Material change for a better environment

WAS003-001: Summary Final Report

Current Practices and Future Potential in Modern Methods of Construction

Modern Methods of Construction (MMC) offer significant potential to minimise construction waste. This report identifies the current use of MMC, the potential for further uptake and the waste minimisation potential.

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1.1 Introduction

The overall objective of the research is to develop a detailed assessment of the current level of use of Modern Methods of Construction (MMC) and market size in different construction sectors, identifying positive and negative factors influencing take-up. The focus of the project is on developing a scoping document reviewing key products, markets etc, and the emphasis is on informing WRAP's work in waste minimisation and identifying markets where significant gains can be made.

In this report, we use the term MMC in preference to the term OSM (offsite manufacturing). This is because this term is increasingly being used instead of OSM and because it also includes several important new types of construction methods that involve some element of fabrication on site.

N.B. This report has been adapted from the report originally submitted to WRAP and any information deemed commercially sensitive has been removed in this version.

1.2 Objectives

The first phase was to develop a detailed assessment of the current level of MMC and usage in different construction markets (Health, Education, Housing etc), identifying positive and negative factors influencing take-up. The focus is on informing WRAP's work in waste minimisation and identifying markets where significant gains can be made.

Key research objectives in this phase included the following:

- Develop an overview of the current UK offsite construction market in terms of value, market share, key players, key construction sectors, benefits and drivers / barriers to growth.
- Identify and prioritise key companies and influencers in offsite construction – industry bodies, manufacturers, contractors, etc, - develop a database of contact details.
- Identify and categorise the range of various construction products and components manufactured offsite, together with examples.
- Evaluate the range of products and components in terms of market size, current sectors where used, split between UK manufacture and imports etc. In the major sectors, we would identify the leading 5-10 manufacturers (depending on sector size and structure) in terms of shares and provide contact details. Analyse and review the key application areas for the products/materials.
- Each of these key product / component sectors would be reviewed in terms of benefits and drivers to use, with a particular emphasis on their impact for waste reduction. In addition, key barriers to growth would be identified and a broad review of current standards, indicative material wastage levels, wider market potential and end-of-life potential for disassembly would be undertaken.
- Identify any emerging areas of MMC where possible.
- Identify manufacturers, products and components to be used as exemplars of offsite construction, in terms of highlighting a reduction in material wastage.
- Develop recommendations for key areas of offsite construction where WRAP should focus to achieve a decrease in material wastage.

The primary objective of the second phase of the research was to identify and prioritise the potential of different sectors of construction to adopt MMC to reduce construction material wastage. This phase of the

project, therefore, focused on identifying key sectors and government initiatives where the potential to increase MMC is highest and provides the best opportunities for material waste reduction. Key research objectives in this phase include the following:

- Identify and prioritise construction industry sectors offering the best potential to increase the use of MMC – based on research in first phase.
- Each key sector will be assessed in terms of value, current and potential share for MMC, and key segments of sectors where MMC can be applied (e.g.: volumetric units, semi-finished 2-dimensional products, or at component/sub-assembly level)
- Identification and scoping of proportion of construction units where MMC can be applied.
- Comparisons with current waste levels from traditional build methods to develop views on where the greatest reductions can be achieved through MMC
- Identify existing /recent projects and case studies where construction waste has been minimised as a result of the use of MMC, which can be used as exemplar projects. Identify key personnel contact details.
- Identify future projects within key sectors offering potential for MMC and provide contact details, e.g.: Olympic Games, Building Schools for the Future programme, LIFT/ProCure21, MoD, Student Accommodation etc., are all sectors which would be reviewed.
- Develop recommendations for key areas of construction where WRAP should focus to achieve a decrease in material wastage.

1.3 Methodology

In overall terms the methodology for this project used a combination of the following:

- Desk research stage, incorporating analysis of existing data from relevant available reports, government sources, and any other secondary data sources, which become apparent.
- A primary research programme of interviews with offsite building product suppliers / manufacturers, main contractors, specifiers, industry consultants, trade associations etc.
- Analysis of findings and compilation of a detailed report, supplemented by a discussion meeting

1.3.1 Existing Data / Secondary Data

A wide range of published information sources were reviewed to assess current usage, players, key products/components, attitudes and trends towards offsite construction processes levels. Given the recent nature of the market and the rapid evolution of products and components, the level of published data quantifying the MMC market was limited, but key sources included Offsite Directory 2005, Government sources, company reports / websites / product catalogues, Trade Organisations/Associations, existing information from AMA Research knowledge bank, etc., with specific sources outlined below:

- Building Research Establishment/Arup: Market Transformation Programme draft report *Opportunities for Waste Reduction Through Modern Methods of Construction*
- Building Research Establishment: case studies - Greenwich Millennium Village, Chiswick Park
- Building Research Establishment: Waste reduction in refurbishment
- Building Research Establishment: Market Transformation Programme draft report *Waste Scoping Study: Waste Arising from Roofing Products (May 2006)*
- Building Research Establishment: Market Transformation Programme draft report *Waste Scoping Study: Waste Arising from Flooring Products (May 2006)*
- Buildoffsite: The value of the UK market for offsite (2004)
- Buildoffsite: Cameo case studies

- Association of British Insurers: Modern Methods of Construction: Insurance Considerations (February 2005)
- Commission for Architecture & the Built Environment (CABE): report for the Housing Corporation*: Design and Modern Methods of Construction*
- Cardiff University/Centre for Research in Built Environment: *Construction Waste Minimisation Good Practice Guide*
- Davis Langdon: Skyline 2006: Office Development Costs
- Envirowise: Saving money & raw materials by reducing waste in construction: case studies
- Envirowise: Saving money & raw materials by reducing waste in construction: case studies from Scotland
- Federation of Master Builders: Offsite construction: for and against
- Loughborough University: Offsite, Modern Methods of Construction in Housebuilding (January 2006)
- Loughborough University: Houseproud: practices & strategies of leading UK housebuilders on Offsite-MMC
- National Audit Office - Using modern methods of construction to build homes more quickly and efficiently (November 2005)
- Office for the Deputy Prime Minister: Survey of Arisings and Use of Construction, Demolition & Excavation Waste as Aggregate in England in 2003 (October 2004)
- Steel Construction Institute: Benefits of off-site steel construction in urban locations (2006)
- Steel Construction Sector Sustainability Committee: Sustainable Steel Construction - Building a Better Future: 1st annual report 2004
- TRADA Technology: Wood Used in Construction: The UK Mass Balance and Efficiency of Use (June 2005)
- TRADA Technology: Wood Used in Packaging: The UK Mass Balance and Efficiency of Use (June 2005)
- Viridis: The Construction Industry Mass Balance: resources use, wastes and emissions (revised 2003)
- AMA Research: range of market reports on timber frame, cladding, volumetric buildings, kitchen & bathroom pods etc

The desk research provided a significant amount of the data at product and market level, together with a substantial amount of the information on key companies, contractors, end use applications for offsite manufactured products.

1.3.2 Primary Research

The primary research programme was used to fill gaps in our knowledge. In certain sectors there was a need to undertake primary research to understand market sizes, potential for MMC, identify case studies on waste minimisation, and develop a better understanding of barriers to uptake etc. We interviewed a mix of the following organisations:-

- Offsite Building Product/Component Suppliers and Distributors.
- Building and construction contractors undertaking a range of private and public projects in all sectors.
- Clients and specifiers in key sectors
- Trade Associations, consultants etc.

MMC in the construction sector is a rapidly changing market and our view is that, given the wide range of product and component sectors, a telephone survey was the most effective way of developing a good understanding of key issues.

The summary mix of telephone, email and personal interviews is outlined below:-

Table 1: Primary Research – Interview Mix	
Sector	Telephone/ Email
MMC product suppliers and manufacturers	56
Trade associations/MMC research organisations	15
Main contractors, housebuilders, specifiers etc.	67
Total	138

1.3.3 Data Collation, Assessment and Report Preparation

Output from the research includes a market assessment of current usage of offsite construction products and components, together with drivers and barriers to growth. In addition, the report includes a market assessment of future potential for MMC in key sectors and provides recommendations on key areas of focus for WRAP to deliver a decrease in material wastage through the use of offsite construction.

In addition, a separate Excel database has been developed of major offsite manufacturers, products and components, together with key stakeholder contacts. This list highlights in bold key companies and contacts where the level of involvement and/or commitment to MMC is considered to be high and would be worth considering for follow-up contact**.**

1.4 Summary

1.4.1 Key waste streams arising from traditional construction methods

The table below provides a summary of the key waste streams arising from traditional construction methods. The figures are derived from case studies provided by contractors and other research organisations. It needs to be strongly emphasised that volumes of waste and the mix of waste material entering the waste stream for disposal vary considerably according to a combination of factors including: the type and size of development, the mix of materials and products used, the nature of the sites (size, accessibility etc) and the waste management procedures at each site – these variables are reflected in the ranges shown in the table below. However, across the various case studies, there is generally a high level of consistency with regard to waste mixes.

Table 2: Key Construction Material Waste Streams on Traditional Newbuild Schemes	
	Modal Average - Range %
Packaging (incl. wood pallets, cable drums, cases)	25 - 35
Plasterboard	5 - 36
Rubble – broken bricks, blocks, tiles etc	25 - 40
Timber - (excludes pallets)	15 - 25
Cement and plaster	10 - 17
Insulation – rockwool and fibreglass	6 - 15
Metal	3 - 9
Dry concrete products – blocks, slabs etc	2 - 12
Plastic products (excludes packaging)	1 - 11
Ceramic material	1 - 8
Source: AMA Research/trade estimates	

The table above highlights that packaging, rubble, plasterboard, timber, cement/plaster and insulation are consistently the main waste streams. It is important to emphasise that the figures purely relate to material that is skipped, whether the skips are for mixed or segregated waste. This does not include offcuts or unused materials and products that are set aside for recovery and recycling. This issue is best demonstrated by plasterboard. Typically, on large schemes managed by major contractors, where substantial volumes of plasterboard waste –supplied by British Gypsum - is generated – this will often be recovered for reprocessing and, consequently, this will not be recorded as waste.

Based upon our primary research, the table below summarises which elements of the construction process are typically generating the key wastes by material and product type and rank these accordingly. Therefore, for example, the use of aircrete blocks for inner leaf construction generates a high level of waste in terms of the packaging required for their delivery to site (wood pallets and shrink wrap) plus the waste generated from their assembly in the form of broken and unused block and unused mortar.

Table 3: Key Waste Streams by Application

(3 = generally high, 2 = reasonably high, 1 = noticeable, blank = not relevant or negligible)

Applications	Packaging material waste streams							Building product/material waste streams							
	Wood pallets	Shrink wrap	Card-board	Metal tins – paint, pres.	Plastic tubs – mastics etc	Plastic bags	Paper	Timber	Con-crete	Plaster-board	Panel prods.	Sheet or roll prods.	Bricks, blocks tiles	Cement mortar plaster mastic	Bldg services prods
Roofing															
Rafters, joists etc								3							
Battens								2							
Tiling	3	3			2								3	1	
Insulation		2	1								2	2			
Membranes												3			
External walls															
Block inner leaves	3	3											3		
Brickwork	3	3											3	2	
Cladding		1						2			1				
Windows & doors	1	2			2			1							
Cavity wall insulation		3	1									3			
Cements, mortars, render	2						1				1				
Flooring															
Ground flooring								3*	3			1			
Ground floor insulation		3	1									3			
Columns								3*							
Decking								2							
Site peripherals															
Hoardings								3							

Notes to the above table – *neither shallow nor deep types of foundation systems are included as very little concrete over-burden is typically generated associated with in-situ concrete ground floors and columns relates to discarded plywood formwork* **timber waste*

Table 3 Continued

	Packaging materials waste streams							Building product/material waste streams							
Interior fit-out	Wood pallets	Shrink wrap	Card-board	Metal tins – paint, pres.	Plastic tubs & guns – mastics	Plastic bags	Paper	Timber	Con-crete	Plaster-board	Panel prods.	Sheet or roll prods.	Bricks, Blocks, Tiles	Cement mortar plaster	Bldg services prods
Interior/party walls															
Plasterboard	3	2								3				2	
Plastering							1								
Paint work etc				3	1		1								
Interior windows					3										
Plumbing equipment		3	2												2
Electrical equipment		3	2												2
Heating equipment		3	2												2
Lighting products		3	2												
Bathroom fittings		3	3			1	1								
Ironmongery		3	3			2	3								
Interior doorsets		3	3				2								
Fitted kitchen	3	3	3					3							
Wall & floor tiling		2	3		2								1		
Floorcoverings		2	2		2										
Mouldings								3							

Source: AMA Research/trade estimates

***Notes to the table**:*

The ratings in the table are derived from a survey of the main contractors and leading housebuilders. The quality of information provided ranges from broad estimates to specific project site assessments of waste arisings and mixes using the BRE's SMARTWaste system. However, as responses were generally consistent, our confidence in the data is high.

1.4.2 Key MMC product sectors

In considering the key waste arisings and the construction activities generating them, as identified in the above table, we have developed a list of MMC products that could possibly make a contribution towards reducing construction site waste where they are substituted for traditional building methods and materials. To date, the use of MMC products has been fairly limited, reflected in the fact that the MMC sector accounts for around 7 - 8 % of the total UK markets for building materials and products. The potential for the use of MMC to contribute towards minimising site waste is dependent on many variables:

- The extent to which particular MMC are established in the UK and whether they have recognised accreditations from the BBA, British Standards, BRE, ISO9000 and the NHBC etc.
- Current industry market size and manufacturing capacity and the potential for growth in order to meet potential increase in end-user demand.
- Perceptions among specifiers and client organisations of MMC with regard to the quality, cost-effectiveness and also their levels of knowledge and experience with MMC.
- The strength and effectiveness of traditional construction lobby organisations, such as the Traditional Housing Bureau, in attempting to curb the use of MMC.
- The current size of existing end user markets for the various types of MMC and the planned anticipated growth levels in these markets plus their potential for the penetration of new end-user markets.
- Design trends. MMC is generally perceived as being best suited, and indeed has mostly has been used, for applications where there is a uniformity in building design and a repeatability of design e.g. buildings with cellular accommodation.
- Comparative costs between traditional methods of construction and MMC on a project basis. In general, cost still remains the over-riding factor in specifications and has been a key reason for the slow uptake of many types of MMC in the UK.
- Potential for economies of scale. MMC are generally well suited to projects where economies of scale can be achieved through factors such as uniformity, simplicity or functionality of design, combined with high-volume requirements.
- Site factors such as size of site, availability of site storage space, degree of accessibility and vehicle/plant manoeuvrability are key factors determining construction methods.
- Skilled labour issues. A key factor driving up demand for certain types of MMC has been the shortage of available skilled labour, especially in the electrical, plumbing and carpentry trades. With the 2012 London Olympic Games construction programme absorbing a large volume of labour away from other developments, this is likely to weigh heavily in favour of MMC.

The table below summarises some of the key issues outlined above with regards to the various types of MMC we have selected as possible solutions to reducing site waste over the short to medium term.

Table 4: Selected Key Types of MMC – Market Size and Construction Applications

Types of MMC	Vol. prod-cap.	UK market £m MSP	Avg growth rates p.a. % 2000 - 2005	Est. % of imports	Main Existing Areas of Construction Application
Volumetric modular	Med	200	10 –15	10 -15	Cellular single living accommodation: MoD, prisons, KWL, budget hotels; out-of-town retail back offices; forecourt stores; stand-alone fast food outlets; hospital wards & operating theatres; primary schools & nurseries; university tutorial blocks; school classroom extensions; 3-4 star hotel extensions; sports pavilions; shower blocks; airport terminal buildings: social housing apartment blocks
Panellised modular		565			
Timber frame	High	475	40 - 45	5 - 10	Up to 4 storeys - private and social housing
Pre-cast	Med	80	10 - 20	5 - 10	Up to 6 storeys - cellular single living accommodation: student accommodation, KWL, hotels; private housing; apartment blocks; school buildings; industrial buildings; prisons
Steel frame	Low	25 - 35	5 - 10	0	Mostly 2 storeys - private and social housing
SIPS/SIRPs	Low	30 - 35	5 - 10	30 - 40	Up to 6 storeys - private and social housing
Building envelope		545			
Composite panels	High	325	4 - 6	10 - 20	Mostly industrial buildings, warehousing, out-of-town retail, business park offices
Pre-cast cladding	High	120	5 - 8	5 - 10	Mostly bespoke/prestigious architect-designed buildings
LSF systems	Med	50	20 - 30	5 - 10	Large facades/high-rise – apartments, SLA, hospitals, hotels, airport buildings, retail
Pods	High	125	40 - 50	50 - 55	Cellular single living accomod'n: MoD, prisons, hotels rooms, student halls of res.; apartment blocks
Pre-cast structural	Med	110	Mixed	Low	Varied & wide-ranging depending on the type of products
Insulating concrete formwork	Low	20	N/a	Low	Mainly housing
Tunnel form	Med	130 *	Strong	Low	Large-scale cellular construction developments

Source: AMA Research/trade estimates

Notes to the table:

Table headings

Vol. Prod. Cap. – volume production capacity. This is our term to help identify which sectors of the MMC/MM have the capacity to be able to manufacture products and systems in high volumes. High indicates that there are at last several large manufacturers or importers/suppliers that together generally have the capacity to be able to meet significant surges in demand from existing markets.

Medium indicates that the UK supply sector is well established and relatively large within the context of MMC. However, we consider that industry capacity to supply on a high-volume basis is limited due to factors such as long-term commitments to specific large contracts or because most major manufacturers tend to supply on a bespoke basis.

Low indicates that these particular sectors are either small and/or they generally operate on a bespoke and/or supply and fix basis and do not yet have the facilities to manufacturer on a large-scale. Therefore:

Timber frame – there are around 6 high-volume suppliers with annual capacities of at least 3,000 units a year, and which are able to supply on a third party basis. There are also other major UK and Continental suppliers able to meet volume growth in demand.

Pods – there are around 8 suppliers with an annual supply capacity of at least 3,000 units p.a. plus another 10 with a combined capacity of 10,000 – 15,000 p.a.

Composite panels – this is a maturing sector consisting of several large manufacturers able to meet large-scale demand from end-use sectors that are relatively mature and showing low growth

Pre-cast cladding – this is a long established sector supplying a high-value niche market where annual growth rates are fairly consistent

Volumetric & panellised steel frame systems - currently the only two manufacturers with the capacity for volume production are Corus Living Solutions and Kingspan Offsite. Most of the other major manufacturers supply bespoke systems on a supply and fix basis and do not have current ability to supply in high volumes. Further more, some - e.g. Corus Living Solutions – have all or most of their production capacity tied up over the next 5 –8 years.

LSF systems – this sector is currently expanding at a steady rate due to the expansion of existing capacity at some key suppliers plus new market entrants

SIPS/SIRPs– these sectors are still small with few suppliers that can manufacturer on a volume basis. In the UK SIPS sectors most are small suppliers of bespoke systems.

Table data

** Tunnel form - the figure of £130m is given at installation prices*

Re: owing to factors such as product definition, lack of trade or Government data etc. the data in the above table should be treated as estimates only

Table 5: Key Types of MMC by Main End User Sectors

(Key 3 = key markets, 2 = some current usage, 1= potential use, blank = limited application)

	Single living accommodation				Residential		Education		Healthcare			Leisure		Other			
	MoD	Stud. accom	KWL	Prison etc	House	Flats	Class-rooms	Other bldgs	S'con h'care	Prmry h'care	Care homes	Hotels	Other	Retail	Airprt bldgs	Arch'l	Ind/ Bus. pk
Volumetric	3	2	2	3	2	2	3	2	3	2	2	2	3	3	3		2
Timber frame		2	2		3	3		3		2	2		2			2	
Pre-cast panels	3	3	1	1	3	1	2	2		1	1	3	1	1			3
Steel frame	1		1		3					1	1	1	1	1			1
SIPS/SIRPs					3	3				1	1	1	1				
Comp. panels	1						2	2	3				3	3	3	2	3
Pre-cast clad						3		3	3			3		2		3	
LSF systems	3	2	1			3		2	3	1	1	3	1	1	2	2	1
Pods	3	3	3	3	1	3		2	2	1	2	3	2		2		
Pre-cast structural	3	2	2	3	3	3	2	2	3	3	2	3	2	3	3	3	3
ICF					1												
Tunnel form	1	3	1	1	1	1						3					

Source: AMA Research/trade estimates

Notes to the table:

1 – Education – 'classrooms' includes teaching blocks I, Other buildings includes shower blocks, pavilions, sports centres/gymnasiums

2 - Leisure – 'other' includes sports centres, pavilions, shower blocks, visitor centres

3 – Architectural – includes all types of bespoke, prestigious or high value end-user applications e.g. shopping malls, corporate head offices, luxury apartments

4 – Retail – refers to standardised construction e.g. forecourt stores, fast food outlets, retail park stores etc Excludes bespoke e.g. shopping malls, dept stores

5 – Industrial, business and retail parks – this covers all types of buildings typically located on these types of development including industrial warehousing

Coding

'3'/green - indicates that the end-user sectors identified are key markets for these type of MMC. E.g. volumetric construction is currently being used extensively on MoD single living accommodation

'2'/ orange - indicates that these end use sectors are not generally key markets for these types of MMC, but nevertheless they have achieved some penetration and have shown that the use of these types of MMC in these sectors is viable.

1'/blue - indicates that current use of MMC products in the end use sectors identified is limited but that we anticipate there could be considerable potential for increased penetration in these markets. The assumptions here are that over the medium-longer term, contractors' output is set to increase significantly and that these types of MMC are well suited to the high volume, standardised design, fast-track construction methods used in these areas. For example, tunnel form construction is a very fast and efficient way of building large cellular units such as student halls of residence and prisons, but that to date, its use in the UK has been limited to just a few projects.

1.4.3 Opportunities for reducing waste through the substitution of MMC

Table 6: Summary of Potential of Key Types of MMC for Reducing Site Waste

Solution ratings: 3 = significant reduction, 2 = moderate reduction, 1 = limited impact, blank = no reduction, or N/A = not applicable

	Packaging material waste streams							Building product/material waste streams							
	Wood pallets	Shrink wrap	Card-board	Metal tins – paint, pres.	Plastic tubs & guns – mastics etc*	Plastic bags	Paper	Timber	Con-crete	Plaster-board	Panel board prods ***	Sheet or roll insulation.	Bricks, blocks tiles	Cement mortar plaster	Bldg services prods
Volumetric	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2
Timber frame*	3	3	1	1	1	1	2	3	1	3	2	1	3	2	N/A
Pre-cast panels	3	3	2	1	1	1	2	3	2	2		3	3	3	N/A
Steel frame	3	3	2	1	1	1	2	3	3		1	3	2	3	N/A
SIPS/SIRPs	3	3	2	1	1	1	2	3	2		3	2	3	3	N/A
Composite panels	2	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	N/A
Pre-cast cladding	3	3	2	N/A	N/A		N/A	3	N/A	N/A	N/A	2	2	N/A	N/A
LSF (open)	3	3	2	N/A	2	2	N/A	3		N/A	3	1	3	3	N/A
LSF (closed)	3	3	3		2	2		3		N/A	3	3	3	3	N/A
Pods	3	3	3	2	2	2	2	1	1	2	N/A	1	2	2	2
Pre-cast structural**			N/A	N/A	N/A	N/A	N/A	3	3	N/A	N/A	N/A	N/A	3	N/A
Insulating concrete formwork	2	2	N/A	N/A	N/A	N/A	N/A	2	2			2		3	N/A
Tunnel form	3	3	N/A	N/A	N/A	N/A	N/A	3	3	1	2	N/A	3	3	N/A

Source: AMA Research/trade estimates

Notes to the table:

**The level of pre-fabrication for timber frame systems ranges from simple open-frame wall panels and trussed rafters (or other roofing systems) with concrete ground flooring, to closed panel building systems comprising plasterboard, insulation, breather membranes, timber floor cassettes etc all but the interior fit-out. In the above table, out assumption is based on the most common type - open-panel systems comprising vertical studs and horizontal rails, trussed rafters, timber floor cassettes, wood-based panel sheathing, plasterboard lining and an external breather membrane. Excluded are thermal insulation and all interior fit-out components. It should be noted that re; bricks/blocks/tiles we give a '3' rating as the use of timber frame negates the need for inner leaf blockwork and although brick cladding is typically required, recovery of bricks for recycling is increasing.*

*** Pre-cast structural (components) comprise the broadest range of products, but for the purpose of this report excludes pre-cast panels, as these are treated as a separate product group. Most pre-cast structural components*

**** panel board products – includes particleboard, OSB boards, drylining etc*

The table above summarises our views on the extent to which the main types of MMC shown can possibly contribute towards a reduction in construction waste levels, where they are substituted for traditional building methods. However, it needs emphasising that these responses should be treated as broad indicators, due to the general lack of firm data.

Colour coding

'3'/green - indicates that there should be sufficient capacity among suppliers to be able to meet increased demand over the short-medium term and that the types of MMC identified do contribute to significant reductions in the product/material waste streams indicated. For example, volumetric construction eliminates all waste except that generated through excavating foundations and a small amount of offcuts from connecting the services pipework/cabling to the mains.

'2'/orange - suggests that the types of MMC identified are likely to have a reasonable level of impact upon reducing waste levels in the product/material areas indicated. However, there will be some need for traditional products/materials that will inevitably generate waste. For example, with SIPS, there is no need for site-installed cavity wall insulation, but sheet insulation is typically needed for the ground floor.

'1'/blue suggests that substitution of the identified type of MMC would lead to a small reduction in the types of waste indicated.

A blank space indicates that where these types of MMC are used, there are still similar volumes of waste being generated in these areas as with traditional building methods. For example, with timber and steel frame systems, plasterboard still has to be cut and installed on site, the same as with brick and block construction.

***N/A** indicates that the use of MMC is not applicable where addressing the types of waste streams listed. For example, composite panels and pre-cast cladding are mostly used as alternatives to on-site cladding and façade glazing. Therefore, products such as paint, cements & mortars, building services products and associated packaging are not relevant.*

Table 7: MMC & Estimates of Waste Reduction
though Substitution for Traditional Building Methods

MMC	Est. % reduction	Level of confidence
Volumetric building systems	70 - 90	Reasonable
Timber frame systems	20 - 40	Broad estimate – depends upon the level of pre-fabrication
Concrete panel systems	20 - 30	Broad estimate
Steel frame housing systems	40 - 50	Broad estimate
OSB SIPS	50 - 60	Reasonable – depends on the level of prefabrication
Composite panels	20 - 30	Broad estimate
Pre-cast cladding	40 - 50	Broad estimate
LSF systems	40 - 70	Reasonable – depends on the level of prefabrication
Bathroom/shower & kitchen pods	40 - 50	Broad estimate
Pre-cast flooring	30 - 40	Broad estimate
Thin joint masonry	30 - 40	Broad estimate
Insulating concrete formwork	40 - 50	Broad estimate
Tunnel form construction	50 - 60	Broad estimate

Source: AMA Research/trade estimates

The chart above illustrates estimates the levels of site waste reduced using these types of MMC compared to equivalent traditional construction methods. They are not indications of the levels of contribution to total waste reduction. For example, it is estimated that using bathroom pods saves up to 50% of the waste typically generated from fitting out a bathroom the traditional way.

It is important to note, however, that while some of these estimates are based upon real life case studies, others are based upon estimates and anecdotal evidence given by respondents in interviews.

1.4.4 Ease of disassembly

The following figure provides a summary of the relative ease with which the various types of MMC products under review are likely to be able to be disassembled at the end of life. It is important to note that these are largely assumptions based upon interviews with manufacturers and an assessment of how these products are manufactured. For example, with products assembled using fasteners such as rivets, bolts, brackets etc – as opposed to adhesives, cements and mortars – it is generally assumed that they should be easy to disassemble. In reverse, the assumption is that where components are fastened using mortars, cement or adhesives they are likely to be relatively difficult to disassemble without demolishing them.

Table 8: Main MMC & End of Life Disassembly for Recycling

MMC Products	Comment
Volumetric building systems	Fastening systems enable ease of disassembly. Main components for recovering for recycling include: light steel frames, cladding, drylining, membranes
Timber frame systems	Easy to disassemble. Most components suitable for chipping but wood treatments make post-use timber unsuitable for some recycling applications
Pre-cast panel systems	Easy to disassemble. Suitable for crushing for use as recycled aggregate
Steel frame housing systems	Fastening systems enable ease of disassembly. Main components for recovering for recycling include: steel frames, cladding, drylining, membranes & insulation
OSB SIPS	Fastening systems enables ease of disassembly. OSB panels can be chipped and urethane insulation core can be powderised.
Composite panels	More difficult to disassemble and recycle where urethane insulation core bonds to panels. Where insulation core is mineral wool, fastening system makes disassembly easy
Pre-cast cladding	Suitable for crushing for use as recycled aggregate
LSF systems	Fastening systems enable ease of disassembly. Main components for recovering for recycling include: light steel frames plus cladding, drylining, membranes & insulation on closed systems
Bathroom/shower & kitchen pods	Easy to disassemble. Steel frames can be recovered for recycling but not the ceramic ware and plastic shells
Pre-cast structural panels, flooring	Not easy to separate insulation from pre-cast leaves

Source: AMA Research

1.4.5 Conclusion

The figure below encapsulates the findings in the survey and identifies the potential for the reduction of site waste through the substitution of MMC in existing and potential key end use markets:

Table 9: Key Areas of Potential for Reduction of Site Waste though the Substitution of MMC

End users	Construction output 2006 - 2012	Current level of use of MMC	Potential for increasing uptake of MMC	Potential for waste reduction through increased use of MMC	Key drivers for MMC
MoD	Increasing substantially to 2012	Very high	Significant	Significant	MoD (Debut Services & Carillion) very pro-active. Requirements for fast-track construction & minimum disruption
Student accommodation	Expected to increase to at least 2012	Very high	Moderate due to current high usage	Significant	Requirements for fast-track construction & minimum disruption
NHS	Increasing substantially to 2020	Low - moderate	Substantial but dependent on specifiers	Significant	Main contractors. Requirements for fast-track construction & minimum disruption
Schools	Increasing substantially to 2020	Low - moderate	Substantial but dependent on specifiers	Significant	Requirements for fast-track construction & minimum disruption
KWL	Increasing over short term	High	Significant	Significant	Affordable Housing
Social/Affordable housing	Increasing over longer term	High	Significant	Significant	Housing Assn, Affordable Housing, progressive builders
Private housing	Increasing over longer term	Low	Significant but dependent on clients & specifiers	Significant	NHBC, progressive builders
Prisons etc	Possible increase	High	Moderate – depending on Govt plans	Moderate - as MMC used	HM Prison Service policy on sustainable development
Hotels	Moderate over short term	High	Moderate due to current high usage	Moderate	Budget hotel sector- requirements for fast-track construction for early revenue generation
Retail	Moderate	Low - moderate	Moderate due to limited applications & low growth in sector	Moderate	Convenience store chain operators, fast food chain operators- requirements for fast-track construction for early revenue
Olympic games	Increasing substantially to 2011	N/a	Substantial – athletes accommodation	Significant	Requirements for fast-track construction + issues of labour availability

Source: AMA Research

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