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A Decision-Support Tool to Increase the Uptake of MMC and Improve the Environmental Impact of the Irish Construction Industry

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Abstract

The availability of suitable living accommodation in Ireland has been cited as a fundamental concern by Irish society. The current housing system needs to meet its required targets for several reasons, including climate considerations, housing costs, and well-being. To alleviate the significant socioeconomic implications of the housing crisis, societal and environmental criteria must be considered. Alongside speed of delivery, health and safety, quality of life and enhanced build quality, stakeholders argue that Modern Methods of Construction (MMC) can advance the overall sustainability of the Irish construction industry and work towards the environmental goals set out in the 'Housing for All' action plan. However, the adoption of MMC is currently limited and a lack of suitable digital tools to fully grasp new materials, methods, and installation processes has led to widespread confusion and increased hesitancy to the transition.

This paper forms part of the "Platform4MMC" project which will develop an assessment tool to analyse and compare the viability of MMC against more traditional methods that can have a considerable, negative environmental impact. The research reports on semi-structured interviews with key stakeholders in the Irish residential sector, including governmental bodies, policymakers, contractors, developers, manufacturers, architects, end users, and many more industry representatives. These collaborators inform the project by providing their insight from completed off-site manufactured projects. To drive behavioural change, private and public bodies can use the tool's recommendations of the MMC products that best suit their criteria and pipeline, establishing a consistent level of demand to incentivise manufacturing capacity in Ireland. The interviews provide key learnings on the challenges and roadblocks to supplying adequate, sustainable housing in Ireland. A key performance indicator list was then developed with the stakeholder engagement findings, which identifies key metrics when assessing a projects suitability for MMC.

Keywords
Housing crisis; pre-fabrication; decision-support tool; Modern Methods of Construction; sustainability

1. Introduction

The availability of suitable housing in Ireland has been cited as a key concern by 52% of Irish society (European Commission. Directorate General for Communication., 2023). The Irish government has recognised this issue and from 2020 to present has published 12 documents relating to Modern Methods of Construction (MMC) as a solution to the housing crisis and a further 21 reports have been published on MMC by industry bodies. In 2021, the Irish government unveiled the Housing for All Plan (HFA), outlining its overall aim that *"Everyone in the State should have access to a home to purchase or rent at an affordable price, built to a high standard and in the right place, offering a high quality of life"* (DHLGH, 2021). To achieve economic sustainability and tackle levels of discomfort for those affected by the housing crisis, the government and state agencies will advance methods to reduce residential construction costs, speed up delivery and improve citizen well-being by promoting and supporting innovation, largely through MMC adoption (DHLGH, 2021).

The term: Modern Methods of Construction (MMC), has created some confusion due to a range of terms used globally, for example, Industrialised or Modular Construction which has lead to a lack of clarity as to what MMC exactly is (Ofori-Kuragu & Osei-Kyei, 2021). A key theme found by the CIF was the "*Lack of understanding of what constitutes OSM / Modular Construction / MMC and what is possible with modular solutions and their limitations*"(CIF, 2022). This project follows the NHBC framework, adopted by the Irish Government,, categorising MMC into seven types, including both on-site and off-site construction (NHBC, 2021). In Ireland, the current, common traditional techniques for new housing are block and brick cavity walls and in-situ concrete formwork (Skillnet et. al, 2022). Traditional construction follows a linear process, where each stage starts only after the previous one is completed, leading to limitations in timeline, scalability, and material sourcing (Nazir et al., 2020).

In recent years, MMC has gained attention in certain countries to build faster, potentially cheaper and better-quality homes to help address the problem of housing shortages (Oti-Sarpong et al., 2022). Up to 50% in construction time and 30% in costs can be saved by utilising MMC all while benefiting the future user in the process (Sánchez-Garrido et al., 2023). Countries like Germany, Sweden, Japan, Singapore, China, Canada and the USA are, in particular, driving a shift from the use of traditional onsite construction to greater use of MMC (Oti-Sarpong et al., 2022). Within Europe, countries such as the UK (16%), Germany (13.5%) and Sweden (45%) have utilised MMC for the overall completed residential projects respectively (NBS, 2024; Savills, 2020; Destatis, 2024).

With the growing popularity of MMC over the past decade, many researchers have identified the leading benefits of MMC such as environmental sustainability (Building Better, 2024), schedule advantage (NIBS, 2019) and quality (Wang et al. 2024).

This paper demonstrates that with the transition from traditional to MMC comes many challenges that must be alleviated first for the benefits to be realised. By gathering the barriers/ challenges alongside the benefits to MMC, this paper will combine the collated information into a formal KPI list that will be used in the Platform4MMC tool to alleviate confusion over MMC and demonstrate the value in utilising MMC methods in a given project.

This study reports on the stakeholder engagement methods and findings gathered throughout the early development of the tool: *Platform4MMC*. Aimed at providing consistent clarity across the industry, the tool will evaluate the viability factors by comparing it with traditional methods to highlight the potential advancements and reduce hesitancies surrounding the digital transition of the sector. The tool will include emerging certified materials, systems, and suppliers connected to a steady MMC supply chain across Ireland, drawing on insights from involved stakeholders.

2. Review of Irish policy and industry reports

59 reports related to construction, published by government departments and industry bodies in Ireland, were initially identified as relavent for this project. These reports were gathered, and an initial screening process was conducted to identify reports specifically relating to MMC. The results in this paper derived from government reports (n=12) and industry body reports (n=7). The reports were analysed, and the most identified barriers and benefits were collated into Table 1.

According to this summary, it can be deduced that the high costs are an inhibiting factor, but which could be alleviated with a strong pipeline to reach economies of scale as the speed of delivery is the greatest benefit of all. The documented environmental benefits greatly outweigh the barriers while viability issues within the industry is a large impediment. Within the social findings, MMC offers an overall improved construction sector for its employees and a higher level of quality for the client. However, the perception of MMC is found to be a common challenge. This is made more clear when analysing the contradictory barriers and benefits. For example, 5 publications reported that high costs associated with MMC is a barrier, while 3 reported that MMC is more affordable. There is a need for clearer reports to be published to alleviate further confusion.

Table 1: The main Barriers-Challenges of MMC found through the literature review

Categories	Barriers to MMC	Reports References (n=19)	Benefits to MMC	Reports References (n=19)
Economic	Upfront costs	4	Time Efficiency	13
	Product costs	5	Affordability	3
			Economies of scale	7
Environmental	High embodied carbon	1	Reduced carbon	6
			Sustainability	7
			Transportation	4
			Waste management	9
			Energy efficiency	8
			Circularity	4
Social	Perceptions	6	Health & Safety	6
	Effective policy execution / communication	1	Productivity / innovation	10
			Labour shortage	5
	Education / training upskilling	4	Build quality	11
	Adaptability	1	Diversity	3
	Industry apability	1	Digital transition	2
Viability	Pre-construction phase	5	Enhanced quality control	2
	Procurement	5	Standardisation / repeatability	4
	Supply chain	7		
	Compliance / certifocation	5		
	Transport	1		
	Quality	2		
	Long wait times	1		
	Capacity	2		

3. Tool development and rationale

The Platform4MMC project arose from a recognition of the need for a decision-support tool to aid stakeholders understanding of MMC solutions, coupled with how a project's needs determine what MMC type is most suitable. The need for such a tool grew from the understanding that the industry has been historically slow to adopt alternative techniques. The

building industry is notoriously slow to innovate and therefore continues to work with known methods of construction (Xue *et al.*, 2014; Farmer, 2016). These methods are often labour intensive and result in long construction times (Vagtholm *et al.*, 2023). For the industry to tackle such barriers aiding the housing crisis, MMC has been chosen as a key solution (Department of Housing, Local Government and Heritage (DHLGH), 2023). However, survey reports on the Behavioural attitudes to MMC showed that only 57% of the general public had heard of MMC and 33% of the construction industry respondents had never used MMC (Shou Wang and Daniel McCrum, 2024). In order for stakeholders to adopt MMC solutions, barriers preventing its entry must be resolved.

A fundamental change is needed with regards to design, development, financing, regulatory systems and construction for MMC to be utilised successfully. Yet, there is no comprehensive guidance on identifying and assessing suitable MMC solutions to aid the initial design phases. Additionally, the public procurement and tendering process should be adapted so the focus is removed from short-term goals like cost, but on the overall value of the system, e.g. carbon footprint, construction duration etc. (DETE and DHLGH, 2023). Such a decision-support tool on system valuations does not exist, nor does a database of available MMC solutions in the Irish market exist in the public domain.

Platform4MMC will enable an impartial assessment of the viability of MMC Construction types for a considered project and its total sustainability value based on economic, environmental, social and viability indicators, enabling MMC optioneering. The tool will guide professionals towards an architectural and construction solution based on the project's needs and priorities that will be assessed against a Key Performance Indicator list created by the authors.

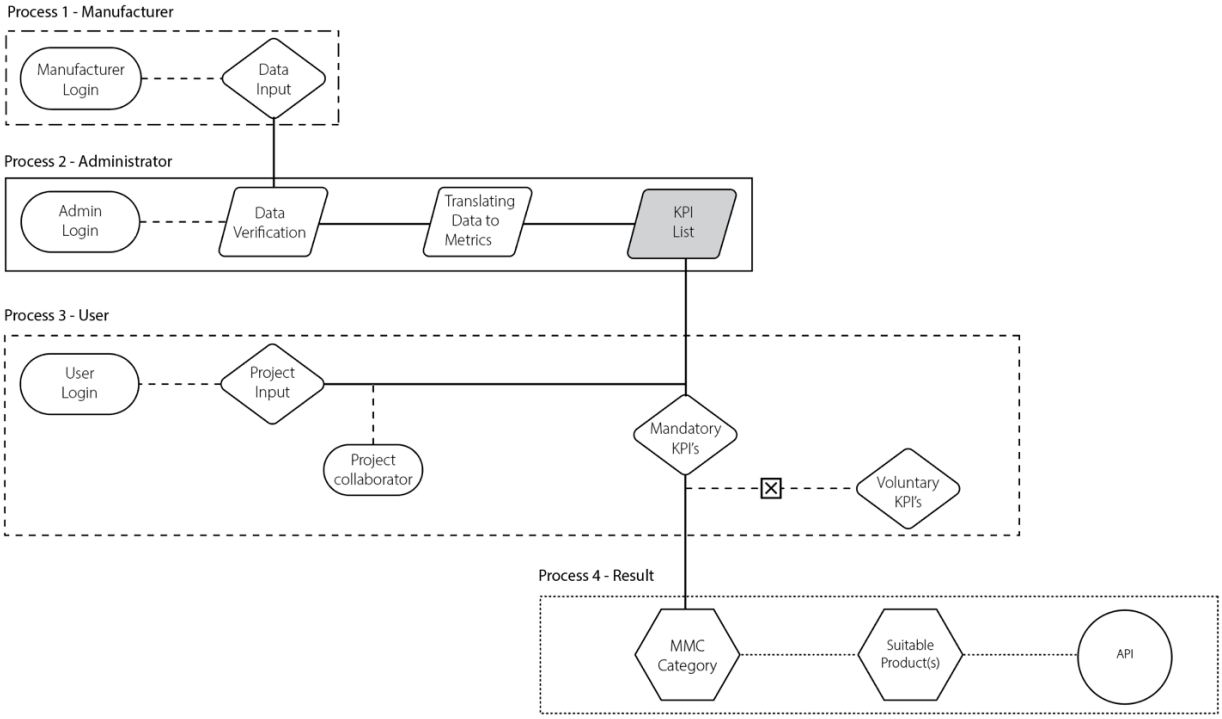


Figure 1: Schematic illustration of the tool. The grey shaded box, marked KPI list, is the focus of the paper.

3.1 KPI development

The decision support tool *Platform4MMC* is comprised of 4 distinct processes outlined in Figure 1. The decision will be based on an overall assessment of a project's suitability to a particular MMC type by not focusing merely on one goal, e.g. cost, but rather offering a multi-

factor approach. Process 1 incorporates information from the manufacturers. In Process 3, the user submits the project requirements and is prompted by the tool to assess where the project's priorities lie. Process 4 then finalises these inputs, resulting in the desired output. Process 2 is the translation of the information from process 1 into an evaluation matrix that the user will engage with in process 3.

This paper focuses on process 2 of the tool. By incorporating the stakeholder engagement findings with qualitative and quantitative data collection, the authors distilled the findings into a KPI list that will formulate the KPI checklist in process 3. The KPI list responds to industry needs by acknowledging the barriers and benefits of MMC along with information professionals currently require in making decisions.

4. Methodology

The four data collection methods used for our stakeholder engagement were surveys, workshops and interviews.

The survey served as the initial data collection method, introducing the early goals of Platform4MMC. It gathered a broad overview of engaged stakeholders, including their industry backgrounds and years of experience with Modern Methods of Construction (MMC). The questionnaire, consisting of 11 questions, was divided into two sections. The first section focused on the stakeholders' positions within their organisations, while the second section explored the development requirements of the tool from the stakeholders' perspectives.

Through further expansion on the broader societal impact, there was a need to thoroughly examine the barriers that impede the adoption of MMC thoroughly examine the barriers that impede the adoption of Modern Methods of Construction (MMC) in the Irish construction market. This required a collaborative review to bridge existing gaps in both research and practical applications. An in-person workshop was launched to physically introduce stakeholders (n=19), validate challenges, test assumptions, and collectively develop solutions crucial for the successful establishment of a decision support-platform.

A revised semi-structured interview method was chosen based on its documented effectiveness in fostering reciprocal communication between interviewers and participants (Galletta, 2013). Each interview followed the five-step framework proposed by Kallio et al. (Kallio et al., 2016). The majority of meetings were conducted digitally, recorded, transcribed internally, and subsequently deleted. The structured interview agenda comprised three main parts: an initial presentation of the prototype tool and current project progress, focused questions related to the stakeholder's industry, and concluding inquiries about the digital tool development and performance. This semi-structured outline ensured coverage of all targeted questions and topics while allowing flexibility for follow-up questions based on 27 participant responses. The stakeholder interviews (n=27) were transcribed into text files. Afterwards, the qualitative data were coded in NVivo using a thematic coding approach, illustrating 2 main themes: 1) Barriers and Challenges of MMC in Ireland, and 2) Benefits of MMC in Ireland.

5. Results and findings

5.1 Stakeholder engagement workshop results

The Engagement Workshop invited leading representatives from the key stakeholder panel. Throughout the first two sessions, discussions focused on the motivations behind integrating a tool such as Platform4MMC, highlighting the need for testing viability, economic benefits, and environmental, and social goals. Barriers such as certification issues, material uncertainty, and regulatory differences were identified. Participants suggested that architects, for example, could enhance the tool by sharing MMC design processes, providing case studies, and contributing to the development of sustainability metrics. A significant insight was the need

for clear communication on the benefits of MMC and the creation of a regulatory pathway to facilitate certification and compliance.

In the third session, participants ranked the significant key performance indicators (KPIs) under the four assessment headings shown in Table 2.

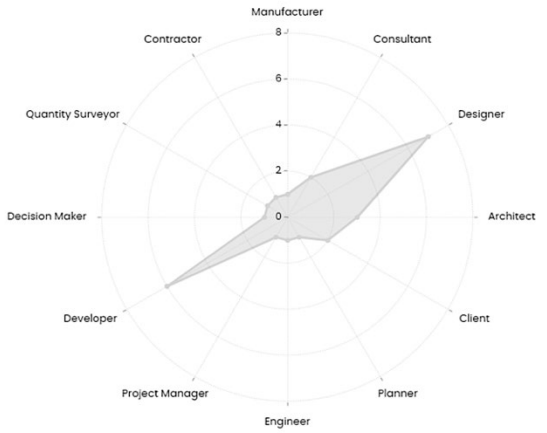
Table 2: Essential KPI's identified at the workshop event.

Assessment headings priority	Essential KPI's	Related KPI's
1. Viability	Secure supply chain Certification	Pipeline, Supply chain security Fire, Can it be certified?
2. Economic	Cost efficiency Speed of delivery	Product cost, profitability Cost vs. time, Time to market
3. Environmental	Life cycle assessments New methods of waste management	EPD's, carbon footprint Construction waste, circular economy
4. Social	Housing affordability Improved workplace conditions	 Workers benefits, inclusiveness

5.2 Stakeholders survey results

The stakeholder survey results indicate that the Platform4MMC tool is perceived as most useful to developers, architects, and engineers (see Table 3). Viability is ranked as the most critical assessment heading, followed in order of priority: economic, environmental, and social factors. Participants, who generally have over five years of experience with MMC, highlighted early engagement and cost certainty as top priorities for viability. For environmental assessment, carbon footprint and waste reduction are deemed crucial, while housing affordability and community development are vital for social assessment. Under the economic headings, developer savings and cost comparisons are prioritised. Overall, the results revealed the range of priorities across the stakeholder groups, emphasising the importance of both practical and sustainability aspects in the Platform4MMC development.

Table 3: Essential KPI's identified from the survey.

Assessment headings priority	Essential KPI's	Key Users
1. Viability	Suitability of design Site layout, access Lead time Early engagement	
2. Economic	Cost Compliance User savings Developer savings Time & labour savings	
3. Environmental	Carbon footprint Waste & material use Climate change Operational energy	
4. Social	Housing affordability Construction disruption Reduction in fuel poverty Intergenerational equality	

5.3 Stakeholder semi-structured interview results

The 27 stakeholder interviews came from an array of professions of the construction industry, including Architects/Engineers(n=5), Academic(n=2), Government-Departments(n=3), Local Authorities(n=1), Industrial Bodies(n=2), Manufacturer/ Contractors(n=5), Consultants(n=4), Quantity Surveyors(n=2), and Developers(n=3). The results of the Barriers/ Challenges and Benefits are sorted under 4 main headings; Economic, Environmental, Social, and Viability, which are plotted on Table 4.

Table 4: The main Barriers-Challenges and Benefits of MMC (Author Work)

Categories	Barriers/Challenges of MMC	Interview References (n=27)	Benefits of MMC	Interview References (n=27)
Economic	Obstacles to growth	19	Time efficiency	20
	Affordability	16	Cost efficiency	17
	Upfront csot	11	Economies of scale	8
Environmental	High embodied carbon	5	Reduced carbon footprint	12
	Circularity			
	Durability	4	Sustainability/circularity	11
	Shipping	2	Waste management	8
		1	Energy efficiency	6
Social	Perceptions	21	Health & Safety	11
	Education, training and upskilling	10	Build quality	11
			Productivity/Innovation	9
	Effective policy and communication	9	Labour shortage	9
	Collaboration	3		
Viability	Early engagement	17	On-site performance	12
	Compliance/certification	16	Standardisation	9
	Insurance		Early engagement	7
	Transport issue	11	Enhanced predictability	5
	Industry capability	7	Enhanced quality control	4
		7		

The expert interviews reveal that the industry bodies with practical work experience in the Irish construction industry possess a deep understanding of Modern Methods of Construction (MMC). However, the main barriers to MMC in the Irish construction industry fall into three categories: perceptions towards MMC, obstacles to growth, and the pre-construction phase. Attitudes towards MMC (n=21) are mentioned as the most significant barrier. The economic category was highest ranked, followed by obstacles to growth (n=19), which incorporates issues such as industry scalability, pipeline of works, overall commercial gain, the cyclical nature of the sector, and felling licenses. The interviews reveal that the barriers are systemic and require resolution at government level.

The two leading benefits of Modern Methods of Construction (MMC) fall under economic categories: cost efficiency (n=17) and time efficiency (n=20); which relates to general project time, shorter planning permission time, and onstruction stage. Additionally, expert interviews identified MMC's reduced carbon footprint (n=12), increased on-site performance (n=12), and improvements in health and safety (n=11) as significant benefits across various categories. Consequently, these benefits are primarily associated with the construction stage.

Though interviews revealed differing opinions within the economic, environmental, viability categories. Most interviewees illustrated cost efficiency as a benefit. Nevertheless, the upfront cost of MMC, including compliance costs and capital investment, is seen as a drawback

by the experts. In the environmental aspect, the carbon footprint was identified both as a barrier (n=5) and a benefit (n=12). This contradiction is due to the doubling of materials in the volumetric system and the use of certain MMC materials, such as Insulating Concrete Forms. However, MMC still maintains sustainability merits in terms of carbon emissions according to many stakeholder opinions. Within the viability group, many interviewees note that early engagement is considered a barrier (n=17) to MMC, while others consider it a benefit (n=7) to the process.

6. Discussion and Recommendations

The interview process was conducted over a 6-month period. Upon beginning the interview process an initial KPI list was developed to induce discussion. This KPI list was included at the end of the presentation of the project. Therefore, after showcasing the project, interviewees could initially give their feedback on which of the KPI's are beneficial, or which KPI's will be difficult in acquiring data on. The KPI list was continuously updated post interview findings. In doing so, the project's KPI list was distilled over time from the recommendations given by stakeholders.

The results from the literature review are found to be similar to the interview results. It can be assumed that the stakeholders interviewed are engaged with current discussions on MMC. Therefore, going forward, a wider range of interviewees who have no experience or lack knowledge on MMC should be interviewed to gather inhibiting factors of their use of MMC.

Table 5: Collated findings related to the KPI list

Categories	Barriers/Challenges	Benefits	Topics discussed/ Presented	KPI
Economics	-	Time efficiency	-	**Time on site**
	Product cost	Cost efficiency	-	**Product cost**
	-	Lead time	-	**Manufacturing time**
	-	Productivity/Innovation	%PMV	**PMV**
	-	-	Developer savings	**Maintenance cost**
	-	-	Cost comparisons	**Bill of quantities**
	-	-	User savings	**Cost of use**
Environmental	-	Waste management	Waste management	**Construction waste**
	-	Compliance/certification	Durability	**Service life**
	-	-	Operational energy	**Energy efficient benchmark**
	Embodied carbon	Reduced embodied	-	**Embodied carbon**
	-	carbon	-	**Trucks on site**
	-	Transportation	-	**End of life recyclability**
	Adaptability	Circularity	-	**Design for adaptability**
	-	-	-	**Design for deconstruction,**
	-	Circularity	-	**reuse and recycling**
	Certification	-	-	**Sustainability credentials**
		-		
Social	Education, training,	Labour shortage	-	**Job prospects**
	upskilling	Improved health & Safety	-	**Health & Safety**
	-	Workplace conditions	-	**Place of work**
	Diversity	-	Construction	**Disruption to community**
	-	-	disruptions	**Localised economic activity**
	-	Enhanced quality control	Local materials/labour	**ISO 9001**
	-	Quality	-	**Build quality**
	-	Quality	-	**Aesthetic quality**
			-	
Viability	Compliance/certification	-	-	**No. Stories compliance**
	Compliance/certification	-	-	**Warranty and guarantees**
	Long lead times	-	-	**Lead time**
	-	-	Specialised/shared	**On-site plant hire/**
	Transport	-	equipment	**Collaboration**
	Ability to deliver	-	-	**Product dimensions**
	-	-	No. units produced a	**Capacity**
	Compliance/certification	-	year	**Certification**
	-	Economies of scale	-	**Repeatability/standardisation**
	-	Economies of scale	-	**Scalability of design**
	Digital transition	-	-	**Digital technologies**
			-	

Table 5 above showcases the correlation between the KPI list and the stakeholder engagement process confirming the metrics used in the tool collected from the stakeholder's engagement process. The column marked 'Topics discussed/ presented' relates to additional topics discussed from the interview analysis. These are direct suggestions from the stakeholders that are not barriers or benefits, but metrics the tool should incorporate.

7. Conclusion

Recent publications such as the DHLGH's Housing for All Report (2023) recommend Modern Methods of Construction as the most viable pathway towards cost-efficient housing that meet national delivery targets (Department of Housing, Local Government and Heritage, 2021)**.** However, as shown above, opinions are divided on whether MMC is more cost-efficient at present. Despite that, the benefits of MMC generally outweigh the barriers, particularly when investigating the environmental benefits of MMC where it is generally understood that MMC is more sustainable than traditional methods. In that regard, MMC is shown to be more energy efficient, more circular and contain less embodied carbon which aligns with the requirements set out in the Climate Action Plan 2024 while also aiding to the levels of comfort for the homeowner (DECC, 2023)**.** Such benefits showcase that MMC is a building typology suited to adapting to climatic changes by reducing its environmental impact.

However, impeding such benefits is the consistent levels of confusion over what MMC is, which is leading to increased hesitation of its use. The lack of knowledge and understanding of the potential benefits has been found to be a major obstacle to the success of MMC.

The stakeholders demonstrated that there are a multitude of factors that must be taken into account when deciding a project's construction typology. This papers showcases the need to develop an unbiased, open-access decision-support-platform to incorporate all benefits and barriers of MMC inclusive of all assessment headings, rather than focusing on a single metric. The interviewees confirmed that if a support tool was available, perceptual barriers could be alleviated as the benefits would be demonstrated to the user.

The findings from this paper will be incorporated into a prototype of the tool to help resolve confusions about MMC and direct the tool's user to the optimum MMC system given their project needs and priorities. This will allow users to assess the suitability of different MMC types based on economic, environmental, social and viability indicators evaluated against the KPI's identified in this paper. MMC requires consistent, updated coordination across industry practices and government policies to roll out the full potential of newly innovative methods of construction. Stakeholder engagement will continue throughout the remainder of the project in order to remain up to date with industry and governmental policies on MMC adoption.

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