly serves. These failings should be of concern to those who privilege evidence-based research as a means of negating the alarming onset of the post-truth society. Research is required that looks beyond the imperatives of narrowly defined productivity. It is essential that policy narratives such as MMC are fully explored in terms of their short-, medium- and long-term implications.

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1. BACKGROUND

The primary aim in proposing this special issue on modern methods of construction (MMC) was to broaden the debate beyond the current narrowly construed obsession with the supposed productivity benefits. The call for papers stated a need to examine the assumptions underpinning MMC and the associated unintended consequences. Any incremental shift towards the increased industrialisation of construction is likely to have longstanding implications for the sector at large. But more importantly, it is also likely to have enduring consequences for the material fabric of the built environment. Given the chequered history of previous attempts at industrialisation, the prevailing presumption in favour of MMC is undoubtedly deserving of critique. This is especially true given that the current policy debate privileges hype over research-based evidence. Yet, the response to the call for papers was undeniably disappointing.

A total of 15 abstracts were submitted for the special issue. Of these, eight were invited for development into full papers. This resulted in six full submissions being sent out to peer review; four were subsequently rejected and two were eventually accepted for publication (Table 1). All submissions were reviewed in accordance with the same rigorous standards as applied to all papers published by *Buildings & Cities*. The quality of the two accepted papers stands as testimony to the rigour of the peer-review process. Before discussing the published papers, it is appropriate to offer a few reflections on why there was relatively little interest in the call for papers.

AUTHORS	TITLE	DOI
S. D. Green	Modern methods of construction: reflections on the current research agenda (Editorial)	https://doi.org/10.5334/bc.265
B. J. Meacham	Fire performance and regulatory considerations with modern methods of construction	https://doi.org/10.5334/bc.201
R. M. Dowsett, M. S. Green & C. F. Harty	Speculation beyond technology: building scenarios through storytelling	https://doi.org/10.5334/bc.213

Table 1: Articles in this special issue 'Modern Methods of Construction: Beyond Productivity Improvement', *Buildings & Cities* (2022), 3(1); guest editor Stuart D. Green.

2. PROBLEMS OF DEFINITION

It is appropriate to begin with the issue of definition. Defining precisely what is meant by MMC is by no means straightforward. Indeed, the essential vagueness of such ideas can be seen as an essential prerequisite of their success. The attractiveness of MMC is undoubtedly enhanced by its appeal to notions of modernity. Yet, modernity is hardly a new idea. In truth, the origins of MMC can be traced back some considerable time. Direct antecedents include industrialised building (Diamant 1964; Dietz & Cutler 1971), system building (Finnimore 1989; Grindrod 2013) and offsite prefabrication (Gibb 1999; Pan *et al.* 2007). Industrialisation has played an especially important role in the context of state-sponsored mass housing (Glendinning 2021). Prefabricated houses have further been cited as 'architecture's oldest newest idea' (Blanchet & Zhuravlyova 2018). Isambard Kingdom Brunel is rightly famous for his railway engineering, but he is also celebrated for his prefabricated hospital constructed on the southern shores of the Dardanelles during the Crimean War (1853–56). Other antecedents include the use of prefabricated modules in the construction in 1851 of the Crystal Palace exhibition hall in London. The Scandinavian tradition of prefabrication can even be traced back as far as the Vikings (Price 2020). It is further clear that the popularity of such methods has ebbed and flowed over time, with as many recorded failures as there are successes (Gibb 2001). The debate often takes place within the context of housing, where there is seen to be significant scope for economies of scale based on standardisation. Yet, substantial uptake has invariably been dependent upon a degree of state subsidy to offset the risk of demand volatility (*cf.* Rosenfeld 1994; Boughton 2018). The advocates of MMC often notably emphasise the importance of increasing pre-manufactured value (PMV). Yet, little research addresses the externalities beyond the narrow drivers of time, cost, quality and productivity (*cf.*

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Pan *et al.* 2007). As ever, the employment conditions and lived realities of construction workers attract little attention (Ness & Green 2012).

MMC is also perhaps already falling victim to what might be described as the 'beyond the beyond myth' (*cf.* De Cock & Hipkin 1997). In response to criticism, the leading advocates of MMC often claim to have 'moved beyond' MMC to become advocates of some other ill-defined recipe. 'Platform approaches' are currently popular, and equally vague. Hence, it is only though critique that recipes such as MMC become properly defined, and their limitations exposed. In short, the champions of modernisation quickly move on to the next ill-defined recipe while denying any responsibility for the shortcomings of what came before. The danger is that this process continuously repeats itself. Unfortunately, decisions made in the name of MMC have long-lasting material consequences. It is here that the research community has a responsibility to act as an institutional memory.

3. PRO-INNOVATION BIAS

The literature on MMC is characterised by a strong pro-innovation bias. The predisposition in favour of MMC is even more pronounced among policy makers. Such tendencies are of course by no means new. There is a long tradition of policy makers advocating simplistic technological fixes in response to complex and politically contested problems. Indeed, the history of the construction sector is littered with supposed panaceas derived from the application of modern technology. Yet, there remains a stubborn resistance to learning the lessons from previous such attempts. There is also a recurring tendency towards technological determinism, with little recognition of the possibility of unintended consequences (Green 2019).

Insights can also be gained by understanding how policy narratives are structured. There is a propensity to emphasise that the construction sector is in some way 'backward', not least in its failure to adopt modern technology (Farmer 2016). The advocated technologies are also habitually promulgated as a means of overcoming a proclaimed crisis. Prominence is sometimes given to the 'productivity crisis', usually with limited effort to engage with the relevant research literature. The other popular target is the 'skills crisis', with a similar lack of interest in the research literature relating to construction sector skills. Politicians are especially fond of citing industrialisation as a means of solving the 'housing crisis'. Such simplistic narratives are in truth part of the problem. The constituent arguments in support of MMC are invariably framed very narrowly, with little recognition of the contested nature of the supposed crises at which they are aimed. For clarity, it is not that extensive research of the three highlighted topics does not exist. The problem is that such research does not easily fit with the pro-innovation bias of policy narratives in support of MMC. Pro-innovation bias might otherwise be construed as gung-ho boosterism. The built environment deserves better.

4. LEARNING FROM THE PAST

Despite the heady talk of innovation, pre-assembled construction components are still routinely installed on site by labour-only subcontractors. Too often the work is performed by semi-skilled operatives subject to a bare minimum of supervision. Despite the overblown claims made in respect of factory-based 'precision engineering', consideration rarely extends to the problems that occur at the interfaces between different systems. There are important precedents from which one can learn. For example, the large panel system (LPS) approach to prefabrication was widely used for high-rise residential blocks in the 1960s. The method comprised the vertical stacking of prefabricated concrete panels. It performed very well in terms of productivity; such prefabricated concrete systems were deliberately incentivised as a means of increasing housing output. Public trust evaporated following the Ronan Point collapse in Newham, London, in 1968. A subsequent public inquiry pointed towards appallingly poor workmanship in the connections between panels. Many such buildings were demolished within 15 years due to structural deterioration and sky-rocketing remediation costs. In 1984, Geoffrey Lofthouse MP famously presented the following question during a parliamentary debate on defects in systems-built housing:

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> We must also ask whether sufficient time and money is spent in appraising new methods of building, and new components and materials. As an example, the Agrément certificate procedure is very weak, and gives little real assessment of how building will work out in practice.
>
> (Hansard, 12 March 1984)

The above question remains especially pertinent in the wake of London's Grenfell Tower tragedy of 2017 and the ongoing international cladding crisis. Yet, at the time of writing, the UK government's stated presumption in favour of MMC remains firmly in place. Hence, there is sufficient cause to be cautious of any pro-innovation bias in the advocacy of construction methods.

Certainly, there would seem to be much to be learnt by studying the failures and successes of previous attempts at industrialised building, not least in terms of how and when success might most meaningfully be judged. Experience shows that too much emphasis on short-term measures of success, such as construction productivity, is ill-placed given the longevity of buildings. Yet, built environment policymakers have long since championed the cause of construction sector competitiveness over that of building performance. Policymakers have seemingly forgotten that building performance should be judged at multiple points throughout the building's life cycle, rather than at the single arbitrary point of 'completion'. Huge questions also remain about the malleability of modular buildings over time, not least in terms of their adaptability to changing patterns of use (Brand 1994; Patel & Green 2020). There is a notable sparsity of research into how buildings constructed using MMC lend themselves to retrofit in accordance with the demands of the circular economy. In truth, the advocates of MMC have little appetite for research of this nature. The research that is valued is that which focuses on overcoming the barriers to an approach to which they are already committed. This should be of concern to those who value independent evidence-based research.

5. HUBRIS AND DISRUPTIVE INNOVATION

Of further concern is the extent to which the current UK policy debate in support of MMC suffers from an overriding sense of hubris. The prevailing emphasis lies on how barriers to innovation might be best overcome. The advocates of MMC unfailingly present themselves as champions of modernisation. The hubristic narratives of MMC can perhaps be best understood as identity work on the part of those involved (*cf.* Sergeeva & Green 2019). Such identity work is invariably aimed at gaining entry to policy circles. There is a further observable tendency to castigate the voices of caution as being misguided defenders of the 'traditional'. Dissenters are seen as outdated in their attitudes, and complacent in the face of a construction sector which is irrevocably old-fashioned and resistant to change. The choice presented by Farmer (2016) is evident in the title of his report: *Modernise or Die*.

The nonsense of the above presented binary division lies in the high reported number of failures of supposedly disruptive innovators. Katerra in the US is perhaps the most obvious example (Rabeneck 2021). There have also been numerous highly publicised failures of modular firms within the UK, including the joint venture previously launched with great fanfare by Urban Splash (Clark 2022). It is of course to be expected that some start-ups will succeed and others will fail. The most cited reason that modular firms go out of business is that the order book was insufficient to service the relatively high set-up costs. In other words, capital productivity too often falls below the expectations of the investors. Labour productivity on-site may well be improved, but capital productivity in the factory is by no means guaranteed. Such failures serve to emphasise the difference in predicted lifespan between buildings and modular start-up companies. They further raise questions regarding the extent to which prefabricated components are malleable over time in accordance with the different service lives of the embedded constituent systems and the needs of through-life retrofit.

Current champions of MMC arguably differ from their predecessors in the extent to which they align themselves with notions of digital transformation. The favoured narrative plays homage

at the altar of the Fourth Industrial Revolution as advocated by global consultancies such as McKinsey & Co. (2016). The advent of 'Industry 4.0' is held to have fundamental implications for the business models of the future. Indicative technologies include the Internet of Things (IoT), robotics, big data analytics, artificial intelligence (AI), machine learning, advanced embedded sensors and digital platforms. So-called smart factories hence become of key importance to the development of MMC. The overriding tone is one of unfettered technological optimism. Disruptive innovation is invariably taken for granted as an inherently 'good thing'. Such storylines were eminently evident in the hype that surrounded Katerra before its demise in 2021. The point is not to deny the potential benefits of such technologies, but rather to highlight the dangers that they become 'technologies of distraction'. Technological optimism is fine insofar as it goes. However, the materiality of our built infrastructure is of fundamental importance to the human condition. It has implications across the entire range of policy areas, including health, education, housing and commerce. The buildings being built need to be resilient. They need to be adaptable for uses that were not envisaged at the point of inception. Above all else, they need to be safe. Hence, it is important to find an appropriate balance between innovation and regulation. To strive for such a balance is central to any measured sense of professionalism, which sadly seems to be in terminal decline.

6. GOVERNANCE AND THE WAR ON 'RED TAPE'

Of further concern is the recurring policy emphasis within liberalised economies on the removal of regulatory barriers, invariably presented as needless 'red tape'. Regulation should be kept under constant review, but it has undoubtedly played a crucial role in improving the safety of the buildings when they are occupied. The same is also true of the health and safety regulations that govern on-site construction. Indeed, regulations are often developed in response to specific tragedies—Ronan Point being a case in point. Regulations are there for a purpose and are not to be jettisoned lightly. Yet, policies in support of regulation have been in widespread retreat within liberalised economies since the 1980s. Governments that prioritise the discourse of competitiveness routinely announce 'bonfires of red tape', which they seemingly see as an essential part of their modernisation agenda (Green *et al.* 2008). This has been especially pronounced in recent years within the UK, but also throughout the English-speaking world. Less dramatic is the erosion of the regulatory system through systemic neglect, weakened enforcement and the progressive withdrawal of funding. In the context of UK housing, all three variants are cited as being directly implicated in the regulatory failures that led to the Grenfell Tower disaster (Hodkinson 2019).

Good regulation is an intrinsic component of modernity. Few would wish to return to the laissez faire approaches of the 19th century. Sometimes it is important to remind ourselves that modernity is not necessarily a linear progression. The advocates of MMC do not embrace modern employment practices such as those advocated by the Taylor Report (Taylor 2017), and neither do they embrace modern approaches to compliance and regulation. The current trend towards so-called platform approaches can perhaps be described as the 'Uberisation' of the construction sector whereby the reliance on the gig economy is progressively normalised. Hence, the modernisation on offer is limited to the variant of technological optimism.

7. THE LEGACY OF GRENFELL

The dangers of consistently privileging innovation over regulation have been ruthlessly exposed by the public inquiry into the Grenfell Tower fire which resulted in the deaths of 72 residents. Although the final report has yet to be published, a wealth of evidence points towards systemic failings within the regulatory system. Of particular note is the way the UK's independent material testing capability was allegedly compromised by the privatisation of the Building Research Establishment (BRE). Notwithstanding the subsequent Building Safety Act 2022, serious doubts remain regarding how meaningful regulation might best be implemented within the context of a liberalised economy. Continued hubristic hype in support of supposed panaceas such as MMC does not help, and neither will any subtle linguistic shift towards vaguely defined 'digital platforms'.

It is further important to recall that the Grenfell Inquiry identified the installed aluminium composite material (ACM) cladding panels as the primary cause of the external fire spread on Grenfell Tower. The use of such innovative construction materials was undoubtedly legitimised by the all-prevailing narrative in support of innovation and MMC. Yet, at the time of writing, the UK government's 'presumption in favour' of MMC remains firmly intact (HM Government 2020; Green 2021). The lobbying power of the global materials industry can further be seen to have appropriated the narrative of MMC for promotional purposes. Despite the findings of the Grenfell Inquiry, numerous firms continue to sell their products under the legitimising label of MMC. In the wake of Grenfell, any meaningful research agenda relating to MMC must surely embrace issues of appropriate regulation.

8. RELUCTANCE TO CHALLENGE MAINSTREAM POLICY NARRATIVES

Perhaps most disturbing of all is the way the bias in favour of disruptive innovation is evident across the institutional landscape of research funding. It is no coincidence that the UK's leading public research funding agency is labelled 'UK Research and Innovation'. Indeed, the discursive linking of 'research' and 'innovation' is so commonplace it is invariably taken for granted. Hence, there are few incentives for research that calls into question supposed innovations such as MMC. Dissent within the research community is further discouraged by a perceived risk of being barred from construction policy circles, and from publication in leading journals. In the author's personal experience such constraints are more imagined than real. Yet even the professional institutions fall in line with the omnipotent discourse of innovation rather than defend the importance of detached professionalism (*cf.* Green et al. 2008). But the biggest constraints are undoubtedly those the research community imposes on itself. Researchers are too often content to pursue their chosen research specialisms without critically engaging with mainstream policy narratives. This could perhaps account in part for the disappointing number of submissions to the current special issue.

As a caveat to the above, it is important to note that there is a plethora of relevant research being undertaken—both within the UK and internationally. It is perhaps more a case of researchers not choosing to align their research with policy narratives which they view as essentially transient and trivial. Therefore, they choose not to engage. Those who do engage are also at risk from the 'beyond the beyond myth'. Hence, there is a danger that they align their research with MMC only to find the bandwagon has moved on.

There is also an argument that those who seek to critique narratives such as MMC are themselves complicit in their reproduction. Such an argument may indeed have legitimacy within the ivory towers of academia. But the unchallenged advocacy of MMC has consequences, not only for the construction sector, but also for the material fabric of the built environment. The relative lack of interest in the current special issue is hence indicative of a wider problem. What is required is a more balanced research agenda on the topic of MMC for the purposes of ensuring policymakers are better informed. The scope of such research would hence extend beyond narrowly defined labour productivity to embrace the full range of externalities relating to any progressive shift to an increased proportion of PMV. But policymakers are seemingly not interested. They have apparently already decided that MMC is a good idea. In time, the narrative will undoubtedly move on to the next supposed panacea. However, the likelihood is that the stark disconnect between policy and research will continue.

9. FUTURE RESEARCH AGENDA

In looking towards the need for future research, very little evidence exists on the implications of MMC for the material fabric of the built environment. There is also a recurring reluctance to investigate and learn the lessons from previous attempts at the industrialisation of construction. This is of particular concern within the context of housing, although it applies equally to other sectors. A lack of data exists on the implications of MMC for the performance and longevity of

buildings, and their ability to respond over time to shifting societal and occupant needs. The durability and adaptability of buildings are of central importance for both resource consumption and the achievement of a net-zero carbon economy. Further concerns relate to environmental performance and occupant wellbeing. Even more importantly, significant concerns remain regarding the implications of MMC for fire safety (Davis 2019).

Any significant increase in the proportion of PMV is also likely to have systemic consequences for the economic structure of the sector. Particular concerns relate to employment practices and the potentially adverse implications for skills within local communities. The increasing emphasis on PMV further exposes the construction sector to competition from global manufacturing firms, with significant implications for barriers to entry and the national balance of payments. Additional questions relate to a lack of transparency in global supply chains, with direct implications for the risk of labour exploitation. The outsourcing of sub-assembly processes to geographically remote locations further raises serious questions about regulatory regimes in respect of environmental protection. Of no lesser importance are the added challenges of ensuring compliance with building standards and codes.

The label of MMC may well be replaced in time by some other faddish representations of the Fourth Industrial Revolution, but the above concerns will remain. The research community cannot afford to be dismissive of the potential of new technologies. But neither can it afford to be beguiled by hubristic narratives. Both civil society and government depend upon independent, robust critical enquiry and clear evidence on which to base individual and collective decisions. Research in the public interest is a principle and practice that needs defending.

10. CONTRIBUTIONS TO THIS SPECIAL ISSUE

The safety of the building in use and the potential risks to occupants are vital issues. Meacham focuses on the fire performance and regulatory considerations associated with MMC. He argues that the adoption of MMC presents challenges to traditional building regulatory approaches. Particular attention is focused on the void spaces between prefabricated components, and especially those that exist between prefabricated modules. These voids—both vertical and horizontal—potentially serve as avenues not only for the spread of fire but also for the spread of smoke and toxic gases. The correct on-site installation of appropriate fire cavity barriers hence becomes of critical concern. Of further note is that the installation of such barriers cannot be easily checked after the event. This raises concerns regarding on-site supervision and the dangers of neglecting the importance of training for those operatives upon whom modular fabricators rely.

Meacham further points towards fire performance concerns with MMC materials. He argues that these concerns are exacerbated by the encapsulation of MMC components and the extent to which they are in proximity to voids. Although individual components may meet fire performance requirements under defined test conditions, this may not be true once they are embodied within MMC systems.

Meacham offers a compelling overview of the distinction between prescriptive and functional approaches to regulation. He further differentiates functional approaches in accordance with the degree of government oversight vis-à-vis reliance on market responsibility. Of particular interest are the regulatory trajectories of different countries. The approach in the US is seen to be predominantly prescriptive, with a defined and broadly understood process for assuring quality in the fabrication process. In contract, functional approaches focus on identifying performance requirements without specifying how they are to be met. Countries that combine this approach with strong government oversight include Singapore and Japan. The third approach is the adoption of a functional approach coupled with a reliance on the mechanisms of the market rather than direct state involvement. Examples of the latter approach include the UK and the Netherlands. Such differences in regulatory approaches render simplistic international comparisons problematic. However, many Commonwealth countries notably follow the regulatory practices adopted in the UK, thus contributing to the internationalisation of the cladding crisis.

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In closing, Meacham observes that MMC comprises complex 'systems of systems' for which the assurance of fire performance present unique challenges. He argues that our success in delivering safe buildings depends upon an engrained safety culture in which the safety of occupants is more important than financial gain. This paper deserves to be read widely, and its recommendations need to be actioned.

Dowsett *et al.* offer something different. They take a broad interpretation of MMC as comprising one of many possible constituent technologies of the Fourth Industrial Revolution. Their particular interest lies in manufacturing robotics. They argue that current debates are too often dominated by notions of 'technological prediction'. These are held to be of limited use to practitioners in that they offer limited insights into how such technologies are likely to play out in a highly heterogeneous construction sector. The authors describe an empirical study where invited practitioners were exposed to four competing scenarios. They especially privilege the views of small and medium-sized enterprises (SMEs) which are held to be more representative of the construction sector than tier 1 contractors. Their justification is that SMEs do not tend to get much airtime in mainstream policy debates about MMC. Indeed, if they are mentioned at all, they are often simplistically depicted as 'barriers' that stand in the way of progress. As an aside, tier 1 contractors have long since divorced themselves from the physical task of construction (Green 2011). Hence, it could be argued that they have been operating a platform-based business model even before the terminology became fashionable.

Dowsett *et al.* further draw from previous research to highlight the complex and diverse interactions between new technologies and the processes within which they are embedded. They argue that foresight-type approaches invariably offer unrealistic and anodyne visions of the future. As an intriguing alternative, they propose a scenario-planning approach rooted in the tradition of storytelling. The adopted approach notably uses images and objects for the purposes of capturing the interest of the participants.

The first developed scenario envisages a vertically integrated construction sector dominated by five mega-contractors. In contrast, the second foresees an industry dominated by software venders and original equipment manufacturers (OEMs). The third scenario portrays a sector comprising regional networks of SME collectives. The fourth and final scenario comprises a nationalised construction sector governed by a national construction board. There was a time, of course, in the 1970s when UK building industry nationalisation was a realistic prospect, serious enough to justify the major contractors funding the Campaign Against Building Industry Nationalisation (CABIN).

The paper describes the reactions of the participants to each of the four scenarios, with an appropriate emphasis on the extent to which they might facilitate the increased utilisation of manufacturing robotics. Needless to say, the fourth scenario evoked the strongest negative reaction. Ultimately, the authors offer the adopted scenario-building approach as a means through which visions of the future are co-created with the active participation of those at the 'coalface' of construction The paper undoubtedly contains much food for thought. It further serves as an important anecdote to the top-down technological determinism that too often prevails. It might also provide a methodology for structuring a much broader and more realistic debate about the future role of robotics in construction. Policymakers take note.

11. CREATING FURTHER EVIDENCE

This editorial and accompanying two papers are not intended to comprise the final word on the sparsity of research relating to MMC. In contrast, they are seen to provide an important beginning. *Buildings & Cities* will continue to welcome papers that examine the unintended consequences of construction innovations such as MMC. Research papers that address the inherent tension between innovation and the societal need for regulation will be especially welcome. Innovation can never be fully evaluated solely based on narrowly defined productivity improvement. Account must also be taken of its wider implications for the material fabric of the built environment, and for the lived realties of those who occupy the buildings that are designed and constructed.

The occupants and victims of the Grenfell Tower tragedy have undoubtedly been let down by the liberalisation of the UK's approach to regulation. But similar failings have occurred globally, as evidenced by the international nature of the cladding crisis. But the Grenfell tragedy also constitutes a failure on the part of the international research community, not least in terms of privileging the needs of the construction and real estate sectors over those of civil society. Researchers frequently point towards the decline of professionalism among practitioners, but researchers must also strive to serve a broader diversity of interest groups. Over the last four decades researchers have allowed themselves to become too constrained in the research questions that are set out to be explored. The next generation of researchers must do better. Research must look beyond the short-term imperatives of narrowly defined productivity. Independent evidence can save lives and avoid costly remediation programmes. It is therefore essential that policy narratives such as MMC are thoroughly considered for their short-, medium- and long-term implications.

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COMPETING INTERESTS

The author has no competing interests to declare.

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