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How modern methods of construction would support to meet the sustainable construction 2025 targets, the answer is still unclear

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ABSTRACT

The United Kingdom (UK) construction industry is world renowned for its volatile boom and bust cycle, its inefficiencies, heavy environmental impact and recurring budget and programme overruns. The Construction 2025 Strategy was published by the UK Government and industry leaders with a vision of changing the industry for the better using four key targets i.e., reduction in construction projects duration, operational cost, level of greenhouse gas emissions, and import/export trade gap. This paper investigates whether a greater uptake in modern methods of construction (MMC) could help us achieve these targets. Key insights and findings from the existing literature on MMCs cost, time, greenhouse gas emissions and trade factors were analysed with strong indications of MMCs benefit to the targets. By using snowball sampling a quantitative survey was conducted on 134 professional working in the Architectural, Engineering and Construction sectors of UK with 23 questions on the four key targets. Cronbach's Alpha and Pearson correlation analysis techniques were employed in conjunction with factor ranking to determine the internal validity, factor links and most important factors. The results showed that the majority of respondents believed that MMC could help us achieve the construction 2025 targets, with a similarity index ranking revealing that MMC would be of the most benefit to the greenhouse gas emissions and trade targets, however, all factors ranked tightly together. This body of research will benefit the UK Government, construction associations and industrial key stakeholders in their pursuit of reaching the reduction targets, and with only three years until the deadline, there is a strong chance they will promote MMC in the industry.

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1. Introduction

The construction industry is one of the most inefficient industries in the UK due to its low profitability, skill shortages and lack of investment in research and development [50]). Despite this, the UK the industry contributes £110bn annually to the economy's Gross Domestic Product (GDP), 40% of its annual turnover is from government investment and the government is a key employer and client of the industry (Cabinet [8]). It employs 10% of the UK workforce at over three million people and is set to grow by 70% between 2020 and 2025 [39]). Construction is however extremely volatile, as t is characterised by low profit margins and being the first to suffer and the last to recover from an economic downturn [48,33]. The number of houses being built has continued to fall against an ever-increasing demand from the 1960′s to present day (ODPM, 2005 [44]). Several government-backed reports into the construction industries problems have highlighted these issues and aimed to improve the quality and efficiency of the industry [2,29;13]however little change has been implemented. The most recent of which is the Construction 2025 Strategy [21].

Construction 2025 is a UK Government and industry backed strategy to improve the construction industry by the year 2025. Construction 2025 Strategy sets out the change that the government and industry leaders want to see in the five most crucial

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areas; People, Smart, Sustainable, Growth and Leadership. It asks for construction to become; 1. An industry known for its talented and diverse workforce. 2. An industry that is efficient and technologically advanced. 3. An industry that leads the world in low-carbon and green construction projects. 4. An industry that drives growth across the entire economy. 5. An industry with clear leadership from the construction leadership council [21]. To achieve these feats, Construction 2025 Strategy sets out an action plan split with forty-three specific actions, those most relevant to this research project are; 2. Adopting BIM and exporting BIM services. 5. Investing in low carbon technologies. 15. Driving up safety standards on smaller projects. 40. Promoting Innovation [21]. Construction 2025 Strategy sets out four improvement targets for the industry to measure progress of change. The targets are; 1. A 33% reduction in cost of construction and in-use maintenance, 2. 50% reduction in project duration., 3. 50% reduction in greenhouse gas emissions and 4. 50% reduction in the trade gap between imports and exports of construction products, materials and services [21].

Modern Methods of Construction (MMC), also widely known as 'Off-Site Construction', have been in mainstream use since 1945, prefabricated housing was the only solution to rapidly replace the 475,000 homes that were destroyed during the second world war ([58]). MMC involves using prefabrication in environmentally controlled factories for 75–95% of a built assets' construction ([47]). The most common types of MMC used in industry are modular/volumetric construction, panellised construction, prefabrication, pre-assembly and off-site manufacturing and production ([40]; [7]). MMC is regarded as a promising new technology in the construction industry, however, conventional construction methods still dominate the industry [31].

Construction is historically one of the most volatile industries in economies the world over [56,35]. It employs circa 10% of the working population and contributes around £90bn of Gross Domestic Product (GDP) per annum to the UK Economy [11].). It is characterised by its low profit margins, being driven by low quality and high quantity output, low levels of communication between stakeholders, low uptake of technology, complex legal disputes and many more (Mills, 2015). It has also been found to be one of the least efficient industries in many first world countries [56].).

The year of 2025 is only three years away, and the key targets of the Construction 2025 strategy are becoming increasing important. The economic pressures brought on by the industries' volatility, the COVID-19 pandemic and the UK's departure from the European Union have caused significant drops in revenue for all sectors and 33% of firms surveyed by the Centre for Economic Performance reported increased costs or prices as a result [32]). Issues regarding greenhouse gas emissions are becoming increasingly vital to humanities survival due to climate change induced wildfires, floods and droughts across the world [49,36]. We are in desperate need of a rapid solution, an approach that is already used in the industry would be of the greatest advantage. One that provides cost, time and emissions reductions as well as a potential for increasing exports in the construction industry would be of the greatest benefit [34].

The main aim of this project is to investigate academic and industry opinion on whether a greater uptake of modern methods construction can help us achieve these targets. These research aims then generate the following research questions which were investigated in this study:

1. Does MMC reduce project duration when compared to conventional construction methods?
2. Does MMC reduce project and operational costs of built assets when compared to conventional construction methods?
3. Does MMC reduce greenhouse gas emissions when compared to conventional construction methods?
4. Could an increase in MMC manufacturing in the UK reduce the import/export trade gap?

This research has focused on the four key targets of cost, time, greenhouse gas emission and trade gap reductions as these are the most concise targets in the Construction 2025 strategy and can be investigated in the time period provided for this research. The MMC were also investigated in this research in its entirety, examining literature and data on different types of MMC used in the industry in relation to the four key target topic areas. To investigate the above research questions, each research question have its own section in the existing literature review along with a dedicated section for the Construction 2025 strategy report. The research questions werealso be expanded on and used in the structured survey later in this paper. The next section contains the literature review, followed by the methodology section. Section 3 details the research philosophy, method and research design. The results and data analysis are contained in section 4 with a Factor analysis and Pearson correlation analysis techniques, followed by the Results, Discussion and Conclusion in sections 4, 5 and 6 respectively.

2. Literature study

The literature review findings for the current research into MMC stems across seventeen years between 2004 and 2021. The most prominent research locations are Australia, Hong Kong, Canada and the United Kingdom. The most discussed topics within the MMC field concern its carbon footprint, carbon embodiment, high initial capital investment and comparative life cycle assessments of MMC vs conventional construction methods ([47,20,51,26].

2.1. The construction 2025 Strategy

The Construction 2025 Strategy was published in 2013 [21]. According to Mills (2015), it was widely ignored at the time of release and therefore has little academic research surrounding it specifically. As the Construction 2025 Strategy is comprised of a seventy-six-page report containing many references to government statistics reports, the researcher feels it must be analysed further. There is little academic research on the strategy itself. In his briefing document on the Construction 2025 Strategy, Hansford [18]claims that people are at the heart of the construction industry and are crucial to helping us achieve the Construction 2025 targets.

The elements of greatest importance in this research are the four key targets outlined in the construction 2025 report. The first target is to reduce the cost of built assets by 33% both during construction and when in operation, this target is based on the 2009/10 benchmarks in the 2011 Government Construction Strategy [21]. The benchmarks used to create the cost reduction target are not defined in the 2011 Government Construction Strategy, instead the report states numerous guidelines for creating cost benchmarks (Cabinet [8]. For example, the aforementioned report states "Cost benchmarking will be established to provide a consistency of value for money across each programme and a baseline for new cost/value-led approaches to procurement. ... Cost benchmarking should not be restricted to construction work. It should cover all project on-costs (consultants' fees, departmental administrative costs, etc) so that the efficiency of total project delivery cost is also plotted." (Cabinet [8]11).

The second target of reducing project programme durations by 50% is based on the industry performance of 2013 as reported by

the Office for National Statistics [21]. Upon examining the statistics of the construction industry in 2013, the research could not find a definitive project duration benchmark. However, if we take the approach of deducing the total number of completed projects in a given year, we can compare 2013 with 2021's outputs. According to the Office for national Statistics [42,43] in the Monthly All Work Index Fig. 1 below, the construction index was 79.5 in July 2013 and reached 94.9 in February 2021.

The third target of reducing greenhouse gas emissions by 50% is based on the 1990 industry benchmark as set out in the Low Carbon Routemap for The Built Environment [21]. According to the 2018 UK Greenhouse Gas Emission report, the UK was emitting 800 metric tones of carbon dioxide equivalent, this figure came down to 451 metric tones in 2018 (see Fig. 2)[9].

The last target of reducing the trade gap between imports and exports of construction products and raw materials is based on the Office for National Statistics monthly report: building materials and components - February 2013 report, with figures showing £12bn imported and £6bn exported (see Fig. 3) (ONS, 2013;[21]. In their June 2021 Monthly Statistics report on Building Materials and Components, the Department for Business, Energy & Industrial Strategy published the following chart displaying the quarterly import and export data for the UK's construction materials.

It shows that the 2018 imports were at circa £18bn and the 2018 Exports were at circa £6bn. It also states the 2013 exports were at circa £4.5bn, contradicting the £6bn states by the two previous sources.

2.2. Project costs

A study by the British Research Establishment in 2007 found that the industrial facilities that fabricate MMC Modules require significant initial investment to set up the production lines, machinery and to train employees in the innovative new methods of construction ([7,14]. These findings are supported in a study by the National Audit Office of the United Kingdom into how MMC can build more efficient housing in a shorter time ([40]). The study also found that MMC fabrication facilities require large fabrication yards to construct the modules prior to site installation and therefore an increased operational cost ([40]).

Rahman's [51]study into the barriers of implementing MMC in the construction industry found that MMC offers many benefits to the industry, however the uptake at that time was low. He also found that the factors most impeding implementation were high initial capital cost, traditional procurement methods causing contractual blockades in projects and many more. The data from his structured survey on 160 AEC professionals in the UK and China showed that less con census in what was considered 'important factors' in larger companies than smaller ones, leading him to find that this was to the benefit of MMC as smaller companies are

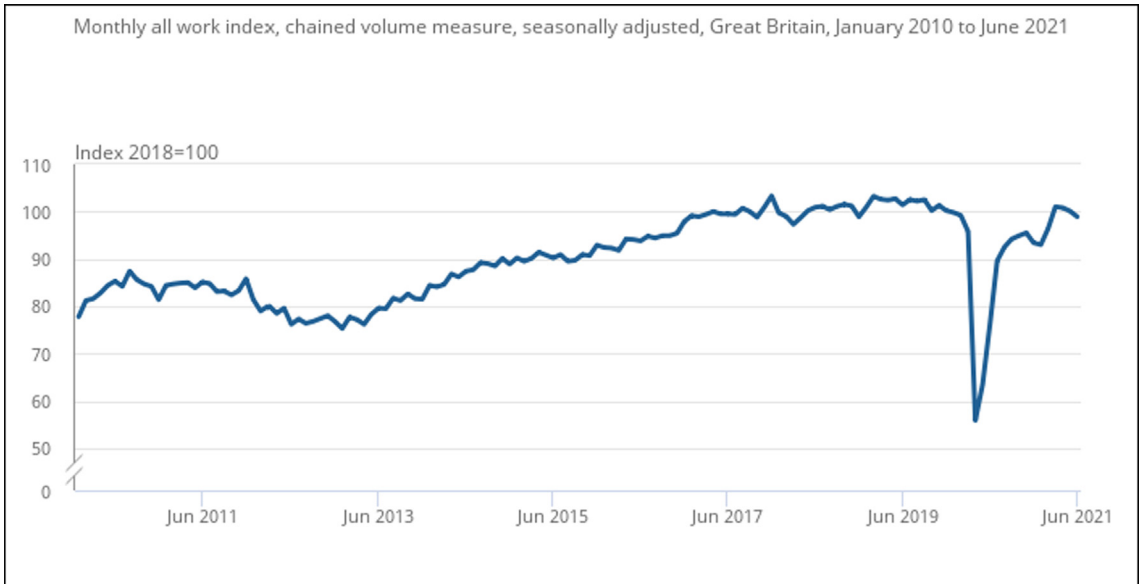

Fig. 1. Monthly Index of Construction Output and Employment. January 2010 to June 2011. *Source: Department for Business, Energy & Industrial Strategy (2021)* [10].

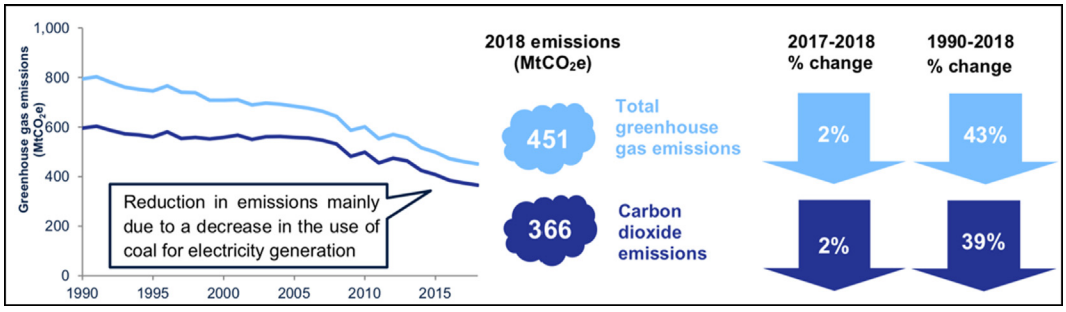

Fig. 2. 1990 vs. 2018 UK Greenhouse Gas Emissions. Source: Department for Business, Energy & Industrial Strategy (2018).

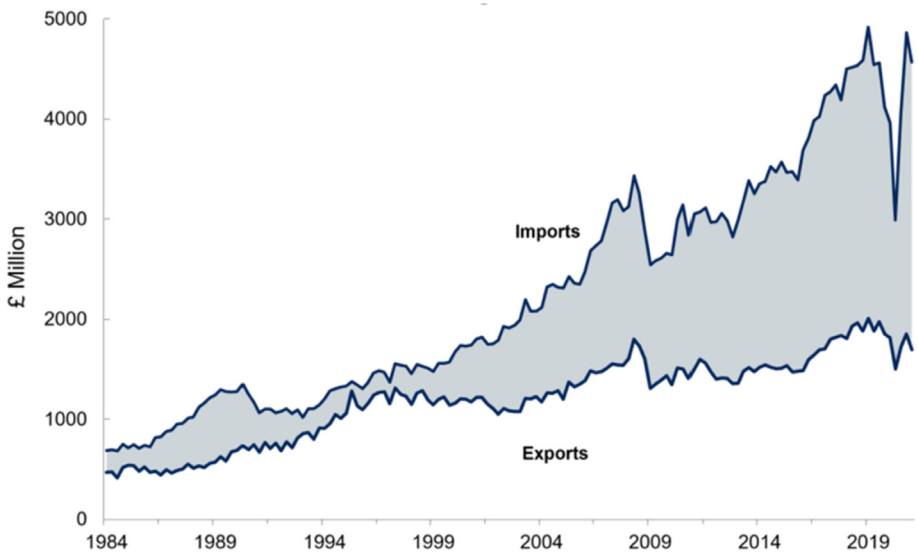

Fig. 3. Quarterly Exports and Imports of Construction Materials, UK. Source: ONS (2021) [43].

sub-contracted by the larger companies to complete the project tasks.

However, Rahman's [51]) findings were collected prior to the UK governments 2016 mandate, this made BIM Level 2 a requirement by law for all government projects over £2m [25]. As BIM and MMC are closely linked and can be applied together to maximize profitability for the construction industry [60]; [29]), the UK BIM mandate may have had a positive effect on MMC uptake. A study into the BIM uptake of 2017 by Ghaffarianhoseini et al [15], stated that the UK BIM implementation was at 39%. In their 2020 BIM Report, The National Building Specification [41] found that the implementation had risen to 73% of the industry.

Since Rahman's [51]study which found that traditional procurement methods were a major barrier to MMC implementation, there has been research conducted into the most appropriate procurement methods for MMC [38]. Molavi and Barral [38]found that in the most ideal scenario, a procurement method in which the MMC contractors and suppliers are involved throughout the design phase is the most appropriate option. This is because it ensures that the fabrication, transport and installation of the modules occur in a cost and time efficient manner [38]. This suggests that using a Design & Build procurement method in which the contractor is involved from project inception to completion (Sacks et al., 2018), the procurement barrier could be eliminated from MMC implementation in the construction industry.

2.3. Project duration

On the subject of time and whether MMC can help us achieve the project duration reduction of 50%, there is much research to suggest it will. In 2004, Goodier and Gibb conducted a cross-industry survey on off-site technologies, they found that one of the main benefits of MMC was its shorter project durations. However, they also found that the perception of MMC was that its duration exceeded TMC projects due to the general lack of technological advancement and industry knowledge of the AEC industries (Goodier & Gibb, 2004).

This finding was strengthened by [47] in their study into the perspectives of UK housebuilders on the use of offsite modern methods of construction. They found that using MMC reduces project waste, duration, costs and environmental impact (Pan et al, 2007 [47]). Their methodology entailed a survey of the top 100 house builders in the UK by number of units built. Their findings also showed that one of the primary reasons contractors used MMC was for its quicker and shorter project programmes (Pan et al, 2007 [47]).

In their report on using MMC to build homes more quickly and efficiently, the National Audit Office [40] found that volumetric MMC can halve the onsite construction duration when compared to brick and block dwellings (see Fig. 4). Comparisons were also drawn against hybrid and panelised MMC solutions, both of which out-performed brick and block construction with noticeably shorter durations (NAO, 2005) [40].

In their report on using MMC to build homes more quickly and efficiently, the National Audit Office [40] found that volumetric MMC can halve the onsite construction duration when compared to brick and block dwellings (see Fig. 4). Comparisons were also drawn against hybrid and panelised MMC solutions, both of which out-performed brick and block construction with noticeably shorter durations (NAO, 2005) [40].

Time to weathertightness was also a highlighted by the National Audit Office [40], they found that all MMC project types could be weathertight in half the time it would take a conventional construction method project. Reducing the time to weather-tight duration is crucial, as water damage can cause major loss of time and resources on a construction site [54]. This is due to water damage requiring rework which requires the affected areas to be stripped out and re-constructed, which can significantly add to a construction programme and increase costs [30].

2.4. Carbon embodiment and greenhouse gas emissions

Monahan and Powell's [37] study into the embodied carbon and energy analysis of MMC over traditional methods involved three case studies of one MMC panelised timber three-bedroom house and two equivalent traditionally built houses in Norfolk, UK. Inventory calculations were used to calculate embodied carbon in materials and transportation using fossil fuels. They found that the MMC project had 34% less embodied carbon than both traditionally built houses.

Kamali, Hewage and Sadiq's [26] comparative cradle-to-gate study of TMC and MMC construction used a similar methodology to Mohanan and Powel's (2011) in which they compared one MMC project with two similar TMC projects. They supplemented

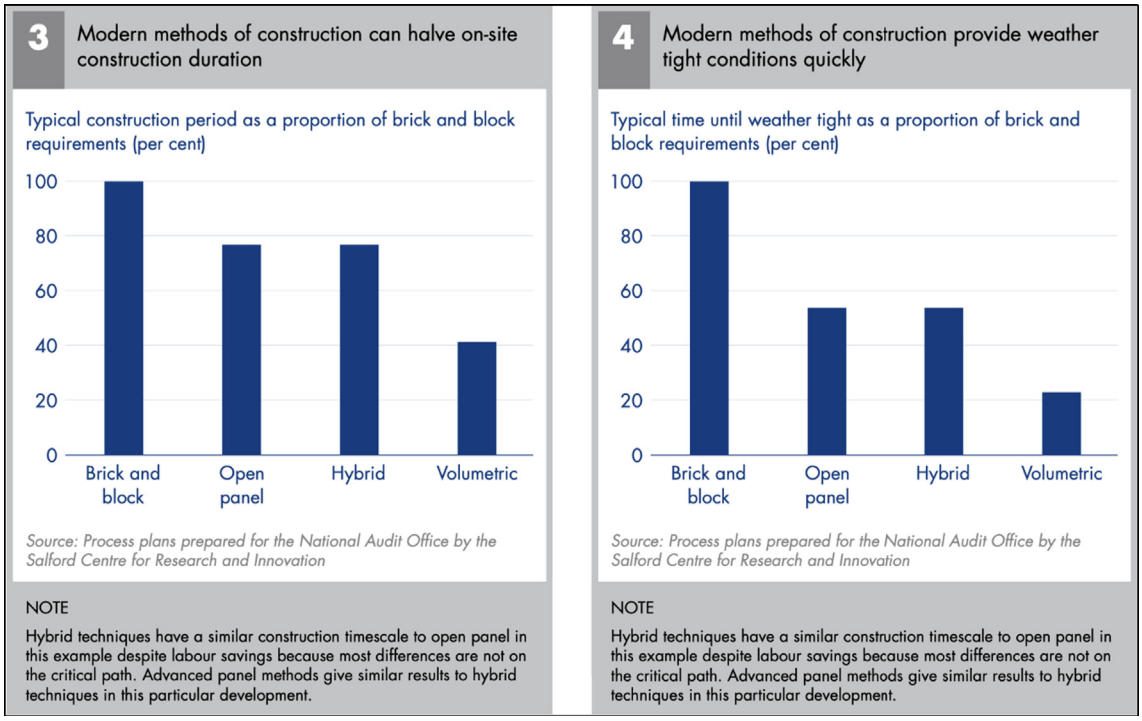

Fig. 4. Comparison of project durations for construction phase and weather-tightness for different methods of construction. Source: NAO (2005) [40].

their study with a structured survey given to all contractors to determine resource use. Their findings on embodied carbon and there being no superior methodology in terms of embodied carbon, were in line with those of Mohanan and Powel (2011). However, they also found that reducing the environmental impact in both construction methods relied on using an optimal design, reducing resource transportation in the project, and a greater uptake in MMC within the industry.

Hwang, Shan and Looi's [22]study into the constraints preventing the implementation of Prefabricated Prefinished Volumetric Construction (PPVC) used a structured survey targeted at 41 construction firms in Singapore to determine what was deemed to be impeding PPVC rollout in the industry. They found that this construction method required extensive design coordination prior to and during construction, additional project planning and detailed design, increased transport and logistical considerations, early client commitment and higher initial capital investment than traditional methods.

In their study into the sustainable benefits of prefabricated construction methods in Hong Kong, Jailon and Poon (2008) found that the environmental, social and economic benefits of prefabricated construction methods were far superior to conventional construction methods. This was further supported by Jaillon and Poon's (2009) study into quantifying the waste reduction potential of prefabricated construction methods, they discovered a 52% waste reduction when using modern methods of construction.

2.5. The Import/Export trade gap

Sun, Mitra and Simone's [56]study into the driving forces behind the construction industries boom and bust cycles in 48 mostly European countries revealed that construction economy crashes are determined by geographic, demographic and economic factors. They also discovered that the main precursor to a crash is when constructions share of GDP is higher than its normal percentage share [56].

Oh, Cho and Kim [45] conducted a study into using quality function deployment in conjunction with the TRIZ method to create an exportable modular construction system. Quality function development is a process in which the needs of the client are formatted into specifications which are then used to create a design using standardization of components [27]. TRIZ is a methodology of deriving creative ideas on new product development through inventive problem solving of contradictions in the design [1]. In combining these methodologies, OH, Cho and Kim [45] found that it was possible to create economically viable exportable modular construction modules by using the TRIZ-QFD methodology to balance the size of the modules and the high manufacturing cost. They also discovered that up to 30% of the construction value of an exportable modular construction project had to be spent on transporting the modules from the fabrication yard to the site [45].

In a construction project, raw and manufactured materials are used to construct the elements of the built asset such as steel for the structural elements and composite materials for the wall panels, systems components and many others [26]. The UK does not currently possess the expertise, knowledge, demand or economic advantage to manufacture every material and component it requires to assemble buildings of any construction method, as construction material imports are more than double construction exports (ONS, 2019).

Procurement is becoming increasingly difficult and costly with issues such as Brexit and COVID-19 causing worldwide supply chain issues and material shortages [3]. The UK Construction industries' afflictions from Brexit are partly due to the UK Government placing it in the low-priority category during trade talks with the EU [13].

2.6. Comparative analysis of the literature

The studies into modern methods of construction (MMC) have used a mixture of qualitative and quantitative methods. The most prominent methodologies used are case studies of live projects,

structured interviews and structured surveys. Rahman's [51]structured survey into the barriers of implementing modern methods of construction (MMC) is the most comprehensive survey has found in the field to date. Rahman's [51] structured survey uses statement-based questions with strongly agree to strongly disagree scales to determine the overall opinion of the participants on various barriers. Table 1 provides the literature review matric on the topic about MMC with its detailed methodology and findings.

Table 1
Literature Review Matrix.

Study	Main Topic(s)	Methodology & Sample	Findings
Goodier and Gibb[16]. Future opportunities for offsite in the UK.	Study into the options for implementing MMC in industry.	Comprehensive literature review followed by a structured survey of 75 UK construction organisations (39 clients, 13 contractors & 23 offsite suppliers and manufacturers.	A total of 40% of respondents had used volumetric MMC. Whereas 73% of clients and designers claimed they were aware of MMC pro's & Con's, compared to 54% of contractors. Less than 30% thought clients were aware of the pro's & cons. Increasing awareness required.
Pan et al. (2007) [47]. Perspective of UK housebuilders on the use of offsite modern methods of construction	Why housebuilders are reluctant to implement MMC in projects.	Structured interviews and Survey of AEC professionals in the top 100 UK housebuilders by unit completion.	Traditional drivers of time, cost, quality and productivity are still driving industry. The perceived higher capital cost, complex interfacing, long lead time and planning process are issues.
Hashemi.[20]. MMCs potential for solving the Iranian housing crisis.	Iran suffers from poor economy, poor quality construction and a housing deficit of 1 million + units per annum, can MMC help reduce it?	Comprehensive literature review of UK and Iranian academic and industry literature.Structured Survey on Iranian Architects.	MMC could help solve the Iranian housing deficit due to its reduced programme durations and higher quality assurance, enabling higher quantity and quality of housing units. However, Iran is prioritising quantity over quality, and not pursuing advances in modern construction.
Mohannan & Powell (2011). An embodied carbon and energy analysis of modern methods of construction in housing: Case study using a LCA assessment framework.	Comparing embodied carbon in a panelised low energy MMC project with two conventional projects of equal scope in Norwich, UK.	Case Study comparison using life cycle assessment framework of calculating material inventory and fossil fuel use from cradle to completion.	MMC project had 34% reduction in embodied carbon compared to conventional construction methods.
Sun et al.[56]. The Driving Force behind the Boom and Bust in Construction in Europe.	Shares of GDP in 48 predominantly European countries 1990–2011 in relation to Boom and Bust cycles.	Equation based research model using common factors such as time, geography, GDP compared with datasets of varying detail.	A precursor to an industry bust is a GDP exceeding its annual norms.
Rahman[51]. Barriers of implementing Modern Methods of Construction.	Study into why MMC uptake is low despite many benefits to the industry.	Structured Survey of 160 AEC professionals in the U.K. and China. Set of 29 statement-based questions with agreeability scales.	Cost is the most prevalent barrier and clients perceive fewer important barriers than consultants.
Molavi & Barral (2014). A Construction Procurement Method to Achieve Sustainability in Modular Construction.	A study into the most sustainable procurement method for modular construction.	A hypothetical case study analysis using existing literature on construction methods, materials and techniques.	Modular construction is most efficient when contractors, sub-contractors and suppliers are proficient in MEP service engineering and involved throughout the project including design stages.
Kamali & Hewage (2017). Development of performance criteria for sustainability evaluation of modular versus conventional construction methods.	Study evaluating the life cycle sustainability of different construction methods.	Literature review of environmental, social and economic factors & Structured Survey of AEC professionals analysed using Cronbach's alpha measure.	Economic factor is of most concern to the industry, followed by the social aspect of sustainability.
Oliviera et al.[46]. MMC modes of delivery in housing: Effects on Housing Association Clients.	Review of MMC applications in housing with regards to lending approaches, clients satisfaction and maintenance.	14 case studies of MMC projects and Semi-structured interviews with 15 Architects.	Cross Laminated Timber & Light Gague Steel fabrication preferred. Volumetric most efficient. Barriers of traditional procurement, statutory consent issues, inferior supply chain knowledge and collaboration reduce effectiveness of the delivery.
Hwang et al.[22]. Key constraints and mitigation strategies for prefabricated prefinished volumetric construction.	Study into the key constraints and solutions to prefabricated prefinished volumetric modules.	Structured survey of 41 Singapore construction companies & one case study	PPVC needs increased collaboration, coordination, longer more detailed design phases and integrated use of BIM throughout.
Kamali et al.[26]. Conventional versus modular construction methods: A comparative cradle-to-gate LCA for residential buildings.	Comparative Life cycle analysis of embodied carbon and energy use in Okhana, Canada.	Mixed Method 3 case studies, one conventional and two modular projects. Structured Survey given to contractor on material and worker transport.	MMC project 1 had lower carbon footprint than other two projects, however MMC project 2 had worst environmental performance so couldn't say which method was best.
Hammad et al. (2019). BIM-based framework to contrast conventional with modular construction methods through sustainability factors.	Proposition of an automated framework which helps decision makers select a suitable construction method based on specific social, environmental and economic factors.	Theoretical case study comparison of granny flat and a school building typology to find the most appropriate construction method for each typology using the proposed algorithmic framework.	MMC options on both projects outperformed the conventional options. Reductions of 56% and 31% in operation energy use, 53% and 61% reductions in embodied carbon were observed.

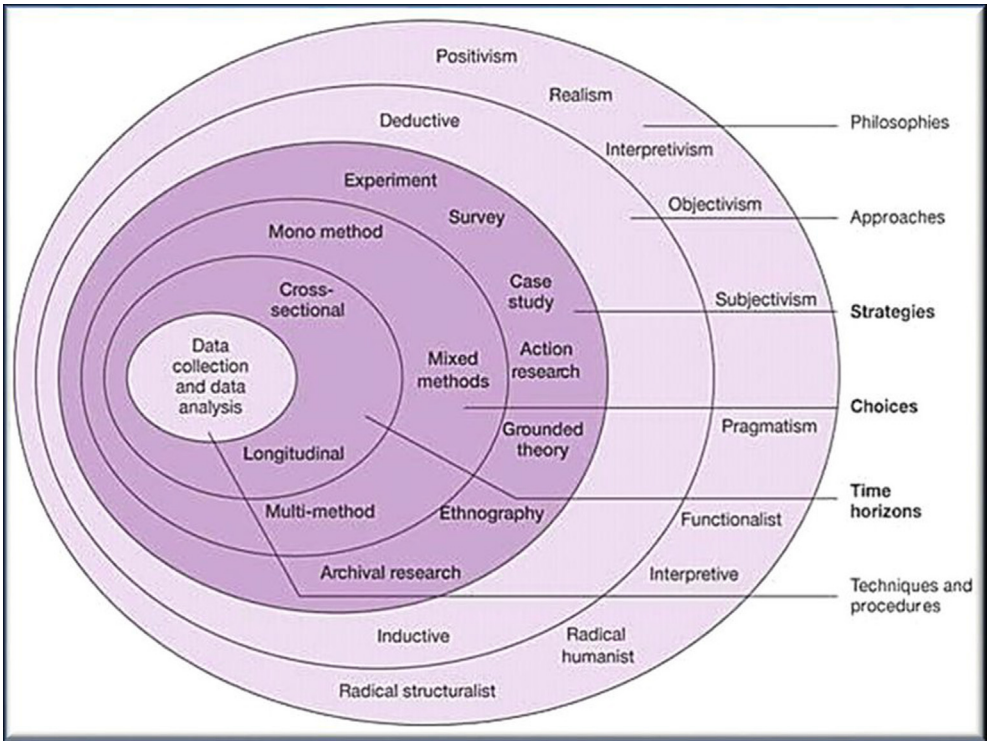

Fig. 5. The research onion. Saunders et al., (2012).

3. Methodology

3.1. Research philosophy

The researcher has chosen Saunders et al. (2012) 'Research Onion' to guide their research philosophy choices. Saunders et al.'s 'Research Onion' is a model for developing research strategies in the social sciences (see Fig. 5). It is supported by various leading social researchers [5,7;62]. The 'Research Onion' is comprised of six layers, the concept is that the researcher must 'peel' through each layer successively to arrive at a sound data collection that suits their research aims (Saunders et al., 2012).

As this study is concerned with constructing the built environment around us which requires the cooperation and collective opinion of the AEC professionals to be considered alongside empirical research into modern methods of construction, the researcher feels a critical realism epistemological approach is best suited to this project.

Pragmatism is a standpoint of philosophy which promotes the linking of theory and practice, it advocates that objectivism and constructivism are both valid and practical ways to approach research and can be used to find solution to problems (Saunders et al., 2012). The researcher has chosen to proceed under the advocation of pragmatism in this methodology due to the linking of theory and practice. This closely aligns with the research topics' reliance on both empiricism and opinion-based data collection detailed in later segments of this paper.

Bryman [5]states that there are two research approaches: Inductive and Deductive. Deductive research is such that the researcher gathers existing information on the topic, ascertains a pattern in the information, creates a tentative hypothesis and lastly produces a theory. A deductive is typically used in quantitative research and is best suited when there is much research in the field [5]. Thus, the researcher feels that a deductive approach is best suited to this paper as there is a significant amount of existing literature in the field.

4. Research methods

The literature review matrix in the previous section shows that research in the field of MMC centres on surveys and case studies. However, all surveys conducted were either in another country or surveying a different aspect of MMC such as its low uptake at that time [53,51]. The researcher feels that due to the short time scale of this research project and the prevalence of the COVID-19 pandemic, a questionnaire survey strategy was the best fit for this study. This because a questionnaire can gather responses remotely and in a larger sample than structured interviews and can be accessed remotely by all participants.

Time horizons in research projects fall into two categories: Longitudinal and Cross-Sectional [5]; Saunders et al., 2012). Longitudinal horizons involve collecting data at two different points in time to ascertain if there is a difference in the results, whereas cross-sectional horizons involve collecting data at a single short period of time. Due to the shortness of timescale provided for this project at just over three months, the research has chosen a cross-sectional time horizon.

4.1. Questionnaire development

The structure of the questionnaire survey has been into divided five sections. The first section determines the participants demographic, asking their vocational status, experience level, and if they had awareness of the construction 2025 strategy prior to their participation in this survey.

The next four sections contains questions pertaining to the four key themes of the construction 2025 targets: cost, time, greenhouse gas emissions and the import/export trade gap. All questions were the single choice, with the majority using agreeability scales in line with Rahman's [51]surveying technique. The researcher believes that accompanied with demographic data, this will allow for a greater depth of analysis than simple 'yes' or 'no' questions.

Table 2
Questionnaire Formulation.

Labels	Category/Topic	Key Supporting Literature	Number of Questions
D.1 - D.4	Demographics questions on Age, Profession.	N/A	4
M.1 - M.4	MMC Experience and opinion.	[16,20]	5
Tm.1 - Tm.3	Project Duration and factors affecting it.	(Pan et al., 2007 [47]), (Hwang et al., 2019)	3
Co.1 - Co.4	Cost related questions.	[16]), (Pan et al., 2007 [47]),[20,51]	4
Gh.1 - Gh.4	Greenhouse Gas Emissions and Carbon Embodiment.	(Pan et al., 2007 [47]), (Hwang et al., 2019)	3
Tr.1 - Tr.5	Construction Trade and Economy.	[51]	5

The Table 2 contains the survey set used for data collection in this project. Questions labelled with 'D' are demographic based questions, 'M' are MMC experience based questions, 'Co' are cost based questions, 'Tm' are time based questions, 'Gh' are greenhouse gas emissions based questions and 'Tr' are trade gap/export based questions.

The survey questionnaire contains a mixture of horizontal and vertical single choice questions. The researcher has chosen mainly horizontal questions with a Likert scale answering mechanism, the reason for this is that a questionnaire survey with mainly vertical questions can be susceptible to repetitive answering in haste and Likert questions provide a higher degree of analysis with regards to agreeability [5]. A selection of vertical questions are contained in the demographic question group at the beginning of the survey. All survey questions are closed questions, this ensures the responses are easily coded in the analysis section and do not veer outside of the scope of the research project [5].

Most of the questions have been designed by the researcher specifically for this project, based on the coverage of topics in the existing literature review. The researcher discovered numerous questionnaire surveys during the literature review with many relevant to the research aims of this project, the researcher has used some of these existing questions as indicated by the 'Source(s)' column detailing which studies and authors first designed them.

Table 3
Respondents' Demographics Data.

Demographic Variables		Frequencies	Percentages
Profession	Contractor	4	2.9%
	Project Manager	5	3.7%
	Site Manager	3	2.2%
	Design Manager	7	5.2%
	Architect/Assistant	21	15.6%
	Engineer	18	13.4%
	BIM Manager/Author/ Coordinator	23	17.1%
	Consultant	13	9.7%
	Quality Assurance	11	8.2%
	Researcher	23	17.16%
	Accountant/Assistant	6	4.4%
	Other	0	0%
	Total	**134**	**100%**
Age (Years)	18–25	35	26.1%
	26–35	22	16.4%
	36–45	20	14.9%
	46–55	28	20.8%
	56–65	24	17.9%
	66+	5	3.7%
	Total	**134**	**100%**
Industry Experience (Years)	0–2	19	14.1%
	2–5	14	10.4%
	5–10	15	11.1%
	10–20	25	18.6%
	20–30	32	23.8%
	30+	29	21.6%
	Total	**134**	**100%**

4.2. Population & sampling

The researcher has targeted a sample of professionals and researchers through snowball sampling in the Architectural, Engineering and Construction (AEC) industries, this was convenient due to the researcher being an active AEC professional and current researcher. The survey was accessed via an online survey site called Jotform.com., respondents were sent a link to complete the survey and submit their responses anonymously at a time convenient to them. The researcher was able to gather 134 responses from UK construction professional through snowball sampling, which was achieved by utilising the researchers' professional network of construction colleagues and university alumni. Respondents' information was treated confidentially and anonymously, with no personal information stored nor used in the data collection or analysis. All survey responses were stored securely on a password protected hard drive and was disposed of once the project is completed. The Table 3 shows the demographics of the sample:

4.3. Reliability & validity

To confirm the internal reliability of the data collected, the researcher conducted a Cronbach's Alpha measure of internal consistency on each factor category, this determines how closely related a set of items inside a category are related to each other (Bryman, 2014). The Cronbach's alpha conducted on all Likert scale questions used in this study produced the following values:

The Table 4 shows that the MMC, Cost, Duration and Time categories have strong internal consistency as their values are close to 0.7, which is regarded as a strong level of internal consistency (UCLA, 2021 [57]). The greenhouse gas emissions category has a low level of internal consistency, this may be due the questions not being explicit enough. However as all of 5 categories ascertained strong levels of internal consistency, it can be ascertained that there is consistent variance within the respondents.

Validity tests are an important part of any research paper. They help to determine whether the conclusions drawn from a research project are strong and trustworthy. The researcher has chosen Pearson's 'r' Correlation to determine the validity of the factors used and their association to one another for in-depth analysis in the data analysis and results section.

A Kaiser-Meyer-Olkin or Bartlett's Measure of Sampling Adequacy test was conducted to determine if the data gathered would benefit from factor analysis. The results showed that the measure

Table 4
Cronbach's Alpha Results by Factor Category.

Category	Cronbach's Alpha	No. of items
MMC Experience	0.868	11
Cost	0.684	4
Duration	0.645	3
Greenhouse Gas Emissions	0.506	3
Trade	0.551	5

Table 5
Kaiser-Meyer-Olkin and Bartlett's Test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.680
Bartlett's Test of Sphericity	Approx. Chi-Square	244.881
	df	120
	Sig.	$p \leq 0.001$

of sampling adequacy was 0.68 (see Table 5). Values close to 1.0 indicate a strong benefit from factor analysis [24]. This is also supported by the Sig. figure of 0.000, Grande [17]states that any value below 0.5 indicates a strong benefit from factor analysis.

Factor Analysis tests the relationships between the observed variables and the underlying theme used in a research project [55]. Factor Analysis can be used to determine if the observed factors have a relationship to the theory suggested in the research. In essence, it tests whether the designed questions have accurately measure the factors as it was intended them to measure [19]. Factors which have a factor loading above 0.5 will indicate a strong relationship to the factor or component shown [52]. The factor analysis results of this study are shown in the Table 6:

The Table 6 shows the factor loading for sixteen of the twenty-three questions listed in the questionnaire, the researcher focused on the factor-based questions and excluded the demographics questions. The component analysis indicates that the MMC factor is of greatest importance to the respondents, with the Cost and Time factors following consecutively.

5. Data analysis and results

The data analysis was undertaken using the popular IBM's Statistical Package (SPSS) version 26 for the Social Sciences. The researcher has chosen SPSS because it contains every analytical tool and model required to process the quantitative data gathered in this study [23,24] which will aid the results and discussion sections of this paper.

The results of this study analysed by topic area in relation to the construction 2025 strategy and MMC, this provides six categories of analysis: MMC, The Construction 2025 Strategy, Cost, Time, Greenhouse Gas Emissions and Trade. In addition to this, a correlation matrix and factor ranking similarity index were analysed to determine significant questions and factors.

Table 6
Factor Analysis Component Matrix.

Component Matrix[a]	Component				
	1	2	3	4	5
A greater uptake of MMC would benefit the U.K. Construction Industry.	0.717	−0.263	−0.065	−0.252	0.006
Projects using MMC require less time to build than Conventional Construction Projects.	0.718	−0.251	−0.164	0.286	0.145
MMC Projects require a longer design phase than Conventional Construction Projects.	0.623	−0.091	−0.381	0.175	−0.175
Lead times on material and product procurement can increase project duration.	0.406	0.647	−0.086	0.439	0.002
MMC can reduce project costs.	0.669	−0.022	0.427	−0.209	0.126
MMC Projects use less materials and resources than Conventional Construction Projects.	0.538	−0.219	0.468	0.084	−0.192
MMC Projects have higher initial costs than Conventional Construction Projects.	0.559	0.226	0.458	−0.118	0.019
MMC Projects are more difficult to finance than Conventional Construction Projects.	0.381	0.563	0.221	−0.350	−0.226
MMC Projects are more sustainable than Conventional Construction Projects due to reduced reduced waste and rework.	0.567	−0.605	−0.027	−0.012	0.146
Using MMC can reduce greenhouse gas emissions due to reduced site plant use.	0.461	−0.157	0.385	0.187	−0.142
Using imported product sis more harmful to the environment than using domestically produced products.	0.501	0.568	−0.039	−0.100	−0.294
Most Construction Products are imported in the U.K.	0.470	0.421	−0.302	0.400	0.124
Modern Methods of Construction can be exported.	0.468	0.203	−0.439	−0.513	0.223
Procurement Shortages caused by COVID-19 and Brexit will continue	0.351	0.121	0.255	0.166	0.754
Exporting products and services provides an economic benefit to U.K. Buinesses in the current climate.	0.473	−0.325	−0.086	0.210	−0.472
The demand for MMC is increasing.	0.621	−0.155	−0.458	−0.244	0.033

Extraction Method: Principal Component Analysis.
a. 5 components extracted.

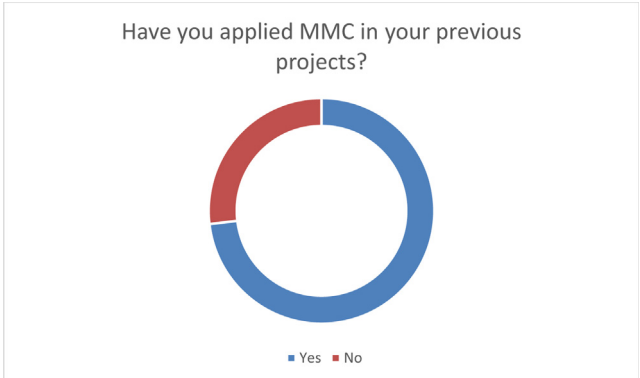

Fig. 6. Respondents use of MMC.

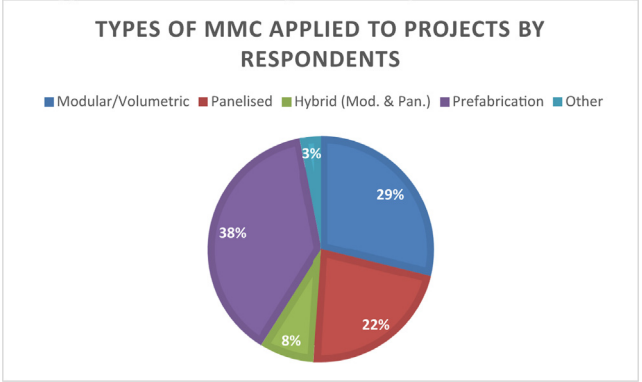

Fig. 7. Types of MMC used by Respondents with MMC Experience.

5.1. Respondents opinion on the use of MMC

The survey then asked the 98 respondents who said they had worked on projects using MMC which types of MMC they had used on those projects, and in which sectors they were applied. This data has been presented in Figs. 6 and 7 below.

Respondents were also asked whether they thought the demand for MMC was increasing (Fig. 8). Fig. 9 shows that the majority of the sample, 62.2%, strongly agreed with that statement. No respondents disagreed nor strongly disagreed.

5.2. Respondents opinion on the construction 2025 Strategy

Fig. 10 shows that 30.6% of respondents strongly agreed and 29.2% agreed that they were aware of the construction 2025 strategy. This indicates that the majority of the sample were aware of the construction 2025 strategy.

5.3. Respondents opinion on the project cost factor

Fig. 11 shows all four cost factor questions on a comparison line chart to demonstrate the correlation of agreeability within the factor. This shows that most respondents believe that MMC can reduce project costs, that it uses less resources, that it requires higher initial capital, and that MMC project are more difficult to finance than conventional projects.

5.4. Respondents opinion on the project time factor

A Similar trend of agreeability was discovered in the time factor variables. Most respondents agreed and strongly agreed that MMC projects could be built faster and that procurement could increase project duration. However, the opinion on the longer design phase duration of MMC was more mixed, with the highest percentage of respondents only agreeing with the statement (Fig. 12).

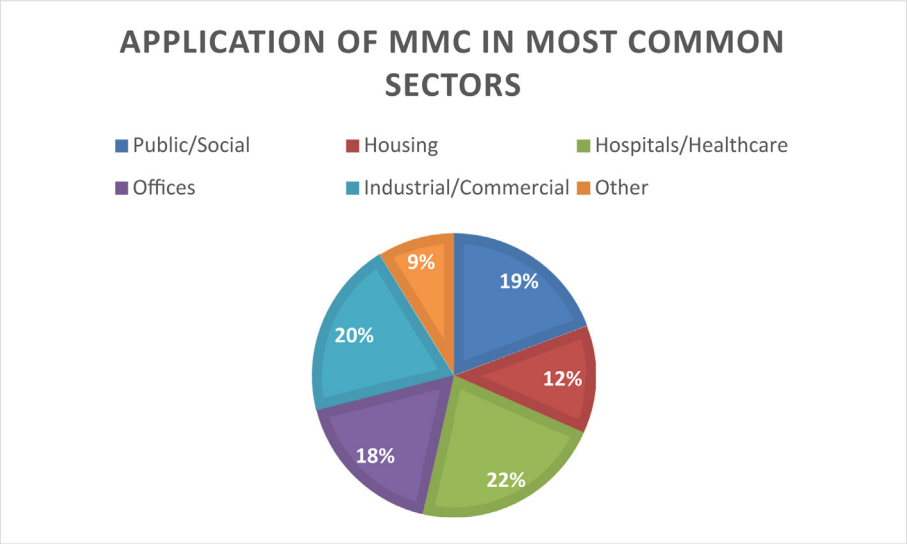

Fig. 8. Sectors of MMC Application by Respondents with MMC Experience.

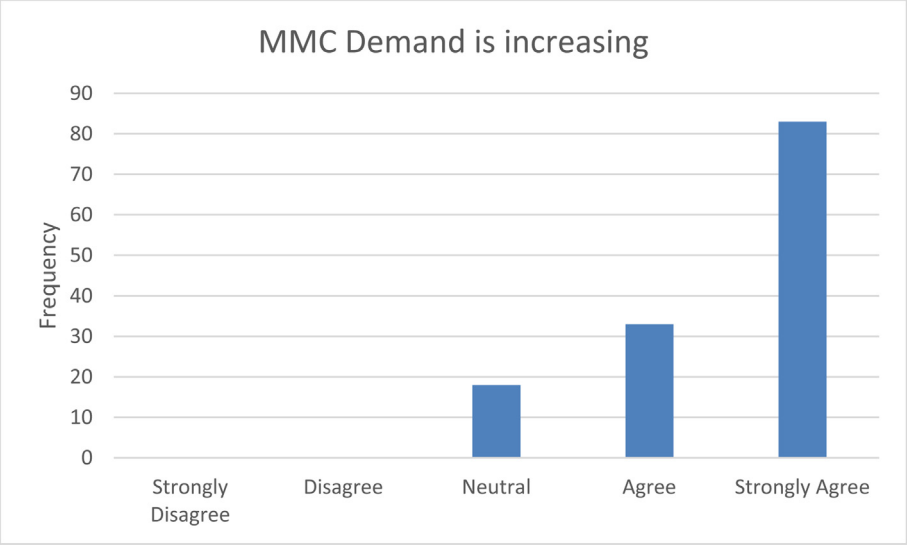

Fig. 9. Respondents Opinion on MMC Demand.

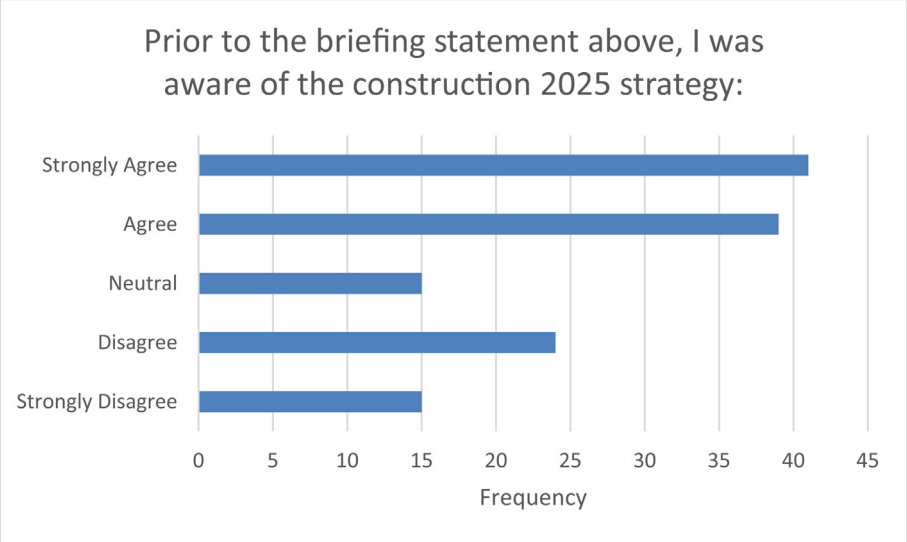

Fig. 10. Construction 2025 Strategy Awareness Analysis.

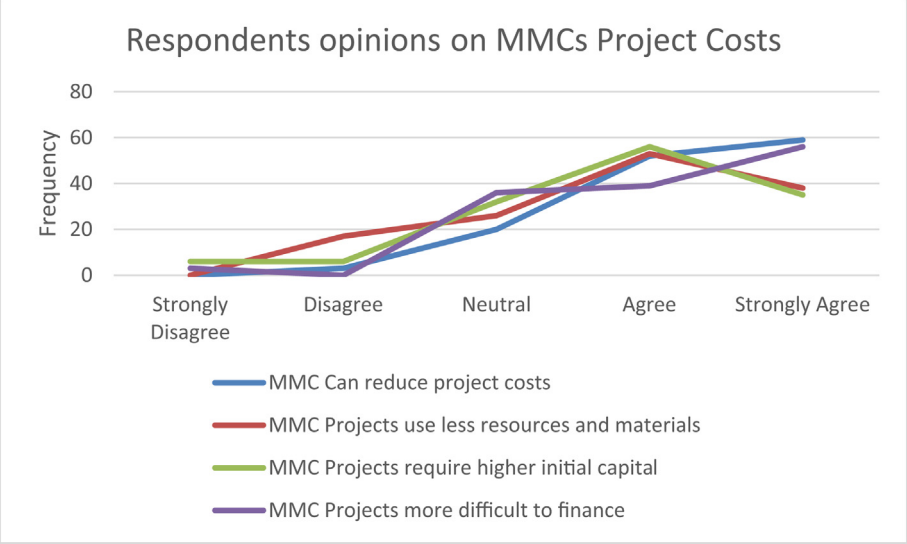

Fig. 11. Comparative Analysis of Respondents opinion on Cost variables.

5.5. Respondents opinion on the greenhouse gas emissions

Fig. 13 shows that the majority of respondents agreed and strongly agreed with all three greenhouse gas emissions variables.

5.6. Respondents opinion on the trade gap

The researcher has chosen to analyse the trade variables into two sub-factors: Import and Export. Fig. 14 shows that in their opinion, most respondents strongly agree and agree that Brexit and COVID-19 will continue to affect procurement. Most respondents also strongly agree and agree that most construction products are imported in the UK.

Fig. 15 shows that most respondents strongly agree and agree that MMC can be exported. It also shows that the majority strongly agree and agree that Exporting provides an economic advantage to business in the current climate.

5.7. Pearson's correlation matrix

In order to determine which factors correlate with each other, a Pearson's Correlation test was chosen. The researcher chose the Pearson method because it is the most widely used correlation statistic for measuring how well two linearly variables are related to each other (Bopko, 2001). Correlations with a significance value closest to 0.000 are of greatest importance, as this indicates a high significance. The higher the r value is, the stronger the correlation is between the variables [4]. The researcher selected all Likert questions in their survey and applied the Pearson's Method, Table 7 shows the results of the test:

5.8. Factor ranking index

A Factor Similarity index was conducted to determine the most and least prominent factors in the survey. The results show that

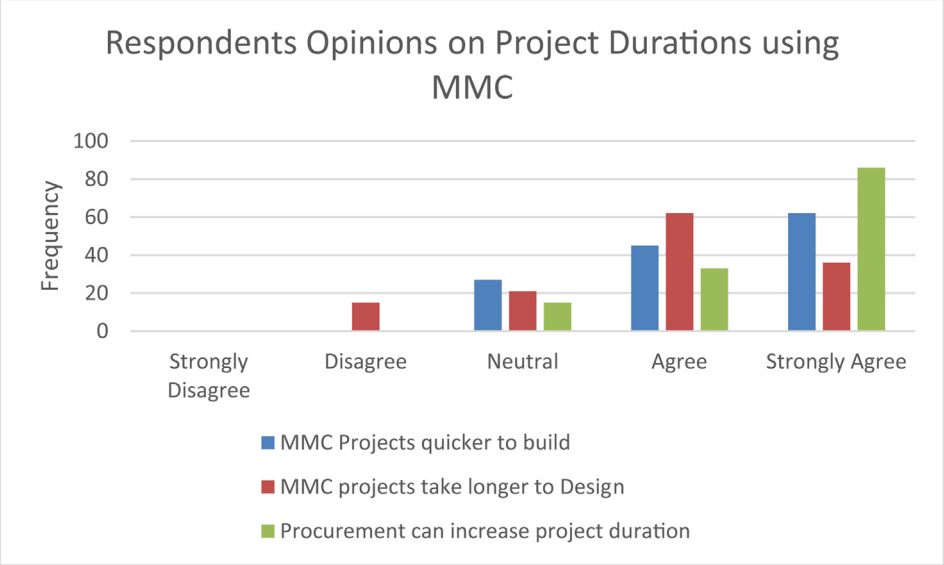

Fig. 12. Comparative Analysis of Respondents Opinion on MMC Project Duration Variables.

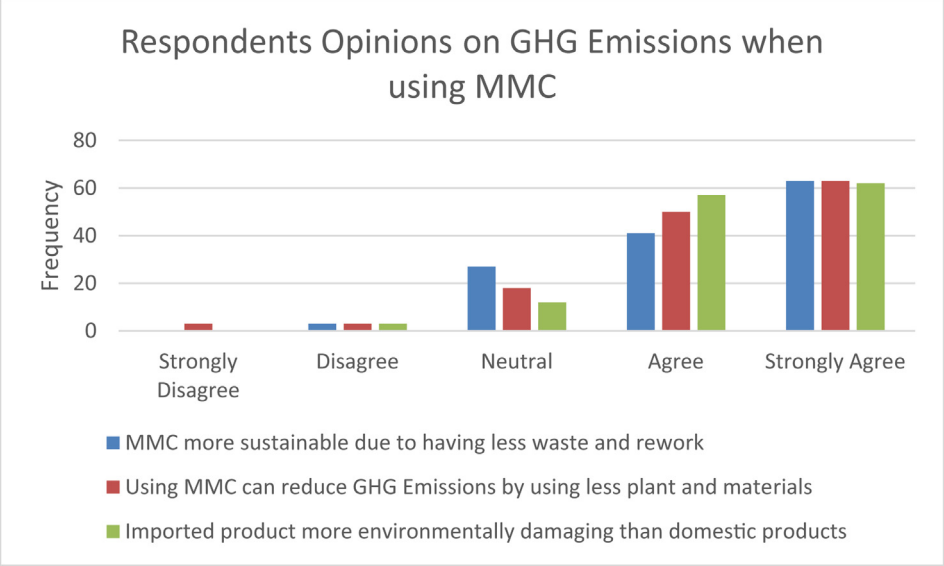

Fig. 13. Comparative Analysis of Respondents Opinions on MMC's Emissions.

the most important factor to the respondents was Trade (see Table 8). The Factor with the lowest average was the MMC Factor, which is due to this category having 'select all' questions. This caused a lot of 'No' responses which thereby reduced the importance of the category.

6. Discussion

The aim of this paper was to investigate whether a greater uptake in modern methods of construction could help us achieve the construction 2025 targets. The following sections details the links discovered between the research questions, key factors, most prominent variables and links to the existing field of research. The results indicate a potential for a greater uptake of MMC to contribute towards the 2025 targets.

6.1. Critical findings

6.1.1. Role of MMC in project cost reduction

The results indicate that MMC can reduce project cost, although it requires a larger proportion of project costs up-front, which the results also showed made MMC projects harder to finance due to the higher initial capital required. However, it was also found that MMC projects require less materials and resources which could potentially make MMC more cost-efficient. The cost factor ranked the lowest out of all factors in the similarity test which indicates it is the lowest priority of all factors according to the sample, with a mean average of 3.98 on a scale of 1 to 5. This contradicts findings from Rahman [51]who discovered that higher initial capital in MMC was a barrier, and therefore making cost of high importance. The Cronbach test of internal validity revealed a result of 0.684 for the cost factor, as this is close to 0.7 we can determine that the questions contained in the factor were a valid measure of cost.

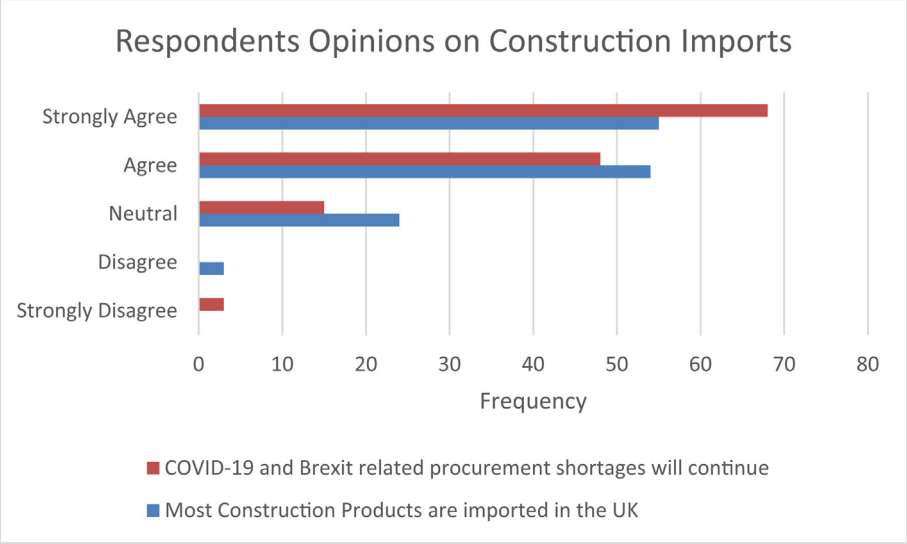

Fig. 14. Respondents Opinions on Construction Import Variables.

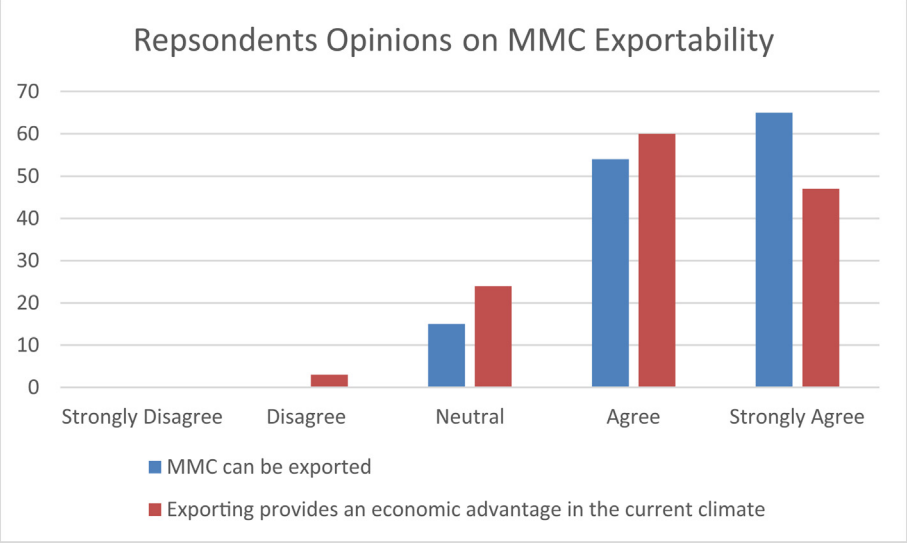

Fig. 15. Respondents Opinions on MMC Exportability.

6.1.2. Role of MMC in project time reduction

The data has shown that MMC can reduce project duration, this supports findings in the existing literature (Pan et al., 2007 [47]). However, it has also shown that procurement is necessary to sourcing resources to construct, and that procurement lead times can increase project duration. This suggests a potential loss of benefit; however, those procurement issues may also apply to conventional construction methods which would suggest there still is a time saving benefit to MMC. A correlation was found linking those who believed MMC reduced project duration, also believed that it required a longer design phase, this supports the graphical results analysis in the previous section. The most prominent correlation was that those who thought that a greater uptake of MMC would benefit the construction industry, also believed that it reduced project durations and costs (0.602 and 0.501 respectively).

6.1.3. Role of MMC in greenhouse gas emissions reduction

The indications are that MMC can reduce greenhouse gas emissions by using off-site prefabrication methods, however transportation of MMC may counteract any potential gains as responses indicated transportation used in imports made products less environmentally friendly. The reduced materials and resource findings suggest that MMC may be less impactful on the environment. This factor achieved a low measure of validity, scoring just 0.346 in the Cronbach test. The researcher believes this is due to some of the questions asking respondents opinions on dual factor 'X and Y' questions. This category was ranked second in the factor ranking index conducted, this indicates it is of high importance in the field of MMC and the Construction 2025 Strategy. This is supported by several carbon embodiment case studies investigated in this project (Mohannan & Powel, 2011;[26]; Hammad et al., 2019).

6.1.4. Role of MMC in trade gap reduction

The analysis indicates that MMC can help to reduce the trade gap in UK construction, most respondents believe that the current COVID-19 and Brexit induced procurement shortages will continue, however they don't believe this will hinder MMCs exportability. The Factor Ranking analysis conducted revealed mostly tight scores, the most popular factor was by far the 'Trade' factor.

Table 7
Pearson's Correlation Matrix – Part 1.

	D.4	M.1	M3.1	M3.2	M3.3	M3.4	M3.5	M3.6	M.5	T.1	T.2	T.3	Co.1	Co.2	Co.3	Co.4	Gh.1	Gh.2	Gh.4	Tr.1	Tr.2	Tr.3	Tr.4	Tr.5
D.4	1	-0.516**	-0.347*	−0.239	-0.430**	-0.350*	−0.234	−0.190	0.468**	0.478**	0.272	0.135	0.224	0.175	0.065	0.206	0.248	0.256	0.251	0.140	0.389**	0.274	0.144	0.511**
M.1	-0.516**	1	0.590**	0.405**	0.674**	0.539**	0.617**	0.322*	-0.343*	-0.404**	-0.308*	−0.176	−0.043	0.021	0.056	−0.111	0.020	0.099	−0.275	-0.324*	-0.337*	−0.119	0.026	-0.340*
M3.1	-0.347*	0.590**	1	0.207	0.696**	0.557**	0.245	0.333*	−0.253	-0.353*	−0.214	−0.082	0.050	0.027	0.004	−0.144	−0.059	0.135	−0.101	-0.340*	-0.440**	-0.299*	0.168	-0.324*
M3.2	−0.239	0.405**	0.207	1	0.118	0.268	0.177	0.218	0.174	0.046	0.023	−0.037	0.190	0.108	−0.070	−0.243	0.406**	0.126	−0.153	0.090	−0.263	−0.019	0.115	−0.077
M3.3	-0.430**	0.674**	0.696**	0.118	1	0.440**	0.378*	0.263	−0.276	-0.367*	−0.134	0.022	−0.025	0.091	0.068	0.058	−0.130	0.070	−0.102	−0.143	−0.103	-0.301*	0.192	−0.235
M3.4	-0.350*	0.539**	0.557**	0.268	0.440**	1	0.249	0.382**	-0.345*	-0.328*	−0.204	−0.217	−0.032	−0.046	−0.244	−0.249	0.024	−0.013	-0.327*	-0.418**	-0.360*	-0.336*	0.038	−0.263
M3.5	−0.234	0.617**	0.245	0.177	0.378*	0.249	1	0.416**	−0.286	−0.165	−0.171	−0.112	−0.220	−0.209	0.040	−0.140	0.006	−0.077	−0.142	−0.218	−0.152	−0.070	0.061	−0.109
M3.6	−0.190	0.322*	0.333*	0.218	0.263	0.382**	0.416**	1	-0.299*	-0.369*	-0.296*	−0.052	−0.257	−0.273	−0.093	−0.177	−0.177	-0.351*	−0.195	−0.216	−0.176	−0.106	−0.115	−0.083
M.5	0.468**	-0.343*	−0.253	0.174	−0.276	-0.345*	−0.286	-0.299*	1	0.602**	0.495**	0.064	0.501**	0.322*	0.289	0.192	0.469**	0.321*	0.229	0.115	0.352*	0.107	0.225	0.444**
T.1	0.478**	-0.404**	-0.353*	0.046	-0.367*	-0.328*	−0.165	-0.369*	0.602**	1	0.540**	0.277	0.305*	0.423**	0.202	0.029	0.491**	0.242	0.197	0.284	0.190	0.307*	0.311*	0.446**
T.2	0.272	-0.308*	−0.214	0.023	−0.134	−0.204	−0.171	-0.296*	0.495**	0.540**	1	0.304*	0.218	0.221	0.144	0.114	0.261	0.230	0.219	0.268	0.280	0.048	0.330*	0.450**
T.3	0.135	−0.176	−0.082	−0.037	0.022	−0.217	−0.112	−0.052	0.064	0.277	0.304*	1	0.234	−0.007	0.295*	0.306*	−0.167	0.128	0.443**	0.517**	0.093	0.192	0.033	0.147
Co.1	0.224	−0.043	0.050	0.190	−0.025	−0.032	−0.220	−0.257	0.501**	0.305*	0.218	0.234	1	0.433**	0.522**	0.275	0.430**	0.368*	0.297*	0.114	0.177	0.291	0.133	0.319*
Co.2	0.175	0.021	0.027	0.108	0.091	−0.046	−0.209	−0.273	0.322*	0.423**	0.221	−0.007	0.433**	1	0.321*	0.261	0.324*	0.338*	0.155	0.102	0.013	0.188	0.356*	0.107
Co.3	0.065	0.056	0.004	−0.070	0.068	−0.244	0.040	−0.093	0.289	0.202	0.144	0.295*	0.522**	0.321*	1	0.342*	0.124	0.318*	0.319*	0.149	0.130	0.302*	0.199	0.271
Co.4	0.206	−0.111	−0.144	−0.243	0.058	−0.249	−0.140	−0.177	0.192	0.029	0.114	0.306*	0.275	0.261	0.342*	1	−0.110	0.056	0.475**	0.187	0.297*	0.131	0.075	0.067
Gh.1	0.248	0.020	−0.059	0.406**	−0.130	0.024	0.006	−0.177	0.469**	0.491**	0.261	−0.167	0.430**	0.324*	0.124	−0.110	1	0.310*	−0.012	0.140	0.204	0.209	0.465**	0.409**
Gh.2	0.256	0.099	0.135	0.126	0.070	−0.013	−0.077	-0.351*	0.321*	0.242	0.230	0.128	0.368*	0.338*	0.318*	0.056	0.310*	1	0.143	0.132	0.046	0.090	0.193	0.065
Gh.4	0.251	−0.275	−0.101	−0.153	−0.102	-0.327*	−0.142	−0.195	0.229	0.197	0.219	0.443**	0.297*	0.155	0.319*	0.475**	−0.012	0.143	1	0.395**	0.330*	0.036	0.157	0.198
Tr.1	0.140	-0.324*	-0.340*	0.090	−0.143	-0.418**	−0.218	−0.216	0.115	0.284	0.268	0.517**	0.114	0.102	0.149	0.187	0.140	0.132	0.395**	1	0.329*	0.243	0.177	0.236
Tr.2	0.389**	-0.337*	-0.440**	−0.263	−0.103	-0.360*	−0.152	−0.176	0.352*	0.190	0.280	0.093	0.177	0.013	0.130	0.297*	0.204	0.046	0.330*	0.329*	1	0.169	0.031	0.489**
Tr.3	0.274	−0.119	-0.299*	−0.019	-0.301*	-0.336*	−0.070	−0.106	0.107	0.307*	0.048	0.192	0.291	0.188	0.302*	0.131	0.209	0.090	0.036	0.243	0.169	1	−0.034	0.061
Tr.4	0.144	0.026	0.168	0.115	0.192	0.038	0.061	−0.115	0.225	0.311*	0.330*	0.033	0.133	0.356*	0.199	0.075	0.465**	0.193	0.157	0.177	0.031	−0.034	1	0.361*
Tr.5	0.511**	-0.340*	-0.324*	−0.077	−0.235	−0.263	−0.109	−0.083	0.444**	0.446**	0.450**	0.147	0.319*	0.107	0.271	0.067	0.409**	0.065	0.198	0.236	0.489**	0.061	0.361*	1

Table 8
One Sample Similarity Factor Index.

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
MMC	**134**	**4.0450**	**0.55800**	**0.08318**
MMC1	134	3.51	1.392	0.138
MMC2	134	4.58	0.583	0.172
Time	**134**	**4.2296**	**0.61882**	**0.09225**
Time 1	134	4.27	0.780	0.116
Time 2	134	3.89	0.935	0.139
Time 3	134	4.53	0.694	0.103
Cost	**134**	**3.9833**	**0.67714**	**0.10094**
Cost 1	134	4.22	0.795	0.118
Cost 2	134	3.80	0.991	0.148
Cost 3	134	3.82	1.029	0.153
Cost 4	134	4.09	0.949	0.142
GHG	**134**	**4.2815**	**0.52202**	**0.07782**
GHG 1	134	4.22	0.850	0.127
GHG 2	134	4.29	0.787	0.117
GHG 3	134	4.33	0.739	0.110
Trade	**134**	**4.3022**	**0.46245**	**0.06894**
Trade 1	134	4.18	0.806	0.120
Trade 2	134	4.38	0.684	0.102
Trade 3	134	4.33	0.853	0.127
Trade 4	134	4.13	0.786	0.117
Trade 5	134	4.49	0.727	0.108

This could indicate construction prioritising business factors over environmental factors, however, the Greenhouse Gas Emissions factor was the second most popular. The correlation matrix also revealed that those who said they were aware of the Construction 2025 Strategy, also believed that MMC demand was increasing with an r value of 0.511.

6.2. Implications

The Variable correlation of Public and Hospital MMC implementation is a positive finding for the aim of this paper. Mills [39]stated that the UK Government is one of the biggest clients of the industry, and two of their largest project types are public and hospital facilities. The high initial capital requirement findings are in line with Rahman's [51]findings on MMC's barriers for implementation and Hashemi's [20]findings on applying MMC in Iran. The findings which show a reduction in greenhouse gas emissions are in line with several case studies conducted. Hammad et al (2018) found carbon reductions of 56% and 31% on their two MMC case studies against conventional projects of a similar type and size. This is supported by Mohannan & Powel (2011) who found a reduction of 31% on their case study project. On the factor of trade being the highest ranked by the sample, this is supported by Kamali & Hewage (2017) who found that the economic factor was most important to their sample.

6.3. Limitations

The COVID-19 pandemic has been non-discriminatory in its effect on the way of life for humanity. Researchers have had to adapt to new ways of working, such as working from home and utilising online lecturing softwares to provide and access learning materials. The requirement to social distance and to self-isolate if in close contact with the virus has meant that the vast majority of institutions and corporations have decided to cancel in-person meetings indefinitely, this has forced researchers to gather data on their samples remotely. This has increased the difficulty of gaining a large enough response rate for adequate data analysis. Although the researcher was able to gain 134 responses for their survey, this was only achievable by asking a sample population of over 600 professionals in the Architectural, Engineering and Construction sectors.

Due to the short time period of this research project, a convenience sample of 134 Architectural, Engineering and Construction (AEC) professionals, and researchers was achieved through snowball sampling. A larger purposive sample targeting professionals specifically in MMC Construction companies would be more advantageous. The short time frame provided for this project also meant that the researcher could only create, collect and analyse responses on 23 variables. The prevalence of the COVID-19 pandemic guided the researcher towards a quantitative survey, as it was not possible to interview people in person for health and safety reasons.

7. Conclusion and recommendations

This research project aimed to answer the question of whether a greater uptake of modern methods of construction could help us achieve the Construction 2025 Strategy Targets. Following a comprehensive review of the existing literature and a quantitative survey on the four key factors influencing the targets, it can be concluded that modern methods of construction will help us achieve the Construction 2025 Strategy Targets. The results indicate that using MMC can help reduce project cost, duration, greenhouse gas emissions and the import/export trade gap.

The researcher designed four research questions specific to MMC's influence on the targets, this was to ensure the strongest link to the aim in the paper's findings. The questions were then followed by a comprehensive literature review which was divided into the main factor of each research question: Cost, Time, Emissions and Trade. Key findings from the literature showed that no study had been conducted on MMC's influence over the Construction 2025 Strategy, displaying a strong gap for the researcher to explore. They also showed indications that MMC had reduced embodied carbon, project duration, higher initial costs amongst others which provided expectations for the data collection section.

The research method involved a quantitative survey conducted on 134 professionals, and researchers in the Architectural, Engineering and Construction sectors. The survey was divided into 6 categories: Demographics, MMC Experience, Project Cost, Project Duration, Project Emissions and Trade. This design was effective in linking to the research questions, however some questions contained two or more factors which reduced the validity of the survey. Results showed that the majority of respondents believed that MMC could reduce project cost, duration, greenhouse gas emissions and the UK Construction industries import/export trade gap.

Due to the time limits of this survey, not all factors could be fully investigated with only 23 variables used in the data collection portion of this survey. Further investigation is needed on the import/export trade gap factor, as analysis of the literature revealed that the global pool of economic data and knowledge was too vast to be fully investigated in this paper. Despite the limitations, there was a strong correlation of agreement on MMC's greater uptake helping to achieve the Construction 2025 Strategy Targets and that the key findings from this paper aligned with prominent sources in the existing literature, the researcher feels that there are strong grounds for practical implementation of a greater uptake of MMC in the UK Construction industry.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. . Additional information

Data collection Instrument: Questionnaire survey

Label	Question/Statement	Please Tick One/Agreeability	Key Supporting Literature
D.1	Please state your profession or most applicable.	Architect – Contractor – Site Manager – Project Manager – BIM Coordinator – Designer/Architect – Engineer – Consultant – Researcher – Other (Please State)	
D.2	Please state your age	18–25 26–35 36–45 46–55 56–65 66+	N/A
D.3	How many years of industry experience do you have?	0–2 2–5 5–10 10–20 20–30 30+	N/A
D.4	Prior to the briefing statement above, I was aware of the U.K. Government's Construction 2025 Strategy	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
M.1	Have you applied MMC in your previous or current projects?	Yes – No – Not Sure	[20,16]
M.2	If yes, what type of MMC have you worked with? Select all that apply.	Panelised – Volumetric/Modular – Hybrid (Mix of Modular & Panel) - Prefabrication	[20,16]
M.3	If Yes, what Sectors have you applied MMC in?	M.3.1 Public/Social M.3.2 Private Housing M.3.3 Hospitals/Healthcare M3.4 Offices M3.5 Industrial/Commercial M3.6 Other Sectors	[16,20]
M.4	How many projects have you implemented MMC in?	0 1–2 3–5 6–10 11+	[16]
M.5	A greater uptake of MMC would benefit the UK construction industry	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	(Pan et al., 2007 [47])
T.1	MMC Projects require less time to build than conventional projects.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	(Pan et al., 2007 [47]),[20]
T.2	MMC projects require a longer design phase than conventional construction projects	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	[20,22]
T.3	Lead times on materials and products procurement can increase project duration.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Co.1	Modern methods of construction can reduce project costs.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	[16], (Pan et al, 2007 [47])
Co.2	Modern methods of Construction use less materials than Conventional Methods of Construction	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Co.3	Modern methods of construction have higher initial costs than Conventional Methods of Construction	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	[20,51]
Co.4	Projects using Modern Methods of Construction are more difficult to finance than conventional construction projects.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	[20,51]
Gh.1	MMC projects are more sustainable due to reduced waste and rework.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	(Pan et al., 2007 [47])
Gh.2	Using MMC can reduce greenhouse gas emissions due to reduced site plant use.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Gh.3	Transporting MMC elements to site often involves long distance journeys.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	[22]
Gh.4	Using imported products is more harmful to the environment than using domestically produced products.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Tr.1	Most construction products and materials are imported in the U.K.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A

Data collection Instrument: Questionnaire survey (*continued*)

Label	Question/Statement	Please Tick One/Agreeability	Key Supporting Literature
Tr.2	Modern Methods of Construction can be exported.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Tr.3	Procurement shortages caused by COVID-19 and Brexit will continue.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Tr.4	Exporting products or services provides an economic benefit to UK businesses in the current climate.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	N/A
Tr.5	The market demand is for Modern Methods of Construction is increasing.	Strongly Disagree (1) – Strongly Agree (5): 1 2 3 4 5	Rahman[51]

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