



Improving resource efficiency in
construction product manufacture

**BeAware Supply Chain Resource Efficiency
Sector Report**

**Modern Methods of
Construction (MMC)**



BeAware is a TSB¹ and industry funded project helping construction product manufacturers to make more efficient use of materials and processes. Use of resources and waste generation associated with the product across its supply chain are the two key areas of focus.

The term 'MMC' is used throughout this document to describe a range of processes and technologies which involve prefabrication, off-site assembly and various forms of supply chain specifications.

Project background

Resource efficiency improvements should always be addressed within the context of the overall environmental impact of the product. A simplified environmental assessment was carried out on 20 construction products as part of the BeAware project, using life cycle assessment (LCA) data. See the *Overview of Methodology* document for further details on how this was carried out.

The supply chain for each product was also investigated to ascertain where resource efficiency improvements could be implemented. This involved examining how a product is distributed, installed, maintained and eventually disposed of. Identified areas of improvement included reduction of waste, efficient raw material use, material substitution, recycled content, packaging materials and options, and diversion of waste from landfill.

The results of the BeAware MMC product assessments form the basis of this guidance document. Also included are the findings from an interactive workshop held in April 2008, whereupon seven MMC product manufacturers discussed the combined results generated from BeAware's MMC product studies.

This guidance has been developed for those working in, representing or advising the MMC sector, to raise awareness of the importance of reducing the use of materials across a product's lifecycle.

Rising costs of materials, the drive to divert waste from landfill and an increased focus on protecting the environment are the key drivers to improving resource efficiency. Moreover, using materials efficiently and reducing waste can produce significant cost savings, as well as improving productivity and contributing to a company's triple bottom line.

This document builds on existing industry advice and activities, whilst highlighting additional sector based improvements to further improve resource efficiency. It is a part of a series of reports that are free to download from the BeAware website². Similar sector guidance is available for polymers, precast concrete and timber windows.

The Modular and Portable Building Association (MBPA) are industry partners from the Modern Methods of Construction (MMC) sector on the BeAware project.

There are five categories used by the Housing Corporation to classify an MMC (housing) construction system³:

- **Off-site manufactured - volumetric**
(three-dimensional units produced in a factory, fully fitted out before being transported to site and stacked onto prepared foundations to form dwellings).
- **Off-site manufactured - panellised**
(flat panel units built in a factory and transported to site for assembly into a three-dimensional structure or to fit within an existing structure).
- **Off-site manufactured - hybrid**
(volumetric units integrated with panellised systems).
- **Off-site manufactured - sub-assemblies and components**
(larger components that can be incorporated into either conventionally built or MMC dwellings).
- **Non-off-site manufactured MMC**
(innovative methods of construction used on-site and the use of conventional components in an innovative way).

The raw materials used in MMC are much the same as those used in traditional construction. MMC systems normally involve replacing the inner aerated concrete block with either a timber or steel frame or with precast concrete. Cladding finishes tend to be completed on-site in a traditional manner.

Pods are a type of volumetric construction and are completely fitted out and finished, such as kitchens and bathrooms coming on-site, including sanitary ware and tiling, ready to be plumbed in⁴.

In 2006, the MMC market split was:

- £414 million for volumetric (based on manufacturer's selling price)
- 52,797 timber frame units (houses and commercial)
- £61 million for light gauge steel frame (which equates to around 6,100 units)
- 750 SIPS units (estimate)⁵.

It is predicted that the markets will continue to increase in size over the coming years, driven by the housing and skills shortages in the building sector.

On a construction project, the manufacturers may choose to use their own erection team or specialist subcontractors that have been trained in the on-site fabrication of MMC products. Problems may arise when products or systems are bought for a project and subsequently erected and installed by a contractor that has not been trained or advised by the manufacturer of the system to an appropriate level of expertise.

The main contractor is responsible for on-site waste and must deal with this accordingly.



3. Market Transformation Programme Briefing Note BNMMC01: Modern Methods of Construction – Industry, Product and Market Overview. Available from <http://www.mtprog.com>

4. <http://www.mmcnw.org.uk/content/view/67/137/>

5. Market Transformation Programme Briefing Note BNMMC01: Modern Methods of Construction – Industry, Product and Market Overview. Available from <http://www.mtprog.com>

The off-site volumetric and panellised systems (timber, structural insulated panels (SIPs) and light gauge steel frame) make up 65% of the permanent building MMC market⁶.

The amount of waste generated by the MMC sector in 2006 is estimated at almost 21,000 tonnes. Of this waste, 63% is from timber frame, 29% is from volumetric and 8% is from light gauge steel frame and SIPs. If no action is taken, these waste arisings could increase to 68,000 tonnes by 2020, owing to the expected take-up of MMC products⁷.

It is easier to manage waste in a factory environment than on a construction site which benefits the MMC sector. This is mainly due to having better control within a manufacturing process, allowing more effective segregation which in turn, results in less contamination and greater levels of recycling⁷.

The Waste and Resource Action Programme (WRAP), have a number of case studies on their website⁸ demonstrating the

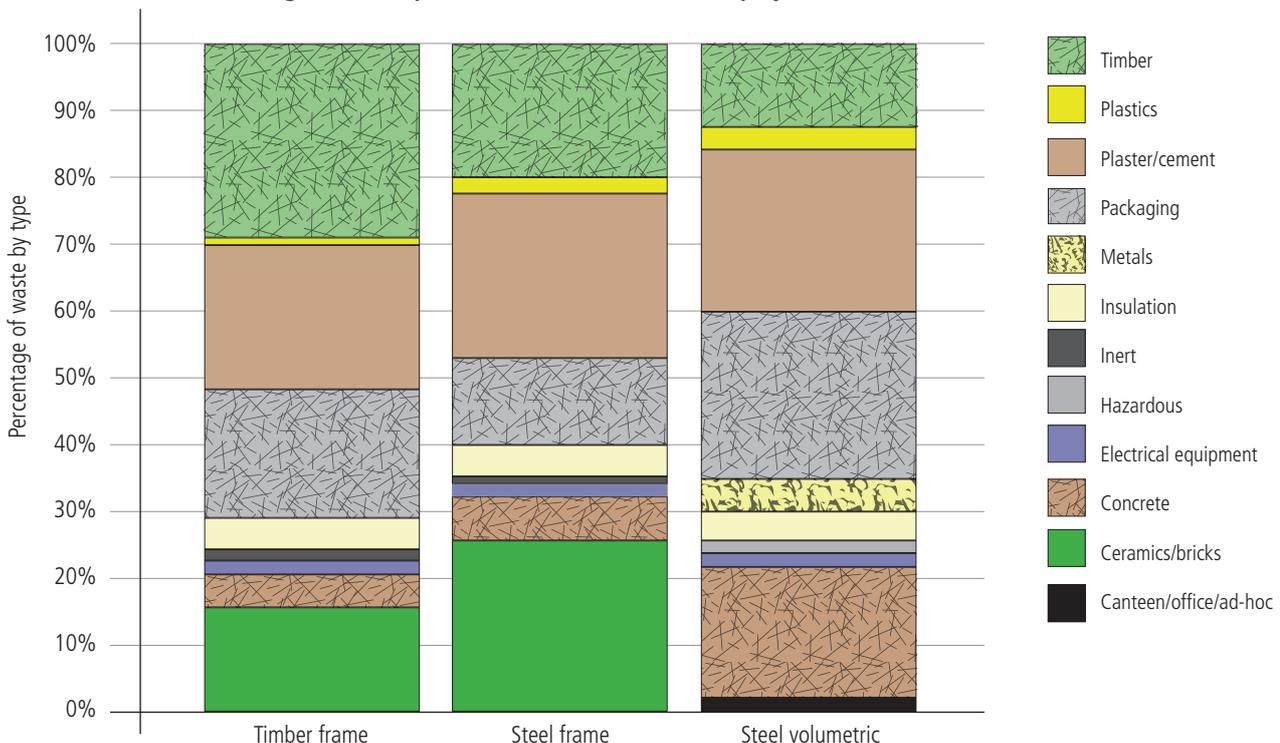
benefits and waste savings achieved from using different forms of MMC construction compared with traditional construction methods. For example, BRE waste measurement studies on the SMARTLife project (carried out on behalf of WRAP) show a 22% waste reduction using light steel frame construction and 11% for timber frame, compared to traditional methods.

The three SMARTLife studies recorded total waste arisings on-site and in the factory for different systems of MMC, using an environmental performance indicator of volume of waste generated per 100m² of construction floor area. The following waste arisings were identified:

- Timber frame (wall panels and floor cassettes):
19.16m³ of waste generated per 100m² of floor area
- Volumetric steel (modular):
5.51m³ of waste generated per 100m² of floor area
- Steel frame (walls and floor cassettes):
16.84m³ of waste generated per 100m² of floor area.

The studies show that the top three waste streams for each system were plaster/cement (largely comprising plasterboard), timber and packaging. Figure 1 shows a breakdown of the types of waste arising from the three SMARTLife studies.

Figure 1 - Composition of waste in three MMC projects



6. Offsite Construction Industry Survey 2006, Buildoffsite, 2007

7. Market Transformation Programme Briefing Note BNMCC02: Modern Methods of Construction – Waste Management. Available from <http://www.mtprog.com>

8. <http://www.wrap.org.uk>

BeAware assessment: the environmental impact of MMC products

Seven products in the MMC sector were assessed including timber frame, timber frame with straw bale, volumetric (modular) steel frame and bathroom pods. In some instances, data supplied for analysis was incomplete but the data available has been used wherever possible to formulate the outcomes outlined below.

Manufacturing waste

The raw materials inputs change depending upon the system of MMC being manufactured. Common raw materials include metal, timber, board materials, plasterboard, concrete, plastic membranes and mineral or glass wool insulation. Off-cuts of these raw materials typically end up as waste within the factory environment.

A considerable amount of sawdust also arises from machining the timber and board products. Timber and sawdust are usually segregated at the factory for recycling. Any timber panel products are usually kept separate from the clean timber as they are currently difficult to recycle and often end up going to landfill.

Steel is readily recycled, due to its value and well established recycling routes.

Greater facilities now exist for plasterboard recycling and most of the manufacturers analysed who had plasterboard waste sent it for recycling.

Mineral and glass wool insulation are potentially recyclable, however, the data returned by manufacturers in this study suggested that it was being sent to landfill.

Generally, apart from timber, metal, plasterboard and plastic (from the bathroom pod), all other wasted raw materials are placed in a mixed skip destined for landfill.

From the products studied, total waste arising from manufacturing MMC products is on average 4% by weight of the materials used to manufacture the product. This takes into account wasted raw materials, packaging and other general waste. When looking specifically at waste directly resulting from raw materials used (e.g. from off-cuts etc), this is 2% by weight on average.

Raw materials are often packaged and it is this packaging (polythene sheet/wrap, cardboard, metal and plastic banding, timber pallets and bearers, plastic containers (from adhesive and paint) and paper sacks) that ends up as waste.

In the manufacturers studied, packaging waste accounted for at least 20% by weight of all waste. In some cases, it was as high as 50% by weight of the total waste. Manufacturers should ensure that they are aware of and are compliant with packaging regulations and associated legislation and this also applies to imported packaged goods.

Packaging wastes have various waste management routes depending on the individual manufacturer. In a number of cases, polythene film was segregated for recycling and timber pallets were either reused or sent for recycling along with other timber waste e.g. off-cuts and timber bearers.

Some manufacturers were sending packaging wastes off-site in mixed skips destined for landfill, along with other wastes. Cardboard was either recycled or sent to landfill.

Although there is some good practice with regards to waste, there is room for improvement in terms of segregation of waste for recycling. Over half of the manufacturers assessed place the majority of their packaging wastes into a mixed skip destined for landfill.

There is also potential to reduce the packaging waste of incoming raw materials. This can be achieved by working with suppliers to gain an understanding of why packaging is used on their products and considering alternative methods to optimise packaging, such as take back schemes and bulk deliveries. In addition, it may be possible for the supplier to take back packaging when they make their next delivery to the factory.

Distribution / installation waste

MMC manufacturers typically add packaging to their finished product to prevent damage in transit to the construction site. The packaging used varies depending on the MMC system. A number of manufacturers use timber pallets and / or bearers, however, one manufacturer in the BeAware study uses reusable steel stillages. This is better practice as stillages can be reused more times than timber pallets which tend to break or are not returned for reuse.

Some form of polythene sheet or wrap is also used, along with banding and cardboard in some instances. Other than the steel stillages, the manufacturers assessed did not take back any of their packaging.

End of life waste

A National Federation of Demolition Contractors (NFDC) spokesperson commented on how the MMC systems studied would currently be dealt with at their end of life by the demolition industry. For timber frame MMC, it was felt that the building would not usually be disassembled and that the frame would most likely be chipped for recycling. Any board materials would probably go to landfill.

Another option would be for all timber based products to be sent for energy recovery. For panels made up of timber frame with straw bales, it was felt that recovery of the panels for reuse would only occur if there was sufficient demand and value of the materials in doing so.

There were further concerns as to whether any damage would be caused by disassembly of the panels. The most viable option would probably be shredding the panels and composting the resulting material or sending it for energy recovery.

With regards to the bathroom pods, it is very unlikely that they would be removed whole for reuse. This is primarily because the demolition contractor would not have the appropriate expertise to disconnect the pod and remove it without causing damage.

It could also be difficult to find an appropriate market for reuse within the short timescale operating on demolition projects. Any reuse of the pods would be subject to final condition of the product and the cost of removal. The plastic used in the pod is likely to end up in a mixed skip and destined for landfill and any metals would be segregated out for recycling.

With the volumetric steel modules, the value in these for the demolition contractor is the steel, therefore this would be segregated out for recycling as a minimum. Again, the demolition contractor would have no knowledge of how to disassemble the modules for reuse.

Other concerns regarding reuse related to building regulations. For example, would the wiring and insulation be up to standard for reuse by the time it has reached the end of its first use?

Simplified environmental assessment results

The combined results of the simplified environmental assessments⁹ for the MMC products identify four key areas that yield the most significant environmental impacts:

 **Raw materials**

 **Energy and water**

 **Packaging**

 **Waste.**

Figure 2 shows that the greatest overall environmental impact for the MMC systems studied is from raw materials, responsible for 94% of the impact. This is followed by energy/water at 3%, and packaging and waste, both at just over 1%. On average, transportation accounts for 12% of the raw materials impact.

It is important to note that the following results are based on incomplete datasets and as such, are only indicative.

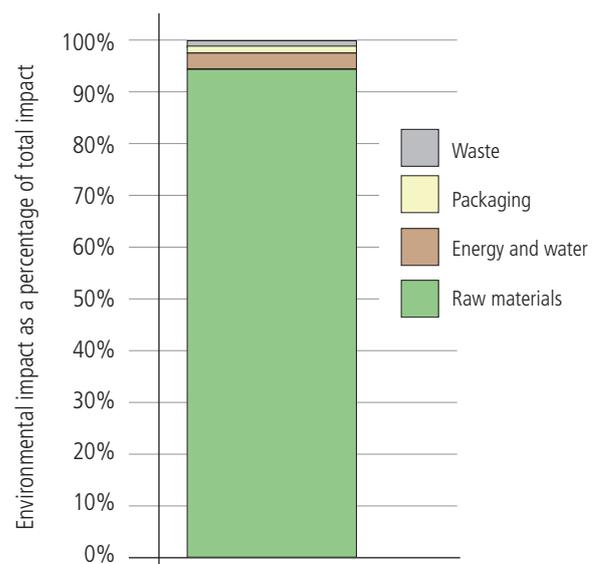


Figure 2
Average MMC Environmental Impact

⁹ A number of assumptions have been made during development of the methodology for assessments. These can be viewed in the *Overview of Methodology* document (available from beaware.org.uk). Some assumptions may also have been made with regards to the individual product assessments. These cannot be displayed in this report as they are confidential to the companies involved.

An interactive workshop was held for the MMC sector in April 2008, whereupon MMC product manufacturers discussed targeted actions to improve resource efficiency in the sector. Discussions centred around the key areas of waste reduction, diverting waste from landfill (reusing, recycling and recovery) and using recycled materials.

Opportunities and barriers were considered for each stage of the supply chain including manufacture, distribution, installation/use, and end of life. Actions for the industry were prioritised and the major points form the basis of the sector action plan detailed later in this document. Some of the key workshop discussions and outcomes are listed below.

Opportunities for resource efficiency across the supply chain

Manufacture

Standardisation of products and materials will help to reduce waste. Linked to this is an opportunity to educate the client with regards to product awareness and ensure that expectations are realistic for specification.

There is potential to use products with greater recycled content and from sustainable sources. Case studies showing the benefits of optimising the use of materials in design and manufacture may encourage companies to address their manufacturing processes.

Packaging and distribution

Although minimal packaging is typically used on the finished product, there are opportunities for considering reusable packaging, such as tarpaulin, rather than single use polythene sheeting. If reusable packaging is adopted, take back or return of this packaging will be paramount to its success.

There is also potential for increasing the recycled content of packaging, particularly that used on raw materials. Close working with suppliers will provide scope to reduce packaging.

Installation

There are opportunities for the return of surplus components or fixings for reuse. Using fix packs with an itemised list of what is needed to construct the system will help drive waste reduction. It is important that information about the product and how any wastes can be dealt with are included within the Site Waste Management Plan for projects.

Monitoring requirements for waste could be reduced when using MMC provided there is less waste arising. For example, shorter lead times are required with MMC which means site activities are minimised compared with traditional construction.

End of life

Systems can be potentially dismantled to enable reuse. There may also be opportunities for the customer to hire the system instead of buying it, therefore encouraging more consideration of recovery for refurbishment and reuse at end of use. The whole life costs and benefits of adopting such a leasing system would need to be considered to determine financial viability.

Barriers to resource efficiency across the supply chain

Manufacture

Customer specifications requiring bespoke designs delivered in short timescales can limit considerations for resource efficiency. This links to customers having a lack of awareness of the product and knock on effects that their design and specification decisions have on waste generation.

There is sometimes a lack of awareness of possibilities for reuse, recycling and recovery of materials. Moreover, logistics and costs (e.g. for storage) can be prohibitive.

Packaging and distribution

There are costs associated with implementing different packaging options. A certain level of packaging is needed for protection and identification/advertising of the supplier. Take back schemes will require management to ensure they operate properly, again a further cost.

Incentives may be required to encourage the return of packaging for reuse. Additional space may also be needed to store packaging or materials taken back for reuse.

Installation

Developing best practice in terms of Site Waste Management Plans (SWMPs) may have a small impact on costs. Clients and main contractors have a responsibility to ensure a SWMP is produced where the project value exceeds £300K, however, they may set additional requirements to achieve targets for waste reduction etc. They will expect the cost of the system to remain the same even if greater input is required for the SWMP.

End of life

Customers expect to have new products and there may be a perception that second life systems are not as good. Compliance and testing, for example, for building regulations energy performance standards may constrain reuse. Products are often made of composite material which may make them difficult to identify and segregate for recycling at their end of life.

▶▶▶ Action plan: The way forward for the MMC sector

1.

Tackling packaging used on raw materials

Issue:

A variety of packaging is used on raw materials supplied for the manufacture of MMC systems such as polythene sheet/wrap, cardboard, metal and plastic banding, timber pallets and bearers, plastic containers (from adhesive and paint) and paper sacks.

This makes up a large proportion of the waste stream from manufacturing (up to 50% by weight) and not all of it is being recovered effectively.

Some of this packaging may be reduced if it is used in an optimal manner, for example by using corner edges rather than full packaging on furniture.

Action:

Work closely with the supply chain to understand packaging types and any specific reasons why they are used, then aim for optimal packaging solutions and take back schemes. Specify that packaging on raw materials is either reusable or recyclable and clearly identifiable.

What next:

Identify the top 50% of raw material suppliers to MMC manufacturers in terms of sales and devise a joint action plan for tackling packaging.

Who to take it forward:

Modular and Portable Building Association (MPBA), Construction Products Association, Build Offsite, UK Timber Frame Association (UKTFA) and British Precast Concrete Federation (BPCF) with support from BRE and other appropriate business support organisations.

2.

Facilitating reuse of modules

Issue:

Modules have the potential for reuse, however, there is currently no system in place to know how many modules there are, of what type, where they are located and when they are likely to be available for reuse.

Action:

Work with system manufacturers to undertake a scoping study on the possibility of having a national registration process that records type and dimensions, manufacture, usage and location of modules. Such a system could also include electronic tagging.

If MMC products are complying to the BRE Product Standard BPS 2020¹⁰, basic details relating to the identification of building systems must be clearly marked on the product.

What next:

MPBA to work with five key manufacturers to develop a specification for the scoping study. Work with BRE to identify appropriate sources of funding.

Who to take it forward:

MPBA.

3.

Developing supplier sustainability credentials

Issue:

MMC manufacturers use a large variety of different suppliers of raw materials and logistics companies without necessarily evaluating their sustainability credentials. Undertaking such an evaluation could help inform decision making.

Action:

To develop sustainability criteria for the industry covering key raw materials and logistics. This will involve evaluating suppliers in terms of their environmental impacts e.g. energy and water usage, recycled content, minimisation and recovery of waste, and types and choices of transportation and associated fuel.

Forthcoming standards should also be considered, such as BRE Global's Responsible Sourcing of Materials standard BSS 6001.¹¹

What next:

MMC manufacturers and appropriate representative bodies, e.g. Build Offsite, to hold talks with Construction Products Association and BRE with regards to environmental assessment of suppliers and responsible sourcing.

Who to take it forward:

MMC manufacturers.

10. http://www.redbooklive.com/pdf/BPS2020_Issue_1_1.pdf
11. <http://www.thegreenguide.org.uk/page.jsp?id=13>

▶▶▶ Action plan: The way forward for the MMC sector

4.

Maximising recovery of MMC systems and components at end of life

Issue:

According to the demolition industry, issues may arise in terms of recovering MMC systems at the end of their life, meaning that the majority would currently be destined for landfill. This is due to the composite nature of some of the products used, the value of materials and the method of assembly and fixing of the systems.

Action:

Determine the recoverability of existing MMC systems and develop an appropriate strategy throughout the supply chain to enhance recovery at the end of life. This is likely to address issues related to design, specification, material choice and durability.

What next:

BRE to initially convene workshop with key industry stakeholders to take this issue forward with the supply chain and also interact with policy makers. BRE are in initial discussions with the NHBC Foundation and the BRE Trust in terms of developing a funded project.

Who to take it forward:

BRE possibly with NHBC Foundation and BRE Trust funding.

5.

Making the right decision for waste management

Issue:

It is difficult for manufacturers to make an informed choice about the proposed waste management route for waste arisings, both in terms of cost and environmental impact.

Action:

For each key waste arising, develop standard guidance with regards to selecting the best practical environmental option, taking into account cost implications, locations and availability of facilities.

What next:

Develop improved guidance (and evidence) on the best practical environmental options for dealing with key wastes arising from MMC products.

Who to take it forward:

Business support bodies such as CRWP¹² working with appropriate trade bodies affiliated with the Construction Products Association.

6.

Optimising system design to reduce waste

Issue:

To reduce waste effectively, manufacturers need a solid understanding of why the waste is arising and where in the manufacturing process. This is often related to the design and specification of systems. Standardisation will aid in the reduction of waste and more effective use of raw materials.

Action:

Review design processes of systems in terms of waste generation and look at the potential for producing standardised systems minimising bespoke elements yet still ensuring customer choice.

What next:

Individual MMC manufacturers to review their own processes with support from appropriate technical bodies.

Who to take it forward:

MMC manufacturers.





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www.beaware.org.uk

BeAware is managed by BRE. The project is carried out in partnership with an industry consortium, led by a steering group chaired by the Construction Products Association. The consortium includes representative bodies from the timber and woodworking, plastics, composites and concrete manufacturing industries, the packaging sector, modern methods of construction, construction clients and advisors, waste processors and technical experts.

