

Modern methods of construction

Who's doing what?



Primary research



Housing research & guidance



NF82

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Thanks to all case study collaborators for allowing use of their images on pages 12-29.

Thank you also to those who have provided images for this report:

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Primary research

November 2018

The NHBC Foundation

The **NHBC Foundation**, established in 2006, provides high-quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st-century new homes. To date, it has published more than 80 reports on a wide variety of topics, including the sustainability agenda, homeowner issues and risk management.

The NHBC Foundation is also involved in a programme of positive engagement with the government, academics and other key stakeholders, focusing on the current and pressing issues relevant to house building.

To find out more about the NHBC Foundation, please visit www.nhbcfoundation.org. If you have feedback or suggestions for new areas of research, please contact info@nhbcfoundation.org.

NHBC is the standard-setting body and leading warranty and insurance provider for new homes in the UK, providing risk management services to the house-building and wider construction industry. All profits are reinvested in research and work to improve the construction standard of new homes for the benefit of homeowners. NHBC is independent of the government and house builders. To find out more about the NHBC, please visit www.nhbc.co.uk.

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 Keepmoat
Homes

Keepmoat
Homes

Foreword

In the two years since the publication of my review of the UK's construction labour model, "Modernise or Die", there appear to be early signs that the house-building and wider construction sectors are responding to the challenge I set down.

The drivers for change appear varied, but there seems to be a common desire for improved predictability in terms of cost, time and quality. The construction industry is entering an unprecedented period of risk driven by an ageing workforce, societal changes increasingly acting against construction in the race for young talent, and the added geo-political pressures of Brexit impacting labour security. More businesses are starting to recognise that the basic production model for new homes needs to change. Any attempt to increase total home/house-building output without improving processes and productivity will result in the predictability of delivery outcomes deteriorating further, reputational damage associated with poor build quality and increased risk of financial failure.

The results of this report are positive: they show that developers of new homes operating across all tenures are already delivering differently, with a general intent to ramp up such activity. The report also demonstrates that these organisations are approaching this challenge in different ways: some are vertically-integrating manufacturing capability to retain control, while others are cautiously forming partnerships with the manufacturing supply chain to diversify their means of delivery without directly owning manufacturing plant and facilities.

This report also starts to show that the term 'Modern Methods of Construction' (MMC) covers a broad spectrum of construction activity. I see moves towards greater MMC uptake in the UK being reflected in an increase in the average 'pre-manufactured value' (PMV) of schemes. The gradual reduction in the proportion of site labour and site overheads is being driven by a combination of different techniques ranging from volumetric modular solutions through to more subtle changes in component or sub-assembly level standardisation. All these routes have equal validity and are part of our industry's journey towards integrating a blend of both offsite and onsite manufacturing with traditional site-based construction.

It is important that the industry focuses on responsible innovation – we cannot afford any repeats of the past mistakes that still stigmatise the concept of offsite construction. Developers are right to be discerning and to ask challenging questions on the technical robustness of new products and systems. The MMC working group I chair for the Ministry of Housing, Communities & Local Government is tasked with improving mainstream acceptance of MMC from a finance and insurance perspective, better defining key industry terminology, and facilitating a broader knowledge and evidence base. I hope the outputs of this working group will further help build confidence in the use of MMC.

Lastly, I would like to applaud the NHBC Foundation for having the foresight to commission this research at what is a crucial time for the house-building industry. Building confidence in MMC starts with sharing what the industry is already doing to innovate. This report clearly shows an industry on a cautious and formative path to embracing change. I would recommend that this publication becomes a benchmark for future updates and measurement of industry progress.

Mark Farmer
CEO, Cast Consultancy



1 Introduction

'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.

Since early in the 20th century, there have been previous periods of engagement with various alternative methods of construction in order to boost the country's house-building output, most notably in the post-war period. With each iteration the new approaches have been linked with significant benefits; speed of delivery, improved quality, reduced labour costs and predictability to name a few.

In recent years there has been renewed interest in MMC, with more developers engaging in project trials and going on to make increasing use of the variety of systems available. The 2017 Government White Paper¹ expressed support for the contribution MMC is expected to make to helping solve the nation's housing crisis and achieve the step-change in housing output that is needed. It pointed to the potential for a 30% improvement in the speed of construction of new homes through the adoption of innovation, with a potential 25% reduction in costs, as well as the potential for advances in improving quality and energy efficiency.

Previous research published by the NHBC Foundation in 2016², confirmed a high level of engagement with MMC at that time amongst house builders and housing associations. In addition to building faster and better quality homes, 'tackling the skills shortage' was identified as a key driver. There have been growing difficulties for developers in recruiting key skills over the past few years and it would appear likely that the situation isn't set to improve quickly as the country heads towards Brexit.

The increasing level of interest in MMC and confidence that it will play a greater role in home building are demonstrated by the case studies in this report. This confidence is reflected in the business decisions being made by these developers, with nearly 30% investing in their own manufacturing facilities and over 25% investing in their own products or systems. These trailblazers provide valuable insights for others considering adopting MMC.

Survey findings in this report have begun to unearth why today's more innovative developers are investing in MMC. A series of benefits of MMC are recognised, some by very high proportions of developers. While their measurable impact on business is not yet available, these perceived benefits, if widely promoted, could contribute much to the wider adoption of MMC within the sector. At the same time the work identifies a number of significant barriers to adoption, with some concern that planners and lenders, through their processes, may be inadvertently hindering innovation through MMC.

The findings and case studies included in this report provide a snapshot of sector activity at the more advanced levels of MMC. The developers who contributed to this research delivered over 55,000 homes across the UK in 2017 and if their plans come to fruition, volumetric and panelised MMC now look poised to break through into mainstream UK housing delivery.

1 Fixing our broken housing market. Ministry of Housing, Communities & Local Government. 2017

2 Modern methods of construction: views from the industry. NHBC Foundation. NF70, 2016.



2 Research methodology

The objective of this research was to improve understanding of housing-development sector innovation (using the more advanced MMC approaches, in particular volumetric or panelised systems). Data, including uptake of systems, current projects and future plans, was gathered from developers across a range of business types including house builders, housing associations, SME developers, institutional investors and local authorities. The research was conducted in three stages:

Stage 1 Overview of MMC activity

This preliminary exercise, involved desktop research and discussions with developers including those that are vertically-integrated. It contributed to the broader picture of engagement with MMC within the housing-development sector and identified potential participants who might contribute more detailed information to this project.

Stage 2 Online survey

An online survey questionnaire was forwarded to those identified in Stage 1 as having at least some activity (in the more advanced forms of MMC). The survey questions explored the following issues:

- Previous and projected housing output;
- Current and future housing output using MMC;
- MMC systems being used;
- Why and how they had invested in MMC;
- Major barriers to their wider use of MMC; and
- Key partnerships and manufacturing relationships.

Though, for commercial reasons, some developers declined to respond, a high proportion (60%) completed the survey questionnaire. Of those who provided survey data, a group of 36 'active MMC developers' was selected, based on whether they met at least one of the following criteria:

- Delivered a significant proportion (over 50%) of their total output using MMC;
- Delivered a large annual number of homes (over 500) with at least 5% using MMC;
- Had made a significant investment in MMC technology for future output.

Survey feedback from these active MMC developers was analysed in more detail and is summarised in Section 3.

Stage 3 Case studies

All of the active MMC developers were given the opportunity to feature as a case study in this report. Those wishing to contribute were invited to take part in a telephone interview to add detail beyond their original survey responses, particularly on completed MMC projects and their future plans. A total of 18 organisations contributed to the case study portfolio, presented in Section 4, including a wide diversity of developers, from volume house builders and large housing associations through to specialist development/manufacturing companies.



3 Survey findings

In this Section, questionnaire feedback is analysed from the 36 developers that were either actively involved in MMC or actively considering its use. It's important to stress that the findings are not representative of general engagement with (or attitudes to) MMC across the housing-development sector but reflect the experiences and views of those companies which have used (advanced forms of MMC) or have committed to do so in the near future.

3.1 Current and future activity

Among these developers, a large proportion (69%) were delivering housing using advanced MMC (mainly volumetric or panelised systems), and overall about 92% had plans to expand its use in future years either by increasing their current use of MMC or by commencing its use (Figure 1).

At the time of the survey a few developers (8%) had no plans to expand their current use of MMC. However of those currently using MMC, the vast majority expected to increase its use in the future, indicating confidence in their chosen approach and providing indirect evidence that innovation through MMC is yielding tangible business benefits in most cases.

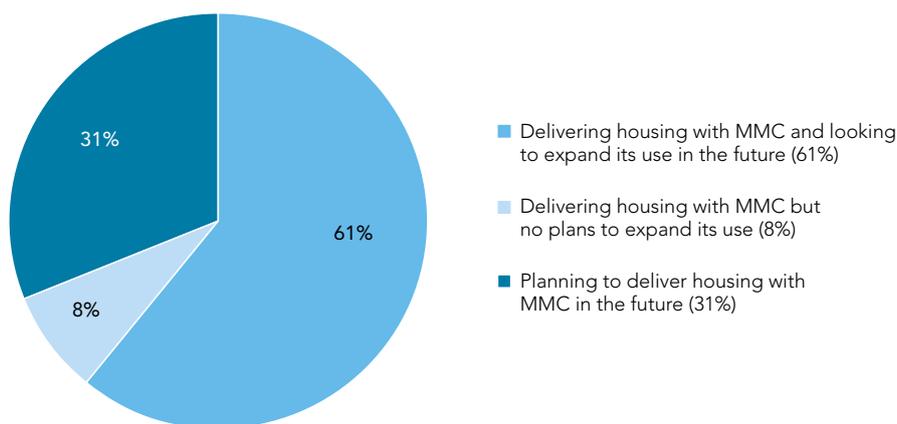


Figure 1 How the developers described their MMC activity. (Sample size – 36)

3.2 MMC systems and technologies

As part of the survey, developers were asked to select the types of MMC they were currently using or, for those yet to adopt a system, the types they planned to use. For the developers in this study, the current/anticipated high level of use of volumetric modules is notable (Figure 2). Previous work³, albeit for a different cross section of developers (house builders and housing associations only), indicated that panelised approaches were much the favoured advanced form of MMC a few years ago, but this study suggests that volumetric modules may be gaining greater acceptance with time. The main finding, however, is that each of these MMC approaches appears to have developed supporters at the time of this survey and each may continue to play an important role as the sector adapts.

For the definitions of these systems and methods, please refer to the glossary of terms.

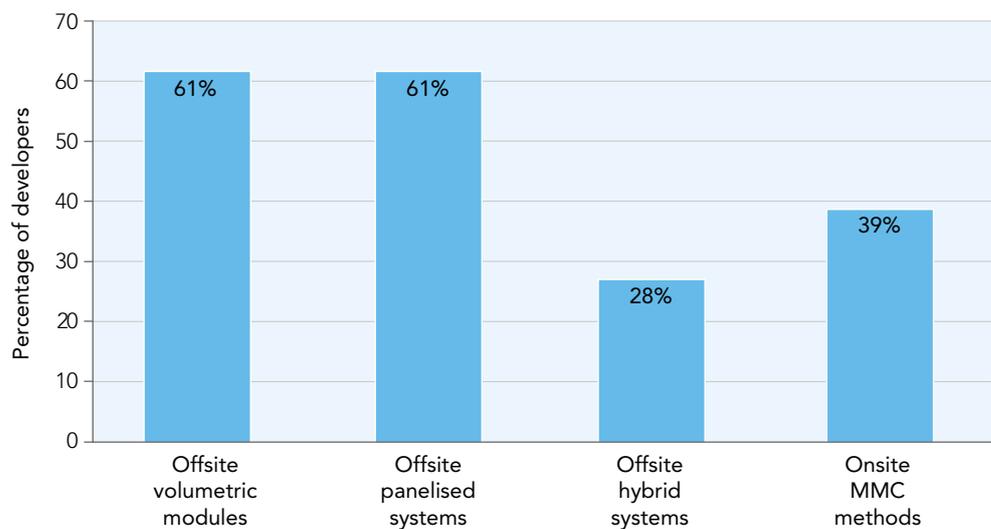


Figure 2 Proportion of developers using or planning to use different types of MMC. (Sample size – 36)



3 Modern methods of construction: views from the industry. NHBC Foundation. NF70, 2016.

3.3 Investment in MMC

For the developers in this sample, who are all seeking success with a new delivery model, it is not surprising that a large number are investing (or expect to invest) in research and development (Figure 3). Many are also investing specifically to establish partnerships and supply chains, and to retain control of processes and production. Nearly 30% have already invested in their own manufacturing facility; a strategic commercial decision to retain close control of production and supply, and perhaps one of the most important trends on the MMC landscape. The case studies in Section 4 illustrate an interesting diversity of investment approaches.

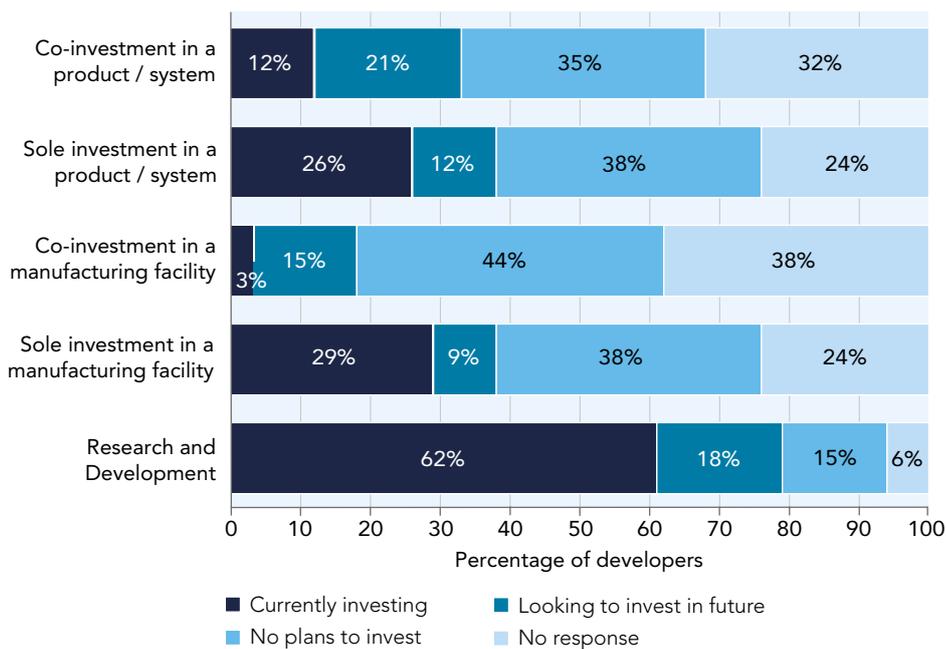


Figure 3 Investment choices made by the developers. (Sample size – 34)



3.4 Factors driving uptake of MMC

The survey invited developers to select their reasons for investing in MMC from a prompted list. Their responses, shown in Figure 4, give some insight as to why these developers continue to invest in MMC and contributes evidence to an otherwise largely theoretical debate on its benefits. For these survey participants, better quality, improved efficiency, accelerated delivery and increased productivity are the most frequently chosen drivers, however this study does not allow us to truly quantify their relative importance in commercial terms. Arguably, even the lower rated drivers such as ‘reduced capital cost’ are highly significant, at 31% at this relatively early point in the adoption cycle of MMC. Detailed new research is needed before we can reliably assess the commercial benefits of MMC.

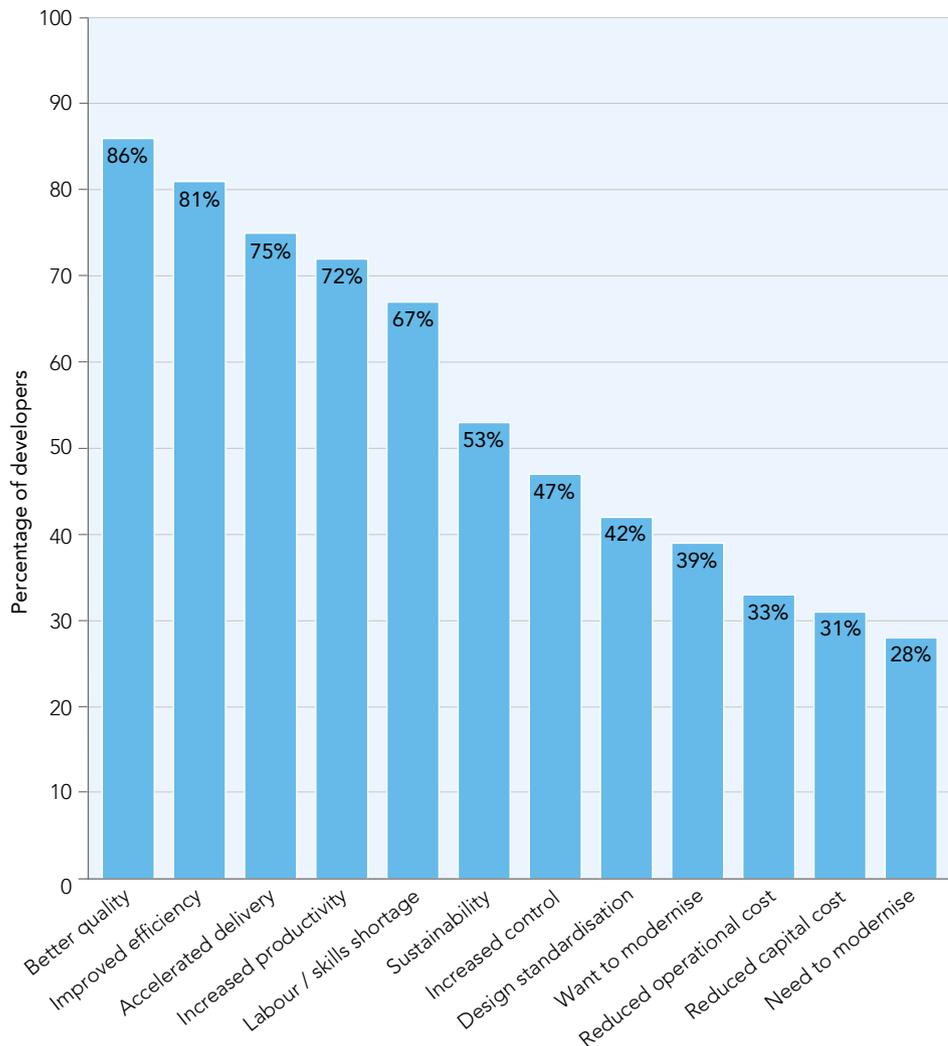


Figure 4 Factors driving the use of MMC. (Sample size – 36)

3.5 Barriers to investment

Even among these MMC 'advocate' developers it is notable that a number of barriers to engagement with MMC are recognised at quite significant levels, Figure 5. Challenges with the procurement of MMC and the MMC supply chain's limited manufacturing capacity (and the risk of interruption of supply) have been longstanding concerns and explain, at least in part, why some developers committed to MMC are establishing their own manufacturing facilities.

It is clear that more needs to be done to overcome misconceptions among planners and lenders, and the Offsite Working Group established by the Ministry of Housing, Communities & Local Government should help to provide a focus for bringing consistency and commonality on how offsite solutions are considered.

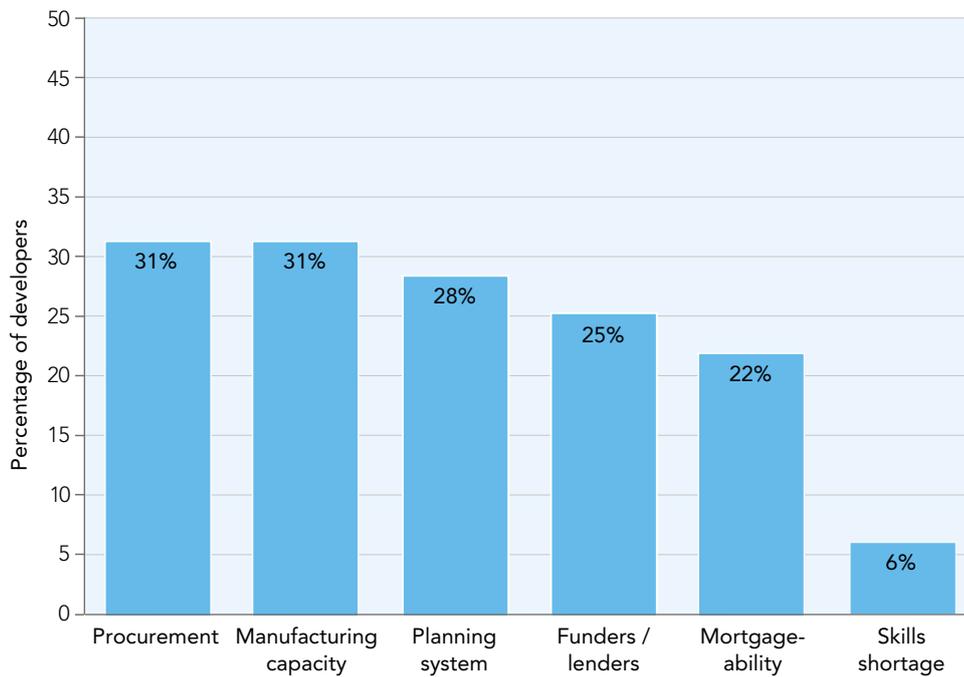


Figure 5 Barriers to MMC uptake selected by developers. (Sample size – 36)

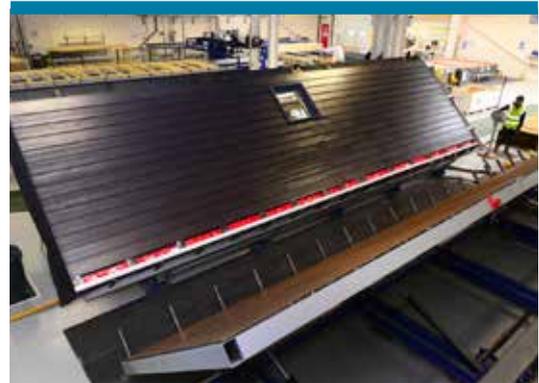


4 Case studies



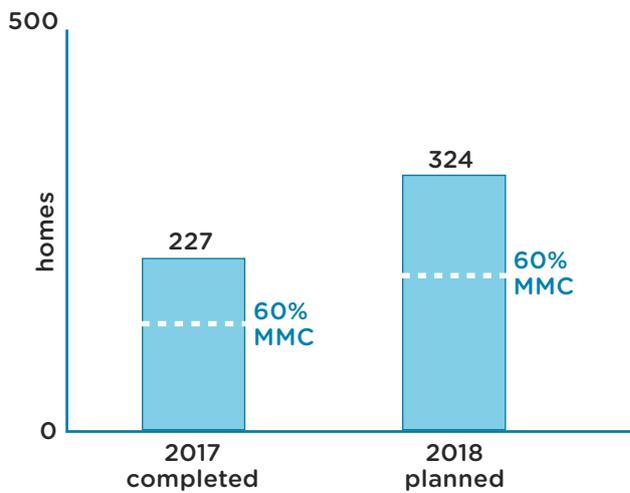
Accord

Accord is a housing association operating throughout the Midlands, which was formed from several charitable organisations and trusts dating back to 1511. Accord currently provides 13,000 affordable homes to rent. Accord's offsite manufacturing arm, LoCaL Homes, delivers new homes for Accord, other housing associations and developing councils.



Manufacture of closed-panel external walls

Homes delivered & planned



Organisation fact file

Type	Housing association
Model	Developer/manufacturer
Employees	4,000
Annual Turnover	£120m
Associated Brands	LoCaL Homes

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Accord's offsite manufacturing business, LoCaL Homes, has been operating for 6 years producing closed-panel timber frame systems.
- LoCaL Homes supplies Accord's own developments and sells to external clients.
- LoCaL Homes moved into a new 56,000 sq.ft factory in Aldridge, West Midlands in October 2018. The new factory can produce up to 1,000 homes per year.
- LoCaL's closed wall panels are delivered to site with completed windows and cladding, ready for assembly.
- Current developments under construction for affordable rent include 112 homes in Woden Road, Wolverhampton and 142 homes in Dudley.



Lifting wall panels at Woden Road, Wolverhampton

Future plans

- LoCaL Homes' factory is designed to be a replicable model that could be used by other housing associations.
- The new factory will allow LoCaL Homes to manufacture their own integrated kitchen and bathroom volumetric pods.



Completed affordable homes, Woden Road

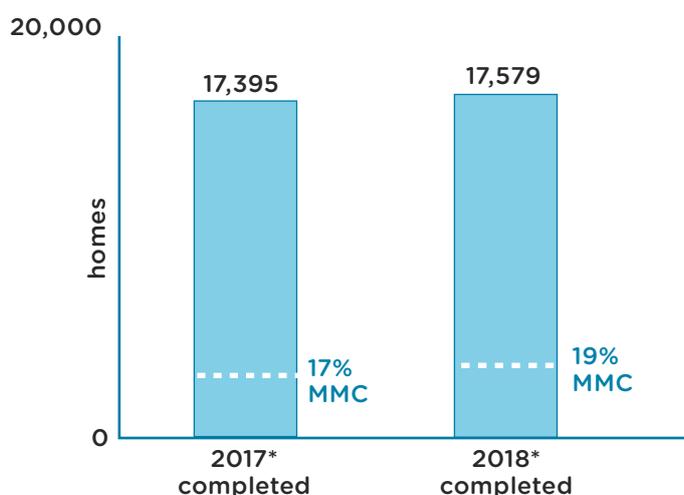
Barratt Developments

Barratt Developments is a private developer and the UK's largest house builder. Established in 1958, Barratt now operates throughout the UK across a network of 27 operating divisions, building around 10% of the UK's new homes each year. In 2014, Barratt appointed a Technical and Innovation Director to explore new construction methods.



Panelised light-gauge steel frame construction

Homes delivered & planned



*represent financial year (to June) figures

Organisation fact file

Type	Private sector
Model	House builder
Employees	6,000
Annual Turnover	£4.8bn
Associated Brands	Barratt Homes, David Wilson Homes

Systems used for MMC output

	✓	Offsite panelised	56%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✓	Onsite MMC	44%

Current activity

- Over a two-year period, Barratt has undertaken a review of over 150 offsite suppliers and identified three potential partners to provide panelised systems for future projects.
- Barratt has tended to use offsite manufacturing where the local absorption rates can't be met by using traditional construction.
- To date, Barratt's offsite activities have included 160 houses and six apartment blocks built with a panelised light-gauge steel frame system, a 336 apartment development in central London with a precast brick façade, and a 194 home development in Bromsgrove built from storey-height aircrete panels.



Installation of volumetric garage modules

Future plans

- Barratt aims to produce at least 20% of its new homes using offsite construction methods by 2020.
- Barratt is continuing the testing of new offsite technologies across its portfolio.



Homes built using storey-height aircrete panels

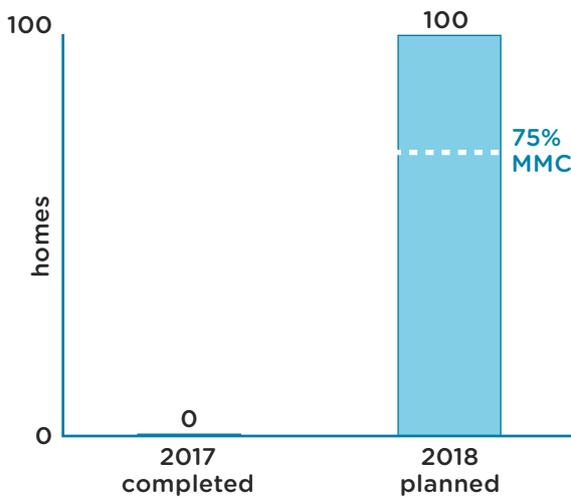
Brick by Brick

Brick by Brick (BxB) is a development company established by the London Borough of Croydon. Brick by Brick builds homes across a variety of tenures including affordable rent, private sale and shared ownership homes. For the first two months after completion these homes are offered exclusively to local Croydon residents.



Proposal for 57 homes at Auckland Rise, Croydon

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer
Employees	17
Annual Turnover	£350m
Associated Brands	Common Ground

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Brick by Brick currently has a development pipeline of around 2,000 homes with around 600 already on site, with developments ranging from four to 157 homes.
- Offsite manufacturing enables several sites in Brick by Brick's 'Smaller Sites' programme, which include challenging infills on existing housing estates and garage sites.
- Across their portfolio, Brick by Brick is working with several different panelised manufacturers using either structural insulated panels or closed-panel timber frame.
- Current developments include 128 homes in a 25 storey tower in Croydon town centre and 157 homes across five buildings in Coulsdon.



Closed-panel timber frame at Auckland Rise

Future plans

- Brick by Brick is looking to co-invest in a manufacturing facility in the future.
- Brick by Brick is looking to create their own housing product which can be sold to other developers and contractors.



Approved plans for a 25 storey development

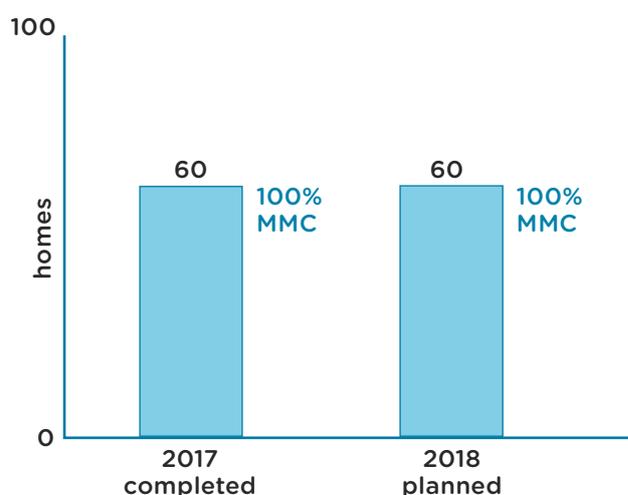
Brooke Homes

Brooke Homes is a London-based developer established in 2006 that builds homes in the commuter belt around London. Brooke has partnered with construction firm Adston Manufacturing Kent (AMK) to create a fully-finished volumetric modular housing product for use across their developments.



Volumetric modules manufactured offsite by AMK

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer/manufacturer
Employees	45
Annual Turnover	£12m
Associated Brands	AMK, Brooke Logistics

Systems used for MMC output

	Offsite panelised	-
	Offsite volumetric	100%
	Offsite hybrid	-
	Onsite MMC	-

Current activity

- Brooke Homes utilises a volumetric modular system constructed from SIPs panels at AMK's factory in Ashford, Kent and distributed to site by their own logistics company, Brooke Logistics.
- Brooke Homes' volumetric modules are delivered to site fully-finished including all brickwork, glazing, wiring and plumbing, kitchens, bathrooms and decoration.
- Brooke Homes' current developments include the 110 home Capstone Green, Chatham (sold to Housing Association L&Q) and a development in Bicester, Oxfordshire.
- Brooke Homes' manufacturing partner AMK is looking to develop their product to sell to other developer clients.



Installation of fully-finished volumetric modules



First completed homes at Capstone Green

Future plans

- Brooke Homes also plans to establish an apprentice training academy to assist in the shortage of local construction and precision manufacturing skills.

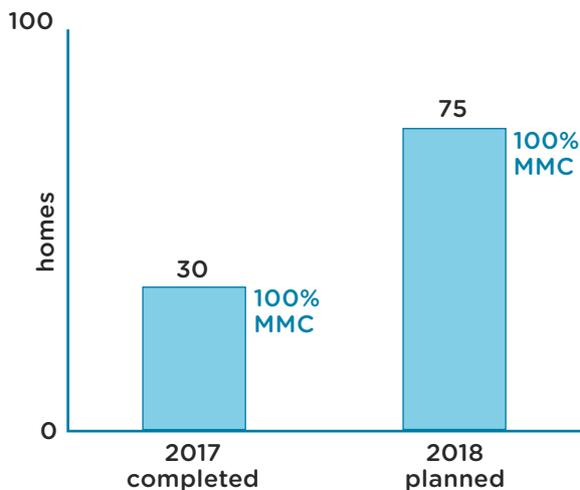
Citu

Citu is a sustainability-driven private developer based in Leeds, established in 2004. Citu has created a vertically-integrated construction system, including a digital design platform, factory and multi-skilled assembly team to deliver their product, Citu House – a highly energy-efficient home constructed using a closed-panel timber frame system.



Completed terrace at Little Kelham, Sheffield

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer/manufacturer
Employees	100
Annual Turnover	£15m
Associated Brands	Citu Works, Citu Studio

Systems used for MMC output

	✓	Offsite panelised	69%
	✗	Offsite volumetric	-
	✓	Offsite hybrid	31%
	✗	Onsite MMC	-

Current activity

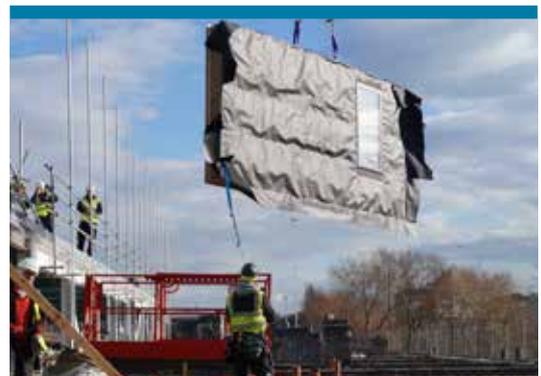
- Citu developed their Citu House with a Focused Innovation grant from the Government through Innovate UK, in collaboration with Leeds Beckett University.
- Their 60,000 sq.ft factory, Citu Works, has the capacity to produce 750 low-carbon homes per year.
- Citu Studio, their online platform, allows the configuration of house types, finishes and fittings by prospective purchasers.
- Current projects include the 312 home first-phase Climate Innovation District (CID) in Leeds, (one of the UK's largest sustainable developments) and Little Kelham in Sheffield.



Phase 1 of the Climate Innovation District, Leeds

Future plans

- Citu aims to develop their factory-built design and incorporate more items into their factory assembly process.
- Phase 2 of the Climate Innovation District is due to commence in 2019.



Closed-panel timber frame being installed

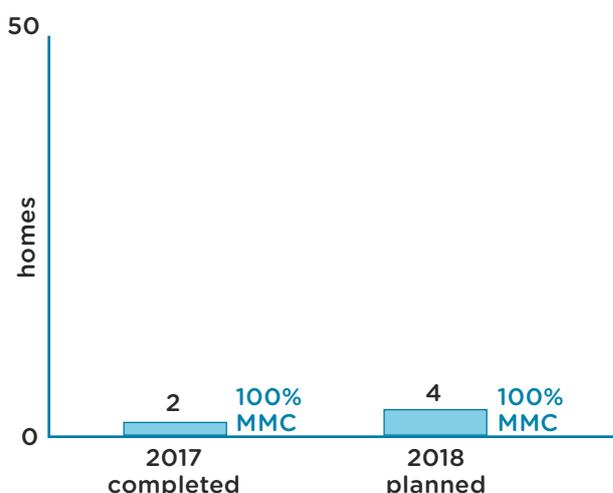
Click Properties

Click Properties is a private developer working in London and the commuter belt, established in 2011. Click Properties specialises in building affordable urban family housing and – together with sister brand Click Above – deliver airspace residential development above existing residential and commercial buildings.



Airspace development with 49 bedrooms, UCL

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer
Employees	5
Annual Turnover	£1m
Associated Brands	Click Above

Systems used for MMC output

	X	Offsite panelised	-
	✓	Offsite volumetric	100%
	X	Offsite hybrid	-
	X	Onsite MMC	-

Current activity

- Click Properties builds using Modern Methods of Construction and works with a range of different manufacturers.
- Click Properties is currently building one of the UK's largest volumetric modular residential developments, Aspire: a 238 home development in Slough.
- Each home at Aspire will be available in 50 different variations which can be customised by the buyer, including a smart home option. The development is targeting a 16 month construction programme.
- Click Above's current projects includes two rooftop penthouses in Battersea and 23 homes above a commercial building in Camden.



Airspace apartments at Corben Mews, Battersea

Future plans

- Click's Aspire development in Slough is due for completion in 2019 with the installation of the volumetric modules programmed to take 10 weeks.
- Click Properties is investing in developing their own volumetric modular product for future projects.



238 volumetric homes at Aspire, Slough

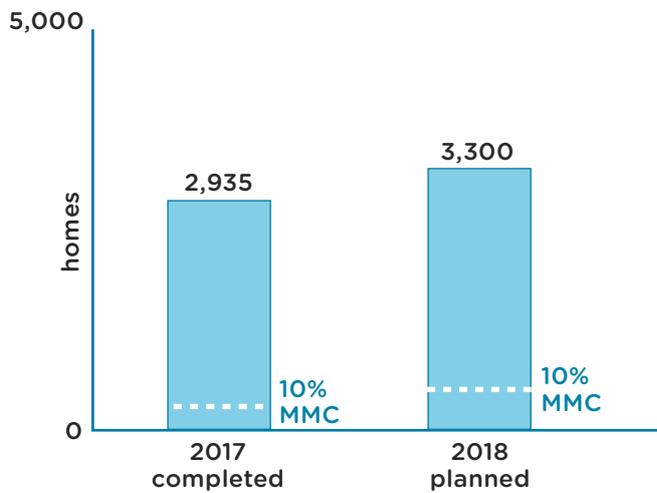
Crest Nicholson

Crest Nicholson, established in 1963, is one of the UK's top 10 house builders and delivers homes across southern England and the Midlands. Crest Nicholson was a participant in the research project Advanced Industrialised Methods of Construction for Homes (AIMCh), challenging the UK house building model using offsite manufacturing.



Fabrication of closed-panel light-gauge steel frames

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	House builder
Employees	c.1,000
Annual Turnover	£1bn
Associated Brands	-

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Crest Nicholson has been researching offsite manufacturing for three years and has developed two advanced panelised systems. These systems include factory-fitted insulation, cavity trays, windows, doors and seals.
- Crest Nicholson has built three prototype houses at Arborfield Green, Wokingham, which were reviewed by 200 Crest Nicholson staff. Detail design is currently underway on four developments that will be utilising this panelised system.
- Crest Nicholson does not own a manufacturing facility, but is identifying partner manufacturers to develop their panelised system further, before committing to its own factory or joint venture agreement.



Prototype house assembly at Arborfield Green

Future plans

- Crest Nicholson intends to extend the use of panelised systems across its portfolio with a partnering manufacturer.



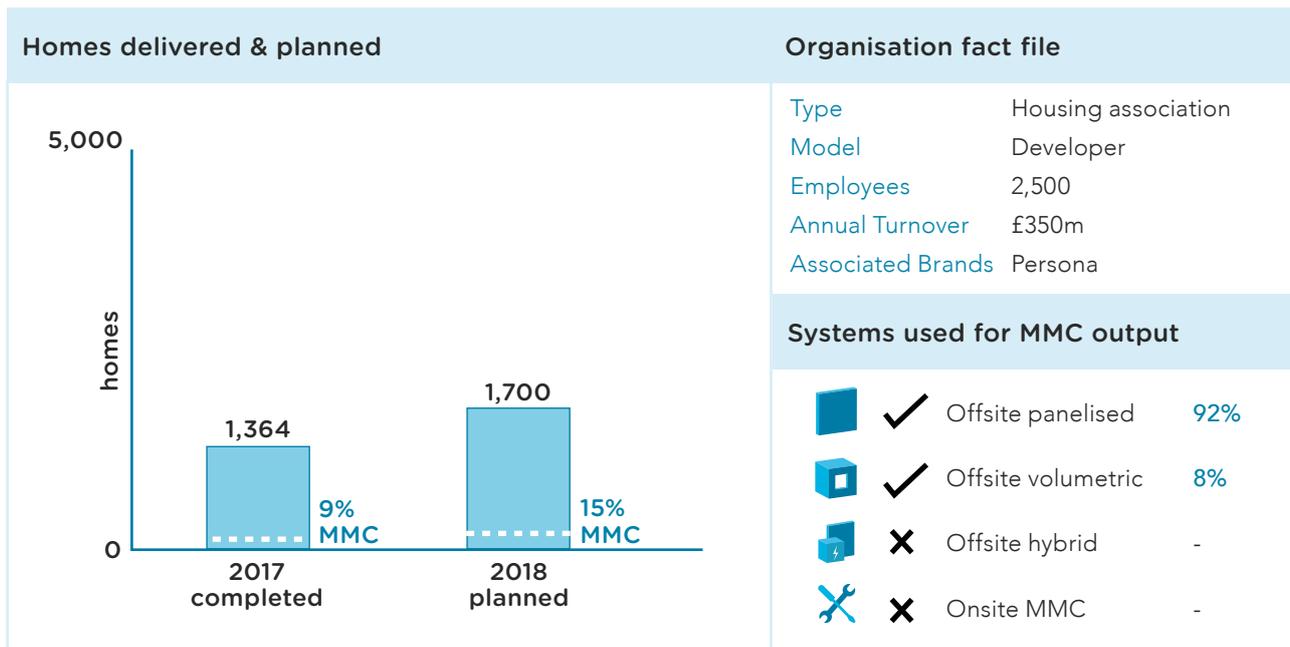
Completed prototype house at Arborfield Green

Home Group

Home Group is a housing association established in 1935 that operates across the UK. Home Group provides affordable housing for rent, for private sale, and for shared ownership and currently manages over 55,000 homes. Home Group's current development plans will deliver more than 12,000 new homes.



Proposed Gateshead Innovation Village development



Current activity

- Home Group has been building its entire offsite manufactured output using closed-panel timber frames.
- Home Group is undertaking a pilot study (supported by Homes England) to compare several different offsite manufacturing systems with traditional construction at their 41 home Innovation Village site in Gateshead.
- Across a range of house types at the Innovation Village, 16 will be built with volumetric modules, 9 using panelised light-gauge steel frames, 10 using large aerated concrete panels and 6 using traditional construction.
- The offsite manufactured homes will be environmentally monitored during and after construction.



Lifting a floor cassette at Maxwell Road, Glasgow

Future plans

- Following the completion of the study at the Gateshead Innovation Village, Home Group intend to significantly increase the percentage of their development pipeline delivered using offsite manufacturing technology.



31 home development at Muirsketh Road, Glasgow

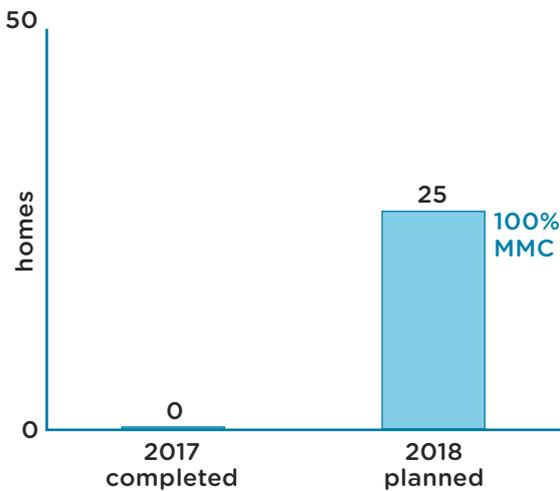
Innerspace Homes

Innerspace Homes is a developer established in 2017 working across London and the Home Counties. Innerspace Homes builds exclusively using offsite manufacturing and, working in partnership with public and private bodies, focus on two specific areas of housing: airspace/rooftop development and sustainable modular housing for key workers.



Proposed Camden rooftop development

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer
Employees	2
Annual Turnover	Trading less than 1 year
Associated Brands	-

Systems used for MMC output

	✓	Offsite panelised	50%
	✓	Offsite volumetric	50%
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Innerspace designs for offsite manufacturing from the project outset, with site-specific challenges defining its offsite manufacturing strategy.
- Innerspace works with three offsite systems: generally light-gauge steel framed panels and closed-panel timber frame units are used for airspace developments (to address lifting and load-bearing capacity of the existing building) and volumetric modular for their larger keyworker housing.
- Current airspace developments include a penthouse in Camden and four apartments in Putney. Current volumetric modular schemes include 128 branded low-rise houses across 2 sites in Cambridgeshire, both of which have planning and start onsite in June 2019.



Open-panel light-gauge steel frame being lifted

Future plans

- Innerspace is increasing their volumetric module typology base for larger sites and refining their product and implementation.
- Innerspace are currently on target to build 200 branded volumetric modular homes by the end of 2019.



Proposed volumetric housing for key workers

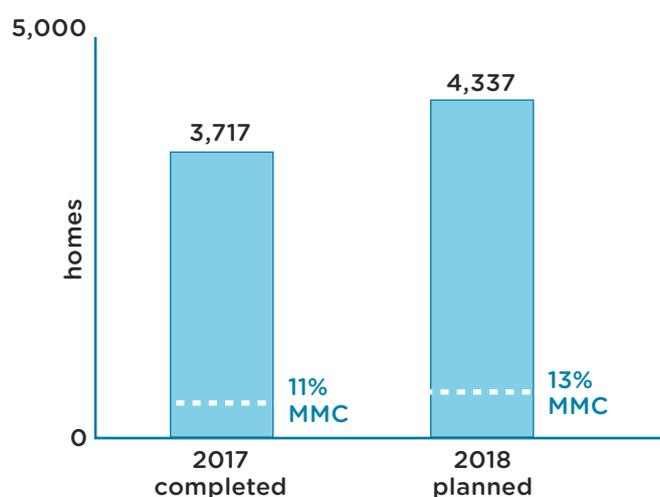
Keepmoat Homes

Keepmoat Homes is a house builder, established in 1983 in Doncaster, that builds homes for sale across the UK. Keepmoat has been working with offsite homes manufacturer ilke Homes since 2016. Their first homes were installed at Keepmoat's 172 home Dominion development in Doncaster in March 2017.



Completed homes from ilke at Dominion, Doncaster

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	House builder
Employees	1,094
Annual Turnover	£555m
Associated Brands	-

Systems used for MMC output

	✓	Offsite panelised	85%
	✓	Offsite volumetric	15%
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Keepmoat's current offsite activity includes 468 homes built from panelised, timber frame systems and 79 homes built from volumetric modules with ilke Homes.
- The largest of Keepmoat's volumetric modular developments are 22 homes in Bridgwater, Somerset and 19 homes in Brookvale, Derbyshire.
- Each house is made of two or three volumetric modules. Each module is delivered to site fully-finished internally and externally, including the windows and roof, with only minor finishing details to complete on site – services connections, rainwater pipes, external fixtures, porch, and module joints.



Fully-finished volumetric modules in transit to site

Future plans

- Keepmoat has signed partnership deals with Homes England for more than 1,000 new homes.
- Keepmoat is working closely with Homes England to incorporate volumetric modular on these sites as part of its Accelerated Construction Programme.



Volumetric modules being installed at Dominion

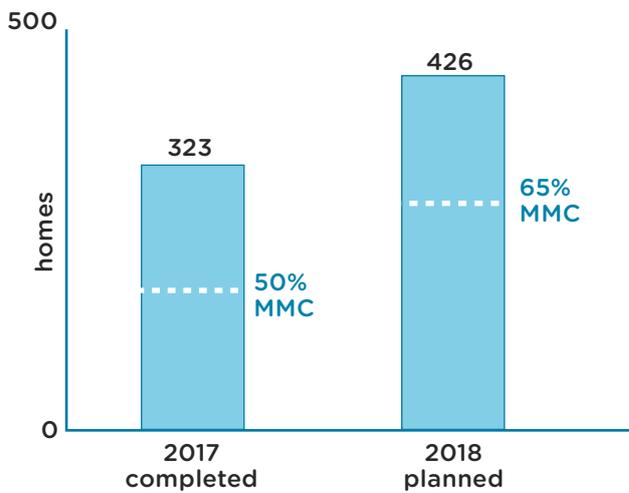
Midland Heart

Midland Heart is a housing association established in 1925 that provides affordable housing for shared ownership, social and affordable rent, and private sale. Midland Heart currently manages 33,000 homes and has a target to build 2,350 homes for social and affordable rent over the next five years.



Installing volumetric modules at Modular Mews

Homes delivered & planned



Organisation fact file

Type	Housing association
Model	Developer
Employees	1,520
Annual Turnover	£206m
Associated Brands	-

Systems used for MMC output

	✓	Offsite panelised	97%
	✓	Offsite volumetric	3%
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Midland Heart is currently delivering several large developments with Westleigh Partnerships using open-panel timber frames: three large regeneration sites in Leicester totalling 395 homes and smaller developments of 84 homes in Coventry and 64 homes in Birmingham.
- Midland Heart has completed a pilot development of four volumetric modular semi-detached family houses in Coventry – ‘Modular Mews’ – built for affordable rent.
- The homes were constructed offsite in a factory in Nuneaton before being transported to site. Each module was built from light-gauge steel frame and was delivered to site fully-fitted and partially-clad. Construction of the development was complete within six-weeks.



Completed volumetric homes at Modular Mews

Future plans

- Midland Heart plans to increase usage of timber frame panelised systems for future developments.
- Following their successful trial, Midland Heart is evaluating the feasibility of volumetric modular construction on larger sites.



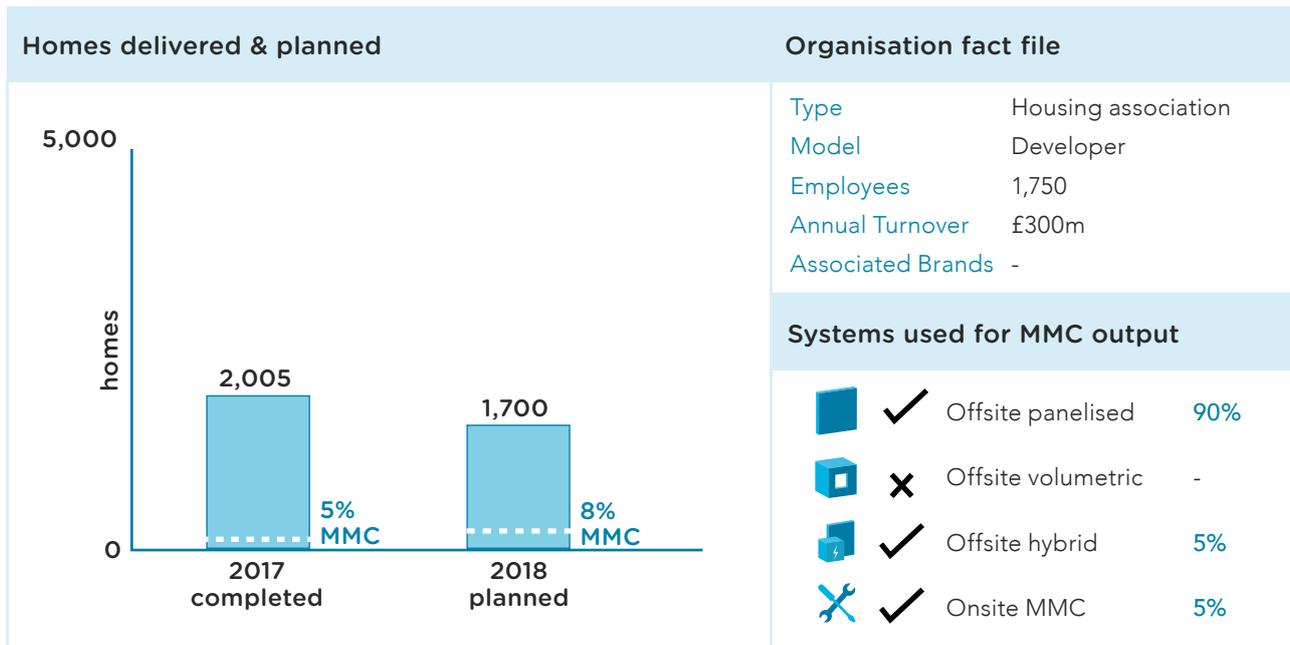
Closed-panel timber frame apartment complex

Orbit Group

Orbit Group is a housing association operating across the Midlands, east and south east of England. Orbit builds affordable rented homes and private sale homes and currently manages over 39,000 homes. As early as 2013, Orbit was piloting building new homes in Coventry to Passivhaus standards using offsite manufacturing.



Proposed 99 home development in Lichfield



Current activity

- Orbit's private sale housing all utilise MMC systems, from panelised structural systems through to component assemblies such as door sets.
- Orbit is currently investing in offsite research and development – its team includes members focused on building methods/manufacturing and digitisation.
- Orbit's team is currently creating a series of offsite design standards and designing a series of volumetric modular housing types, that could be built traditionally if required.
- Orbit's digitisation team is creating an offsite manufacture component BIM library for future developments to be built from.



Installation of storey-height aircrete panels

Future plans

- Moving forward, Orbit intends to maximise the offsite manufactured content of their private sale products.
- Orbit is also looking to create a land development pipeline to facilitate their offsite output, including PRS and affordable rent developments.



567 homes at Erith Park, Bexley

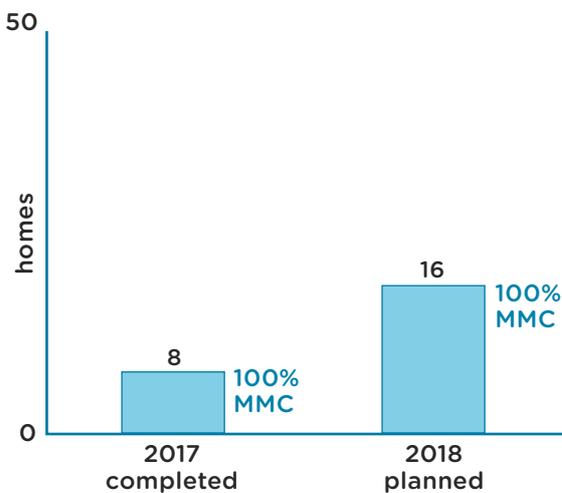
Oscos Homes

Oscos Homes is a residential vertically-integrated not-for-profit development company operating in the north of England, established in 2015. Oscos is committed to building 100% of its housing through offsite manufacturing. Their system allows a dwelling to be structurally complete and watertight within 12 hours of delivery to site.



External wall panels being installed at St Hilda's

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer/manufacturer
Employees	12
Annual Turnover	£1m
Associated Brands	Procure Plus Holdings

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Oscos's homes are all built using a light-gauge steel frame panelised system manufactured at their own factory in Manchester. The factory also builds homes on behalf of other developers.
- The panels are assembled into wall, floor, ceiling and roof units and delivered to site complete with cladding, windows/doors and weatherproofing. The assembled panels remain open internally to allow for onsite fit out.
- Completed Oscos projects include The Lockies, an 8 home development in South Kirby and St Hilda's, a 7 home development in Leeds.
- In 2019 Oscos will be completing Baycliff View, a 19 home development in Liverpool designed by Haworth Tompkins.



Complete semi-detached homes at St Hilda's

Future plans

- Oscos believes offsite manufacturing maximises value for public sector landowners over other development routes.
- Oscos is marketing its panelised housing product to custom-builders, allowing buyers to configure options from their standard house types.



Forthcoming Baycliff View homes in Liverpool

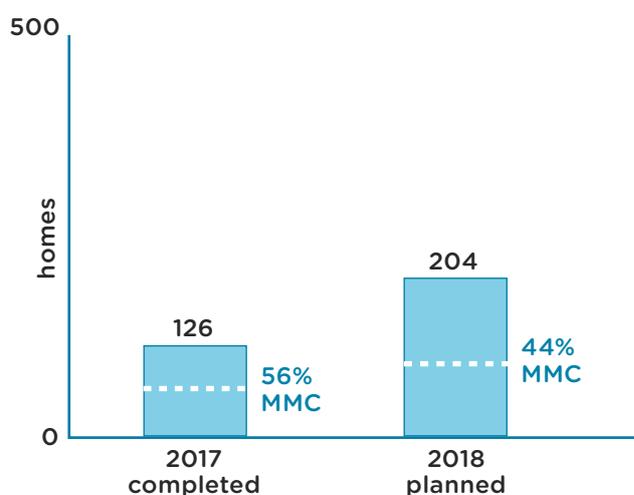
Pocket Living

Pocket Living is a London-based private developer formed in 2005, specialising in affordable one and two bedroom homes. Their new-build homes are aimed at first-time buyers who already live/work in the local London borough. Pocket Living's homes are sold with a minimum of a 20% discount on the local market rate.



Fully-fitted volumetric modules delivered to site

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer
Employees	43
Annual Turnover	£77m
Associated Brands	-

Systems used for MMC output

	✗	Offsite panelised	-
	✓	Offsite volumetric	100%
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- As of June 2018, Pocket Living had delivered 200 homes through volumetric modular, and is planning a further 265 homes by April 2020.
- Pocket Living received £25m loan from the London Mayor's Innovation Fund in 2017 to help finance ongoing site purchases.
- Pocket Living's 89 home development in Wandsworth is currently one of the tallest residential towers in Europe built using volumetric modular construction.
- Current developments include 153 homes in Croydon and 112 homes in South Acton.
- Pocket Living is developing relationships with new turnkey manufacturers to facilitate future delivery.



Installation of fully-fitted volumetric modules

Future plans

- Pocket Living plans to continue constructing developments using Modern Methods of Construction to help address the challenges of working with volumetric modular on smaller constrained sites.



Mapleton Crescent, 89 homes in Wandsworth

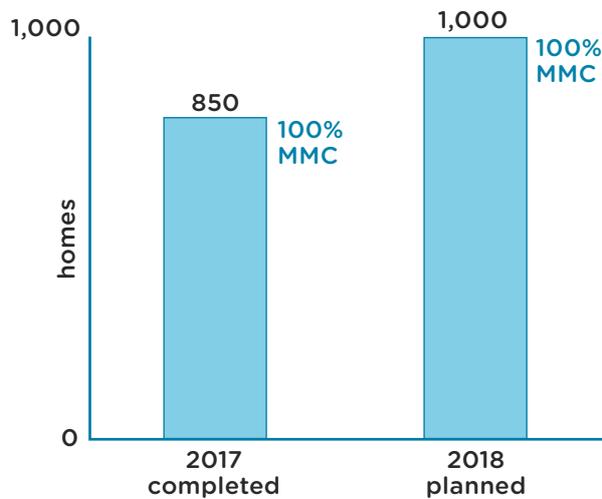
Stewart Milne Homes

Stewart Milne Homes (SMH) is a house builder established in 1975 that operates across Scotland and north west England, as part of the Stewart Milne Group (SMG). The group’s manufacturing arm – Stewart Milne Timber Systems (SMTS) – has the capacity to manufacture timber frames for up to 14,800 homes per year.



Offsite timber frame manufacturing centre in Witney

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer/manufacturer
Employees	850
Annual Turnover	£262m
Associated Brands	SMTS

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Stewart Milne Homes is currently using their timber frame system – built at their own factories – to deliver their entire housing output.
- Their factories in Oxford and Aberdeen have a combined output of 14,800 homes. The extra manufacturing capacity is used to build offsite systems for other house builders in open and closed-panel format with optional fitted windows.
- Stewart Milne Group has employed a full-time R&D director for 8 years, responsible for overseeing several innovation projects and a transition to 3D design.
- Current projects include the new £800m 3,000 home community at Countesswells, Aberdeen.



Erection of open-panel timber frame in Glasgow

Future plans

- SMH is looking to increase the pre-manufactured value of their developments by developing more advanced offsite timber frame systems with SMTS.
- SMTS intends to double output through investment in new facilities, automation and digital working.



Completed development at The Plaza, Aberdeen

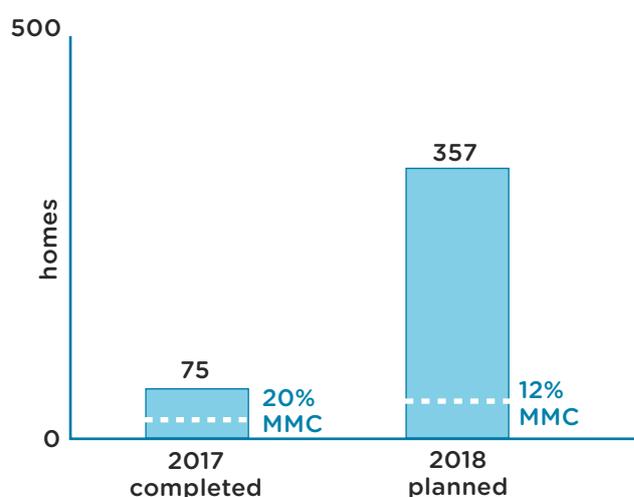
Swan Housing

Swan Housing is a housing association established in 1994, operating throughout Essex and East London. Swan provides affordable homes to rent and to buy and currently manage over 11,000 homes. Swan's own in-house delivery arm, NU Living, is responsible for delivering their offsite construction programme.



Swan's NU build factory in Basildon

Homes delivered & planned



Organisation fact file

Type	Housing association
Model	Developer/manufacturer
Employees	450
Annual Turnover	£150m
Associated Brands	NU Living, NU build

Systems used for MMC output

	Offsite panelised	25%
	Offsite volumetric	75%
	Offsite hybrid	-
	Onsite MMC	-

Current activity

- Swan Housing currently has a secured pipeline of 6,500 homes – the majority will be delivered by their in-house developer, NU living.
- Swan Housing's 75,000 sq.ft factory, NU build (based in Basildon, Essex), has capacity to build 300-400 cross-laminated timber homes per year, either as volumetric modules or as panelised systems.
- The NU homes design platform allows each buyer to customise their home from a number of interior and exterior material palettes to create a bespoke home for manufacture.
- Current projects include the 900 home regeneration of the Beechwood Estate, Essex.



Two fully-fitted volumetric modules in transit to site

Future plans

- Swan Housing plans to grow its manufacturing capacity, potentially through a second factory.
- Swan Housing also has plans to sell its factory-built product to other developers/contractors.



Completed homes at the Beechwood Estate

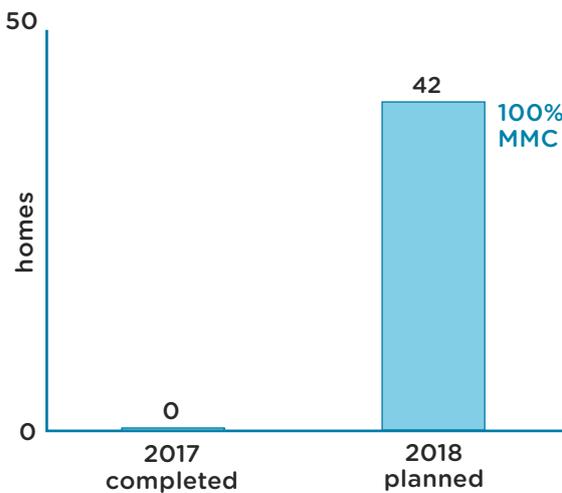
TOWN

TOWN is a developer, and custom-build enabler working across the south and east of England, established in 2016. TOWN builds residential and mixed-use developments to create compact, walkable and sustainable places. TOWN also plans and promotes urban extensions, regeneration developments and new settlements.



Marmalade Lane development in Cambridge

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer
Employees	2
Annual Turnover	£0.5m
Associated Brands	-

Systems used for MMC output

	✓	Offsite panelised	100%
	✗	Offsite volumetric	-
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- TOWN is currently delivering a residential co-housing development, Marmalade Lane in Cambridge, consisting of 42 dwellings and a 'common house' shared by the residents.
- The project is being delivered in joint venture with investor-supplier Trivselhus, who is supplying the panelised systems and funding construction.
- The townhouses are built from a closed-panel timber frame system and the apartments are built from a cross-laminated timber structural frame.
- TOWN has delivered the development as 'custom-build' – purchasers configure the internal and external layout and specification from a defined options menu.



Brick facade to closed-panel timber frame houses

Future plans

- TOWN is developing three developments with partner U+I; including 5,200 homes in Cambridge's Northern Fringe and 3,500 homes outside Norwich.
- TOWN is looking to implement MMC as standard across their future developments.



Cross laminated timber frame apartments

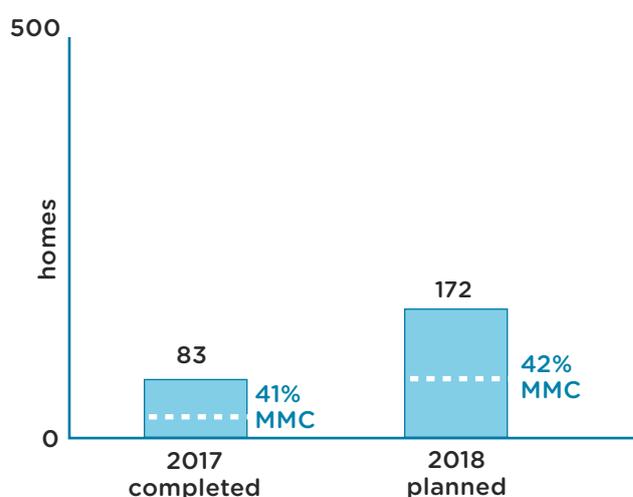
Urban Splash

Urban Splash is a specialist design-led regeneration developer working in cities across England, established in 1993. Having originally made its name from transforming former industrial buildings, Urban Splash now also builds new townhouses and apartments as part of wider neighbourhood regeneration developments.



Volumetric module installation at New Islington

Homes delivered & planned



Organisation fact file

Type	Private sector
Model	Developer/manufacturer
Employees	250
Annual Turnover	£19.1m
Associated Brands	Urban Splash Modular

Systems used for MMC output

	✓	Offsite panelised	10%
	✓	Offsite volumetric	90%
	✗	Offsite hybrid	-
	✗	Onsite MMC	-

Current activity

- Urban Splash has been delivering offsite developments since 2006 and is currently delivering volumetric module townhouses and panelised apartment developments.
- Urban Splash has developed a configurable volumetric townhouse concept – simply named 'House' – that was first employed on a 43 home development in New Islington, Manchester and has since been used for further developments in Salford and North Shields.
- To secure future manufacturing capability, Urban Splash acquired SIG Building Systems and their 70,000 sq.ft East Midlands factory in 2018 and formed Urban Splash Modular.



Manufacturing volumetric modules

Future plans

- Urban Splash is looking for opportunities to bring their modular townhouses to other sites around the UK.
- Further offsite house designs will be coming on line from Urban Splash Modular's factory.



The Fab House development in North Shields



5 Conclusions

MMC is a wide term, covering a range of offsite manufacturing and on-site techniques that provide alternatives to traditional house-building methods. This study sought to explore the current level of interest and engagement with MMC, particularly the more advanced approaches of volumetric modular or panelised systems, in order to provide a snapshot of what is happening across the industry at the end of 2018.

Although many of the systems that now fall under the MMC banner have been used to deliver housing in the UK for many years, the notable difference today is how these systems are being integrated into projects at an early stage; in some cases they are even being integrated into developers' pipelines.

The research confirms the growing level of engagement with MMC across the housing-development sector, from existing house builders and housing associations, through to new SMEs setting themselves up specifically to exploit opportunities in MMC. Although the sample size was limited, the research illustrates a clear belief among developers that new homes can be better delivered through the adoption of MMC.

The level of interest in volumetric modules is striking, with over 60% of survey respondents already using or planning to use them in future. Whilst it sometimes seems that volumetric modules are the subject of the majority of the press coverage, there is also the same level of interest in the use of panelised systems, mostly timber-framed or steel-framed.

Better quality, improved efficiency, accelerated delivery and increased productivity are cited by those surveyed as key factors driving the uptake of MMC. These confirm the potential advantages of innovation identified in the 2017 Housing White Paper. However, as Brexit is implemented, the potential for labour/skills shortages (the factor ranked fifth in this research) will perhaps become a more significant issue, further driving the adoption of MMC.

The case studies add texture to the survey results and serve to illustrate the variety of companies already engaged and the different approaches they are using. The research identifies the supply-side constraints that give rise to concerns about procurement and continuity of supply; in response to those concerns there are already a growing number of developers who are themselves beginning to take part in the manufacture of MMC systems. Of particular note is the survey finding that 24% of firms are looking to make a sole investment or co-investment in a factory.

However, despite the bold steps being taken by some, the research has found a justifiable nervousness from those who are in the early stages of a long journey in publicly promoting their activity with alternative technologies. We hope this publication helps to allay some of those concerns and demonstrate the scale of current and planned activity from contemporaries and competitors.

System integration is starting to take place early in the design process, with many developing standard apartment and house types that can work across multiple manufacturers to increase resilience and reduce the delivery risk that may arise from relying on a single manufacturer.

While this report has focused on volumetric and panelised systems, there is also a growing interest in the use of components and sub-assemblies. These innovations increase the level of 'pre-manufactured value' (and therefore efficiencies) across a developer's pipeline without limiting construction to a single type of MMC.

Notwithstanding the range of systems being employed, the mindset for change is in its infancy and there is still much work to be done in developing the procurement models associated with offsite manufacturing systems that don't lend themselves to a traditional form of procurement. There remains a desire across the industry to demonstrate confidence in products and systems through internal pilot testing before employing such technologies on a larger scale. As industry confidence grows and MMC concepts are proven to improve the negative outcomes which are associated with traditional construction, we will begin to realise the full potential for MMC to build better homes and more sustainable construction industry.

Glossary of terms

Term	Definition
Building Information Modelling (BIM)	The process of creating and managing information across a construction project in a computer model, which describes every aspect of the building asset.
Building system	A defined method of building.
Cassette	A prefabricated wall, floor or roof sub-assembly.
Closed-panel	Panels based on a framing system which are closed on both sides and may include factory-fitted insulation, windows, doors, services and internal wall finishes. Panels can be structural or non-structural.
Cross-laminated timber (CLT)	A wood panel product made from gluing layers of solid-sawn timber together and used for walls, floors and roofs.
Custom-build	A self-build home that is facilitated, either in procurement or construction, by a developer.
Developer/manufacturer	A company developing new homes which also manufactures an MMC system.
Hybrid systems	Construction that combines a volumetric pod system with a panelised system.
Light-gauge steel frame (LGSF)	Structural panels assembled from cold-formed galvanised steel sections, which can be used in panelised or volumetric systems.
Modern methods of construction (MMC)	A collective term used to describe a number of approaches to construction that offer an alternative to 'traditional' construction onsite.
Offsite hybrid	Refer to 'Hybrid systems'.
Offsite panelised	Refer to 'Panelised systems'.
Offsite volumetric	Refer to 'Volumetric modular systems'.
Onsite MMC	Construction processes that are carried out on the building site, but utilise different processes, technologies and systems from those used for 'traditional' construction. Onsite MMC includes thin-joint blockwork, large format blockwork, insulated formwork and onsite factories.
Open-panel	Panels based on a framing system where all framing members are visible until wall linings have been fitted on site. Panels can be structural or non-structural.

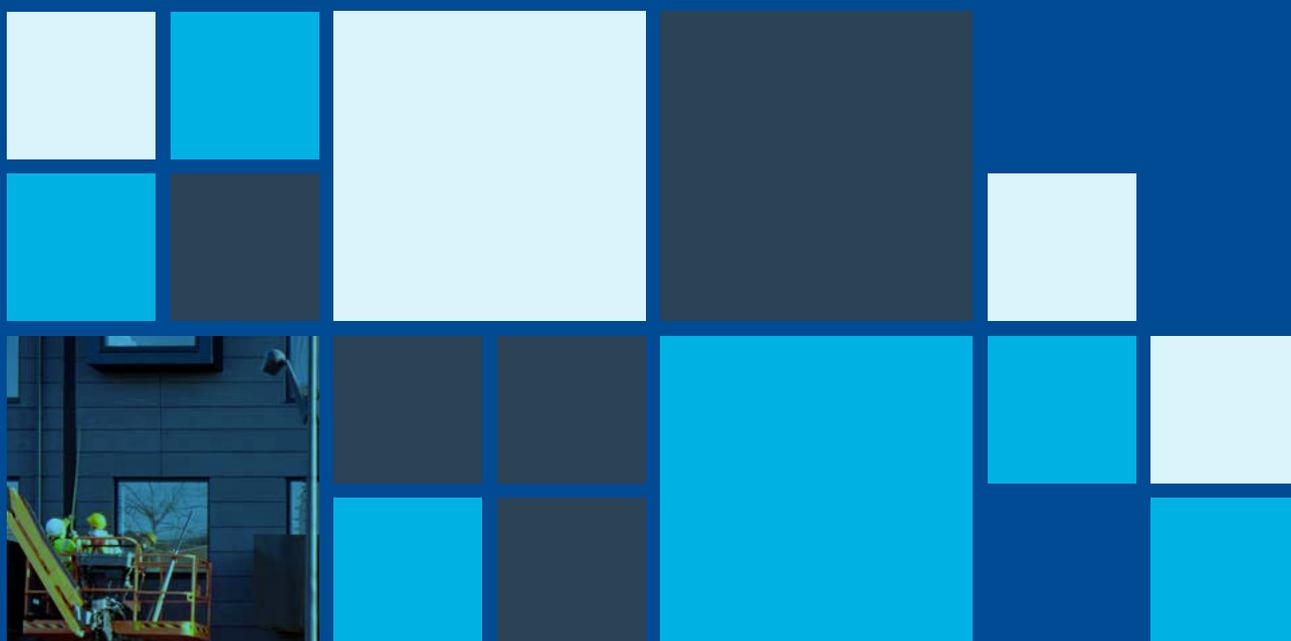
Term	Definition
Panelised systems	<p>Building systems comprised of two-dimensional units that are typically manufactured offsite and assembled onsite. Panelised systems include timber frame, light-gauge steel frame, cross-laminated timber and structural insulated panels.</p> <p>Note: Full-storey height aircrete blocks are often described as panel systems. Where these have been used by the developers in this report's case studies they have been included in panelised output.</p>
Pre-manufactured value (PMV)	The percentage measure of the element of a construction project's cost that is derived prior to any further assembly or process change made on the building site. Pre-manufactured value = 'value of components at point of delivery to site' divided by 'gross construction cost' multiplied by 100.
Structural insulated panels (SIPs)	A panelised system comprising a layer of insulation sandwiched between two structural facings, typically wood-based oriented strand board (OSB).
Sub-assembly	An assembly of building components to form a building element which is then incorporated with other elements to form the building. Examples include prefabricated chimneys, porches and dormers.
Turnkey manufacturer	A manufacturer who is able to provide a fully-finished product.
Vertically-integrated	A procurement model in which the developer manufactures all or part of the homes being constructed.
Volumetric modular systems	Building systems composed of three-dimensional units (volumetric modules), produced in a factory and fully fitted out before being transported to site. Modules are stacked onto prepared foundations to form the homes.
Volumetric pod	A volumetric module forming a single room, most commonly a kitchen, bathroom or utility space. They can either be used with traditional construction, or as part of a hybrid system.

Modern methods of construction

Who's doing what?

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 approaches range from whole homes being constructed from a single factory-built volumetric module through to the use of innovative techniques for laying concrete blockwork onsite.

The increasing level of interest in MMC and confidence that it will play an increasing role are demonstrated within this report's case studies, from a diverse group of housing developers. Confidence is reflected in the business decisions being made, with nearly 30% investing in their own manufacturing facilities and over 25% investing in their own products or systems. These innovators provide valuable insights for others considering the adoption of MMC.



The NHBC Foundation, established in 2006, provides high quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st century new homes. Visit www.nhbcfoundation.org to find out more about the NHBC Foundation research programme.

