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Benefits of Modern Methods of Construction in Housing

Performance Data & Case Studies

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Executive summary

This report is an output of a collaborative project entitled “Enabling housing innovation for inclusive growth”, a demonstrator project supported by an Innovate UK grant. One of the project’s key objectives was to define ‘key performance indicators’ (KPIs) for MMC and benchmark against existing housing delivery models. The project partners included Bristol City Council (a leader in modern methods of construction (MMC)-based housing solutions) and nine manufacturers of different MMC systems. BRE coordinated the definition of KPIs and data capture. This report sets out the KPIs from the demonstrator project and provides data from real sites. These KPIs have informed a major programme of data/information capture from participating MMC supply chains and buildings in-use to quantify the benefits of MMCs.

The report provides performance data (cost and time) from several MMC builds projects and across several MMC systems. It also sets out some of the indirect benefits to housing providers and occupants (including broader revenue, social benefits, and social value).

Costs of MMC are currently approx. £3,000 per m^2, but these arise from typically small volumes/short pipelines for manufacturers. Costs are expected to fall to approx. £2,000 per m^2 as manufacturers scale up to volume production. Procurement clubs (bringing together several local authorities and MMC solutions) are a potential means to achieve this.

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Foreword

It is clear that the prominence of MMC is growing, perhaps accelerated by the assumption that changing the ways we build will help resolve the increasingly daunting delivery challenges the construction industry faces. However my view is that if we are going to truly advance the adoption of MMC and make it mainstream, we need to develop a much more tangible benefits case based on real data and evidence, not just warm words and positive sentiment.

This report is an important response to that challenge and looks to explore how we can create a dataset that spans both financial and non-financial outcomes and benchmarks results back to a traditional delivery baseline. It quite rightly also highlights the difficulty in doing this unless we are all aligned on the measures being captured, how we evaluate holistically and create the transparency to harvest the data in the first place. It is great to see Bristol City Council as a commissioning client once again showing leadership in modernising homebuilding, pulling together a comprehensive array of stakeholders from across industry to underpin to the credibility of this report.

The findings support the intuitive sense that the incremental move towards higher pre-manufactured value (PMV) across an array of MMC categories and approaches can drive positive outcomes. Although in capex terms there are still some challenges, we know that the main blocker to this is lack of demand aggregation and standardisation to drive economies of scale. Once we can reshape the market through greater collaboration on both the demand and supply side of the equation to achieve this then we should see the raw capital cost economics of the MMC v traditional comparison invert. We also need to recognise that MMC versus traditional is increasingly not a binary choice and most projects are, whether they realise it or not, now using hybrid combinations of MMC categories that are reflected in a broad range of PMV. In turn we should be looking at correlations between levels of PMV and positive outcomes across a range of KPIs in line with Government policy.

What is already clear from this research is that delivery speed and qualitative benefits of MMC use are compelling which in turn leads to wider linked economic and societal benefits. I very much look forward to seeing this pilot programme being followed through not only in Bristol but by Local Authorities and housing providers across the country.

Mark Farmer
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Introduction

Background to government targets and MMC

Modernising the construction process involves using off-site manufacture and digital technologies to increase productivity, improve resource efficiency, and contribute towards reducing whole-life carbon. Unlike the UK manufacturing and services sectors, the construction sector has not seen a significant increase in productivity since 1995. (MACE 2018) Bringing the construction process up-to date is also seen as a key vehicle towards meeting UK housing targets, particularly for affordable housing.

Modern Methods of Construction (MMC) is a term that refers to a range of innovative offsite manufacturing and onsite construction techniques that provide alternatives to traditional building methods. The Ministry of Housing Communities and Local Government's MMC Joint Industry Working Group defines seven categories of MMC, which cover a range of techniques from pre- manufacturing of 2D and 3D structural systems (such as floor panels) to 3D printing or pre-casting building components (such as staircases). (H M Government Ministry of Housing, Communities & Local Government 2019) When used appropriately, MMC has the potential to improve resource efficiency, build quality, environmental performance, and the predictability of delivery timescales. However, there are little or no data on these aspects from real builds.

Demand for housing in the UK is growing (c.3.9M new homes are required). The Government aims to develop c.300,000 new homes pa to meet this demand. There is a general recognition that construction targets cannot be met without extensive use of MMCs; the significant benefits that are claimed include:

- Reduced construction programme cost (20-40%) time (20-60%) and improved quality
- 70% less on-site labour, improved Health and Safety and local employment opportunities
- Fewer deliveries to site and more efficient materials use (waste <1%)
- Opportunities for customisation
- 20-33% lower energy in use
- Lighter-weight construction

However, only 15,000 homes per year are currently factory-made.

Reasons for slow uptake of MMC (UK Govt 2019) include:

- The fact that many MMC-based solutions are relatively untested. Housing providers need evidence on in-use performance, maintenance and repair costs, adaptability, resilience (e.g. addressing concerns of warranty/mortgage providers), and compliance with regulations to support selection
- Perceived risks associated with of limited chain capacity, poor productivity and reliability in delivering homes that meet quality standards
- Poor public perception
- The impact of skills shortages

To date, KPI data from real sites on the impacts of MMC on costs on construction have been very limited.

Background to the demonstrator project

This report is an output of a collaborative project entitled “Enabling housing innovation for inclusive growth”, which was a **demonstrator project** supported by an Innovate UK grant. One of the key objectives of the project was to define ‘**key performance indicators’ (KPIs)** for MMC, and benchmark against existing housing delivery models. The project partners included Bristol City Council (a leader in the use of modern methods of construction (MMC)-based housing solutions), nine manufacturers of different MMC solutions. BRE coordinated the definition of KPIs and data capture.

This report sets out the KPIs from the demonstrator project and provides data from real sites. These KPIs have informed a major programme of data/information capture from participating MMC supply chains and buildings in-use to quantify the benefits of MMCs.

The **demonstrator project** has enabled coordinated, synergic data capture and analysis to provide robust evidence of MMC solution efficacy (aligning with programme targets: 50% quicker, 33% more cost-effective than traditional methods).

The KPI data in this report has been provided by the demonstrator project partners to BRE. The data are “self-declared” and have not been independently verified by BRE through audit or site visits.

What are Modern Methods of Construction (MMC)?

MMC is a broad term that covers a range of building processes which spans off-site, near site and on-site pre-manufacturing, process improvements and technology applications. The term is often conflated with offsite or modular construction, although in its widest sense MMC can cover onsite process improvements as well. In the present-day context, no standard definition of MMC exists. In their 2018 publication ‘Modern Methods of Construction – Who’s doing what?’ The National House Building Council (NHBC) states within the introduction that:

> *As the ‘Modern Methods of Construction’ (MMC) is a wide term, embracing a range of offsite manufacturing and onsite techniques that provide alternatives to traditional house building. MMC ranges from whole homes being constructed from factory-built volumetric modules, through to the use of innovative techniques for laying concrete blockwork onsite.* (NHBC 2018)

The term MMC is frequently interchanged with other descriptions of construction innovation and is also subject to present-day analysis via pre-manufactured value (PMV) indices, where the proportion of off-site construction is assigned a number. To try and clarify/distinguish between the various manufacturing and construction processes, The Ministry of Housing, Communities & Local Government (MHCLG) published a definition framework during March 2019 with a graphic entitled 'Category Definitions'. The header states:

> ***'Pre-Manufacture*** *– Many different terms are used in the realm of construction innovation including 'off-site manufacture' 'modern methods of construction' or 'pre-fabrication'. This review uniformly adopts the term pre-manufacture as a generic term to embrace all processes which reduce the level of on-site labour intensity and delivery risk. This implicitly includes a 'design for manufacture & assembly' approach at all levels ranging from component level standardisation and lean processes through to completely pre-finished volumetric solutions. It also includes any element of on-site or adjacent to site temporary or 'flying' factory or consolidation facilities which de-risk in-situ construction, improving productivity and predictability* (H M Government Ministry of Housing, Communities & Local Government 2019)

In summary, the categories within the MHCLG document can be considered to refer to:

- Pre-manufactured 3D structural systems (e.g.: volumetric)
- Pre-manufactured 2D structural systems (e.g.: skeletal frames, walls/floors/roof)
- Pre-manufactured structural components (e.g.: steel sections/ precast concrete
- Additive manufacturing (e.g.: 3D printing)
- Pre-manufactured non -structural assemblies (e.g.: non-structural volumetric pods)
- Traditional building productivity improvements (e.g.: brick slips, large format walling products)
- Site labour reduction (e.g.: robots, drones, exoskeletons)

Off-site manufacture is not a new process within the building industry and examples, for instance, of mass volumetric housing were particularly prevalent in the post-war years as the housing crisis deepened. Unfortunately, whilst solving an immediate need, the structures were ultimately proved to be of poor quality, a legacy which modern day versions aspire to eliminate. Modern methods of construction (MMC) inevitably develop and evolve over time. Examination of historic construction would reveal that most construction techniques used, were at some point when introduced, considered "modern methods".

Automated systems: The fastest developing technologies within the MMC environment are those which seek to reduce the amount of traditional workmanship and technologies in favour of automated systems.
Volumetric: The most familiar systems currently in use are the structural and non-structural volumetric approaches which offer large reductions in on-site activity whilst maximising quality and accuracy through factory-controlled production.

Figure 1 Stacked volumetric housing units (Zed Pods Limited)

Structural volumetric approaches possess the advantage of being able to stack units on top of each other, leaving minimal on-site work to control the treatment of junctions. The use of non-structural pods has also gained momentum over the past couple of decades and is an increasing feature of large inner-city developments, where the ability to be able to deliver and 'slide' a pod into position between floor slabs offers huge advantages in time, cost, and quality. The largest (but by no means the only) examples of these are bathroom pods, where not only the walls are constructed, but also the internal finishes, fittings and IPS units before delivery to site.

Figure 2 2 bed volumetric (Boklok Housing Limited)

Figure 3 Volumetric (Tempo Housing Modular UK Limited)

Figure 4 Prefabricated units in a factory (Legal & General Homes Modular Limited)

2D systems: The MHCLG paper distinguishes between structural and non-structural pre- manufactured 2D systems, both of which are familiar territory for both designers and contractors, with perhaps the rise of the mass-produced timber roof trusses during the 1960's being one of the most common examples of a structural system.

Figure 5 Prefabricated Roof Trusses for installation on site (Etopia)

The 2D systems technology has evolved to include the pre-fabrication of framed systems for walls and floors, with increasing degrees of finishing and component installation being integrated at the factory. Walls, both internal and external will commonly incorporate doors and windows, with the latter frequently complete with external masonry or cladding panels.

Figure 6 Skeletal Steel Frame (Totally Modular Limited)

Traditional building productivity improvements: Processes that continue to be exclusively site- based are currently focused on the need to reduce waste and speed up productivity. In this respect, components such as large format brick-slip panels as a substitute for traditional masonry construction continue to be used, fitting together in a zip form, to provide an appearance indistinguishable from a traditional elevation. If the pre-fabrication of volumetric and 2D facades continues to develop, the inevitable consequence will be the reduction of even these types of on-site activities.

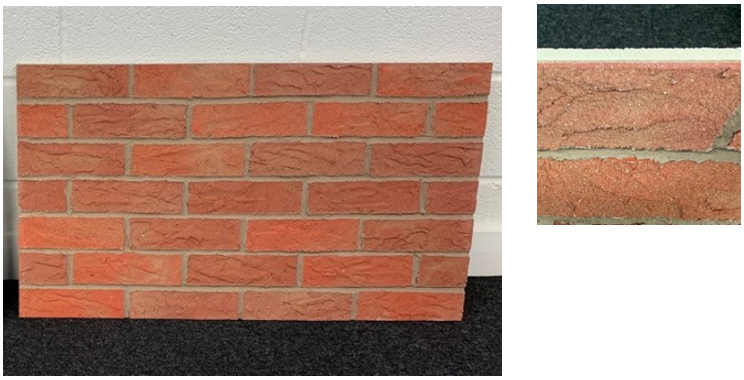


Figure 7 Prefabricated brick slip panel section (Boklok)

Figure 8 Finished MMC housing incorporating prefabricated brick slip panel envelope (Boklok)

Existing KPIs for MMC

According to 'KPI Report for The Minister for Construction' by the KPI Working Group (KPI Working Group 2000):

> *Clients of the construction industry want their projects delivered: on time, on budget, free from defects, efficiently, right first time, safely, by profitable companies.*

A key performance indicator (KPI) is a measure used to evaluate the success of an organisation or activity. They can then be used for benchmarking purposes, supporting an organisation's move towards achieving best practice.

The identification of appropriate KPIs requires an understanding of what is important to the organisation (part of, individual etc.) in question and its key activities. KPIs can be quantitative or qualitative.

The CIRIA C792 report (CIRIA 2020) lists the metrics that could be collected for MMC across the range of projects considered in their study in developing the methodology- this covers a range of buildings, such as schools, hospitals. Referenced in CIRIA C792, the earlier report "Innovation in buildings workstream: housing energy metrics" (CLC 2017) describes 13 KPIs for the housing industry with details on what information is required and how to calculate the metrics. These are arranged on a smart construction dashboard with targets and benchmarks suggested to measure progress.

The above two documents (published by the Construction Leadership Council (CLC) and CIRIA) define KPIs for MMC's in detail and give benchmark data. In summary, the metrics are:

CLC metrics

The Construction Leadership Council (CLC) have defined a range of KPIs for MMCs (CLC 2017). KPIs include:

- Pre-manufactured value (PMV)
- Productivity
- Capital cost
- Prelims cost per home built
- Days on-site, quality rating
- Waste generated
- Embodied carbon
- Energy Performance Certificate (EPC) rating

CIRIA C792 metrics

CIRIA C792 (CIRIA 2020) describes a range of possible direct project metrics under the headings:

- Cost
- Time
- Quality
- Health and Safety
- Labour requirements
- Environmental impacts
- Local disruption

These two documents have been considered by BRE and the project consortium in developing a reduced range of programme stages and costs KPIs that have been used in the project to assess MMC. The project has also devised new metrics on “redefining value” and includes a consideration of social value as described below.

Introducing Social Value & Social Value KPIs

Social Value is a broad term which encompasses the wider benefits or impacts that an organisation, project or programme can have, going beyond the basic financial ‘bottom line’ and covering economic, social and environmental considerations. There is an increasing conceptual overlap between Social Value, which is underpinned by government legislation, and terms such as Corporate Social Responsibility and ESG (Environmental, Social, Governance) on the other.

The National TOMs (Themes, Outcomes, Measures) (Social Value Portal n.d.) is an evidence-based framework using a standard set of metrics to assess social value. The TOMs framework is used by Bristol City Council, along with a large number of public and private sector organisations in the UK and is the leading social value measurement framework in the UK. It is prevalent in the construction, development and built asset sectors, so well suited to assessing the social value delivered by Bristol’s MMC programme. The TOMs framework is designed to record ‘added value’, namely value that goes beyond the core scope of a contract to wider benefits beyond what is considered as “business as usual”. In this context, the ‘core scope’ is the construction of the units themselves, and considerations around delivery (e.g., time to complete) and cost sit within the ‘core scope’. Considerations that fall into the ‘added value’ category cover aspects such as:

- Enhanced job and training prospects
- Improved social purpose by design (e.g., energy efficiency leading to lower fuel poverty)
- Ability to localise economic activity
- Supply chain opportunities, particularly for SMEs and social enterprises
- Community benefits – e.g. improved flexibility around public spaces, better / closer engagement with the end-product
- Environmental impacts both onsite and through transportation

At this stage of the MMC programme there is obviously limited ‘in-use’ data, so any available evidence will relate mainly to the construction phase. Similarly, as MMC approaches are relatively new (in the UK at least), the general research on social value in the sector is also restricted and largely conceptual rather than evidence based.

Social value is a relative term (= ‘added value’) so by implication requires a baseline or comparison to determine additionality. The implied baseline here is a ‘traditional’ build, although that also covers a broad range of approaches, some of which may well encompass MMC elements. If MMC is successful in becoming part of the housebuilding ‘mainstream’ in the UK, it would be reasonable to expect more MMC techniques to bleed into traditional housebuilding over time.

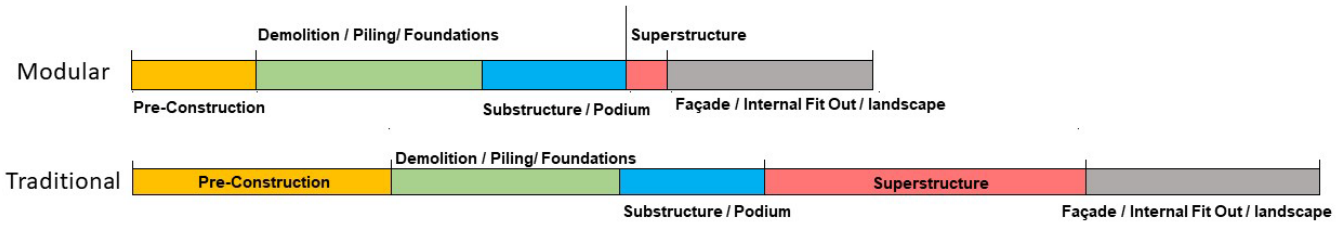
So, at this stage the social value review in the context of this report is bound to be quite broad-brush and hypothetical, developing several lines of analysis that can be tested as the evidence base is built up. A key consideration is how this pilot programme is followed through; self-evidently, perhaps, the potential social impact of the in-use phase is likely to be much greater than during construction, so implementation of a longer-term monitoring programme to understand better what happens during occupation would seem an obvious next step.

Selection of the KPIs used in the project

Nine MMC housing manufacturers and Bristol City Council were consulted in the “Enabling Housing Innovation for Inclusive Growth” project to discuss the relevant KPIs to prove that MMC can result in housing being built faster and cheaper to meet the UK Government targets described in the introduction. A restricted range of KPIs, based on those of the CIRIA and CLC, were selected by the project partners.

Programme duration KPIs

The partners in the project agreed the project objective to show that MMC housing can be built faster than traditional build. They proposed collecting of time data to complete the different build phases of a dwelling or development as shown in ***Figure 9*** below.



	Modular	Traditional
Pre construction design / sub contract tender	12 weeks	25 weeks
Demolition / Piling / foundations / reduced level dig	22 weeks	22 weeks
Substructure and slab to podium	14 weeks	14 weeks
Superstructure	4 weeks	31 weeks
Façade / fit out / external works	20 weeks	20 weeks

Figure 9 Representation of hypothetical build programmes making a comparison of duration of five different phases of the programme for MMC, with traditional methods

Redefining Value KPIs

Bristol City Council were keen to capture the cost and wider benefits associated with building MMC quicker for social housing vs traditional build and they termed this “redefining value”. The figure below shows the high-level redefining value parameters/KPIs that Bristol City Council wanted to capture. There is a strong element of social value in these KPIs.

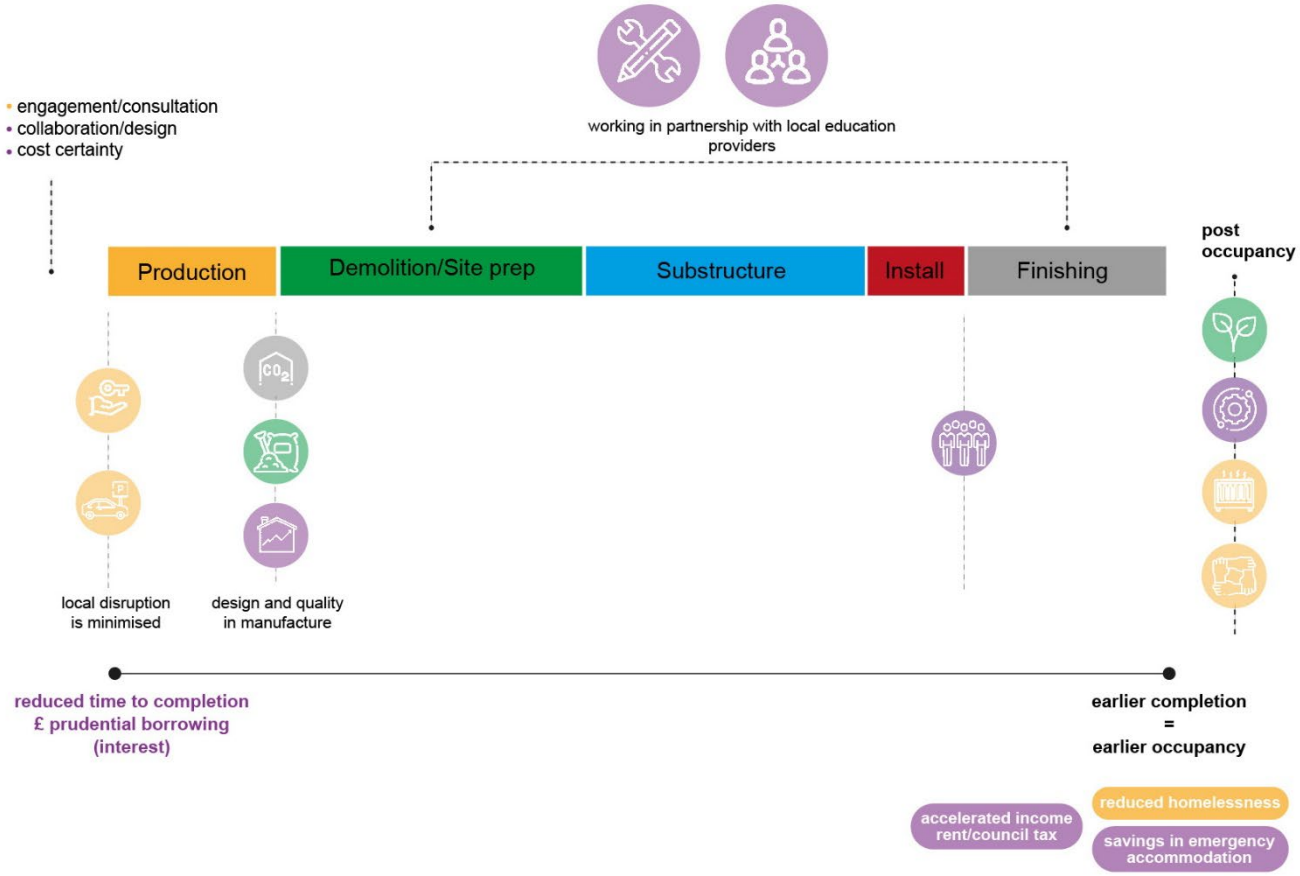


Figure 10 Cost and benefit consideration for redefining value for MMC housing vs traditional build

The KPIs selected for the project

Based on the CIRA C792 report (CIRIA 2020) and Bristol Council requirements, the MMC manufacturers requirements for collecting KPI data on time taken to complete different phases of a house build and Bristol’s redefining value requirements, the KPI’s used in the project are:

a) KPIs relating to cost and time of programme stages in MMC builds relative to traditional builds
b) “Redefining value” KPIs

The following range of simple KPIs have been selected to compare the different MMC builds with traditional methods. These cover time savings at the various stages of the build programme and cost savings (***Table 1***). Also “redefining value” KPIs (***Table 2***). A far more extensive and complex range of KPIs exist for MMC, which appear in the CIRIA and CLC reports.

KPI	Units used for each KPI
Decision at conceptual stage - why MMC was selected for the build?	-
No. of houses/apartments in build scheme (and area of build)	Number of dwellings Floor area m^2
Pre-construction design/ subcontractor	-
Demolition/ Piling/ Foundations/ Reduced Level Dig	Weeks
Substructure and slab to podium	Weeks
Superstructure	Weeks
Façade/ fit out/ external works	Weeks
Total build time	Weeks
Cost per m^2 per build Price per m^2 does not include land value	£

Table 1 The programme stages and costs KPIs

KPI	Units
No of houses/apartments in build scheme (area of build)	Number of dwellings Floor area m^2
Social Value (TOMS notional value)	Bristol TOMS notional value
Savings and income due to early completion of MMC vs traditional	
Reduced interest payments on loan	£ per 100k loaned
Saving on cost due to housing tenants earlier Examples: Cost of B&B and other temporary accommodation savings compared to rent being paid by tenant or by central government,	£ per earlier occupancy
Income to councils Examples: Additional income, council tax, car park income etc Potential income from PV generated, power, stored and traded.	
Occupant Experience	
Costs of use, such as consumption of energy and other resources	£ per month
Carbon Savings (EPC)	kWh/m2/annum
Whole Life Costs	
Maintenance costs	Cost per year (£) per dwelling based on 10, 20 30 years cycle
End of life costs, such as collection and recycling costs % of dwelling that can be recycled; end of life costs per dwelling (£)	Costs £, % recycled etc

Table 2 The redefining value KPIs

Results

Difficulty in collecting housing KPIs

This section (***Table 3***) describes which KPIs are easy, which are difficult to measure (in the project partners experience). It also highlights the KPIs that really help the client/housing provider in reaching procurement decisions.

KPIs that:	Narrative/discussion
are **hard** to collect (and comments)	1) Cost- per m² (clarity/confusion about what to measure or include in the costs) 2) Financials (due to commercial confidentiality issues) 3) Innovation and sustainable systems and benefit (off-the-shelf systems including new, sustainable and/or emerging technologies that exceed minimum build standards and requirements need to be capable of being captured separately to allow for comparison with standard systems and traditional build. Occupant in use savings and benefits need to be known with some degree of certainty to be capable of being captured in whole-life costing) 4) Carbon impact and savings (due to complexity and/or varying approaches to capturing, quantifying or calculating and definitions in use 5) Waste (savings from waste reduction during production, construction and end of life) 6) Whole-life costs (due to the variations in measures used by commissioners/client/employer) 7) Additional community benefit/social value – economic, social and environmental (due to the way in which this is defined, quantified and qualified and in being an emerging suite of measures)
are **easy** to collect (and comments)	1) Total build time- weeks 2) Total build cost (may be subject to commercial confidentiality issues, although in the context of public sector total contract price should be published) 3) Quality (using recognised and established industry metrics) 4) Economic impact uses a more established methodology in the sector making these 'easier' to collect in the context of larger schemes/major construction projects
really **help/inform** the client	1) Time, and cost KPIs derived from/concerning: a. site surveys b. ground preparation (time and cost) c. production (time and cost) d. installation (time and cost) e. finishing (time and cost)-etc. 2) Quality a. Minimum build standards together with additional quality measures 4) Sustainable measures together with savings, whole-life and to the occupant 5) Economic, social and environmental benefits – see separate section on Social Value

Table 3 Difficulty in collecting housing KPIs

Programme benefits of MMC vs traditional build

Parallel activities in the MMC factory and on-site

One of the partners has carried out a time analysis of an MMC factory production and installation of MMC housing on site. ***Figure 11*** illustrates the results.

Figure 11 Programme for an MMC build illustrating time and sequencing of factory and site processes (25 units)

A development of 25 housing units included an 11-week phase of factory works which progressed in parallel with installation of screw piles, pile caps and substructure on site. Factory works also started at the same time as groundworks on site. The delivery and installation phase of the units was completed within a period on site of less than 3 weeks and the overall programme duration on site was 14 weeks. Parallel working on site and in the factory (and associated time savings) as illustrated by this example, is one of the opportunities provided by MMC methods.

Programme charts across the builds - compared with traditional builds

The following section shows bar programme charts across the builds and range of systems represented by the project.

a) Programme for builds

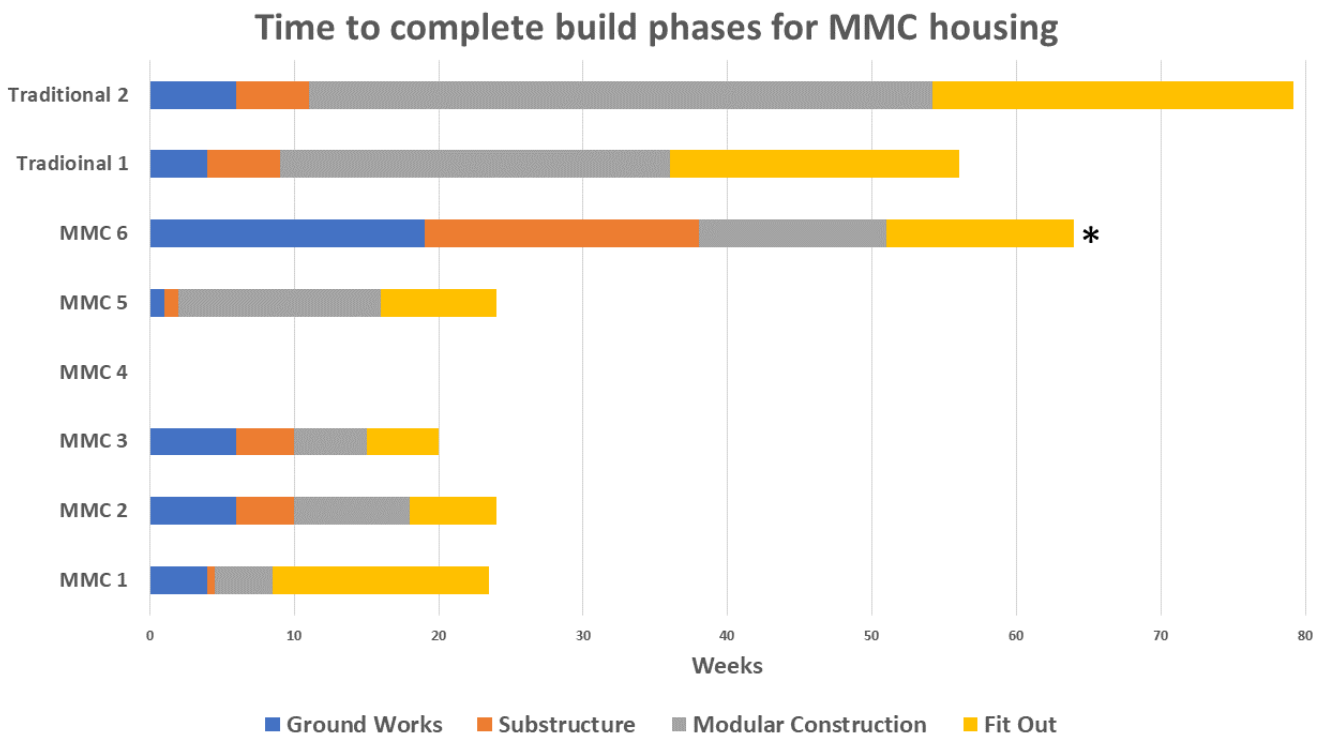


Figure 12 Time to complete build phases for MMC housing compare to traditional housing (linked with Table 4 below)

	MMC 1	MMC 2	MMC 3	MMC 4	MMC 5	MMC 6	Trad 1	Trad 2
Total Build Time (weeks)	23.5	24	20	No data	24	64	56	79.2

Table 4 Total build times (weeks)

*Significant overlap between the build phases. Start and finish of each stage of the build are not as distinct as implied here for MMC6.

Summary of the benefits of MMC vs traditional build across the builds/ providers

Build	MMC 1	MMC 2	MMC 3	MMC 4	MMC 5	MMC 6	Traditional 1	Traditional 2
Category in MMC definition. framework, see Appendix2	1 -Pre-manufacturing (3D primary structural systems) 1c Structural chassis fit-out and external cladding/ roofing complete Light gauge steel framed(LGSF) And CLT on some units i. Whole building systemised	1 -Pre-manufacturing (3D primary structural systems) 1b Structural chassis and internal fit-out 1c Structural chassis fit out and external cladding/ roofing complete Hot rolled steel i. Whole building systemised	1 -Pre-manufacturing (3D primary structural systems) 1b Structural chassis and internal fit-out 1c Structural chassis fit out and external cladding/ roofing complete Hot rolled steel and cold rolled steel hybrid. i. Whole building systemised	1) Houses Closed panel 2D forms constructed into 3Dfullstructuralunits, Structural Timber 2) Apartments Close panel 2D forms constructed into 3D structural units, Structural Timber	1 -Pre-manufacturing(3Dprimary structural systems) 1a Structural chassis only–not fitted out Timber frame (TF) ii. Hybrid construction –part systemised &part traditional	1 -Pre-manufacturing (3Dprimary structural systems) 1b Structural chassis and internalfit-out1c Structural chassis fit-out and external cladding/ roofing complete Hot rolled steel i. Whole building systemised	Non-applicable	Non-applicable
No of houses and apartments in build scheme (area of build)	11 houses–50m^2 (all affordable)	6 two storey flats-50m^2 (all affordable)	1 house –50m^2 (all affordable)	173 units 4 Apartment blocks (96 units) 77 houses (including 79 affordable units)	1 house – 44m^2(affordable)	180 houses (including 90 affordable)	4 houses and 10 flats	19 houses and 13 flats
% affordable housing inbuild (MMC)	100%	100%	100%	46%	100%	50%	-	-
Pre-construction design/subcontractor	4 weeks	6 weeks	6 weeks	Houses: Circa 16 weeks Apartments: Circa 8 weeks	No data	19 weeks	No data	No data
Demolition/ Piling/Foundations/ Reduced Level Dig	4.5 weeks	Included in above	4weeks concurrent with modular construction.	Complexity of site – including mixture of apartment and houses–means timings are not representative of a typical site.	2 weeks	19 weeks	4 weeks	> 6 weeks *
Substructure and slab to podium	Included in above	4 weeks	Civils and Utility connection 3 weeks. Concurrent with modular construction.		Included above	45 weeks–considerable overlaps between these build phases	5 weeks	5 weeks
Modular / traditional construction	4 weeks	8 weeks	5 weeks		14 weeks		27 weeks	43.2 weeks
Façade/ fit out/ external works	15 weeks	6 weeks	Majority included in the factory build. Zip-up on site will be 2 weeks.		8 weeks		20 weeks	25 weeks
Total build time	23.5 weeks	20 weeks	20 weeks		22 weeks	64 weeks	56 weeks	79.2 weeks
Cost per m2perbuildPrice per m2doesnotinclude land value	£2,925[1]	Approx. £3,000	£2,950 due to single unit site.	House superstructure £1,076/m^2 Apartment super structures £1,465/m^2 All in £2,192/m^2	£2,995		£3,049	£2,952

Table 5 Summary of MMC KPIs vs traditional build

[1] This is much higher for traditional than the RLB figures. Also, our cost on Hope Rise Bristol includes full net zero specification which is circa £400/m2 uplift on achieving Building Regulations.

Redefining value of MMC vs traditional

Build	MMC 1	MMC 2	MMC 3	MMC 4	MMC 5**	MMC 6	Traditional1	Traditional 2
Additional Economic, Social and Environmental Value (Social Value)								
No data available								
Savings and income due to early completion of MMC vs traditional **Limited data are currently available on this topic (see below): it is anticipated to be completed in future iterations of this report**								
Savings and income due to early completion of MMC vs traditional Reduced interest payments on loan (£ per 100k loaned)	-	-	-	-	-	-	-	-
Saving on cost of housing tenants earlier (£ per earlier occupancy)	Approx £60 k	-	-	-	Approx. £5.5 k	-	-	-
Income to councils (Additional income, council tax, car park)	Approx £6.4 k	-	-	-	Approx. £0.6 k	-	-	-
Occupant Experience	-	-	-	-	-	-	-	-
Costs of use, such as consumption of energy and other resources (£ per month)	Electric £300 per year * for 1 bed. Based on current data the allowance for covid of 15%-20% increased electricity use should be factored into first year data No gas	Aiming for zero cost or rent with power option. Also aiming for under 499kg/m2 CO_2 embodied carbon in the construction.	-	-	Water: Single person values Electrics: £250/yr No Gas: £0	-	-	-
Carbon Savings (EPC) (kWh/m2/annum)	SAP 105 / zero SAP rating 105	Zero	-	-	SAP Rating: 98 Passivhaus assessment still to be done. (With one more row of PV's on roof, the home is net zero on carbon).	-	-	-

Table 6a Summary of redefining value MMC vs traditional build

(Continued in the next page)

Whole life costs						
Maintenance costs (10, 20 and 30 years)	MVHR = 0 Heat pump = £100 PV = 0 See spreads sheet for other material life cycles	£250 a year per dwelling based on a 30year cycle.	-	Yearly: MVHR[1] = £150 ASHP[2] = no maintenance PV[3] = no maintenance 5yr = Decorating (£1,000) Domestic electrical installation condition report (£250) 10yr = new inverter (£1,000) 30yr = Cladding (£5,000) Further items to be considered PV replacement (£3,000)	-	-
End of life costs, such as collection and recycling costs Costs, % recycled etc)	95% of house and podium can be recycled, includes: • All steel • All insulation • All cladding • All roofing • All membranes • Pv take back recycling rate 85% • All pipework	100 % of house can be recycled	-	95% of house can be recycled. Predominantly made of low impact materials (timber, recycled newspaper).	-	-

** Savings and income due to early completion are 1/11th of MMC 1

Commentary in relation to MMC 4 in relation to the table above:

- The information is incomplete and reflects the stage of completion (incomplete at the time of writing).
- The site is very complex, with a long and detailed phasing plan, on a site over a kilometre long and very thin, and which includes apartments and houses. It's therefore difficult to know how to input timings for demolition/ substructure/ construction/ total build time etc. as this would be very different if the site was simpler. The data is not properly representative of modular development and would be difficult to represent in the table.

[1] MVHR = Mechanical ventilation with heat recovery
[2] ASHP = air source heat pump
[3] MVHR = Mechanical ventilation with heat recovery

Savings and income due to early completion of MMC vs traditional

In addition to the values and "redefining value" benefits identified above, there are a range of financial savings derived from the increased pace and off-site production/construction of MMC. Whilst these have not been quantified in time for the publication of this report, the following financial benefits have been recognised and can be included when providers (such as local authorities) are assessing schemes for best value and value for money:

Interest accrued – this can be considered on a scheme-by-scheme basis in respect of the reduced time between commissioning and the commitment and expenditure of capital to completion and the point at which income streams become effective and/or revenue savings can be made. It is with the adoption of a long term MMC strategy and development programme that these savings can be fully exploited.

Additional or increased realisation of income streams - from sales, rental and/or council tax, as a consequence of commissioning MMC which is delivered and occupied significantly sooner than its traditional build comparator.

Revenue savings – from local authorities moving service users from temporary emergency and/or supported accommodation into new and additional social housing more quickly (or for individuals moving from private rented to affordable housing) than had traditional build methods been commissioned for this purpose.

Retained income – for example- where MMC is utilised over existing car parks (where chargeable) or garage sites that maintain or create income generating capacity exploiting air rights.

Table 6b summarises the range of benefits across the different build and occupancy phases.

The main benefits of MMC from the housing providers point of view

Benefits of MMC	Stages of factory production, site installation and post-occupancy where the benefits apply						Across all stages
	Production (factory)	Demolition/site prep	Substructure	Installation on site	Finishing	Post-occupancy	
Cost	Better cost control/predictability	-	Lower cost foundations: Simplified foundations	Shorted installation time on site	Less finishing required on site and time/cost predictability	Planned routine maintenance and/or repairs rather than reactive. Reduced retro-fitting	Better cost predictability due to design being fixed at production stage
Collaboration	Collaborative design: Design needs to be fixed/defined by client earlier	-	-	-	-	-	More collaborative design and construction process with stakeholder buy in
Skills	New skills development/ employment (working with local education providers)	-	-	New skills development; in HVAC replacing declining trades (eg gas boiler installation)	New skills development: finishing of MMC	New skills development: long term maintenance of MMC	Development of new skills in local economy
Engagement	Engagement with residents: Residents can be engaged with earlier and "bought in" to the design-which is more "tangible" for residents	-	-	Jobs: Local supply chain	Jobs: Local supply chain	Residents feel supported and connected to their community	Better and earlier engagement with residents/communities throughout due to greater tangibility of the finished construction throughout stages
Time	Saving time on site: Production in factory can proceed in parallel with site phases	Time saving: Can proceed in parallel independently from production phase	-	Fewer last-minute changes due to design fix at production phase	Less finishing time on site	-	Saving time on site: Production in factory can proceed in parallel with the site phases
Construction process	Local disruption and the costs at site are minimised during production/factory stage	-	Construction more straightforward; Simplified foundations	Less disruptive/shorter duration site processes	Reduced snagging (flaws designed out/better consistency)	-	-
Social	Local disruption on site is reduced	-	-	-	-	Tackles fuel poverty, reduces economic inequality, loneliness/isolation Residents feel supported and connected to their community	Faster completion: Reduced homelessness/emergency accommodation Greater social value
Environmental	Reduced site waste	-	May be possible to re-use foundations (eg screw piles)	Less noise/disruption	-	Sustainability/environmental efficiency	Possibility of de-commissioning/re-use at end of (first) life
Other benefits		-	-	-	-	-	Financial benefits of faster completion; earlier council tax collection; earlier moving out of temporary accommodation

Table 6b Benefits of MMC vs traditional housing- redefining value from the viewpoint of a local authority (as social housing provider)

The potential for MMC solutions in Bristol

MMC is recognised as one of the solutions to addressing the housing crisis that requires the bringing together of a range of opportunities that can meet the diverse needs of the city of Bristol.

The adoption of MMC in Bristol has seen the unlocking of sites not previously deemed suitable or viable for housing development. In Bristol, this has included the space above existing car parks, micro sites, (small and difficult to access sites) and the re-drawing of the boundaries of gardens of existing residential properties. Further consideration is being given to utilising MMC in unlocking contaminated land. It should be recognised that these sites can comprise a pipeline in their own right, (where a strategy exists promoting the scale and pace of delivery across a variety of sites). In turn, these pipelines start to address the question of economies of scale and promote supply by defining demand for the market, which in turn starts to establish an MMC 'ecosystem' that draws in the potential for local production, supply, and employment opportunities.

Assessment of cost effectiveness of MMC

Rider Levett Bucknall (RLB) carried out a comparative review of costs and programme of several MMC and traditional build housing projects on behalf of Bristol City Council.

MMC: Build project	Brief description of build (and number of units)	Current build costs (£/m2)
Build A	Located in Horfield, Bristol, the development consists of 9 new Gap House two storey residential units which replace existing garages	£2,827/m^2
Build B	Located in Knowle West, Bristol, the development consists of an 11-unit affordable living scheme. The scheme is being delivered by modular supplier Tempo Housing Modular UK Limited.	£2,887/m^2
Build C	Located in Lockleaze, Bristol. The proposed scheme consists of two apartment blocks, north and south, which are identical in plan on ground and first floor with one 1-bed apartment and two 2- bed apartments on each floor. The development will be constructed by Modulous Limited who have been appointed to supply their system of "high-performing kit of parts".	£2,202/m^2
Average cost		£2,638/m^2
Average benchmark costs		£1,926/m^2

Table 7 Build cost (3 builds)

These build costs are £712/m^2 higher than the average benchmark cost of £2,170/m^2 but still fall within the range of benchmark project costs which is £1,655/m^2 to £2,938/m^2. The benchmark cost data is taken across ten projects using a range of MMC and modular systems and ranging in scheme size from eight to 149.

It is perceived that a premium is being paid both on these schemes and across the sector for MMC schemes are a consequence of inbuilt R&D costs and risk provisions made for relatively untested MMC systems.

In order to address the above point that a premium is being paid from MMC schemes, we have undertaken an analysis against standard timber frame affordable housing projects. The unit numbers are similar and comparable to those of Bell Close, Inns Court and Romney Avenue. The intention is to provide a true comparison. The costs below have abnormal costs normalised and are as follows:

- Rodney Crescent, Little Stoke £1,818/m^2
- Irving Close, Staple Hill £1,584/m^2
- Beaufort Road Downend £1,698/m^2
- Corbett Close, Lawrence Weston £1,786/m^2
- Average Cost £1,704/m^2

Based upon the above, the average difference of £934/m^2 between the MMC projects and standard timber projects would suggest this is the capital cost differential to MMC projects.

Often the cost savings are hidden and MMC may not stack up on a component-by-component analysis. It is for this reason that some clients and suppliers are looking at vertical integration through the supply chain.

Savings such as prelim savings are not always fully recognised through main contractor tender prices.

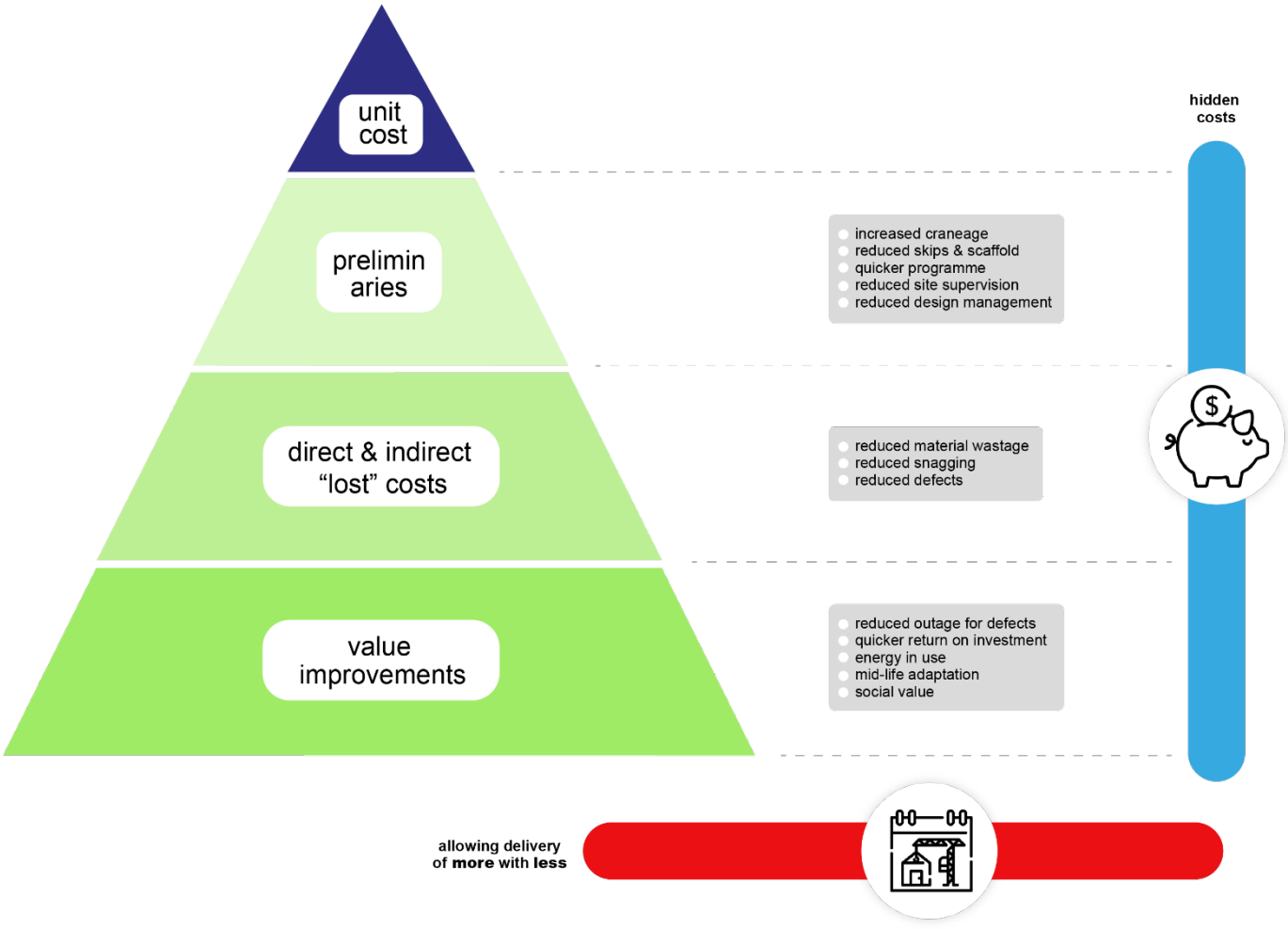


Figure 13 Sources of additional costs and cost savings in MMC

A view on future build costs projections for MMC

- Many MMC systems are produced using mould / templates meaning standardisation of unit type and avoidance of steps, staggers and multiple unit types is required to reduce cost.
- As producing the mould / templates are a fixed cost, it follows that increased unit numbers that can be produced will reduce cost per unit meaning that larger sites will have a lower cost per m^2. This is evidenced by a development in Newport, South Wales which is £1,971 per m^2 for a timber panelised MMC solution on a scheme of 149 units.
- It follows that increased scale of MMC production reduces unit cost. Given there are such a wide variety of MMC / modular providers, there would be an argument for build clients to limit the number of preferred providers to a small number to take advantage of increased scale and cost reduction.

Deployment of MMC housing solutions: Lessons learned

1) MMC offers a cost and quality certainty in the exploitation of production. When materials are costed and tendering prompt, thus securing known prices, there can be a level of confidence in prices quoted. Equally, there is a level of confidence that comes from design and production over on- site build that can be subject to 'human' error and uncertainty/unpredictability. Improvement can be "designed-in" in future productions with ease and to client requirements. However, it should be noted that MMC does require certainty at an early stage as these systems do not lend themselves well to late design changes, which can be done but at a cost (as it can be said of any design change)
2) The adoption of MMC requires and cultural and system change for those familiar with commissioning traditional build. The process of commissioning a product in place of works has some significant differences and requires regard to manufacture/production and particularly, contracting. There are several frameworks and dynamic purchasing systems (DPSs) that have been established in response to the findings of early adopters of MMC, particularly in the public sector that can assist in commissioning MMC in the context of the Public Contracts Regulations. (*Public Contracts Regulations 2015*) (*Procurement for Housing 2021*)

Conclusions/summary of findings

1) Costs of MMC are currently approx. £3,000 per m^2 but these arise from typically small volumes/short pipelines for manufacturers. Costs are expected to fall to approx. £2,000 per m^2 as manufacturers scale up, and pipelines lengthen. Procurement clubs (bringing together several local authorities and MMC solutions) are a potential means to achieve this
2) MMC brings together the benefits of faster/cheaper. However, whilst speed is a key concern in social housing, it not a driver of building for owner occupied market (where development is typically in phases in response to the market)
3) MMC offers a cost and quality certainty in the exploitation of production.
4) MMC does require certainty at an early stage as these systems do not lend themselves well to late design changes
5) The adoption of MMC requires and cultural and system change for those familiar with commissioning traditional build.

6) Procurement clubs, bringing together different housing providers (housing associations, local authorities) to procure MMC solutions, have potential to reduce costs per m^2. Such mutual co-operation has the potential to increase the throughput of production pipelines and bring in other economies of scale into production. Advantages to providers of pooling of orders would include the possibility of a wider choice/increase number of preferred MMC solutions.

Next steps

This report represents a snapshot across a limited number of sites but provides a sound basis and methodology for moving forward. Constructing Excellence is planning to convene an MMC Group. Working with this group, CE will take ownership of this report and ongoing gathering of KPI data across manufacturers and builds.

References

CIRIA. 2020. “Methodology for quantifying the benefits of offsite construction.” file:///C:/Users/VIHRIS~1/AppData/Local/Temp/MicrosoftEdgeDownloads/48beb418-a92f-4d22-8371-538d4933b13f/Methodology%20for%20quantifying%20the%20benefits%20of%20offsit.pdf.

CLC. 2017. “Innovation in buildings workstream: Housing energy metrics.” https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2017/11/Demand-Surity-Report-September-2017-VF-WEB-final.pdf.

H M Government Ministry of Housing, Communities & Local Government. 2019. “Modern Methods of Construction - Introducing the MMC Definition Framework.” https://www.cast-consultancy.com/wp-content/uploads/2019/03/MMC-I-Pad-base_GOVUK-FINAL_SECURE.pdf.

KPI Working Group. 2000. “KPI Report for the Minister of Construction.” https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/16323/file16441.pdf.

MACE. 2018. “Construction Productivity - The Size of the Prize.” file:///C:/Users/VIHRIS~1/AppData/Local/Temp/MicrosoftEdgeDownloads/5d302268-351b-4ed5-bc5e-0d2e80cab201/Mace%20Insights%202018%20-%20Construction%20Productivity%20-%20The%20Size%20of%20the%20Prize.pdf.

NHBC. 2018. “Modern Methods of Construction - Who’s doing what?” https://www.cast-consultancy. com/wp-content/uploads/2019/03/MMC-I-Pad-base_GOVUK-FINAL_SECURE.pdf.

Procurement for Housing. 2021. “Modern Methods of Construction Category 1 Framework Guide 2021-2025.” https://file-eu.clickdimensions.com/inprovagroupcom-aymta/files/buildingbetterframeworkguide2021.pdf?m=7/28/2021%2010:40:42%20AM&_cldee=amFrZS5zbmVsbEBhYnJpLmNvLnVr&recipientid=contact-d787ff4839e6eb11bacb000d3a442a8d-c061b16ade524b83b0c8e3961a82ee3e&utm_.

Public Contracts Regulations. 2015. “The Public Contracts Regulations.” https://www.legislation.gov.uk/uksi/2015/102/contents/made.

Social Value Portal . n.d. Social Value Portal. https://socialvalueportal.com/.

Acknowledgements

Appendix 1: Case studies

MMC build 1

MMC Build number: 1	MMC type: 1 - Pre-manufacturing (3D primary structural systems)
Purpose of build – social housing, housing association, private development etc:	Social housing for Bristol City Council
Reason(s) why MMC build was chosen?	The site is an existing car park and the only way to bring the site into residential usage was to keep the car park as the public car park during construction. This enabled a brownfield site to be use for social housing. The only way to build such a scheme was to utilise innovations in off-site manufacture and to undertake a large percentage of the build off-site to reduce impact on the neighbours. The off-site build enabled a net zero-carbon scheme to be developed.
Ownership- eg housing association, local auth, owner occupied etc.	Local Authority
Description of build Include type of location for build i.e. brown field site, carparks etc. Please do not mention actual site for the build.	11 number two-storey apartments of 9 x one-bed and 2 x two-bed apartments. The development, working with the local authority, is an example of innovative elevated, sustainable development above an existing public car park (including improvements to the car park layout and other associated works) with retention of the site's use as a public car park.
Type of dwelling- e.g. flat, terraced house, single storey, multi storey etc	2-storey maisonette apartments
Key savings and benefits of the MMC build to council, tenant and owner	• training and skilling up of local community members as community builders • Reduced running costs for residents • Contributed to climate emergency goals through zero-carbon design • Allowed development of brownfield site already owned by the council whilst keeping existing land use • Developed and contributed to TOM's social value targets • Reduced carbon in travel miles by the development being close to city centre and a car-free development. • Reduced energy consumption in use. • Contribution to health and wellbeing of residents living in a cosy and safe home.
Lessons Learnt:	• Best use of OJEU compliant frameworks for suppliers who could meet project requirements, as a direct call-off could save considerable time. • How to adapt contractual terms from the standard form of contract to include all the provisions necessary for offsite construction. • using turnkey solutions as beneficial to reducing the risk of errors arising at the interface between the site works and the modules. • balancing site works to maximise efficiencies in delivery programme. • Developing cross-skilled project team as early as possible to secure buy in to the desired project outcomes and draw on a breadth of expertise in the necessary sensemaking and de-risking process. • Meticulous planning is necessary to ensure that volumetric modules can and do arrive in the correct order for immediate offload. • To prevent disruption on neighbouring roads, identify an arrange use of a nearby car park as a holding bay for volumetric modules being transported as part of a convoy. • Optimising build system to reduce costs and increase efficiencies • Reducing long item lead in times and factor times • Reducing production line time /costs • Changing how we engage with utilities providers • BIM for facilities management

MMC build 2

MMC Build number:2	**MMC type: 1 - Pre-manufacturing (3D primary structural systems)**
Purpose of build – social housing, housing association, private development etc:	The scheme is for Bristol City Council a move on accommodation for Bristol citizens who have experienced homelessness and who are currently living in emergency housing or temporary housing.
Reason(s) why MMC build was chosen?	MMC would provide a rapid build solution while minimising the impact to local residents, businesses and users/operators of community facilities.
Ownership- eg housing association, local auth, owner occupied etc.	Local Authority
Description of build Include type of location for build i.e. brown field site, carparks etc. Please do not mention actual site for the build.	This is a brownfield site currently with a concrete base leftover from a previous structure. There are houses to the rear of the site and it opens onto a close with retail and community buildings
Type of dwelling- eg flat, terraced house, single storey, multi storey etc	Two storey block comprising 11 one bedroom flats and a communal space
Key savings and benefits of the MMC build to council, tenant and owner	The units will be zero energy and zero carbon in use, so tackling fuel poverty amongst the most vulnerable. The council reduces its costs on temporary accommodation. The homes keep rent income under the council's control and offer power with rent options. The scheme can create an income from the excess renewable energy generated. The units have been developed to provide the highest levels of comfort, thermally and acoustically for the tenants, with enough space to benefit health and wellbeing.
Lessons Learnt:	Manufactured units rely on standardisation of products so making changes to the design can be problematic, but it has allowed Tempo Housing Modular UK Ltd to build flexibility into its standard portfolio without creating too many variables. We also note that the MMC supplier should be engaged very early on in the RIBA design stages, preferable at stage 2 to reap the benefits of a standardised system.

MMC build 3

MMC Build number:3	**MMC type: 1 - Pre-manufacturing (3D primary structural systems)**
Purpose of build – social housing, housing association, private development etc:	Social Housing scheme (single bungalow) for a housing association in Coventry on garage infill site.
Reason(s) why MMC build was chosen?	MMC was chosen for speed and the site is not viable for traditional housing construction. MMC also minimises the impact to the surrounding residents.
Ownership- eg housing association, local auth, owner occupied etc.	Housing Association
Description of build • Include type of location for build i.e. brown field site, carparks etc. Please do not mention actual site for the build.	Construction on a brownfield site with several existing garage units. These garages have been demolished and a single unit bungalow will be added to the site. This site is surround by other residents' houses.
Type of dwelling- eg flat, terraced house, single storey, multi storey etc	Single 50 m^2 bungalow.
Key savings and benefits of the MMC build to council, tenant and owner	**Time and disruption on site.** The increase speed of delivery and completion decreases the disruption to the surrounding area, the type of delivery also reduces noise from deliveries, dust nuisance etc. **Quality of build.** Higher consistent quality of build, reducing the levels of snags and faults in the property. **Eco performance.** Reduced carbon emissions from the property – A rated EPC with additional eco to technology to reduce the running costs for the tenant. Fabric-first approach means an improved fabric specification.
Lessons Learnt:	• Amount of work for a single unit site works out more than on multi-unit sites.

MMC build 4

MMC Build number:4	**MMC type: Closed panel 2-D forms constructed into 3-D full structural units, Structural Timber**
Purpose of build – social housing, housing association, private development, etc:	The development project contains: - Private housing - Social rented housing - Housing in shared ownership through Bristol City Council
Reason(s) why MMC build was chosen?	The business model is entirely offsite, which suited the nature of the site (brownfield land).
Ownership- eg housing association, local auth, owner-occupied etc.	Private homes Bristol City Council Housing Revenue Account
Description of build • Include type of location for build i.e. brown field site, carparks, etc. Please do not mention the actual site for the build.	Prior to the project, the land was brownfield land and had been unused for decades.
Type of dwelling- eg flat, terraced house, single storey, multi storey etc	The build contains 96 No. 1-2 bedroom apartments and 77 No., 2-3 bedroom, two-storey houses.
Key savings and benefits of the MMC build to the council, tenant, and owner	The key benefit of using MMC to the council is the speed of delivery. Another development of similar size local to the building project took 4 ½ years to finish, compared to 1 ½ years in this case. This level of efficiency, combined with the provision of 46% affordable housing, means more quality homes can be built for those who need it the most. Benefits to occupiers potentially include money savings due to the high energy efficiency provided. Each home is manufactured in a controlled, offsite environment, assuring that the highest levels of accuracy in assembly can be attained.
Lessons Learnt:	• Completion of RIBA Stage 4 design is required well in advance of installation • Improvements need to be sought to the following interfaces between components, construction stages, and different trades on site: ○ Co-ordination of foundation and sub-structure incoming/outgoing services/utilities ○ Tolerances of sub-structure ○ Co-ordination of sub-structure/module installation ○ Co-ordination of externals works/module installation

MMC build 5

MMC Build number: 5	**MMC type: 1 - Pre-manufacturing (3D primary structural systems)**
Purpose of build – social housing, housing association, private development etc:	Provision of social housing through a private development: Used by Bristol City Council's Syrian Resettlement Team.
Reason(s) why MMC build was chosen?	To undertake a large percentage of the build off-site to reduce impact and disruption on the neighbourhood, and to enable community members to participate in the build at the production space.
Ownership- eg housing association, local auth, owner occupied etc.	Private owner and leased to the city council which is providing a home to a refugee.
Description of build • Include type of location for build i.e. brown field site, carparks etc. Please do not mention actual site for the build.	One dwelling. The home is located on a rear drive of a terraced house. The land built on was covered in concrete.
Type of dwelling- eg flat, terraced house, single storey, multi storey etc	2 storey detached house (x 1).
Key savings and benefits of the MMC build to council, tenant and owner	The key benefits include. • training and up-skilling of local community members • training and up-skilling of future residents (future builds) • Increase in empowerment and knowhow of the resident (future builds) • Input into the Bristol economy and finance into the local economy - Local trades and sub-contractor in Bristol used. • Reduced carbon (travel miles in moving the home from fabrication space to site). • Reduced maintenance, and increased skill of resident to undertake some maintenance • Reduced energy consumption • Reduced carbon footprint • Increase health and wellbeing of resident through living in a warm and safe home
Lessons Learnt:	The space required on site for volumetric construction is significant and may not always be possible within a community setting.

MMC build 6

MMC Build number: 5	**MMC type: 1 - Pre-manufacturing (3D primary structural systems)**
Purpose of build – social housing, housing association, private development etc:	50% private, 50% affordable homes
Reason(s) why MMC build was chosen?	Quicker delivery of quality, affordable homes
Ownership- eg housing association, local auth, owner occupied etc.	Private owner-occupiers and Bristol City Council
Description of build • Include type of location for build i.e. brown field site, carparks etc. Please do not mention actual site for the build.	Infill development on land that was part railway and part allotments/open space. Work was undertaken to deliver a positive biodiversity gain on site and to improve an existing adjacent Site of Nature Conservation Interest. Transport and amenity use was also improved including a substantial upgrade to a cycle/pedestrian footpath. The site is surrounded by existing residential homes.
Type of dwelling- eg flat, terraced house, single storey, multi storey etc	185 new modular homes are being provided, comprising: - 74No. 1- and 2-bed apartments - 111No. 2-, 3- and 4-bed homes Homes are arranged in blocks of 2 to 4 homes. Apartments are provided in 2, 3 storey buildings and 2, 4 storey buildings. 50% of the properties will be affordable homes.
Key savings and benefits of the MMC build to council, tenant and owner	**Reduction in time spent on site.** This leads to lower levels of disruption for neighbours, a reduction in the amount and duration of transport to and from site and a reduction in construction costs. **Higher quality standards** Consistent quality and lower levels of snags in the properties. **Better performance levels** Lower carbon emissions from the homes and apartments – all of which are EPC A rated. Better levels of daylighting and acoustic performance.
Lessons Learnt:	None noted as too early in the development process.