

Implementing Modern Methods of Construction: Challenge in Construction Management in UK

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Abstract. State-of-art techniques and tools are contributing in construction sector in a great manner with never experienced efficiencies and effectiveness. The main aim of this study is to represent the research findings that investigated the boosting of Modern Methods of Construction (MMC) within the construction sector in the UK, and to reveal the challenges preventing the successful implementation of MMC within the industry. MMC is a traditional term used in ACE sector, originated after the world war 2nd with a commercial scale. Although the primary reasons for the uptake are due to the huge population growth, high housing demand that government could not meet, and government transfer the risks ventures to the private sector. The results from this study undertaken is that MMC provide the best quality and safety as compared to the traditional usage and that modern processes and technologies give the assurance of better quality that are now available. However, the findings also highlighted that a negative perception is still appeared in public about the implementation of MMC, which will need to be eliminated and a positive perception generated by the government for a win-win position for all construction professionals to be understood.

Keywords: Modern methods; UK; Modular; Construction; Challenge; Implementing.

1. Introduction

The definition of recent Methods of Construction (MMC) isn't well defined and established within the global construction by one term. While MMC represents a collective term of definition or description, usually refers because the techniques and tools which aren't traditional, old and inefficient with characteristics of innovative and state-of-art technologies. Now, the question is why construction introduce this MMC? The solution is to reinforce the development product and therefore the process in term of profitable for all stakeholders, ensuring standard

quality, increase customer satisfaction, adopt sustainability in construction project up to the limit, reduce the environmental impact and fork over the finished project on scheduled time and resources. If any organization want to adopt a state-of art MMC in their management system, a minimum standard of process, performance and production is required during this case (Pan, Gibb, & Dainty, 2007). It's seen from the previous experience that the MMC is obstructed by miss-concept speeded by media and it had been influenced to the implementation of more MMC for improving product and lifting up the profit level. It's not applicable for each organization, some construction firm who are renowned for innovating MMC, were ready to successful implementation of MMC and achieved the advantages. It's only happened because those firms got up their traditional process of working and took policy to adopt the MMC. On the opposite hand, some SME construction firms are beginning to use MMC but just for limited a part of their works plan or not with the complete swing. Now the key concern during this industry may be a sizable number of consultants are expressed their judgement to the support of MMC implementation by the development organizations. But the surprising thing is that the whole industry doesn't consider this recommendation of consultants and make a technique and policy to enhance the development sector by effective MMC.

In key housing industry reports (Durdyev & Ismail, 2019; Egan, 1998; Farmer, 2016), there's a persistent push for the utilization of MMC to enhance the method and minimize risks on projects. Currently, MMC is seen as a way to enhance efficiency, build ability, and considerably decrease overall works programmer. Many companies see MMC as a tool to extend housing output, however there are many emerging commercial solutions to large scale residential, healthcare and academic projects that some companies are yet to undertake as knowledge and inexperience with methodologies are still seen as a risk thanks to unfamiliar techniques.

The research undertaken consists of a literature review, which planned out the evolution of MMC, challenges, benefits and innovation of recent methods of construction. The key findings of the literature review were utilized in shaping the first research. The first research involves the case study review of key demonstration projects, also as questionnaire survey conducted within the industries of major stakeholders. The survey was analysed, and therefore the final section of the work may be a discussion on our findings, when all the research efforts are considered holistically.

2. MMC Systems Overview

The current trend of MMC development and its impact on the development industry from the literature review are discussed under following headings: Volumetric (Modular) Construction and Semi Volumetric (Pod) Construction.

Volumetric / Modular Construction

Modular Construction is usually mentioned as three-dimensional building under factory conditions, the whole building would be manufactured off- site under controlled conditions. It also can be defined as "units that enclose usable space, but don't themselves constitute the entire building" (Gibb, 1999).

Modular Construction entails; factory production of pre-engineered building units, these are then delivered to site and assembled to make the structure. This method normally has structural properties and may acts as a delivered JIT (Just in Time) solution.

Volumetric / Modular construction enablers

- Overall program reduction
- Repetitive building techniques
- Good price certainty
- Weather has little effect to planned activities
- Re-usability, (future relocation)
- Mechanical and Electrical (M & E) is plug and play philosophy mitigating commissioning processes

Usually around 90% of total construction is off-site and administered under factory conditions, this results in better quality, building performance and eliminates the snagging procedure, making the whole procedure efficient.

The main body of site work is assembly, and this is often administered in an accelerated manner compared to standard methods thanks to the standardized processes and repetitive nature of modular or volumetric construction.

Volumetric challenges

- Early collaboration for design purposes
- Design freeze, from a particular stage any changes after this point prove costly
- Accurate foundations usually 5mm tolerance of line and level
- Logistical constraints on
- There are a spread of manufactured materials wont to create

Material Variations include

- Light gauge steel framing
- Timber
- Concrete
- Hybrid composites (Knaack, Chung-Klatte, & Hasselbach, 2012)
- Semi Volumetric / Pod Construction

Semi volumetric construction would usually contain non-structural enclosable spaces like bathroom pods, kitchen pods or pre-finished plant rooms. These are used typically on student accommodation and commercial hotel schemes thanks to the repetitive nature of the bathrooms / service riser co-ordination.

Bathroom Pods would usually be delivered in clusters of ten, thanks to the dimensions and manoeuvrability of those prefinished modules, it's common practice to possess these delivered and positioned before the structure's envelope is progressed. Counting on the project, they will be positioned by means of crane or fork lift (Gibb, 1999).

Semi Volumetric / Pod enablers

- A good ideology for hotels and student accommodation.
- Pre-manufactured Plant rooms can save multiple trade congestion during the commission / execution phase of the project
- Mitigates the M & E sequencing constraints during construction
- Consistent quality
- High level of customer satisfaction (NHBC., 2006)

Semi Volumetric / Pod challenges

- Some pods need housing into the floor to make level access, this will prove difficult to accommodate in some scenario's
- Substantial repetition is required to make sure pods are cost-competitive with conventional methods of construction
- Design freeze, from a particular stage any changes after this point prove costly
- Some sequence of works will get to be planned differently and administered beforehand of normal timescales (for example fire Compartmentation)

As it is often seen from the above MMC literature, recent innovation in materials and construction technology has improved the standard of construction as compared to traditional approach that was previously not envisaged. This has been highlighted within the recent case study within the next section.

2.1. Illustrative case study: Kingston hospital

The client had an urgent need for a surgical block consisting of an additional 132 beds, planning permission was sought and received but just for the five-year duration, The Trust knew that to realize the project within this timescale, prefabrication would wish to be considered.

Kingston NHS Trust went out for competitive tender in September 1997; the project was awarded to Terrapin Prospex LTD for a capital value of £3.4 Million pounds. The trust worked directly with Terrapin to scale back the overall

construction period to 18 weeks (without increasing the original tender price). All tenders received from Principal contractors had scheduled the development programmer at 36 weeks; the request from The HNS Trust was an overall reduction in time-based construction operations by 50%. The project was to contain a three-story complex, with the utilization of "pre-engineered modular design" (Office, 2001). The accommodation was specified as "Five bed and single-bed bays, each with an en-suite bathroom. There are two assisted-use toilets and bathrooms on each floor. Each bed is served with medical gases and a nurse call system. The block had to supply all facilities one would expect during a normal hospital" (Ahmed, Islam, Hoque, & Hossain, 2018; Ahmed & Sobuz, 2019; Office, 2001).

This new hospital project used the Terrapin Matrix system, which may be a hot rolled steel frame with light steel secondary members. The modular elements comprise of toilet pods (i.e. differing types of toilet units) and plant rooms. The modular unit elevation also demonstrates the pliability of the modular system to accommodate a spread of wall finishes, cladding and architectural features (Rogan AL, 2000). All of those techniques are further reviewed in "Off-site Fabrication" (Gibb, 1999).

The Project commenced on the 14th of April 1998 and was handed over to the hospital on the 4th of September 1998 with an overall construction period of 20 weeks. The hospital was opened to patients every week afterward on the 10th of September 1998. End users had only three issues with the scheme post-completion, all associated with design issues, not a functionality of the modular bathroom pods. Terrapin had met their commitment and both parties were proud of the finished scheme.

2.2. Advantages in utilizing modular/ volumetric construction at Kingston hospital

Some of the teachings that came out from the case study highlighted above contain important advantages of using the MMC approach. Close and early collaboration between client and contractor resulted during good planning and adaptability during design stages. Both parties were committed to the success of the project. Terrapin saved on preliminaries and overhead forecasts for the initial 36-week programmer. The NHS Trust received the building for the initial Tender price and also had early possession thanks to their involvement with up-front planning and co-ordination of logistics with the prevailing live buildings. Components and modules adopted the "Just In Time" delivery practice, because the site was congested, the logistics were targeted as a risk and managed well from the offset by Terrapin LTD. Reduced disruption to the occupied buildings on the hospital campus, thanks to the utilization of modular innovations also leading to less on-site activity (modules were pre-finished right down to Mechanical and Electrical with minimal finishing trades needed). The benefits of the utilization of MMC were evident within the success of

this particular scheme.

The Construction industry has been directed to use MMC to enhance and de-risk projects. Currently, MMC is seen as a way to enhance efficiency, buildability, and considerably decrease overall works programmer. Many companies see MMC as a tool to extend housing output, however, there are many emerging commercial solutions to large scale residential, healthcare and academic projects that some companies are yet to trial as knowledge and inexperience with methodologies are still seen as a risk thanks to unfamiliar techniques. Within the next section, a primary survey is conducted with stakeholders to negate or reinforce a number of the findings within the writing within this section.

3. Research Methods

For the aim of this study, a mixed research methodology was used. The research design was in two stages. The primary targeted, 3-SMEs, and a quantitative questionnaire was sent to the three Small and Medium Enterprises (SMEs) who are specialist in MMC. This was supported the literature review information about MMC systems and experiences. The second stage was to send questionnaire bent the broader construction organizations. The questionnaire was distributed to the audience, which might have fortnight to finish and return the survey via the web internet tool adopted. The survey consisted of ten questions and targeting MMC methodologies and current usage of systems/processes. The sampling method for the quantitative study may be a quota sampling (C., 1952). The survey was distributed as widely as possible within the chosen organizations.

This data was collated by the web survey tool and analyzed after the deadline date. This study was aimed to possess over 30% responses for the questionnaire, of which can make inferences about large populations using relatively small samples of collected statistics. All responses are going to be industry based and within a little to medium organization.

Secondly, qualitative interviews were undertaken. The semi-structured interview was designed to determine different attitudes from construction professionals towards sorts of MMC not used before. The interview's questions were trying to extract relevant information and experiences about MMC and using the opinions and experiences of the interviewees to formulate data provided enablers or challenges for MMC. All interviewees were asked specifically due to their use of conventional and modern construction methods.

There are not any closely defined rules for the sample size in qualitative research within the literature. Sampling during this study was rather purposefully than randomly selected, as using initially small numbers of samples, seeking for richness of knowledge on the topic of 'MMC' with the aim to review in-depth and intimately the experiences of the experts in traditional modern methods of

construction. Sampling keeps going until the purpose of recognition that no new data are forthcoming. Information redundancy is then like data saturation and therefore the research continues to the purpose that no new information is heard of the interviews that are conducted (Patton, 1987).

The semi-structured interviews were conducted and therefore the employed interview technique was face-to-face, this gave participants enough time to process the question and answer to the simplest of their knowledge; also some opinions were likely to be very helpful to the aims of this study.

The interviews were conducted on live projects where the development professionals were working. A complete of eight people are asked to undertake an interview, of which seven had accepted. It's been assured that each one personnel undertaking the interview have had a least ten years construction management/procurement experience in both modern and traditional methods of construction. The semi-structured interviews undertaken for this study are analyzed with only manual content analysis. There have been six main questions/issues within the semi-structured interviews. The manual content analysis approach was adopted for analyzing the collected data and this approach allowed the researchers to objectively study the collected data and relate the findings to the aims and objectives of the study.

3.1. Questionnaire survey

Respondent profile data collection

This is important as this demonstrates to the audience that the collected information has been received from. As are often seen from Table 1 the bulk of respondents were Principal Contractor based 70%. For the aim of this study that's beneficial as principal contractors control what sort of construction method is procured and implemented.

The second question of Section 2 of the questionnaire survey was designed to capture the present position of the respondent, if position doesn't relate on to construction, this is able to make evident the respondents input would wish removing from the questionnaire to stay data at a continuing. 'Site Manager' were highest proportion of respondents (38%), followed by "Project Manager" (27%). this is often an honest set of data as site managers and project managers are more likely to be involved both conventional and modern methods of construction. Also, among the respondents, 19% were "Quantity Surveyor", 8% for every where Architect' and 'Managing Director.

Table 1: Respondents Characteristics

Role	%
Principal Contractor	70%
Sub-contractor	14%
Supplier	3%
Consultant / Architect	8%
Other	5%

3.2. Main findings of the questionnaire survey

Respondents' experience with MMC

One of the questions within the questionnaire was designed to extract overall experience with MMC, including sorts of MMC currently getting used and kinds previously adopted. the bulk (57%) of the respondents to the questionnaire survey have extensive experience while the remainder (43%) of the respondents stated that they need limited experience in MMC. This highlights an honest overall experience from the respondents; this is often nearly as good as might be expected. Despite the respondents being from a variety of backgrounds they need all been a neighbourhood of MMC in one among the subsequent disciplines; design, procurement or execution of a minimum of one MMC system. Although this doesn't directly answer any of the aims or objectives of the questionnaire survey it demonstrates that the right audience is chosen for the aim of this study.

Current sorts of MMC being utilized

The participants within the questionnaire survey were asked about current sorts of MMC being utilized, and if possible to determine what types are now becoming standing operating procedures within the development Industry (See Table 2). The most findings from responses are as follows:

- Curtain walling scored the very best weighted average with 74%. This establishes that the majority of companies would utilize this type of MMC.
- Composite panels recorded the second-highest weighted average, these form a part of the envelope, hence the rationale for MMC. it had been assumed this was high due to the time/cost optimization opportunity concerning installation speed and quality of finish.
- What was interesting from the results, the volumetric/semi volumetric solutions were quite low weighted average.
- The average "Always used" percentage was 2%, it had been found that this was quite alarming that the industry couldn't find or adopt workable solutions and still implement them within their organizations. When considering the sort and availability of MMC methodologies, it had been expected that a way higher

percentage of respondents would have regularly used MMC.

Table 2: Current forms of MMC

Use Frequency	Never	Rarely	Sometimes	Often	Always
Volumetric / 3D units	23%	23%	41%	4%	9%
Semi Volumetric / Bathroom Pods	20%	8%	44%	24%	4%
Open Panels	19%	0%	67%	14%	0%
Closed Panels	19%	0%	71%	10%	0%
Composite Panels	8%	0%	32%	56%	4%
Structural Insulated Panels (SIPS)	20%	16%	32%	32%	0%
Curtain Walling	16%	0%	16%	48%	20%
Tunnel Form (in situ formwork)	33%	25%	33%	9%	0%
Floor Cassettes	32%	28%	32%	8%	0%
Pre-fabricated Foundation	37%	46%	17%	0%	0%
Pre-fabricated Dormers	39%	39%	17%	5%	0%
Timber I Beams	22%	13%	43%	22%	0%
Metal Web Joists	13%	17%	37%	33%	0%
Prefabricated Lift Core	32%	20%	40%	8%	0%
Pre-finished Roof Structure	37%	37%	21%	5%	0%
Wiring Looms	32%	40%	16%	8%	4%
Kitchen Pods	40%	24%	28%	4%	4%
Pre-finished Plant Rooms	44%	40%	8%	8%	0%
Modular M7E Distribution (horizontal or vertical)	44%	20%	24%	8%	4%
Concrete Panels	20%	24%	40%	16%	0%
Pre-fab Plumbing	28%	40%	20%	8%	4%

- The lowest weighted percentage was “prefabricated foundations” with only 17% of the respondents choosing “sometimes used”. Again, this was unexpected, and it's been assumed that the commercial ratio between conventional & modern approaches must be far apart.

The general overview is that, MMC may be a good solution to the talents shortage however, one respondent goes as far to imply "It has potential, but it'll never be realized". the most issues raised from the respondents are:

- Upfront design timescale
- Commercial competitiveness (against conventional methods)

- Education of project managers in Procurement (and the associated risks)
- Upfront costs are difficult to report back to senior managers (often choosing Conventional)
- Change management becomes a problem with MMC as once designed calculations got to be re-run and this leaves principal contractors at an obstacle with their clients (interchangeability during construction)

3.3. Interviews

Interviews were conducted with experts in MMC to realize further insight into their experiences in construction projects using MMC and what effect it's on cost of capital, timescale delivery and quality of the finished product. The interviews also gauged their knowledge of and opinions on MMC and their usage pattern of MMC supported comparative analyses of conventional and modern methods, these interviews encompassed small sample of individuals from which an outsized amount of knowledge was captured.

The construction industry professionals were selected for this research study supported their experience with both conventional and modern methods of construction (See Table 3). These individuals and their positions were targeted due to the range of experiences in handling procurement, execution and management of live construction projects within alittle to medium enterprise.

The interview discussed:

- Issued associated with the precise MMC schemes are the interviewee been involved and whether there was more opportunity available than conventional methods.
- Why MMC was utilized for the developments.
- The implications of MMC on cost and quality of the projects
- Their opinions on clients' implementation of MMC because the method of construction restricts the selection of fixtures and fittings.
- Whether the present supply chain can deal with MMC demand and early collaboration constraints.

The analysis of the interviews highlighted the industry's issues with being client driven, if there was more scope for MMC at the front of the project and increased design time, it had been found that project efficiency and quality increased and there in some cases might be an honest commercial opportunity. The most issues with MMC were the first collaboration and extended design interfacing. However, if longer is allowed for this within the tendering stage, it are often realized that a far better quality of finished product and an honest working relationship are often built between client and principle contractor.

Table 3: Interviewees background profile

Interviewee Code	Job Title	Construction Experience	Project Type	MMC Experience
Int 1	Operations Manager	12 Years	Retail, Infrastructure, Commercial & Residential	Pods, panelized systems & trialed volumetric solutions
Int 2	Design Manager	32 Years	Retail, Commercial & Residential	Semi-volumetric pods
Int 3	Commercial Manager	24 Years	Retail, Commercial & Residential	Precast concrete & preformed lift shafts
Int 4	Site Manager	30 Years	Retail, Commercial & Residential	Pre-finished roofing – roof components & precast concrete foundations
Int 5	Project QS	15 Years	Retail, Commercial & Residential	Precast manufacturing, Pods and precast façade panels
Int 6	Ops Manager	25 years	Retail, Commercial & Residential	Volumetric solutions
Int 7	Site Engineer	10 Years	Retail, Infrastructure, Commercial & Residential	Precast and volumetric solutions

4. Discussion

From this study, it's clear that the development industry should still promote the implementation of MMC. Whilst wholesale changes aren't yet manifesting throughout the development sector, there'll come a time within the near future when there won't be a choice due to the talent shortage. It's been shown that MMC is often successful on numerous schemes and through every sector within Construction (Retail, Commercial and Residential), however, a uniform system of labor must be generated to permit companies that are less conversant in MMC to completely recognize all benefits. Principal contractors and government would be invited to incentivize MMC for the advantage of the industry. This must be implemented alongside MMC training of trades and management. The standard constraints of your time, cost, quality and health, and safety all have better records of efficiency and outcome when managed correctly however correct training must be filtered to companies and personnel that aren't familiar with the MMC process. The simplest way for this to be implemented is through framework agreements and partnering of the availability chain. Early collaboration is significant if MMC is to figure efficiently.

This study has established that MMC features a mixture of positives and negatives; this is often mostly suffering from the sort of scheme and therefore the

client's preference for building. This study has found that whilst MMC is seen as the relatively well-established process within the industry, a mixture of economic competitiveness against conventional methods & developers or clients build specification is making their implementation difficult. Interestingly all the interviewees shared an equivalent view with regards to the longer-term of MMC "within subsequent five years I expect to ascertain an outsized increase within the use and implementation of MMC systems of labor due to the United Kingdom skills shortage crisis" (Int 6). Also, the interviewees shared equivalent thoughts on the talents crisis which it might deepen following the 'Brexit' and triggering Article 50.

The study has found that whilst time, cost and quality are the determining factors when procuring and construction any scheme, that when using MMC there's the simplest balance between the three. a comparatively high percentage of respondents said they used MMC due to programmer savings and increased quality concerns, again this further promotes MMC and is sweet positive based evidence that if planned correctly, the advantages from MMC are recognized by all.

The findings are often correlated with the literature review as there's an ignorance toward MMC as proven from respondent analysis "Methods are Unfamiliar to management and workforce" in some instances. This was also reviewed in Dimarakis (R., 2008.) Where it had been found a scarcity of research and development within companies is holding back the progression of MMC systems and implementation. In measurement against the 5:4:7 targets set in Egan (Egan, 1998). It's not believed that any targets are fully achieved with exception to a discount in accidents. This is often further demonstrated within the survey findings as accidents gained the very best weighted responses. It's difficult to live current progress against these targets as some respondents skipped this question and this is often a limitation of this study.

In years to return, the Farmer Review is going to be considered an impetus for change within the development industry and if the govt is to adopt the recommendations and strive to mandate the utilization of MMC as advised in Farmer (Farmer, 2016), large opportunities for the availability chain and main contracting might be available, and this is often also a view shared in KPMG (KPMG, 2016). The results that are realized form the questionnaire survey have found that both recommendations 3 and eight from the Farmer Report are favorable within the industry and will be targeting within the near future.

Overall, the literature review found a regeneration, however, the survey analysis has found a mixed reaction from the bulk of construction professional's responses. Current MMC usage was but expected and again this is often right down to knowledge sharing throughout the industry and familiarization of techniques and procedures. There are however good sources of data sharing, for instance, the Build-off site is a corporation that collectively promotes and offer guidance on MMC and

innovative construction techniques. This demonstrates that MMC guidance and knowledge are often sought if there's enough design and procurement time.

Design timescale is that the biggest challenge within the implementation of MMC, as early design freeze was mentioned by numerous respondents as a contributing factor against using MMC. This is often also found in HCA (HCA, 2010) as some schemes in DFM competition suffered expense due to early design freeze, as found within the literature review.

5. Conclusion

The first wave of MMC struggled from negative reports, due to reasons like the reliability of the product, poor workmanship, and sturdiness was lacking and not quality assured. Since then construction firms have learned from the past. The new sorts of MMC are quality assured, but challenges are that the planning time of projects isn't frozen early enough to permit for lead manufacturing time of such products. Such problems are often overcome through better procurement routes for instance on PFI projects. Although the results have shown some positive attitudes toward MMC, there's still much reach to be made if the quality principles are to be adopted throughout the industry. It had been expected from most construction professionals that there would be basic awareness of the Egan & Farmer reports, however, the results proved that only a comparatively small population are aware. Wider dissemination of the recommendations within such reports is required. Without awareness of the recommendations found in both of those reports, it's difficult to ascertain how the principal contractors are often implementing and benchmarking best practice, while endeavoring to innovate new solutions last, from the findings presented, it's quite clear that MMC has still not developed to the position that Egan had advised, also Mark Farmer's report wasn't recognized by many of the respondents so a real conclusion to the topic matter can only be extrapolated from the results gathered. Within the development sector, the deciding factor has and always are going to be cost-driven until the MMC supply chain can make MMC more cost-efficient, SME's that are the most important building stakeholders/practitioners, not considering clients, will presumably to choose methodologies that are familiar to acquire and build. Once solutions to MMC challenges and challenges are addressed the longer term is bright as MMC will become cheaper, and there's a market out there for it to be used and replicated especially in developing countries where quality may be a big issue.

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