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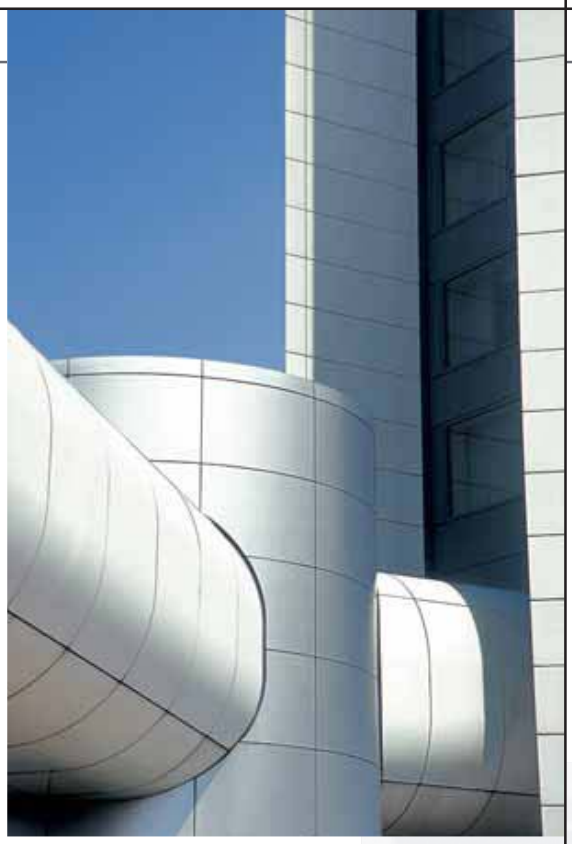
Your guide to specifying **Modular Buildings**



Your guide to specifying

Off-site manufacture

Maximising value and minimising risk

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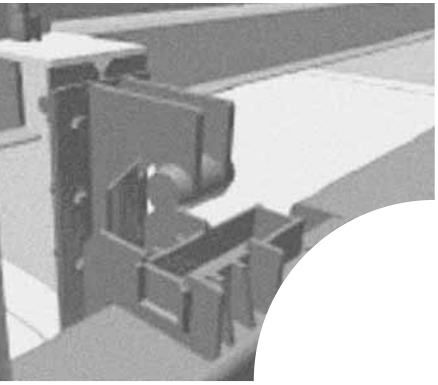

Contents

Courtesy BWA

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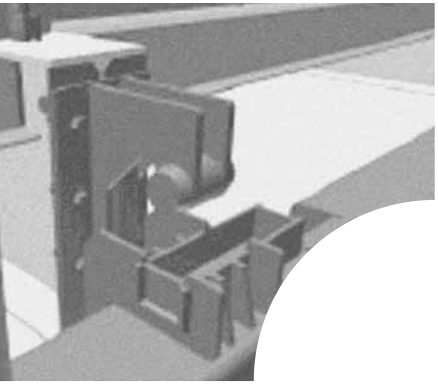
Abbreviations used:

BRE:	Building Research Establishment
CIRIA:	Construction Industry Research and Information Association
GA:	General Arrangement drawing
IMMPREST:	Trademark derived from: Interactive Method for Measuring PRE-assembly and STandardisation
M&E:	Mechanical and Electrical services
OSM:	Off Site Manufacture
RHA:	Road Haulage Association
SCI:	Steel Construction Institute.

Your guide to specifying Off-site manufacture. Maximising value and minimising risk

R Kelly, BAA

Revision 2, 17 August 2009



1 Executive Summary

Buildoffsite and BAA recognised a need for guidance to help client and specifier organisations to get best value from off site building suppliers. Generally, it has been observed that tender packages are sent out with too restrictive design information and too late in the design process. This inhibits the off site suppliers from fully exploiting their skills and expertise to deliver efficient economic solutions to meet clients and specifiers needs.

These guidelines aim to address this problem by advising when in the design process to involve off site manufacturers and to what level of design projects should be taken before tenders or requests for information are issued.

The guidelines are the result of two workshops and a series of follow up meetings which have been held at CIRIA using the Buildoffsite membership. This has provided knowledge and expertise to advise on the level of information that is required and when involvement can most effectively be used in the project process.

There are a number of conclusions which can be drawn as a result;

- Initially, design should be kept outline, flexible and should not be too detailed. Ideally the design should be limited to performance specifications with clear definition of the purpose of the building and its functionality, supported by basic layouts, plans and elevations.

  It should be understood at the start of the project that offsite manufacture has implications for the design, manufacture and assembly programme. Project programmes must reflect these variances in stage durations from the start as late adoption of offsite manufacture may adversely affect completion dates whilst early adoption can pull it forward.

- It is beneficial to introduce design freezes into the programme as these will help to mitigate the effects of any late design changes, which may not be as easy to incorporate when using an offsite solution.

- The offsite specialist should be involved during the design stages, working with the designers, to ensure that the design is not taken to a stage where it restricts the benefits that can be brought through the use of offsite manufacture. An integrated design team will generate most value.

- The client should be satisfied that the off site supplier has the appropriate level of competence required. This is difficult to establish without carrying out an indepth audit by a manufacturing specialist. Accreditation schemes such as the Buildoffsite Lloyds Register will help

Courtesy BAA

These guidelines provide practical advice which may be applied to a wide range of projects, from designing and constructing complete buildings to designing and manufacturing the service modules which fit within them.

BAA and Buildoffsite wish to thank all those who took part in the development if these guidelines, providing information, thoughts, comments and guidance.

2 Introduction

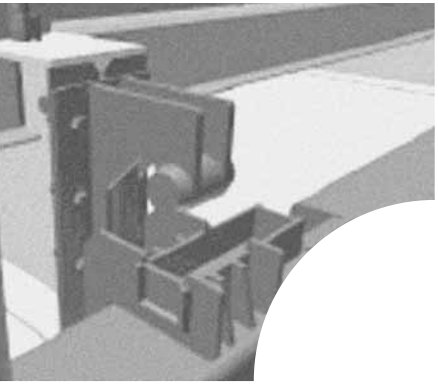
It is generally accepted that off site manufacture (OSM) can in many circumstances present a significantly beneficial alternative to traditional on site construction. To achieve the optimal level of intervention by the client and their consultants it is necessary for the OSM to be allowed to contribute their expertise to bring the full benefit of OSM early in the project.

To investigate the correct level of intervention and the levels of specification to be provided in tenders a series of workshops have been held by BuildOffsite and BAA Limited to consult with the off site industry.

This is the output from those workshops and it is hoped that their use by clients and consultants will encourage increased submissions to tenders invited by construction clients and ensure more effective use and continued growth in the off site market.

Benefits that may be expected from OSM:

- Shorter overall programme
- Predictability & reduced risk
- Lower project cost
- Better & consistent quality
- Less impact on site operations
- A safer project
- Reduced material waste
- Reduced construction traffic on site



3 The Traditional Approach

While the informed client may have an excellent understanding of what they want their building to do and how they want it to be delivered this can miss the opportunity of further success by using offsite manufacture. Too much constraining information included in a tender based on pre-conceived construction solutions will restrict the benefits that the OSM can bring to the project

Whilst there are a number of procurement approaches, typically the client and their consultants will produce a package of information for a tender design up to 'scheme design' as a minimum which will include;

Purpose of the building

- Temporary, permanent or re-locatable
- Required lifespan or number of moves
- Access by customers or staff only
- Defined occupancy levels
- Footprint, GA's and elevations
- Room relationships and data sheets
- Critical restraints
- Floor loading requirements
- Foundation designs
- Ceiling/storey heights
- Internal environment criteria
- Full internal finishes specification
- External finishes specification
- M & E requirements

Budget & Time

- Budget expectations
- Timing expectations

Design

- Clear ambitions for final design and visual profile for the project
- Local authority planning constraints
- Consideration of future proofing

Relevant site information

- Location
- Site constraints & restrictions
- Site access
- Hours of working
- Incoming services
- Adjacent structures

This level of information is generally acceptable for a traditionally constructed in situ building but could become too detailed to allow the OSM to bring their product benefits and knowledge to the project. Once the design has progressed past outline scheme design any OSM will have to redesign the project to suit the constraints of their modular system. All methods, whether steel or timber framed, will have limitations on spans, loadings, numbers of floors and transportation. This is a wasteful use of the consultants and the OSM's resource and hence the client's money, while restricting the useful benefits that offsite manufacture can bring to the project. Involving the OSM too late in the project results in more preconceived ideas which then require re-assessment.

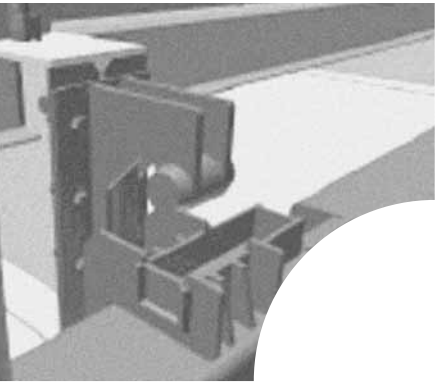
4 Avoidable Pitfalls

The offsite manufacturers who were consulted in the preparation of these guidelines have suggested that the following points are the most prevalent causes of tenders being returned incomplete or project resources not meeting client's expectations.

- Over design by consultants
- Lack of clarity in performance standards
- Too much detailed design too early
- Being over prescriptive in non-essential areas
- OSM supply chain capabilities & cost drivers not understood early enough
- Consultants trying to design for manufacture without the specialist skills
- Budget constraints ignored
- Practicality of build ignored, is it suitable for OSM?
- Engineering constraints overlooked
- Client standards (especially M&E) which are not appropriate

The result of these items is a high proportion of tenders returned incomplete, or projects which when completed, fall short of client expectations, bringing the OSM industry into disrepute. This may cause both clients and consultants to doubt the benefits which OSM can bring to future projects.

Courtesy BWA



5 Early Involvement of the OSM

If it is agreed that a project may benefit from off site manufacture then early involvement of potential OSM suppliers is vital if the design is not to be allowed to go too far down the traditional construction route. Involvement should be as early as possible and can start by a review of the strategic brief including the items listed below;

Strategic Briefing Stage

- Assess strategic brief with client
- Identify key drivers for success
- Identify constraints and risks
- Agree process and decision making for design brief development and approval
- Does the project release the inherent benefits OSM can bring?

Some clients may feel that involvement of the OSM at this stage is not appropriate and will detract from the production of an unbiased strategic brief. If this is the case, then the activities listed below should be assessed for their influence on the project and to prevent excessive amounts of unsuitable design work being carried out before the offsite manufacture route has been fully investigated.

Outline, Detailed and Final Proposal Stages

- Identify opportunities and aspirations for design for manufacture and assembly, agree strategy
- Agree process and timing for cost verification and relate these to design process
- Collect historical cost data from similar projects from potential off site suppliers
- Identify opportunity and benefits in early engagement of supply chain
- Identify skills required and who should provide (consultant versus potential supplier)
- Develop processes for seamless engagement of consultants and suppliers – agree deliverables and processes for cost control
- Identify site logistics and buildability issues to inform option selection and design for manufacture and assembly strategy
- Agree phasing strategy

The following items have been raised as being of importance to the off site manufacturers

- Purpose: the need for a clear definition of the solution's purpose is considered paramount in the completion of a specification. Above all other concepts the importance of a simple performance specification that does not include prescriptive pre-design is key
- Manufacturing Concerns: design freeze and exploiting standard elements can be important points of compromise that must be negotiated between clients and the potential off site manufacturing suppliers
- Contextual Requirements: the situation within which and surrounding the solution to be proposed should be correctly articulated if an effective and efficient product is to be feasibly presented
- Costing Considerations: clients need to be made aware of the costing implications of off site solutions. Understanding the impacts of risk, prelims, programme etc not just considering capital cost except where this is the key driver
- Simplicity is vital: keep the design simple and flexible, this does not mean boring and box like, to allow the OSM to bring the benefits of their products to the project. Define level to visual "flair" required
- Costs: clients are likely to benefit from considering the whole life cost of a building

6 Design & Specification

The key to gaining the benefit of OSM is to provide a performance specification which has ideally been produced in consultation with the OSM supply chain through early involvement during brief production and proposal development.

There needs to be a shift of emphasis away from design onto purpose and performance. This allows the OSM to tailor the design to suit their method of off site manufacture, to allow maximum benefit from their knowledge of module sizes, configurations, spans and loadings and transportation restrictions. The OSM market seems to be developing into two distinct streams with manufacturers who produce standard products and those who produce mass customised products.

The design requirements will indicate one stream or the other. The parts of the design which affect the client's brand or signature can be protected by being specified. Other parts of the performance specification, acoustics, thermal, lighting levels etc can be set as levels of performance which need to be met but which the OSM may design how they are achieved.

Any pre-design that features in a specification will most likely immediately disadvantage the OSM community, due to the design consultant's lack of expertise in the field of offsite manufacturing.

Solutions to design challenges have often already been addressed by OSM's.

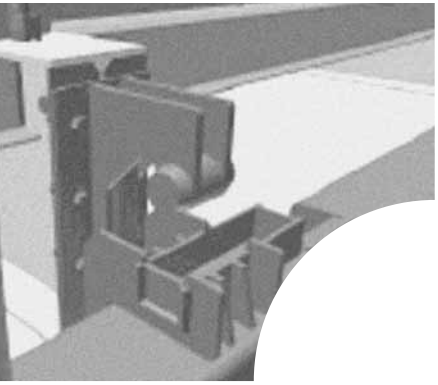
Do's

- Share ambitions with the OSM industry
- Be open & honest
- Work with the industry to raise standards & develop products
- Keep specifications simple
- Employ consultants who understand & embrace OSM
- Look for value for money, use tools like IMMPREST to assess benefits
- Be receptive to supplier ideas
- Use consultants for peer review
- Reward success
- Use design reviews and a change control process
- Give value to speed, quality, safety, waste and predictability
- Use off site companies with modern manufacturing methods

Don'ts

- Be over prescriptive too soon
- Allow consultants to over design
- Try to design for manufacture without understanding capabilities and cost drivers
- Select the off site supplier on cost alone without understanding their critical capabilities

Courtesy T.G. Bailey



Specification Contents

Any specification should inform as to the purpose and the use that a solution will satisfy rather than providing a detailed design that tells the manufacturer how the solution should be fabricated.

Specifications should be made as simple as possible, outlining the solutions purpose and how it will be utilised, not how it should be designed and manufactured. This requires either earlier involvement by the manufacturer in the design stage or design consultants who understand the OSM's processes.

An aspiration is for the specification to be a single A4 sheet which identifies internal & external finishes, environmental concerns and project specifics, not a full design that informs the modular builder how to do their job. Manufacturers do not require details on how solutions are to be constructed.

Purpose and functionality are the key to effective solutions, for example, forecourt check-in facilities at an airport may well be sized to suit check-in desks and queuing arrangements. This information would be key, allowing the manufacturers to understand how layouts could be made to work within standard module sizes.

How the solution has to be integrated with existing facilities is important to allow tolerances to be included in the design and again allowing the manufacturers to understand what can be standard modules and what needs to be bespoke.

Programme

Programming should be realistic. Detailed design needs to be advanced early and then frozen. Preparation for offsite generally takes longer due to the level of design information required prior to production, start on site is later but work on site is of shorter duration. Tender periods need to be a minimum of four weeks to allow the OSM to properly work up their offer. Two stage development of an offer should be considered.

M & E examples:

Project	Category	Traditional (weeks)	Off-site (weeks)	Difference (weeks)	Benefit
Office	Off-site and pre-construction	2	8	+6	-300%
	On-site	7	2	-5	+71%
	Overall project	9	10	+1	-11%
Hospital	Off-site and pre-construction	17	22	+5	-29%
	On-site	140	106	-34	+24%
	Overall project	157	128	29	+19%

Source: buildoffsite business case studies 001 & 002

Compliance

In the case of statutory compliance it is suggested that only exceptions, where variations from the standards/regulations are required, should be included. Otherwise compliance is to be as per current standards/regulations and is taken as read.

Contractual Arrangements

Contractual and commercial arrangements of the tender must be clear including options for purchase, lease purchase or hire plus maintenance requirements where appropriate. Some suppliers may ask for stage payments ahead of a traditional build programme.

Future Flexibility

Relocation requirements should be realistic and specific. Extra cost is added to a solution by specifying a requirement for relocation, which may never actually be required. Consideration should also be given as to whether requirements for future adaptability, extension and modification are really necessary.

It is more cost effective to build in future flexibility during manufacture than as a post construction modification but these will add cost to the final solution which may be completely unnecessary.

For example, at BRE's Innovation Park a show house has additional support structure built in to allow for the installation of a mobility hoist from bedroom to bathroom should it be required at a later date. Inclusion of this support work during manufacturing would be a fraction of the cost and disruption of a post completion installation.

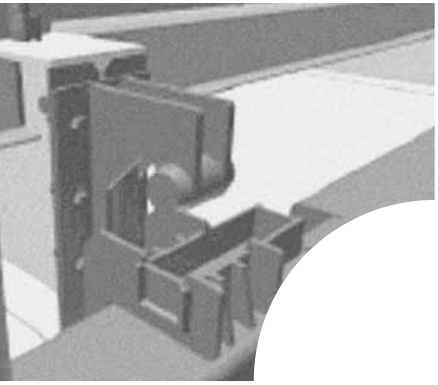
Logistics

The importance of logistical considerations is not to be underestimated. Information about site restrictions and integration with existing facilities is essential and should be fed into the specification as early as possible. The complexity of the logistics demands professional expertise which should be the responsibility of the supplier/manufacturer.


Courtesy Buchan

Consultants

The consultant's role should be to interpret the specific requirements of the client and produce a performance specification. Current practice is for a client's consultant to complete a comprehensive specification including a bespoke design for every solution. For example structural engineers should only request specific loadings and provide information on ground conditions. Most OSMs have in house design capability which is 3rd party verified.



Additional duplicating of consultancy is considered to be inefficient, leading to redesign on the part of the OSM and not allowing them to use their standard designs and manufacturing expertise.

Design Freeze

A complete design freeze such as that used in the manufacture of automobiles on receipt of a customer order would be necessary for off site manufacture to be fully effective. However, it would be unrealistic to believe that a final design could be decided at a very early stage and remain unchanged throughout the construction process. Instead a suggested phased freeze might be a more achievable target.

Clients also need to be made more aware, at the time, the impact of changes to a design, so that time and cost overrun on a project could be easily attributable and not come as a surprise to the client. Further to this, clients should be made aware of what are the largest cost drivers in modular manufacture so that decision making is more informed. Clients should state what is set in stone and must be adhered to, for example client's colour schemes and branding.

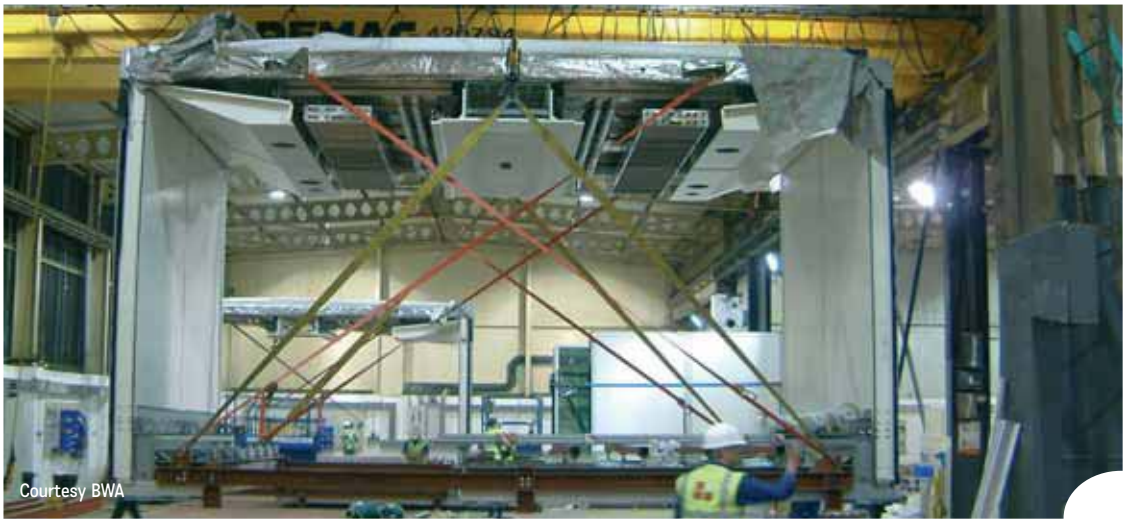
Clients should be careful to select off site manufacturers who operate modern manufacturing methods. Although progressive design fixity is still going to be important, they will be the ones with most agility to respond to detail change, lead time changes and quantity design

Handover information

OSMs have accurate 2D drawings and 3D models of their products. This combined with a well controlled manufacturing process enables delivery of very representative "as built" information, which clients are encouraged to ask for.

Keep it simple and:

- Involve OSM early in the design process
- Allow flexibility to accommodate module design & structure
- Keep specifications concise & clear with scope for development by supplier within agreed parameters
- Use the capability of the supply chain
- Understand that every supplier is different
- Be prescriptive only where you must; finishes, claddings, acoustics, bomb blast resistance etc
- Avoid wasteful design activity



Courtesy BWA

7 Key Requirements for a Performance Specification

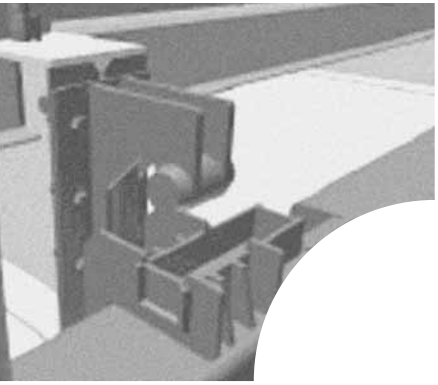
The following list of key requirements should be considered for inclusion in any performance specification issued for projects to adopt off site manufacture:

- Requirements (usage, quantity, quality, true design life)
- Criteria associated with the site, including location
- Limiting dimensions and volumes
- Critical functional relationships
- Service Requirements: electricity, gas, water, sewerage, fire
- A guide to cost and programme
- Strengths and forces: imposed loads, exceptional loading
- Cladding preference and thermal performance
- Fire performance
- Acoustic performance, internal & external
- Logistic requirements: flat-pack/space frame, transportation, restrictions, speed of erection, erection requirements
- Specific interfaces
- Security requirements
- Finishes required
- Sustainability – energy targets and materials use
- Maintainability and hand over information
- Re-locatability


Courtesy Southern Housing Group

In addition the tender will need to confirm the type of contract, the appointment of principals (planning supervisor, clients agent, architect, and engineer etc) and details of cost and programme targets. Commercial arrangements for the tender should also be clear stating options on purchase, lease purchase or hire.


Courtesy Caledonian



8 Conclusions

The following simple conclusions can be drawn;

- Involve the offsite manufacturer in the design process during outline, detailed and final proposal stages
- Understand the cost drivers
- Provide clear definition of the purpose of the building and its functionality
- Understand and fully cost the benefits and risks of offsite manufacture
- Keep design simple & flexible, but not boring, to maximise benefits from the OSM
- Don't take the design too far or make it too detailed and don't try to design for manufacture
- Assess the critical capabilities of the off site suppliers that are intended to be used (NB the Buildoffsite Lloyds Register accreditation scheme has been established to assist clients select the best off site suppliers)
- Issue performance specifications, don't be too prescriptive too early in the process
- Understand the effect of offsite manufacture on the design, manufacture and assembly programme stages and make sensible allowances
- Allow professionals to manage the logistics
- Programme in phased design freezes and understand the implications of late design changes
- Don't allow design work to be duplicated (consultant/OSM)


Courtesy BWA

Appendix A Exploit Supplier's Capabilities

It was suggested by the OSM suppliers involved in the workshops that an awareness of the current products available on the market and the associated details would be of great value to design consultants and to a slightly lesser degree, clients and their project managers.

Other useful sources to provide further guidance are manufacturer's design guides, e.g. Yorkon and design guides provided by the industry sectors: steel, timber, concrete.

The following information is generic with the exception of the table of sizes which will ultimately vary with manufacturer.

Types of Modules

Modules can be manufactured and delivered in a number of different formats to suit the needs of the client and the project constraints.

The options typically include:

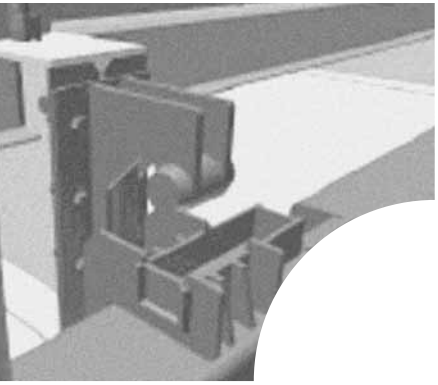
- Four-sided modules
- Partially open-sided and open ended modules
- Open-sided (corner supported) modules
- Mixed modules and planar floor cassettes
- Modules supported by a primary structural frame
- Other module types
  - Stair or lift modules
  - Non-load bearing "pods"
  - Open floor modules

Dimensional Planning

The dimensions of the finished project are critical to the success of the use of modular construction and OSM.

The design should give due consideration to:

- The planning grid for internal fit out
- Transportation requirements, including access
- Building form, as influenced by its functionality
- Foundation tolerances
- Production controls
- Alignment with external dimensions of cladding
- Repeatability in modular manufacture



Modular dimensions

Application	Internal wall height (mm)	Internal module width (mm)	Internal module length	Ceiling floor zone (typical)
Study bedrooms	2400	2500–2700	5.4 to 6 m	300 mm
Apartments	2400	3600	6 to 9 m	450 mm
Hotels	2400–2700	3300–3600	5.4 to 7.5 m	450 mm
Schools	2700–3000	3000–3600 open-sided	9 to 12 m	600 mm
Offices	2700–3000	3600	6 to 12 m	600–750 mm
Health sector	2700–3000	3000–3600 open-sided	9 to 12 m	600–750 mm

Source: RHA

Transportation and Logistics

Not only do projects need to consider designing to suit where possible generic module sizes but also for the restrictions on transportation and site logistics.

Movement of modules of different widths requires different police notices, escorts and additional crew as listed below for the UK:

- Modules exceeding 2.95 m width require two days police notice
- Modules exceeding 3.5 m width require a driver's mate and two days police notice
- Modules exceeding 4.3 m width require police escort
- Maximum practical height of the load is 4.95 m although there are no legal height restrictions on UK roads.
- Standard container vehicles are typically 6.2 m or 12.2 m long; they can delivery one large or two small modules

Source: RHA

NB "Air suspension" equipped vehicles may rise when in motion causing the load height to increase

Appendix B Useful Sources of Information

Buildoffsite
www.buildoffsite.com

Buildoffsite
Glossary of Terms
www.buildoffsite.com

Loughborough University
IMMPREST Toolkit
www.immprest.com

SCI
Case Studies on Modular Steel Framing
The Steel Construction Institute, ISBN 978 1 85942 095 9

Gibb, A G F
Off Site Fabrication
Whittles Publishing, ISBN 978 1 87032 577 6

Lawson, R M and Grubb, P J
Modular Construction Using Light Steel Framing: An Architect's Guide
The Steel Construction Institute, ISBN 978 1 85942 096 6

Department for Education and Skills (now Department for Children, Schools and Families)
Toilets in Schools
DFES 00365 2007, ISBN 978 1 84478 925 2

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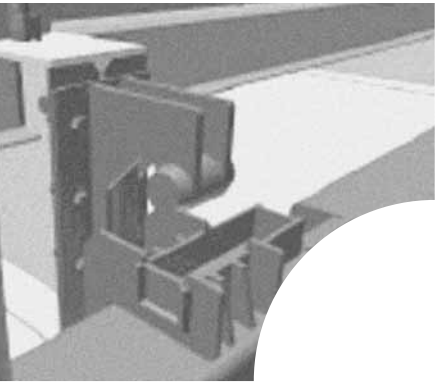
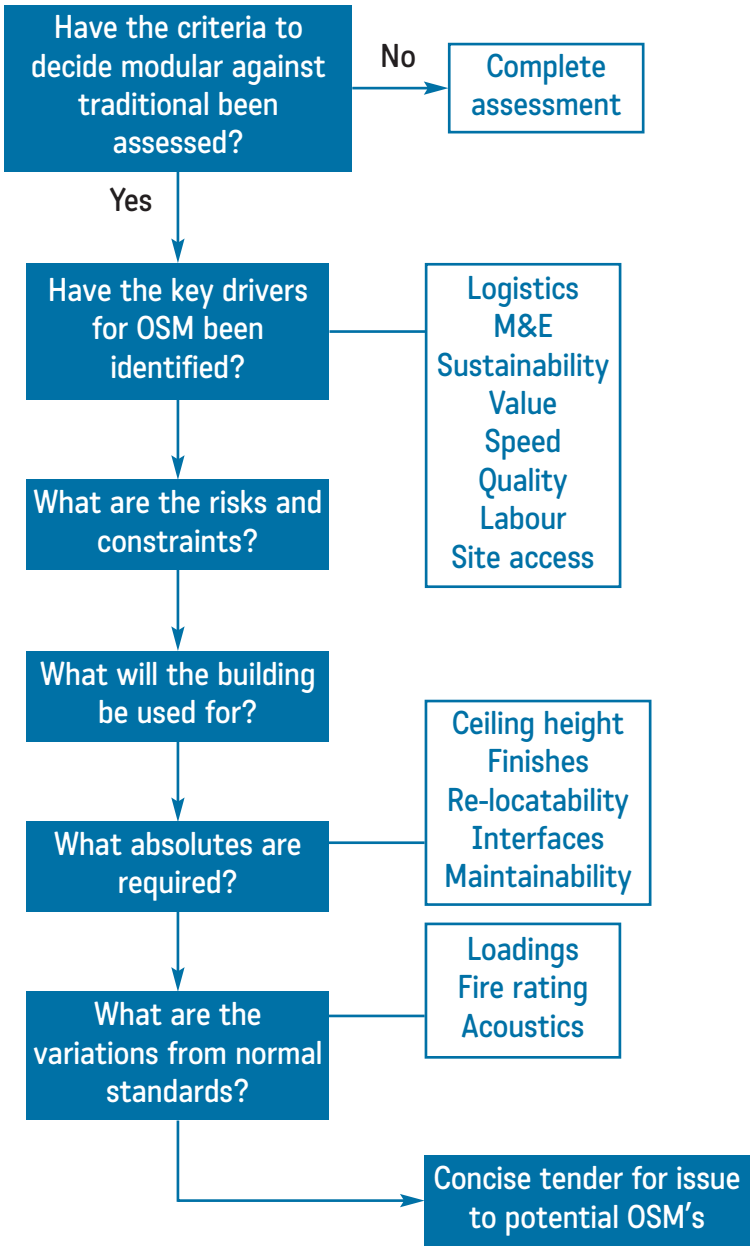
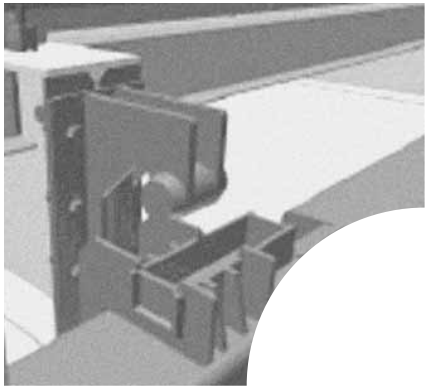


Appendix C Preparing a tender

Flow Chart to help create a concise tender for issue to Offsite Manufacturer





Your guide to specifying modular buildings: maximising value and minimising risk

Buildoffsite and BAA recognised a need for guidance to help client and specifier organisations to get best value from modular building suppliers. Generally, it has been observed that tender packages are sent out with too restrictive design information and too late in the design process. This inhibits the modular suppliers from fully exploiting their skills and expertise to deliver efficient economic solutions to meet clients and specifiers needs.

These guidelines aim to address this problem by advising when in the design process to involve modular manufacturers and to what level of design projects should be taken before tenders or requests for information are issued.

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