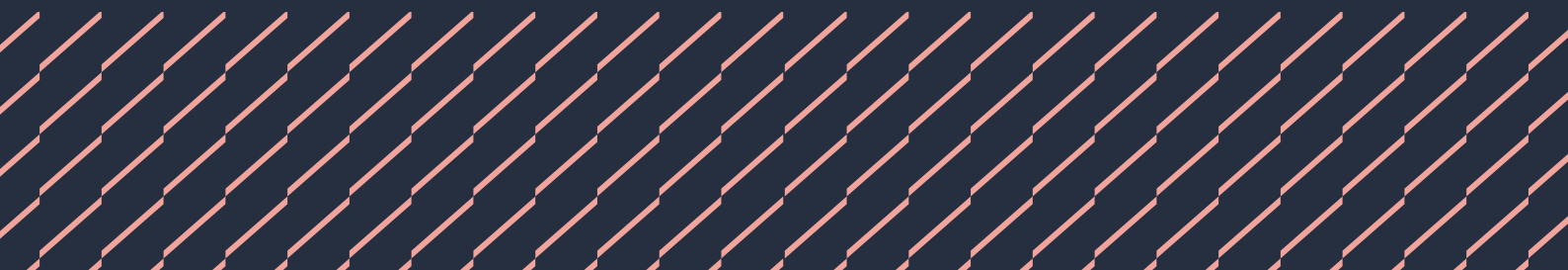




Part 11

Modern Methods
of Construction



MMC Systems: general requirements

This chapter provides guidance on meeting the Technical Requirements for certification, quality management, site management, installation, verification, and handover requirements for MMC systems used to form homes where the height of the top floor above ground does not exceed 18m. This chapter should be used in conjunction with Chapters 11.2 and 11.3.

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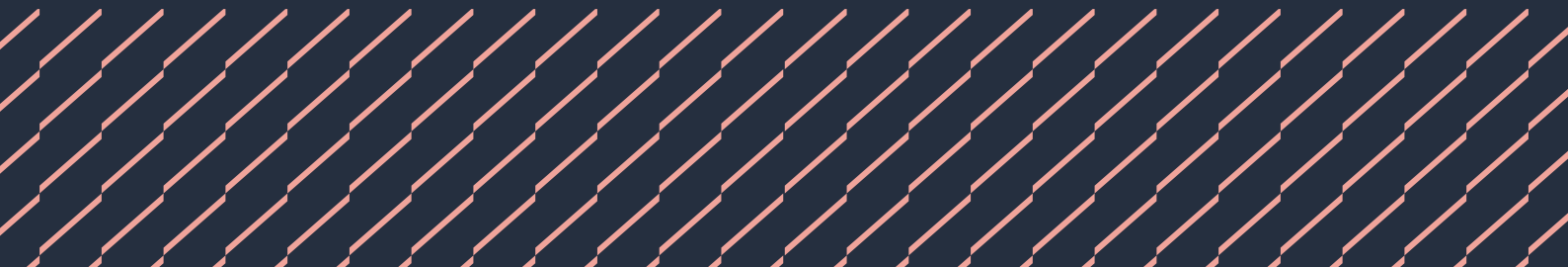


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Introduction

This chapter gives guidance on meeting the Technical Requirements for certification, quality management, site management (handling, storage, and protection), structural design, structural design checking and certification, installation, verification, and handover requirements for MMC systems used to form homes where the height of the top floor above ground does not exceed 18m.

The guidance in this chapter is intended to outline the common general requirements applicable to MMC systems manufactured in a factory environment. This chapter should be used in conjunction with Chapter 11.2 Closed panel systems and Chapter 11.3 Volumetric systems, where further guidance is given relevant to the system type being employed.

Users of this chapter should also refer to Part 6 of the NHBC Standards, particularly Chapters 6.2 and 6.10 when either timber frame or light steel frame respectively are to be used.

'Modern Methods of Construction' is a collective term encompassing a wide range of system types, including off-site manufactured systems that cannot be inspected on site in a traditional manner due to high levels of offsite fabrication, innovative technologies and other non-conventional methods of construction that form the structure and envelop of the home. As such, methods of construction that are described in the preceding chapters of the NHBC Standards, such as open panel light steel and timber frame, and can be inspected on site during the build process are considered as conventional construction rather than MMC.

MMC types have been categorised and defined in the MHCLG Cross Industry Working Group 'MMC Definition Framework'. The definition framework identifies the following seven MMC categories:

Category 1	Pre-Manufacturing — 3D primary structural systems
Category 2	Pre-Manufacturing — 2D primary structural systems
Category 3	Pre-Manufacturing — Non-systemised structural components
Category 4	Pre-Manufacturing — Additive Manufacturing
Category 5	Pre-Manufacturing — Non-structural assemblies and sub-assemblies
Category 6	Traditional building product led site labour reduction/productivity improvements
Category 7	Site process led labour reduction/productivity improvements

The guidance in this Part will focus on systems that fall under Category 1 ie, volumetric systems, and Category 2 (closed panel only) ie, panelised in the definition framework:

Category 1 — 3D primary structural systems (volumetric)

Three-dimensional structural volumetric units fabricated offsite in a factory environment used to form all or part of the basic structure of a building. Volumetric units may incorporate varying degrees of offsite fabrication and finish, including internal and external linings, external claddings, windows and doors, internal finishes, concealed insulation, membranes, internal services, internal fixtures and fittings and fire-stopping.

Volumetric units can be used in varying configurations to form the entire structure of the home or be supported by surrounding construction. Units can be manufactured in varying structural forms and be formed from timber, concrete, steel or light gauge steel or a combination of those materials.

Category 2 — 2D primary structural systems (panelised)

Flat two-dimensional panelised units fabricated offsite in a factory environment used to form walls, floors, and roof structures. The category encompasses panelised units supplied as 'open' or 'closed' panel, however the scope of this Part only encompasses 'closed' panel systems. Definition of 'closed' panel systems is given in Chapter 11.2 Closed Panel.

Definitions for this chapter

Cavity	A space enclosed by elements of a building such as the space between the cladding system and the backing wall. The external wall cavity should be adequately drained, and ventilated where required.
Cavity barrier	A construction within a cavity, other than a smoke curtain, to perform either of the following functions: <ul style="list-style-type: none"> • Close a cavity to stop smoke or flame entering • Restrict the movement of smoke or flame within a cavity.
Factory installed	An element of the construction that is placed, positioned, fitted, or secured in, on or as part of the unit as part of the factory construction process.
Fire-stopping	A seal provided to close an imperfection of fit or design tolerance between elements or components, to restrict the spread of fire and smoke.
Hold Point	A point in the manufacturing or construction process beyond which work may not proceed until the required inspection and verification has been undertaken.
Installation Manual	Detailed installation guidance and information for the system compiled by the system manufacturer. The Installation Manual describes general instructions for storage and transport of the system, and procedures for on-site assembly and installation.
MMC systems	Modern Methods of Construction is a collective term encompassing off-site manufactured systems that cannot be designed or be inspected on site in a traditional manner due to high levels of offsite fabrication, innovative technologies and other non-conventional methods of construction that form the structure and envelop of the home. As such, methods of construction that are described in the preceding chapters of the NHBC Standards and can be inspected on site during the build process are considered as conventional construction rather than MMC.
Manufacturer	The company which is responsible for the design and assembly of the MMC system.
Non-standard components	Components that are assembled as part of the system but vary for individual projects. These may be windows, doors or services that may be built into the system.
Robustness	A quality in a structure/structural system that describes its ability to accept a certain amount of damage without that structure suffering disproportionate failure. Robustness implies insensitivity to local failure.
Standard components	Components that are assembled as part of the system and are common to all projects.
Strong point	A structural element, frame or assembly oriented in a vertical plane that act to resist lateral loads supporting both horizontal and vertical stability systems together with façade (including wind posts, cladding rails, etc) and transfers the lateral actions through the assembly generally down to the foundation. Examples are reinforced concrete shear walls like lift cores or stair wells.
System	For the purposes of this chapter, this term refers to acceptable forms of either closed panel or volumetric MMC systems.
System Manual	Detailed technical information on the system compiled by the system manufacturer. The System Manual describes the system, the declared performance of the system and evidence to support the declared performance.
Unit	A prefabricated building element, manufactured offsite as a structural assembly in three-dimensional or flat panel format used as part of a system to form the superstructure of a building.
Volumetric	Three-dimensional structural units which are commonly stacked to form a building. Volumetric units may incorporate varying degrees of off-site fabrication and finish, including internal and external linings, external claddings, windows and doors, internal finishes, concealed insulation, membranes, internal services, internal fixtures and fittings and fire-stopping.

11.1.1 Compliance

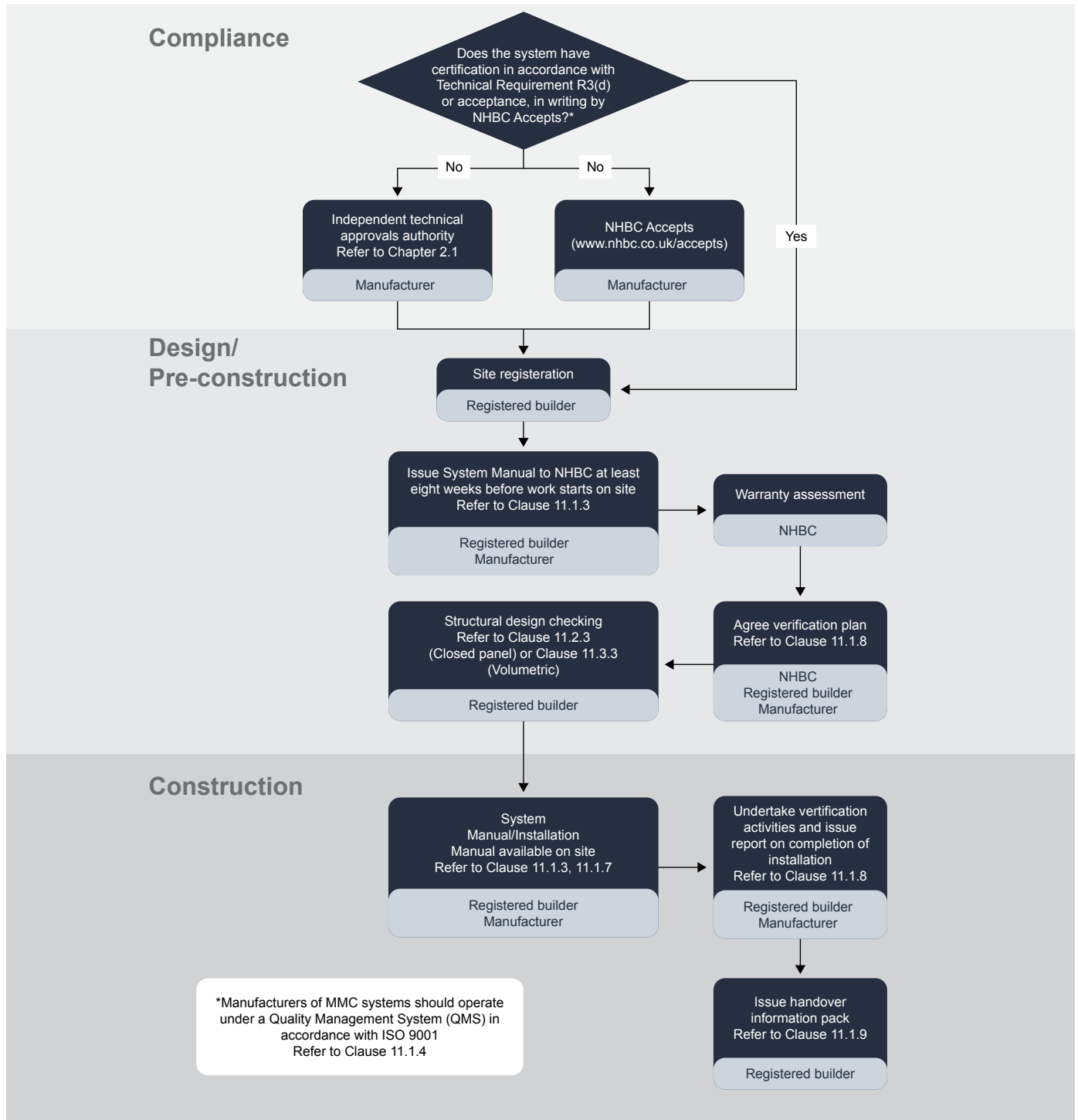
Also see: Chapter 2.1

MMC systems shall comply with the Technical Requirements.

MMC systems should comply with the guidance in this chapter. Further reference should be made to relevant chapters ie, Chapter 11.2 Closed panel or 11.3 Volumetric, appropriate to the MMC system type being used.

Early engagement with NHBC should be undertaken prior to use of MMC systems on projects.

Figure 1: MMC process



11.1.2 Certification

MMC systems shall be adequately certified as being suitable for their intended use.

MMC systems should have certification confirming satisfactory assessment, undertaken by an independent technical approvals authority, or acceptance in writing by NHBC Accepts.

The scope of certification by an independent technical approvals authority should include:

- inspection and surveillance of factory production
- strength and stability (including temporary loads)
- fire resistance including details of critical junctions between elements
- reaction to fire classification
- thermal performance
- acoustic performance
- system junctions and joints
- maintenance and reparability
- condensation risk
- resistance to weathering in use, including temporary resistance during transport and during construction
- regulatory compliance
- design considerations
- installation guidance and acceptable superstructure tolerances
- durability
- approval of installers.

Certification and system documentation should be:

- made available to NHBC before work begins on site, and
- used as a reference to ensure compliance.

Use of the system should be within the scope of the certification. Where relevant, certification should make reference to test evidence or documentation used to support or justify any declarations or conclusions made.

Standard components assessed as part of the system certification and performing critical functions should not be substituted or replaced unless agreed otherwise by NHBC.

11.1.3 System Manual

Designs and specifications, in the form of a System Manual, shall be produced in a clear and understandable format, include all relevant information, and be distributed to all appropriate personnel.

A System Manual and supporting design information should be issued to NHBC at least eight weeks in advance of the works starting on site, in accordance with NHBC rules. Further performance issues may be considered at the discretion of NHBC, and further information requested. If in doubt, consult NHBC Standards, Innovation and Research (technicalsupport@nhbc.co.uk).

The System Manual should contain the information described in Table 1 as relevant for the system.

Table 1: Items included in the System Manual

Topic	Description
System Details	<ul style="list-style-type: none"> • manufacturer name • system name • document revision number • issue date
Scope and limits of application	<ul style="list-style-type: none"> • description of the system and scope of offsite manufactured elements • intended use and limits of application or exclusions (geographic/environmental, storey height, dimensions, building type and shape, etc) • confirmation of parties, who have responsibility for the design and coordination of the system, certification of the system quality assurance and who has overall responsibility for the delivery of the home
Standard detail drawings	<ul style="list-style-type: none"> • schedule of standard detail drawings
Material specifications	<ul style="list-style-type: none"> • specifications and relevant third-party certificates for all key materials and standard components critical to the performance of the system
Durability	<ul style="list-style-type: none"> • demonstration of adequate durability of components and assemblies in accordance with Technical Requirement R3 • specification of fixings, including corrosion protection • temporary weather protection design and method

Strength and stability	<ul style="list-style-type: none"> ● structural design philosophy (including codes of practice referenced, test reports and identification of design aspects not covered by codes for which additional checks or assessment are required) ● sample structural calculations for typical design ● material strengths and/or grades (traceability) ● section properties ● loading ● ultimate limit state ● serviceability limit state ● resistance to overturning ● racking resistance ● holding down ● connections within the system ● connections with other building elements ● structural integrity ● positions and sizes of holes through members ● unit-to-unit connections (strength as well as accuracy) ● unit-to-foundation connections ● rigidity in transportation ● lifting
Behaviour in relation to fire	<ul style="list-style-type: none"> ● reaction to fire ● resistance to fire including fire test reports, and supporting assessments where required, demonstrating compliance with Building Regulations ● fire compartmentation design ● design and specification of cavity barriers and fire-stopping
Resistance to moisture	<ul style="list-style-type: none"> ● vapour permeability and moisture resistance of building fabric and suitable assessment of interstitial and surface condensation risk ● watertightness of the building envelope including integrity and continuity of building membranes and weather resistant detailing at junctions and interfaces ● resistance to moisture from the ground
Safety in use	<ul style="list-style-type: none"> ● consideration of changes in levels ● resistance to eccentric loads, including impact resistance
Resistance to the passage of sound	<ul style="list-style-type: none"> ● sound insulation performance and design
Energy efficiency	<ul style="list-style-type: none"> ● thermal resistance of building fabric including assessment of thermal bridging at typical junction and interface details ● air permeability design
Coordination of services	<ul style="list-style-type: none"> ● specification of factory installed services ● method of testing and commissioning ● method of access for site connections, inspection, and commissioning ● allowance for tolerances of site connections to factory installed services
Quality of finish	<ul style="list-style-type: none"> ● quality assurance process for achieving quality of finish in accordance with NHBC Standards
Evaluation of conformity	<ul style="list-style-type: none"> ● evidence of Quality Management System (QMS) in accordance with ISO 9001:2015 ● Factory Production Control (FPC) plan ● non-conformity procedure ● traceability and unit identification procedure ● inspection and test plan ● storage, transport, and installation procedures

11.1.4 Quality management

MMC systems shall be from a manufacturer operating under a quality management system acceptable to NHBC. Issues to be taken into account include:

- 1) factory production control
- 2) traceability of components and manufactured units
- 3) storage.

MMC systems must be supplied by a manufacturer who operates under a Quality Management System (QMS) which is certified by a UKAS accredited, independent certification body in accordance with the requirements of ISO 9001. The scope of the certified QMS should cover the following activities:

- design and development
- storage of goods and completed system units
- transportation
- externally provided products
- production controls
- identification and traceability
- site installation and handover.

Refer to Clause 11.1.9 for guidance on quality management of installation and handover.

11.1.4.1 Factory production controls

The manufacturer's Factory Production Control (FPC) plan should include:

- inspection and test plan, setting out the scope and frequency of inspection and testing of critical components
- description of controls between design and manufacture to demonstrate the accepted design is being produced
- traceability of all components used in the system
- process flow chart of activities, including change control mechanism
- process for identifying and resolving non-conformities
- hold points, evidence and method of inspection and documenting inspections.

Units formed from steel should be manufactured and installed in accordance with the relevant parts of BS EN 1090.

11.1.4.2 Traceability

MMC system units should be provided with a unique identifier in the form of an indelible Unit Identification Number (UIN), or unique digital marker containing a UIN affixed to the structure of the unit.

The indelible Unit Identification Number (UIN) should be accessible as far as practicable up to the point of handover. In addition:

- UINs or markers that can easily be damaged, dislodged or lost will not be acceptable
- digital markers should be of a type that can be easily read and accessed on site
- the location of UINs or markers should be indicated in the System Manual and Installation Manual
- as a minimum, the UIN should indicate the production number, unit descriptor (ie, unit type and variant), and date and place of manufacture.

The Unit Identification Number (UIN) should allow for traceability of all standard and non-standard components used to form the unit in accordance with the manufacturer's Quality Management System.

11.1.4.3 Storage

The manufacturer's Quality Management System (QMS) should provide suitable provision for long term storage of units at the manufacturing facility if required. Consideration should be given to:

- indoor, covered, or conditioned storage areas
- regular inspection of stored units
- records and tracking of storage duration
- exposure limits of protective materials.

Refer to Clause 11.1.5 for guidance on site storage requirements.

11.1.5 Site management (handling, storage, and protection)

Materials, products, and systems shall be handled, stored, and protected in a satisfactory manner to prevent damage, distortion, weathering, and degradation. Issues to be taken into account include:

- 1) storage
- 2) temporary weather protection
- 3) protection from damage during storage, transportation, and installation.

MMC systems should be:

- transported, lifted, handled, and stored in accordance with the manufacturer's recommendations, site installation manual and temporary weather protection method statement
- stored off the ground
- delivered in a sequence to avoid or minimise storage
- suitably protected against condensation, weathering and mechanical damage during storage, transport, and installation.

11.1.5.1 Storage

The storage of MMC systems should ensure:

- units are stored in accordance with the manufacturer's recommendations
- storage areas are clean and dry, level, and free from contaminants
- units are arranged and protected to prevent accumulation of trapped water
- units are arranged in sequence for erection, with markings visible and adequate access for lifting gear
- storage areas are suitably located, or protection provided to avoid staining and accidental damage by site traffic.

Packers or bearers placed under units should be located under stud positions or suitable bearing points in accordance with the manufacturer's recommendations.

Stacking

Where units are stacked on top of each other during storage, the storage area and bearing points should meet the required tolerances defined in the System Manual for foundations and be suitable packed and levelled to ensure no deformation of the structure. The System Manual should define:

- the maximum stacking height of units (ie the number of units that can be stacked on top of each other)
- method of temporary unit connections (for volumetric units) to ensure effective load transfer and resistance to sliding.

11.1.5.2 Temporary weather protection

The System Manual should include a moisture management plan to outline the design, method and controls for protecting the units from weather exposure and damage during storage, transport and installation. The plan should consider:

- details of any temporary openings that may be required in the protection layers (eg for lifting or installation/connection of units)
- continuity of temporary weather protection post installation
- method of sealing between units and around lifting/connection points
- method and timing for removal of temporary weather protection materials (materials left in situ post installation should be assessed for condensation risk in the permanent design).

To minimise the effect of condensation or moisture trapped within the unit, consideration should be given to:

- choice of materials used as temporary weather protection (ie, vapour resistivity of membranes)
- periodic condition inspections
- use of desiccant products
- storage time limits
- providing drainage points to allow trapped water to escape.

The System Manual should include details about any relevant exposure time limits. Exposure time limits should consider:

- maximum duration for external storage, and
- maximum duration of exposure following installation until permanent claddings are installed.

The performance of gypsum plasterboard linings can be significantly affected by wetting. Factory installed gypsum linings showing signs of facing paper delamination or mould growth due to construction moisture during the storage, transport or installation phase should be removed and replaced in accordance with plasterboard manufacturers recommendations, and the supporting structure checked.

Closed panel systems

Where timber and light steel framed walls incorporate linings or opaque membranes to both internal and external faces there is a risk of moisture being trapped within the frame void during the storage or construction phase. Consideration should be given to providing means of drainage to the base of panels to allow trapped moisture to escape.

Volumetric systems

The tops of volumetric units should be designed with adequate falls to avoid the risk of standing water. Water should be directed away from unit joints and cavities. Suitable provision should be made to provide temporary drainage to discharge to rainwater outlets or be designed to shed water clear from the building façade.

Materials used for sealing between units or around lifting points and temporary openings should be suitable for use in cold and wet conditions and UV resistant suitable for the exposure period.

Floors

Consideration should be given to the location of water-resistant membranes in floors (eg to the undersides of floors), and care should be taken to avoid the risk of trapped moisture within the floor structure.

Timber

Moisture content readings of structural timber to closed systems (including: closed panel timber frame, volumetric systems formed entirely of timber or volumetric systems incorporating timber frame backing walls and floors) should be undertaken as part of system verification activities, further guidance can be found in Clause 11.1.10.

SIPs

Panel edge protection should be provided at the base of SIP panels susceptible to moisture damage to prevent wicking of moisture from the floor during construction. If a panel becomes saturated during construction, specialist advice should be sought.

11.1.5.3 Protection from damage

MMC systems should only be handled in accordance with the manufacturer's recommendations, lifting methods and handling positions should be clearly defined.

To minimise risk of damage from handling of units, consideration should be given to the following:

- handling of units should be planned and reduced to a minimum
- packing should be used to ensure that scaffolding does not damage units during installation where panels incorporate factory installed external finishes
- protection to permanently exposed surfaces, especially arrises and decorative features with timber strips, hessian, or polyethylene.

Practical steps should be taken to avoid the risk of damage and staining to units and finishes during construction.

Internal finishes and fitments

Appropriate protection should be provided to all internal finishes and factory installed fitments (including to doors, trim, balustrades, panelling, and other special features) to ensure they are not damaged. Factory installed sanitaryware and kitchens, including cupboards, doors, fittings, and worktops, should be suitably protected.

11.1.6 Structural design

MMC systems shall be designed to support and transfer loads to foundations safely and without undue movement and shall have adequate resistance to all imposed loads. Issues to be taken into account include:

- 1) compliance with relevant standards
- 2) stability or resistance to lateral load
- 3) structural robustness.

11.1.6.1 Compliance with relevant standards

All load bearing elements should be designed to comply with relevant standards:

Basis of structural and geotechnical design	BS EN 1990 and relevant NA
Actions on structures	BS EN 1991, all parts and relevant NAs to these parts
Material codes	BS EN 1992 — EN 1999. Eurocodes for all materials and their relevant NAs
Low-rise building structures	BS 8103 (all parts)
Medium rise building structures of over three storeys high	Designed by an engineer in accordance with Technical Requirement R5
Structural robustness and mitigation of disproportionate collapse in buildings	BS EN 1991, all parts and relevant NAs to these parts Building Regulations — eg AD A in England & Wales IStructE's publication of Practical guide to structural robustness

11.1.6.2 Stability/resistance to lateral load

MMC systems forming homes or buildings containing homes shall be adequately designed to ensure that all loads are safely transferred to the foundations, without undue movement/distortion or impairing the health and safety of the building occupiers.

Whatever the system of resistance to lateral loads (ie, single material or hybrid system) that is being deployed for stability purposes, they should be demonstrated as being fit for purpose and within acceptable deflection limits for the type of structure and cladding used.

Effective connections of MMC modules or panels to any structural framing or strong point(s) used should be adequately provided and should be visible or inspectable. Where such connections are to be covered up in their final state, the installation is to be inspected and verified in accordance with the system verification plan (see Clause 11.1.10).

Manufacturing and erection tolerances should be clearly stated and allowed for in the design.

11.1.6.3 Structural robustness

MMC systems forming homes or buildings containing homes shall be adequately designed to ensure that the building is sufficiently robust to reduce the sensitivity of the building to disproportionate collapse in the event of an accident. This requirement will be considered met when the building is sufficiently robust to sustain a limited extent of damage or failure, depending on the consequence class of the building, without collapse. Further guidance can be found in The Institution of Structural Engineers publication 'Structural robustness and disproportionate collapse in buildings'.

11.1.7 Structural design checking and certification

MMC systems shall be adequately designed, checked and certified. The design of the MMC superstructure forming home(s) shall be adequately checked by an NHBC registered certifier.

Homes made from MMC systems to form the superstructure require certification confirming that the design of each house or apartment block has been satisfactorily checked by an NHBC registered MMC certifier.

MMC certifiers should:

- be listed on NHBC's list of MMC certifiers
- be a suitably qualified civil or structural engineer with a minimum of three years' experience in the use a particular MMC system or in the main components of the MMC system
- not be the designer of the MMC system or from the same firm as the designer of the MMC system
- complete and sign a certificate confirming assessment of structural adequacy for each specific project
- provide the registered builder with the completed and signed certificate to cover the different house(s) or apartment block(s).

The registered builder should ensure that the completed MMC certificate is available on site for inspection and a copy sent to the NHBC project manager.

Contact NHBC Standards, Innovation and Research via operationsupport@nhbc.co.uk

- if you require contact details of MMC certifiers, or
- to apply to become a MMC certifier.

11.1.8 Temporary stability, robustness, and integrity

MMC systems shall be sufficiently rigid to resist the forces imposed during transport, lifting and installation.

MMC systems should be sufficiently rigid to resist the forces imposed during transport, lifting and installation and prevent loosening of factory installed fire-resistant linings, claddings, cavity barriers and fire-stopping.

They should be provided with:

- designated anchorage or lifting points for lifting and securing during transport and installation
- suitable straps and/or frames to hold units safely in position during transport without undue movement
- temporary support or bracing to prevent excessive distortion and damage to the structure and finishes during transport and installation for units incorporating large openings.

Details of anchorage or lifting points and any temporary supports and their positioning should be included in the system Installation Manual and supporting drawings.

Consideration should be given to the design of racks and other equipment for large panels for transport with allowance made for the flexing of transport platforms.

11.1.9 Installation

MMC systems shall be installed in accordance with the manufacturer's recommendations and provide satisfactory performance. Installation instructions, in the form of an Installation Manual, shall be produced in a clear and understandable format, include all relevant information, and be distributed to all appropriate personnel. Issues to be taken into account include:

- 1) competence of installers
- 2) preparation
- 3) design, manufacture and erection tolerances
- 4) structural connections
- 5) sealing of joints and temporary openings.

A set of clear installation instructions should be submitted to NHBC, distributed to appropriate personnel, and made available on site in the form of a system Installation Manual and relevant accompanying drawings, detailing the assembly and installation of the system as appropriate. These instructions should cover factory and site assembly as required.

The system Installation Manual should:

- be supported with site-specific information, including drawings, or detailed fixing specifications
- be used as a reference to ensure compliance
- be current and specific to the system variant/type.

The system Installation Manual should contain the information described in Table 2 as relevant for the system.

Table 2: Items included in the Installation Manual

Topic	Description
Roles and responsibilities	<ul style="list-style-type: none"> • site process and responsibilities of key personnel • competence requirements for installers • duty holders for verification in accordance with the verification plan • key inspection stages and hold points in accordance with the verification plan — ie, hold points, checklists, provision and/or taking of photographic records
Scope and limits of application	<ul style="list-style-type: none"> • overview of the system including a description of key components and/or assemblies • confirmation of limits of application
Storage	<ul style="list-style-type: none"> • process for site storage and correct maintenance and removal of any temporary protection • method of providing adequate ventilation • requirement for periodic condition surveys
Tolerances	<ul style="list-style-type: none"> • clear description of tolerances for substructure (including square/dimensional/straightness & level) • clear description of dimensional tolerances for units and erection • clear description of tolerances for unit junctions and interfaces including cladding finishes
Pre-installation checks	<ul style="list-style-type: none"> • inspection and verification procedure for condition of units prior to and following delivery to site • tolerance survey of the substructure • dimensional survey of units pre-installation
Installation procedure	<ul style="list-style-type: none"> • sequence of erection • method of connecting to foundations • process and detail of structural connections — with a reference to either type, size, centres, quantity, specification of fixings and reference to bolts requiring specific torques (if standard) or reference to drawings for all module connections, panel joints, etc or where this information can be found on site • temporary bracing requirements (if applicable) • checks and verification procedures associated with cavity barriers and fire-stopping • method and verification for the sealing and completion of junctions between units • method and verification procedure for sealing of temporary roofing membranes including temporary openings and lifting points and adequate drainage provision • detail about removal of temporary protection (unless included in the design as part of the system) • tolerance survey of installed units (level/plumb/deviation)
Services	<ul style="list-style-type: none"> • method for connection of building services such that fire protection and damp proofing are not compromised • method for making good of service connection access points in the structure • method for commissioning of services
Non-conformities	<ul style="list-style-type: none"> • remedial action procedure for damaged or non-conforming units

11.1.9.1 Competence of installers

Installation of MMC systems should be carried out by trained and competent installers. Specialist installers should understand storage and handling procedures, tolerances, and installation methods relevant to the system type, and have been provided with all product technical data sheets and installation guidance documentation.

Systems should be installed by operatives who:

- are competent
- are familiar with the system being installed
- are registered or hold a current and valid certificate confirming that they have been trained by the system manufacturer, supplier, or installer.

11.1.9.2 Preparation

A pre-installation survey of both the foundations and surrounding construction should be undertaken to ensure compliance with the product specification requirements prior to installation of units.

Volumetric systems

A pre-installation survey of service entry points and pop-ups (eg below ground drainage) should be undertaken prior to installation of units to ensure they align.

11.1.9.3 Design, manufacture and erection tolerances

MMC systems should be installed, within reasonable tolerances, in accordance with the design and as defined in the system Installation Manual.

Units should be checked to ensure that they are dimensionally accurate and not deformed in shape before erection commences.

Closed panel systems

Timber frame walls should be installed in accordance with the relevant tolerances in Clause 6.2.4.

Light steel frame walls should be installed in accordance with the relevant tolerances in Clause 6.10.10.

SIPs should be installed in accordance with the System Manual and certification requirements.

11.1.9.4 Structural connections

MMC unit connections should be installed in accordance with the design.

The supporting structure may have local deviations in level along its length or at individual base plate locations, and packing will be required to achieve the required tolerances and to provide for effective load transfer. The type and extent of packing should be in accordance with the System Manual.

Volumetric systems

Connection plates and brackets should not be drilled, cut, or welded unless required by the design.

11.1.9.5 Sealing of joints

Only the materials and method specified in the design should be used for sealing of joints between units and temporary openings. Tapes, sealants, and membranes should be installed in accordance with manufacturer's instructions.

Before joints between units or temporary openings are sealed, installers should ensure:

- all cavities are dry
- all surfaces are clean and dry
- insulation is complete
- cavity barriers and fire-stops have been installed.

11.1.10 Verification

Documentation shall be provided in a clear and understandable format to confirm that the system has been supplied and installed in accordance with the System Manual and the design.

In addition to system certification and structural design checking (see Clause 11.2.3 and 11.3.3), NHBC requires verification, comprising documentation in a clearly understandable format, to show that MMC systems have been manufactured, stored, transported, and installed:

- in accordance with the design
- in accordance with the Quality Management System (QMS)
- to an acceptable standard
- in accordance with the System Manual and manufacturers instructions
- in accordance with statutory requirements.

Verification plan

A verification plan should be provided to NHBC before construction works commence on site.

The verification plan should:

- name duty holders
- define competence and responsibilities of duty holders during the factory production and construction phase
- outline key inspection stages and hold points, covering pre-installation, installation, and post-installation phase checks
- refer to the System Manual and system Installation Manual.

Verification reports should clearly state which elements of the system have or have not been subject to inspection and verification. The report should also record where verification is based on photographic evidence or other information supplied by a third-party.

Systems are assigned risk categories according to the complexity of the system and installation, see Table 3.

Table 3: System risk categories

Risk category	System type
1	Closed panel (no factory installed external claddings) — See Chapter 11.2
2	Closed panel (factory installed external claddings) — See Chapter 11.2
3	Volumetric (houses up to 4 storeys) — See Chapter 11.3
4	Volumetric (apartment buildings and buildings above 4 storeys) — See Chapter 11.3

The verification reporting requirements will be appropriate for the risk category of the system. Inspection stages and verification requirements will vary according to the system but should consider activities listed in Table 4. The manufacturer should determine the verification activities appropriate to the system, and present these in the verification plan for submittal to, and agreement by NHBC.

Table 4: Verification stage activities

Verification inspection stage activities	Risk category			
	1	2	3	4
Storage				
• regular condition survey of units in storage	•	•	•	•
• suitability and condition of storage areas	•	•	•	•
Transport				
• secure fixing to transport or support in transport stillage	•	•	•	•
• adequate bracing of openings	•	•	•	•
• temporary weather protection	•	•	•	•
Pre-installation				
• recording of delivery dates for individual units	•	•	•	•
• damage/condition inspection of units	•	•	•	•
• visual inspection and moisture readings of structural timber elements (if applicable)	•	•	•	•
• dimensional, square, straightness and level check of substructure and surrounding construction	•	•	•	•
• dimensional and square check of panels	•	•	•	•
Installation				
• recording of installation dates for individual units	•	•	•	•
• unit to foundation connections	•	•	•	•
• unit to unit connections	•	•	•	•
• connections of secondary elements eg balconies (if applicable)	•	•	•	•
• unit to surrounding construction (eg building core, staircases, roof, etc) connections	•	•	•	•
• temporary/permanent weather sealing of unit junctions	•	•	•	•
• installation of cavity barriers and fire-stopping	•	•	•	•
• location referenced photographic records of concealed fire-stopping		•	•	•
• service connections			•	•
• third-party verification (if required)				•
Post-installation				
• visual inspection and moisture readings of structural timber elements (if applicable)	•	•	•	•
• survey of top of units (ie standing water)			•	•

For systems incorporating specialist materials or complex construction methods not covered by NHBC Standards that are critical to the structural stability of the building, NHBC may also require additional verification from an independent third-party engineer in accordance with Technical Requirement R5.

Suitable persons for the level of verification

The manufacturer of the system should specify the requirements for specialist installers and verifiers.

The manufacturer should clearly establish the roles and responsibilities of verifiers within the verification plan, recognising that installation teams may be responsible for providing information to support the overall verification strategy for the system (for example concealed fire-stopping and cavity barriers or tolerance surveys).


The registered builder’s site team should be fully aware of the installation procedures and hold points for inspection.

11.1.11 Handover requirements

Clear information about the system and guidance on its future use or maintenance shall be provided to the homeowner.

A pack of handover information should be provided to the homeowner. The pack of information should be in a format intended for a non-technical user and include:

- user-friendly description of the building system
- method statement for the replacement of materials and components with a lesser durability that will require replacement during the lifetime of the home
- maintenance requirements
- product data sheets or relevant certification for key components that make up the building system
- contact details for the manufacturer.



Chapter 11.2



Closed Panel systems

This chapter gives guidance on meeting the Technical Requirements for closed panel systems used to form homes where the height of the top floor above ground does not exceed 18m.

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Introduction

This chapter gives guidance on meeting the Technical Requirements for closed panel systems used to form homes where the height of the top floor above ground does not exceed 18m. For the purposes of this chapter, closed panel systems shall include:

- timber framed wall and floor panels
- light gauge steel framed wall and floor panels
- Structural Insulated Panel (SIPs) walls.

The guidance in this chapter does not apply to roof cassette systems or pre-manufactured panels formed from mass engineered timber, hot rolled steel or precast concrete. It also does not apply to use of the systems below ground level.

This chapter should be used in conjunction with Chapter 11.1 MMC systems: general requirements. This chapter seeks to focus on areas of guidance that are unique to the system type and method of construction employed, giving references to complimentary existing guidance provided elsewhere in the Standards where relevant.

There is a strong link to all chapters in Part 6 of the Standards, particularly Chapters 6.2, External time framed walls and 6.10, Light steel framed walls and floors.

The term 'Modern Methods of Construction (MMC)' is very broad and covers a wide range of differing offsite manufactured systems and onsite construction techniques.

MMC types have been categorised and defined in the MHCLG Joint Working Group 'MMC Definition Framework', see Chapter 11.1 MMC systems: general requirements. The scope of the guidance in this chapter will cover 'closed' panel systems that generally fall under Category 2 under the MMC Definition Framework and as defined below.

Definitions of Open and Closed panel

MMC Category 2 light gauge steel and timber frame building systems are typically constructed from panels manufactured offsite under factory-controlled conditions. The extent of prefabrication can vary, with panels being as simple as studs and sheathing, or include external cladding, internal linings, windows and services. Where building systems utilise high levels of offsite prefabrication, traditional site inspection regimes for installation of critical materials, junctions and components are not possible. In addition, the greater the level of factory prefabrication, the greater the potential risks associated with exposure to moisture during construction.

Whilst the extent of offsite prefabrication can vary significantly, light gauge steel and timber frame building systems are typically categorised by NHBC as either 'open panel' or 'closed panel'. For the purpose of Warranty provision, NHBC's definitions are set out below.

Open Panel

Flat two-dimensional panelised units fabricated offsite in a factory environment used to form wall and floor structures.

Open panel assemblies typically include:

- a structural frame of studs and joists
- floor decking and sheathing boards as required.

Additionally, open panel assemblies may also include:

- a fixed breather membrane to external walls
- insulation (between the studs only)
- a transparent air and vapour control layer (AVCL) in order that the construction/insulation can be viewed on site (note — if a non-transparent air and vapour control layer is used, the system will be considered by NHBC as being closed panel)
- battens forming a service zone
- temporary weather protection.

Closed Panel

Closed panel systems are also defined as flat two-dimensional panelised units fabricated offsite in a factory environment used to form wall and floor structures, but in addition to the items set out above for open panel systems, where any one of the following items are factory fitted NHBC will consider the system to be closed panel:

- non-transparent air and vapour control layer
- sheathing boards to both sides of panels
- internal linings (such as plasterboard)
- continuous insulation installed to either the inner or outer face of the panels
- external cladding or finishes
- windows and doors
- fixed services such as plumbing pipes and electrical cables
- cavity barriers and/or fire stopping.

Guidance for traditional open panel construction formed from timber or light steel frame is given in Chapter 6.2 External timber framed walls and 6.10 Light steel framed walls and floors.

Definitions for this chapter

Cavity	A space enclosed by elements of a building such as the space between the cladding system and the backing wall. The external wall cavity should be adequately drained, and ventilated where required.
Cavity barrier	A construction within a cavity, other than a smoke curtain, to perform either of the following functions: <ul style="list-style-type: none"> • close a cavity to stop smoke or flame entering • restrict the movement of smoke or flame within a cavity.
Closed panel	Flat two-dimensional panelised units fabricated offsite in a factory environment used to form wall and floor structures, including where any one of the following items are factory fitted: <ul style="list-style-type: none"> • non-transparent air and vapour control layer • sheathing boards to both sides of panels • internal linings (such as plasterboard) • continuous insulation installed to either the inner or outer face of the panels • external cladding or finishes • windows and doors • fixed services such as plumbing pipes and electrical cables • cavity barriers.
Factory installed	An element of the construction that is placed, positioned, fitted, or secured in, on or as part of the unit as part of the factory construction process.
Fire-stopping	A seal provided to close an imperfection of fit or design tolerance between elements or components, to restrict the spread of fire and smoke.
Floor cassette	Flat two-dimensional panelised units fabricated offsite in a factory environment used to form a load-bearing element of floor construction. Typically includes a series of floor joists joined together with trimmers or end-joists and floor decking.
Installation Manual	Detailed installation guidance and information for the system compiled by the system manufacturer. The Installation Manual describes general instructions for storage and transport of the system, and procedures for on-site assembly and installation.
Interface	Interface either between similar or dissimilar envelope systems (eg at panel joints) or between envelope systems and other elements of the building (eg walls, roof, doors, and windows).
Junction	The point where components, including panels are joined with each other or with other elements of the building (eg supporting structure, roofs and foundations).
Manufacturer	The company which is responsible for the design and assembly of the closed panel system.
Non-standard components	Components that are assembled as part of the system but vary for individual projects. These may be windows, doors or services that may be built into the system.
Primary structural components	Elements of the structure designed to carry and transfer primary loads of the building, including self-weight, dead loads, and live loads.
Secondary structural components	Elements of the structure which do not play a wider role in the structure, but carry loads directly imposed on them (and transfer them to the primary structure) such as self-weight, wind loads, cladding and openings.
Standard components	Components that are assembled as part of the system and are common to all projects.
System	For the purposes of this chapter, this term refers to acceptable forms of closed panel systems.
System Manual	Detailed technical information on the system compiled by the system manufacturer. The System Manual describes the system, the declared performance of the system and evidence to support the declared performance.
Unit	A prefabricated building unit, manufactured offsite as a structural or non-structural assembly in three-dimensional or flat panel format used as part of a system to form the superstructure of a building.

11.2.1 Compliance

Also see: Chapters 2.1 and 11.1

Closed panel systems shall comply with the Technical Requirements.

Closed panel systems that comply with the guidance in this chapter and associated chapters will generally be acceptable. This chapter should be used in conjunction with guidance in Chapter 11.1 MMC Systems: general requirements.

As many components of closed panel systems cannot be inspected on site, they should be treated as a building system as defined in Chapter 2.1, Standards and Technical Requirements and subject to assessment by an independent technical approvals authority or assessed under the NHBC Accepts service; www.nhbc.co.uk/accepts.

11.2.2 Provision of information

Also see: Chapter 11.1

Designs and specifications shall be produced in a clearly understandable format, include all relevant information, and be distributed to all appropriate personnel.

Design, specification and installation information should be issued to site supervisors, relevant specialist subcontractors and suppliers, and be made available on site to enable work to be carried out in accordance with the design. This should include:

- a System Manual (see Clause 11.1.3)
- a system Installation Manual (see Clause 11.1.9).
- clear, coordinated and fully detailed drawings providing sufficient information for construction and installation of the system

Refer to Chapter 11.1 MMC Systems: general requirements for further guidance.

11.2.3 Structural design

Also see: Chapters 6.2, 6.3, 6.4 and 6.10

Closed panel systems shall be designed to support and transfer loads to foundations safely and without undue movement and shall have adequate resistance to loads imposed during manufacture, transportation, and installation.

Closed panels should be securely fixed together and securely fixed to the floor and roof framing and surrounding construction.

Connections between closed panel and between closed panels and surrounding construction should:

- be designed to be structurally adequate
- be designed to avoid the risk of damaging or compromising the functional performance of factory installed elements such as breather membranes, AVCLs and lining boards.
- include clear method of connection in the System Manual and Installation Manual

Closed panel timber frame

The design of structural walls should be in accordance with Chapter 6.2 External timber framed walls. Load-bearing internal walls should be designed in accordance with Chapter 6.3 Internal walls, and floors should be designed in accordance with Chapter 6.4 Timber and concrete upper floors.

Structural insulated panels (SIPs)

The design of SIPs should be in accordance with the independent technical approvals authority certification. The scope of the certification should consider the design of a structure using the system, including panel connections and connections with other supporting elements such as intermediate floors, and not the panels in isolation.

Load-bearing internal walls should be designed in accordance with Chapter 6.3 Internal walls, and floors should be designed in accordance with Chapter 6.4 Timber and concrete upper floors.

Closed panel light steel frame

The design of structural walls, structural floors and overall stability should be in accordance with Chapter 6.10 Light steel framed walls and floors.

Temporary loads

Structural design of the units should consider the loads imposed during manufacture, storage, lifting and transportation and provide sufficient stiffness or protection against inadmissible deformation or deflection. See also Clause 11.1.8.

Where required, the design should specify temporary bracing and/or additional support arrangements for large openings or weak points in the structure and clearly identify the conditions under which such works can be removed.

11.2.4 Structural design checking and certification

Also see: Chapters 6.2 and 6.10

The closed panel system shall be adequately designed and the design certified. Design of the superstructure shall be adequately checked by an NHBC registered certifier.

Closed panel timber frame

Structural design checking and certification should be in accordance with Clause 6.2.3.

Structural insulated panels (SIPs)

Structural design checking and certification should be in accordance with Clause 6.2.3 where SIPs incorporate structural timber.

Closed panel light steel frame

Structural design checking and certification should be in accordance with Clause 6.10.3.

11.2.5 Behaviour in relation to fire

Closed panel systems shall have adequate fire resistance and resist the spread of fire and smoke. Issues to be taken into account include:

- 1) fire resistance of the unit or panel
- 2) cavity barriers and fire-stopping
- 3) services.

Guidance within supporting documents to Building Regulations should be fully considered in the design and construction of closed panel systems.

The design and System Manual should clearly define:

- the overall fire protection strategy of the system
- which elements of fire protection are either factory or site installed.

11.2.5.1 Fire resistance of the unit or panel

Walls and floors should have adequate fire resistance in accordance with Building Regulations, supported with representative test evidence to appropriate standards.

The performance of specific details should be taken into account, including:

- fire protection to the structure around openings
- junctions between adjacent panels and interfaces of wall and floor panels
- compartmentation including interfaces with fire doors and junctions with adjoining building elements
- service openings, voids and penetrations.

Structural insulated panels (SIPs)

Lifting holes should be filled and sealed using a material providing the same level of protection as the material removed.

11.2.5.2 Cavity barriers and fire-stopping

The provision and installation of cavity barriers and fire-stopping should:

- be in accordance with Building Regulations and the design
- be designed to accommodate ventilation or drainage paths
- be used in accordance with manufacturers recommendations
- account for movement in the frame
- be specified to accommodate design, manufacturing and installation tolerances.

Moisture protection should be provided to horizontal and vertical cavity barriers.

Detailing and specification of cavity barriers and fire-stopping should be in accordance with the manufacturer's recommendations and supported with representative test evidence to appropriate standards.

11.2.5.3 Services

Only the services shown in the design should be installed in closed panel system floors and walls, and:

- service penetrations should not impair the fire resistance of floors and walls
- service mains should not pass through separating wall cavities.

11.2.6 Acoustic performance

Also see: Chapters 6.2, 6.3, 6.4 and 6.10

Closed panel system walls and floors shall have adequate resistance to the passage of sound.

Separating walls and floors should be in accordance with Building Regulations. In England, Wales, and Northern Ireland, separating walls and floors may be built in accordance with Robust Details 'Resistance to the passage of sound' as an alternative to pre-completion sound testing.

Separating walls and floors should be in accordance with the design. Care should be taken to avoid gaps:

- between mineral wool quilt or batts
- between internal lining board layers
- between cavity barriers
- around openings for services.

Internal walls should be in accordance with Clause 6.3.7

Proprietary partitions

Closed panel systems when used as proprietary partitions should be independently assessed or tested for 'sound transmission' performance in compliance with Technical Requirement R3.

11.2.7 Differential movement

Also see: Chapters 6.2 and 6.10

Buildings formed using closed panel systems shall account for differential movement between the frame wall and other building elements or supporting structures.

Where closed panel systems connect to surrounding construction and differential vertical movement is expected, consideration should be given to:

- accommodation of suitable movement joints in self-supporting and lightweight claddings
- the design of joint details and accommodation of differing floor levels at thresholds at staircases and lift shaft enclosures
- service entries, risers and fixed vertical external services
- design and provision of suitable weather resistant and durable joints
- interface of self-supporting cladding and cladding attached to the unit
- design of connection brackets, anchors, and ties to accommodate movement.

Where claddings are factory installed and supported by the panel, consideration should be given to interfaces with self-supporting cladding.

Closed panel timber frame

The design for differential movement in closed panel timber frame structures should be in accordance with Clause 6.2.8.

Structural insulated panels (SIPs)

SIPs not incorporating structural timber should be designed in accordance with the manufacturer's recommendations.

The design for differential movement in SIP structures incorporating structural timber should be in accordance with Clause 6.2.8.

Closed panel light steel frame

The design for differential movement in closed panel light steel frame structures should be in accordance with Clause 6.10.20.

11.2.8 Protection from moisture

Also see: Chapters 5.1, 6.1, 6.2, 6.10 and 11.1

Closed panel systems shall be adequately protected from the effects of moisture. Details of closed panel systems at low level shall fully consider the durability of materials, protection of the building from moisture ingress and condensation as a result of thermal bridging. Issues to be taken into account include:

- 1) cavities in external walls
- 2) protection at low level
- 3) DPCs, DPMs and cavity trays
- 4) junctions between adjoining panels.

Guidance on temporary weather protection can be found in Clause 11.1.5. Guidance on moisture management strategies for structural timber buildings can be found in Structural Timber Association publication 'Moisture management strategy'.

11.2.8.1 Cavities in external walls

A clear cavity in accordance with Table 1 should be provided between the cladding and insulation.

Table 1: Minimum cavity widths

Cladding	Cavity width
Masonry	50mm
Render on board background	25mm
Vertical tile hanging ⁽¹⁾ where a breather membrane is provided and fixed to sheathing	Dependant on batten support layout and spacing ⁽¹⁾
Other cladding ⁽¹⁾	See Chapter 6.9 Curtain walling and cladding

Notes

1. See Chapter 6.9 Curtain walling and cladding.

Cavities should be:

- drained (for light steel frame walls)
- extend at least 150mm below DPC
- drained and vented (for timber frame and SIP walls)
- be kept clean, free from obstructions and capable of draining freely.

Closed panel timber frame walls

Cavities to closed panel timber frame walls should be in accordance with Clause 6.2.10.

Structural insulated panels (SIPs)

Cavities to SIP walls should be in accordance with Clause 6.2.10.

Closed panel light steel frame walls

Cavities to closed panel light steel frame walls should be in accordance with Clause 6.10.16.

11.2.8.2 Protection at low level

Closed panel timber frame and structural insulated panels (SIPs)

The lowest timber should be a minimum of 150mm above finished ground level. This may be reduced to 75mm in situations where the site is not subject to a high water table or where the cavity will not have standing water.

DPCs should be installed below the sole plates of walls and ground floor internal partitions.

Where external ground levels are raised locally to accommodate accessible entrances, consideration should be given to the following:

- appropriate drainage installed along the perimeter or ground falling away from the building
- adjacent surface finishes which do not promote splashing
- additional cavity ventilation either side of raised ground levels
- use of a 'kerb' or 'upstand' to raise level of timber frame elements.

Closed panel light steel frame

The protection of light steel frame at low level should be in accordance with Clause 6.10.16.

11.2.8.3 DPCs, DPMs and cavity trays

Damp proofing should:

- be installed correctly to provide a physical barrier to the passage of water, and to ensure water is directed to the outside
- use only appropriate tapes and sealant (but not solely rely on sealant) in accordance with the design and manufacturer's recommendations
- use DPCs/DPMs where necessary, including junctions between systems and any other component or systems.

DPCs

The following materials are acceptable for use as DPCs:

Bitumen-based materials	BS 6398, BS EN 14967
Polyethylene (except as cavity trays in walls, below copings and in parapets)	BS 6515, BS EN 14909
Proprietary materials	Technical Requirement R3
Thermoplastics and Elastomers	BS EN 14909

DPMs

Where DPMs are required, they should be linked with any DPCs in the supporting structure, in order to provide continuous protection from moisture from the ground or through the supporting structure.

DPMs should be properly lapped in accordance with Chapter 5.1 Substructure and ground-bearing floors.

Suitable materials for DPMs include:

- 1,200-gauge (0.3mm) polythene sheet
- minimum 1,000-gauge (0.25) polythene sheet where assessed in accordance with Technical Requirement R3
- bitumen sheet to BS 6398
- proprietary materials assessed in accordance with Technical Requirement R3.

Cavity trays

Cavity trays should be provided at all interruptions to the cavity (eg window and door openings and air bricks) and abutments unless otherwise protected (eg by overhanging eaves) or alternative means of protection are provided (eg profiled metal flashings) such as part of a proprietary cladding system.

Clause 6.1.17 contains further guidance on the installation of cavity trays in masonry cladding.

The following materials are acceptable for use as cavity trays:

- plastic and rubber to BS EN 14909 and hold satisfactory assessment by an appropriate independent technical approval's authority accepted by NHBC
- proprietary materials as part of a cladding system holding satisfactory assessment by an appropriate independent technical approvals authority accepted by NHBC.

11.2.8.4 Junctions between adjoining units

At junctions between closed panel systems or between closed panel systems and surrounding construction, particularly where they incorporate factory installed external claddings, consideration should be given to:

- providing suitable access to seal laps of breather membranes and AVCLs and achieve minimum vertical and horizontal laps
- providing suitable access to adequately link DPCs and DPMs in the substructure
- use of appropriate tapes and sealant (but not solely rely on sealant) in accordance with the design and the manufacturer's recommendations
- design of suitable cladding joints in accordance with the manufacturer's recommendations
- interaction of cavity barriers and cladding joints
- use of damp proofing materials which are compatible with adjoining components.

Connections between closed panel systems and between closed panel systems and surrounding construction should be designed to avoid the risk of fixing through and thus puncturing or damaging AVCLs or breather membranes.

11.2.9 Insulation

Also see: Chapters 6.2 and 6.10

Insulation shall be suitable for the intended use, correctly installed, and be of a suitable material and thickness to comply with Building Regulations and reduce the risk of surface and interstitial condensation.

Insulation should be:

- in accordance with the design
- installed correctly to minimise the risk of thermal bridging, surface, and interstitial condensation
- installed in accordance with the manufacturer's recommendations.

The System Manual and design should include control measures to mitigate risk of slump of non-rigid insulation during transport and site installation.

Where insulation is to be installed to the external/cavity face of the frame, workmanship and tolerances of external walls, particularly at panel joints, should be maintained to minimise the risk of:

- reducing the width of clear cavities
- gaps between insulation boards
- ledges between insulation boards forming moisture traps.

Closed panel timber frame

Insulation to closed panel timber frame walls should be in accordance with Clause 6.2.15.

Structural insulated panels (SIPs)

Insulation to SIPs should be assessed as part of current certification by an appropriate independent technical approvals authority accepted by NHBC, as an integral part of the wall system.

Closed panel light steel frame

Insulation to closed panel light steel frame walls should be in accordance with Clause 6.10.17.

11.2.10 Junctions and interfaces

Also see: Chapters 6.2 and 6.10

Junctions and interfaces shall be suitably detailed, built to appropriate tolerances and provide satisfactory performance.

The use of closed panel systems, particularly where finished linings or claddings are installed may introduce junctions and interfaces between adjoining units that are not common in traditional construction.

The junctions of panels should be designed with appropriate tolerances to avoid excessive deviation:

- to external faces of adjacent panels, which may impact cavity widths, installation of insulation and cladding as well as performance of cavity barriers or fire-stopping
- to internal faces of adjacent panels, which may impact continuity of acoustic or fire-resisting linings or installation and fit of surrounding construction (eg staircases).

The manufacturer and designer should consider:

- guidance on jointing methods for structures, claddings, openings, and services passing through building elements given in BS 6093
- undertaking of mock-ups or trials to ensure satisfactory fit and tolerances can be achieved.

Closed panel timber frame

When fixing closed panel timber frame walls to the substructure, they should be installed in accordance with the manufacturer's design and Clause 6.2.4 and 6.2.5.

Closed panel light steel frame

When fixing closed panel light steel frame walls to the substructure, they should be installed in accordance with the manufacturer's design and Clause 6.10.10.

Floor cassettes

The design should clearly specify where connections are required to provide lateral restraint or robustness at floor to wall junctions. Installation instructions should be given in the System Manual and Installation Manual. Where floor cassettes incorporate permanent floor decking, care should be taken to design cassette junctions at thresholds or intermediate walls to minimise large joints in open rooms.

Adjoining cassettes should be securely fixed to ensure structural continuity and to avoid differential deflection in accordance with the manufacturer's design.

Junctions between decking to adjoining floor cassettes should be designed to achieve necessary tolerances to allow installation of floor coverings. Interfaces of decking may either be designed as a butt joint or by using a transition piece to accommodate minor tolerances between decking finishes.

Cassette junctions should:

- have a nominal 3mm gap at decking joints
- be kept clear of debris
- filled with an appropriate gap filler or covered with a cover strip
- not exceed 2mm level difference between floor decking at any position.

Foundations

Foundations should be installed to tolerances in accordance with the System Manual. The foundation tolerances should consider:

- level of foundation
- level between foundation and substructure brickwork
- straightness of foundations
- squareness of foundations.
- dimensional tolerance

11.2.11 Cladding

Also see: Chapters 6.1, 6.2, 6.9, 6.10 and 9.1

External claddings shall be suitable for their intended purpose, have suitable junctions and interfaces to resist the penetration of water and wind, be suitably durable and have an acceptable finished appearance. Issues to be taken into account include:

- 1) junctions and interfaces between cladding types and adjoining units
- 2) movement
- 3) continuity of insulation, breather membranes and AVCLs
- 4) tolerances
- 5) finished appearance.

Masonry external cladding should be in accordance with Chapter 6.1 External masonry walls.

Lightweight external claddings, whether factory or site installed, should be:

- in accordance with Chapter 6.9 Curtain walling and cladding
- compatible with the framing system
- supported by systems assessed in accordance with Technical Requirement R3 which ensure that cladding design loads are effectively and safely transferred to the building structure.

Further guidance on render onto board backgrounds can be found in Clause 6.11.8.

The design and construction of cladding to external walls should consider:

- cavity drainage
- differential movement
- restraint
- performance in relation to fire
- durability.

Closed panel timber frame and structural insulated panels (SIPs)

Further guidance on the use of masonry and lightweight claddings with closed panel timber frame and SIP walls can be found in Chapter 6.2 External timber framed walls.

Closed panel light steel frame

Further guidance on the use of masonry and lightweight claddings with closed panel light steel frame walls can be found in Chapter 6.10 Light steel framed walls and floors.

11.2.11.1 Junctions and interfaces

Junctions and interfaces, including those between factory installed lightweight cladding systems to adjoining panels, and those between lightweight cladding systems and other elements of the building, should be carefully designed and detailed to be weather resistant, and prevent moisture reaching parts of the wall it could adversely affect.

The design should take account of:

- differing profile characteristics
- movement
- design of suitable interfaces between differing cladding types
- tolerances and deviation
- the erection sequence.

For lightweight cladding finishes applied to an insulation backing, the use of small infill pieces at panel junctions or differing types of backing insulation (eg to form cavity barriers or fire-stopping at compartment lines) should be detailed in accordance with the manufacturer's recommendations and within the scope of certification by an independent technical approvals authority acceptable to NHBC.

11.2.11.2 Movement

Movement joints to masonry cladding should be in accordance with Clause 6.1.3. Refer to Clause 6.2.8 for further guidance on accommodating movement in masonry cladding to timber frame structures, and Clause 6.10.20 for masonry cladding to light steel frame structures.

Lightweight claddings

Where lightweight or self-supporting cladding is used movement joints should be provided where required by the design.

Movement joints should be:

- formed in accordance with the cladding system manufacturers recommendations
- positioned to accommodate calculated movement
- continued through the depth of the cladding.

Accommodation of differential movement should be made at floor zones between lightweight cladding.

11.2.11.3 Continuity of insulation, breather membranes and AVCLs

Junctions and interfaces of adjoining panels or panels with surrounding construction should be carefully designed and detailed to ensure continuity of insulation, breather membranes and AVCLs.

The design should:

- ensure adequate laps of membranes or provision for a suitable method of sealing in accordance with the manufacturer's recommendations
- make allowance for secure fixing of insulation, including at panel junctions, to the support frame or wall.

11.2.11.4 Tolerances

Where factory installed lightweight claddings extend to the edges of panels, the cladding interfaces should meet the following tolerances unless specified otherwise by the design:

- be adequately straight in elevation, with a maximum $\pm 6\text{mm}$ deviation from the nominal design width in any unit edge width or height up to 3m (see Figure 1)
- a maximum of 5mm from plumb or level in the overall interface joint between units (see Figure 2)
- a maximum deviation of 6mm in plan or section between faces of adjoining units (see Figure 3)
- a maximum deviation of 6mm in elevation between in-line edges across a transverse or cruciform interface joint (see Figure 4).

Figure 1: Straightness of interface joint widths

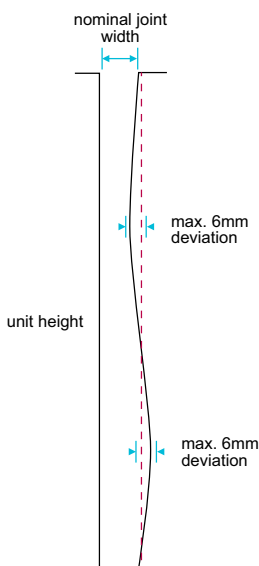


Figure 2: Taper of interface joints

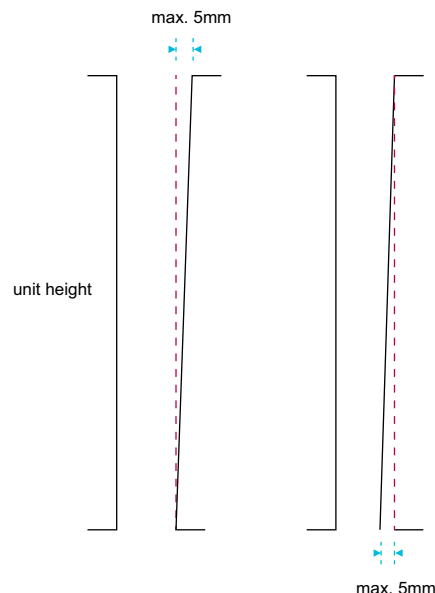


Figure 3: Offset of cladding faces

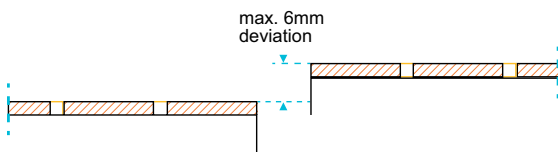
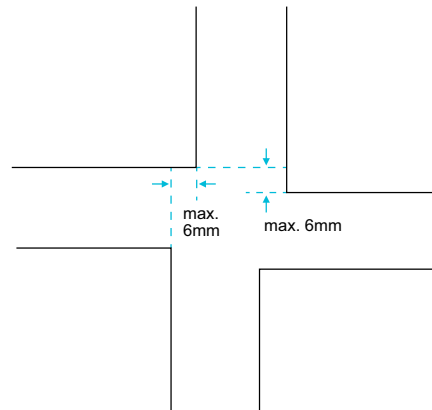


Figure 4: Accuracy of cruciform interface joints



11.2.11.5 Finished appearance

Tolerances and finishes for factory installed external claddings should be in accordance with Chapter 9.1 A consistent approach to finishes.

Brick slip cladding

Factory installed brick slip claddings should be set out to co-ordinate with adjacent panels and surrounding construction to avoid:

- cutting of brick slips, particularly in the storey heights, at corners, around openings, and at panel edges except when it is essential
- irregular or broken bonds of brick finishes, particularly at openings
- small cuts of brick finishes
- broken bond and out of line joints at junctions of panel and junctions with surrounding construction (eg substructure brickwork).

Care should be taken to ensure the finish specification of mortar used for site installed brickwork is the same as used for factory installed brick slip claddings to avoid variation in the texture, finish, and colour.

Weatherboard cladding

Factory installed weatherboard cladding should be set out to co-ordinate with adjacent panels and surrounding construction to avoid:

- cutting and notching cladding boards around window and door openings
- misaligned cladding boards at panel junctions.

11.2.12 Doors, windows, and glazing

Also see: Chapter 6.7

Doors, windows, and glazing shall comply with the Technical Requirements and be designed and specified to ensure adequate in-service performance.

Doors, windows, and glazing should be designed, specified, and installed in accordance with Chapter 6.7 Doors, windows and glazing.

The specification of fixings for doors and windows should be adequate to resist the effects of vibration and loads imposed during storage, transport and installation.

Adequate protection against damage should be provided to factory installed doors and windows, particularly where protruding from the face of the panel.

11.2.13 Air and vapour control layers

Air and vapour control layers shall be designed and installed correctly to restrict the passage of water from within the home to the structural frame.

A high resistance air and vapour control layer should be provided, unless a condensation risk analysis shows that it is not necessary, and the air and vapour control function is being provided by another solution compliant with NHBC Technical Requirements. Modelling where appropriate should be undertaken in accordance with BS EN ISO 13788 or BS EN 15026. The following boundary conditions should be used for the purposes of calculation to BS EN ISO 13788:

- at 21°C internally
- at -2°C externally
- >60% internal RH.

Where they are provided, AVCLs should be:

- sealed around service penetrations
- 500g polyethylene sheet, vapour control plasterboard, or material assessed in accordance with Technical Requirement R3
- in accordance with the design
- overlapping the base rail
- fixed on the warm side of the wall insulation and frame
- placed to cover the external wall, including base rails, head rails, studs, lintels, and window reveals
- taped or sealed in accordance with the manufacturer's recommendations and punctures made good.

Air and vapour control layers should be:

- stapled at 250mm centres to the top and bottom of the frame, at laps and around openings to closed panel timber frame
- fixed with double-sided tape or adhesive as a temporary fixing before the wall board is fixed to closed panel light steel frames.

Joints in air and vapour control membranes should:

- have 100mm minimum laps
- be located on studs or noggings.

Where vapour control plasterboard is used:

- joints between sheets should be positioned on studs or noggings
- joints should be filled, taped, and finished
- care should be taken not to displace the vapour control material when cutting vapour control plasterboard.

Where internal linings or sheathing boards are factory installed to panelised units, provision should be made to allow adequate access to achieve correct lapping and sealing of vapour control layers at junctions when installed in the final position on site.

Multiple layers of AVCL-type material through the thickness of the element should be avoided, except where condensation risk analysis shows it to be acceptable.

Closed panel timber frame and structural insulated panels (SIPs)

For closed panel timber frame systems and SIPs, where they incorporate structural timber, all structural timber elements (including the OSB of the SIP, if applicable) should have a moisture content of less than 20% before any internal AVCLs, insulation or plasterboard linings are installed.

11.2.14 Breather membranes

Breather membranes shall be correctly installed to protect the sheathing and frame from external moisture, and capable of allowing vapour to pass into the cavity.

Breather membranes should be:

- vapour resistant to less than 0.6MNs/g (0.12 Sd) when tested in accordance with BS EN ISO 12572 using the set of conditions C and using five test specimens
- at least Class W2 to BS EN 13859-2 with no water leakage during testing. In areas of very severe exposure (see Clause 6.1.6 for classification of exposure zones) or where liquid water penetration of the cladding is anticipated, for example open-jointed cladding, Class W1 should be used. When open-jointed claddings are used or the membrane likely to be left exposed during construction for a duration longer than normally to be expected (also see the membrane manufacturers recommendations on exposure times), performance should be based on artificial aged behaviour in accordance with BS EN 13859-2. Where a vented and ventilated cavity with full rainscreen and no gaps, for example masonry or rendered board claddings, are used, performance should be based on artificial aged behaviour in accordance with BS EN 13111
- self-extinguishing
- fixed so that vertical joints are staggered where possible, and at regular intervals, to prevent damage by wind
- installed so that each joint is protected, and moisture drains outwards
- lapped so that upper layers are over lower layers to ensure rain runs away from the sheathing
- lapped to a minimum of 100mm at horizontal joints and a minimum of 150mm at vertical joints
- fixed at a maximum spacing of 600mm horizontally and 300mm vertically
- fixed at a maximum spacing of 150mm around openings
- marked with stud positions for wall tie fixing
- applied using austenitic stainless-steel fixings
- repaired or replaced before proceeding with the cladding, if damaged
- durable and adequately strong when wet, to resist site damage
- capable of resisting water penetration.

For panelised systems without studs such as SIPs, fixings to the breather membrane should be at regular centres and suitably spaced at openings and panel edges.

Closed panel light steel frame

Breathable membranes should be used to protect sheathing boards and insulation. Breather membranes may be omitted where water resistant insulation boards with taped joints are used. Tape should be of a type recommended by the insulation manufacturer, breathable to allow water vapour to move freely and resist water penetration. Suitable taping should be applied at the lintel interfaces and other penetrations to direct water outside.

11.2.15 Sheathing boards

Also see: Chapters 6.2 and 6.10

Sheathing boards shall be durable and suitable for their intended purpose.

Sheathing boards should be:

- of a suitable strength and quality
- compatible with the frame
- attached using suitably specified and durable fixings.

Sheathing boards contribute to many functions critical to the performance of the system and building and cannot be easily replaced, so should comply with Technical Requirement R3.

Closed panel timber frame

Sheathing boards to closed panel timber frame walls should be in accordance with Clause 6.2.7.

Closed panel light steel frame

Sheathing boards should be appropriate for the exposure of the building and suitable for use in humid conditions.

Sheathing boards to closed panel light steel frame walls should be in accordance with Clause 6.10.20.

11.2.16 Wall ties

Wall ties and fixings shall adequately connect the cladding to the frame.

Wall ties and their fixings should be:

- compliant with BS EN 845-1
- fixed to studs and not the sheathing
- in accordance with and of the type specified in the design
- of austenitic stainless steel or assessed in accordance with Technical Requirement R3
- kept clean and free from mortar droppings
- inclined away from the sheathing so that the slope is maintained following differential movement
- capable of accommodating differential movement
- installed at a minimum density of 3.7 ties/m² for masonry cladding, eg spaced at a maximum of 600mm horizontally and 450mm vertically
- spaced at jambs of openings and at movement joints at a maximum of 300mm vertically and within 225mm of the masonry reveal or movement joint; additional studs may be needed
- spaced within 225mm of the top of the wall, including at gables.

Structural insulated panels (SIPs)

Where wall ties are fixed directly to the outer sheathing layer, screw fixings should be used. The pull-out strength of screw fixings should be:

- tested, or
- designed in accordance with relevant standards.

11.2.17 Services

Also see: Chapters 6.2 and 6.10

Internal services shall not adversely affect the stability or performance of the panel and be adequately protected from damage.

Service mains and service outlets should be:

- designed to ensure the fire resistance of walls and floors is not impaired
- designed to ensure that the required sound insulation of walls and floors is maintained
- installed in accordance with the design
- on the warm side of the insulation
- designed to accommodate differential movement where required.

Closed panel timber frame

Services to closed panel timber frame walls should be in accordance with Clause 6.2.9.

Structural insulated panels (SIPs)

Services passing through SIPs should not adversely affect the fire performance of the building. Issues to be taken into account include:

- suitable detailing of services passing through panels
- location and type of firestops to be used
- integrity of walls and floors.

Where holes are required to accommodate services, this should only be carried out in accordance with the manufacturer's recommendations or be designed by an engineer in accordance with Technical Requirement R5.

When installing services to SIPs, they should:


- be planned in advance so that ducts and conduits are provided
- not be chased into the core of the panel
- be installed in such a way to avoid cutting, igniting, or damaging the panel
- have additional engineered designed support for heavy loads from central heating and ventilation systems, or kitchen appliances.

Closed panel light steel frame

Services to closed panel steel frame walls should be in accordance with Clause 6.10.22.

11.2.18 Further information

- *Structural Timber Association — Moisture management strategy*



Chapter 11.3



Volumetric systems

This chapter gives guidance on meeting the Technical Requirements for volumetric systems used to form homes where the height of the top floor above ground does not exceed 18m.

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Introduction

This chapter provides guidance for volumetric systems used to form homes where the height of the top floor above ground does not exceed 18m.

The guidance in this chapter does not apply to volumetric roof systems or pre-manufactured structural components made of mass engineered timber.

This chapter should be used in conjunction with Chapter 11.1 MMC systems: general requirements. This chapter seeks to focus on areas of guidance that are unique to the system type and method of construction employed, giving references to complimentary existing guidance provided elsewhere in the Standards where relevant.

There is a strong link to all chapters in Part 6 of the Standards, particularly Chapters 6.2 and 6.10.

The term 'Modern Methods of Construction (MMC)' is very broad and covers a wide range of differing offsite manufactured systems and onsite construction techniques.

MMC types have been categorised and defined in the MHCLG Joint Working Group 'MMC Definition Framework', see Chapter 11.1 MMC systems: general requirements. The scope of the guidance in this chapter will cover volumetric systems that generally fall under Category 1 under the 'MMC Definition Framework' and as defined below:

Volumetric

Three-dimensional structural volumetric units fabricated offsite in a factory environment used to form all or part of the basic structure of a building. Volumetric units may incorporate varying degrees of offsite fabrication and finish, including internal and external linings, external claddings, windows and doors, internal finishes, concealed insulation, membranes, internal services, internal fixtures and fittings and fire-stopping.

Volumetric units can be used in varying configurations to form the entire structure of the home or be supported by surrounding construction. Units can be manufactured in varying structural forms and be formed from timber, concrete, steel or light gauge steel or a combination of those materials.

Definitions for this chapter

Cavity	A space enclosed by elements of a building which may either be the space between the cladding system and the backing wall or the space between building elements such as volumetric units. The external wall cavity should be adequately drained, and ventilated where required.
Cavity barrier	A construction within a cavity, other than a smoke curtain, to perform either of the following functions: <ul style="list-style-type: none"> • close a cavity to stop smoke or flame entering • restrict the movement of smoke or flame within a cavity.
Factory installed	An element of the construction that is placed, positioned, fitted or secured in, on or as part of the unit as part of the factory construction process.
Fire-stopping	A seal provided to close an imperfection of fit or design tolerance between elements or components, to restrict the spread of fire and smoke.
Installation Manual	Detailed installation guidance and information for the system compiled by the system manufacturer. The Installation Manual describes general instructions for storage and transport of the system, and procedures for on-site assembly and installation.
Interface	Interface either between similar or dissimilar envelope systems (eg at panel joints) or between envelope systems and other elements of the building (eg walls, roof, doors, and windows).
Junction	The point where components, including panels are joined with each other or with other elements of the building (eg supporting structure, roofs and foundations).
Manufacturer	The company which is responsible for the design and assembly of the volumetric system.
Non-standard components	Components that are assembled as part of the system but vary for individual projects. These may be windows, doors or services that may be built into the system.
Primary structural components	Elements of the structure designed to carry and transfer primary loads of the building, including self-weight, dead loads, and live loads.
Secondary structural components	Elements of the structure which do not play a wider role in the structure, but carry loads directly imposed on them (and transfer them to the primary structure) such as self-weight, wind loads, cladding and openings.
Standard components	Components that are assembled as part of the system and are common to all projects.
System	For the purposes of this chapter, this term refers to acceptable forms of volumetric systems.
System Manual	Detailed technical information on the system compiled by the system manufacturer. The System Manual describes the system, the declared performance of the system and evidence to support the declared performance.
Unit	A prefabricated building unit, manufactured offsite as a structural or non-structural assembly in three-dimensional or flat panel format used as part of a system to form the superstructure of a building.
Volumetric	Three-dimensional structural units which are commonly stacked to form a building. Volumetric units may incorporate varying degrees of off-site fabrication and finish, including internal and external linings, external claddings, windows and doors, internal finishes, concealed insulation, membranes, internal services, internal fixtures and fittings and fire-stopping.

11.3.1 Compliance

Also see: Chapters 2.1 and 11.1

Volumetric systems shall comply with the Technical Requirements.

Volumetric systems that comply with the guidance in this chapter and associated chapters will generally be acceptable. This chapter should be used in conjunction with guidance in Chapter 11.1 MMC Systems: general requirements.

As many components of volumetric systems cannot be inspected on site, they should be treated as a building system as defined in Chapter 2.1, Requirement R3 and subject to assessment by an independent technical approvals authority or assessed under the NHBC Accepts service; www.nhbc.co.uk/accepts.

11.3.2 Provision of information

Also see: Chapter 11.1

Designs and specifications shall be produced in a clearly understandable format, include all relevant information, and be distributed to all appropriate personnel.

Design, specification, and installation information should be issued to site supervisors, relevant specialist subcontractors and suppliers, and be made available on site to enable work to be carried out in accordance with the design. This should include:

- a System Manual (see Clause 11.1.3)
- a system Installation Manual (see Clause 11.1.9).
- clear, coordinated and fully detailed drawings providing sufficient information for construction and installation of the system

Refer to Chapter 11.1 MMC Systems: general requirements for further guidance.

11.3.3 Structural design

Also see: Chapters 3.1, 3.3, 6.2, 6.5 and 6.10

Volumetric systems shall be designed to support and transfer loads to foundations and supporting construction safely and without undue movement and shall have adequate resistance to loads imposed during manufacture, transportation, and installation. Issues to be taken into account include:

- 1) overall stability
- 2) unit connections
- 3) temporary loads
- 4) durability.

The structural design of the building should ensure adequate resistance to loadings in accordance with either the relevant Eurocode parts and their corresponding National Annexes relevant to the materials used to form the structural frame of the volumetric unit.

Where necessary, supplementary industry guidance should be followed where permitted by the relevant Eurocode and corresponding National Annex.

The design data may be supplemented with appropriate values derived from structural tests, acceptable to NHBC, where permitted by the relevant Eurocode and corresponding National Annex.

11.3.3.1 Overall stability

The building comprising volumetric units should be capable of supporting the specified loadings with adequate safety against structural collapse, inadmissible deformations, vibration, and disproportionate collapse.

Each unit should be framed in order to support itself fully and safely, by either:

- being designed as a rigid frame, or
- additional bracing or sheathing.

Overall stability of the building should be provided by either:

- the fully braced volumetric units, or
- connection to an independent bracing system such as a building core, shear walls and/or stability frame/s.

Design of a completed building should account for the effect of discontinuities in any system providing overall stability, eg the interruption of diaphragms or shear walls between modules.

Where differential movement between the volumetric units and any supporting structure such as a building core is expected, this should be considered as part of the design.

11.3.3.2 Unit connections

Connections between volumetric units should be designed by a Structural Engineer in accordance with Technical Requirement R5.

The design of connections between units or between units and surrounding construction, typically in-situ, should be compatible and have sufficient strength to transfer the necessary design loads and stiffness to enable the connected units to behave as a complete structure.

Connections should be designed and installed to achieve the required structural performance, and:

- accommodate movement where required
- allow for tolerance and adjustment
- be designed to avoid the risk of damaging or compromising the functional performance of factory installed elements such as breather membranes, AVCLs and lining boards.

The design, System Manual, and Installation Manual should include details of:

- specification and limits for shimming or adjustment of connections
- design and specification of fixings
- sequencing of installation.

Volumetric units should be mechanically fastened to supporting slab or foundations and not rely wholly on frictional resistance to resist sliding.

11.3.3.3 Temporary loads

Structural design of the units should consider the loads imposed during manufacture, storage, lifting and transportation and provide sufficient stiffness or protection against inadmissible deformation or deflection. See also Clause 11.1.8.

Where required, the design should specify temporary bracing and/or additional support arrangements for large openings or weak points in the structure and clearly identify the conditions under which such works can be removed.

11.3.3.4 Durability

The durability of materials and components should be specified in accordance with Technical Requirement R3. Structural elements and components that cannot easily be repaired or replaced should be suitably durable for the environment to which they will be exposed.

Metal fasteners, connectors and other structural steel parts in the element should either be:

- inherently corrosion resistant, or
- protected against corrosion to provide the required design life for the expected exposure condition.

Reinforced concrete should be in accordance with Chapter 3.1 Concrete and its reinforcement.

Timber should have adequate natural durability or be preservative treated in accordance with Chapter 3.3 Timber preservation (natural solid timber).

Steelwork should have protective coating in accordance with Chapter 6.5 Steelwork.

Light steel frame should have corrosion protection in accordance with Chapter 6.10 Light steel framed walls and floors.

11.3.4 Structural design checking and certification

Contact us: operationssupport@nhbc.co.uk

Design of the superstructure shall be adequately checked by an appropriate NHBC registered volumetric frame certifier.

Homes with a volumetric frame superstructure require certification confirming that the design has been checked by an NHBC registered volumetric frame certifier.

The certifier should:

- be listed on NHBC's list of volumetric frame certifiers
- be a suitably qualified civil or structural engineer with relevant experience in volumetric construction
- not be the designer of the volumetric frame or be employed by the same practice
- check supporting details and calculations
- complete and sign a certificate confirming assessment of structural adequacy for each specific project
- provide the registered builder with the completed and signed certificate.

The registered builder should ensure that the completed certificate is available on site for inspection by NHBC.

Contact NHBC Standards, Innovation and Research via operationssupport@nhbc.co.uk.

- if you require contact details of volumetric frame certifiers, or
- to apply to become a volumetric frame certifier.

11.3.5 Behaviour in relation to fire

Volumetric systems shall have adequate fire resistance and resist the spread of fire and smoke in accordance with Building Regulations. Issues to be taken into account include:

- 1) cavity barriers and fire-stopping
- 2) services
- 3) fire resistance of the unit
- 4) movement.

Guidance within supporting documents to the Building Regulations should be fully considered in the design and construction of volumetric systems.

The design and System Manual should clearly define:

- the overall fire protection strategy of the system
- which elements of fire protection are either factory or site installed.

11.3.5.1 Cavity barriers and fire-stopping

The provision and installation of cavity barriers and fire-stopping should:

- be specified to accommodate design, manufacturing and installation tolerances
- be in accordance with the Building Regulations and the design
- be designed to accommodate ventilation or drainage paths
- be used in accordance with manufacturers recommendations
- account for movement in the frame.

Detailing and specification of cavity barriers and fire-stopping should be in accordance with the manufacturer's recommendations and supported with representative test evidence.

Moisture protection should be provided to horizontal and vertical cavity barriers.

Where cavity barriers or fire-stopping cannot be easily replaced they should be specified in accordance with the design life of the building.

Buildings incorporating volumetric units may have significant concealed cavities between units. The building design should consider appropriate subdivision of cavities at horizontal and vertical junctions of volumetric units and between volumetric units and surrounding construction. Fire-stopping should be provided where necessary at junctions, to complete lines of compartmentation.

Factory installed cavity barriers or fire-stopping may be damaged or dislodged during the transportation or installation of volumetric units on site. Manufacturers and installers should allow for suitable access to inspect and verify concealed cavity barriers and fire-stopping post-installation.

When providing cavity barriers and fire-stopping:

- fire-stopping should be specified and sized to accommodate dimensional and installation tolerances of the unit
- gaps between compartments should be sealed
- presence of temporary weather protection membranes should not affect the performance, and should be removed unless tested or approved by the design.

At compartment walls fire-stopping should be provided to seal any gaps between the underside of units and the tops of foundations or substructure walls.

11.3.5.2 Services

Only the services shown in the design should be installed in volumetric system floors and walls, and:

- service outlets should not impair the fire resistance of floors and walls
- service mains should not pass through separating wall cavities.

11.3.5.3 Fire resistance of the unit

All building elements should have adequate fire resistance in accordance with Building Regulations, supported with representative test evidence and supporting engineering assessments to appropriate standards.

The design should specify:

- whether primary structural members require individual encasement or are protected by fire-resistant linings to the wall, floor, or ceiling frame
- details of junctions of secondary attachments to the primary structural frame and how fire resistance is maintained
- details of service openings, voids, and penetrations
- details demonstrating that columns and beams, where provided, are protected on all sides for the full height or width, including connections to other structural members, and how protection is maintained where the members extend through a ceiling or floor voids.

Where units join together and continuous linings are required or where access points are left open to facilitate connections, internal fire-resisting linings should be:

- installed with minimum laps in accordance with manufacturer's recommendations, or
- in accordance with the design and supported with representative test evidence to appropriate standards.

11.3.5.4 Movement

Fire-stopping should be specified and designed to accommodate anticipated movement in the building structure.

Where units are connected to surrounding construction, differential vertical movement should be considered in the design and specification of suitable fire-stopping and cavity barriers.

Non-loadbearing infill walls within volumetric units should accommodate anticipated deflection within the primary frame in accordance with the design. Should these walls be fire resisting, detailing at the head should be such that performance in this regard is not compromised.

11.3.6 Acoustic performance

Also see: Chapters 6.3 and 6.4

Volumetric system walls and floors shall have adequate resistance to the passage of sound.

Separating walls and floors

Separating walls and floors should be in accordance with Building Regulations and the design. Care should be taken to avoid gaps:

- between mineral wool quilt or batts
- between internal lining board layers
- between cavity barriers
- around openings for services.

Walls and floors in volumetric units will commonly be of complex construction and independent test evidence of acoustic performance or assessment by a suitably qualified expert should be provided prior to construction and detailed in the System Manual. Values derived from partition manufacturers data may not be appropriate to determine the sound performance of the wall construction where additional structural elements are included in the wall, or the panel serves as an infill.

Bedrooms and rooms containing a WC

The construction of internal walls should comply with Building Regulations, including the recommended sound reduction between bedrooms and rooms that include a WC and:

- living rooms
- dining rooms
- studies
- bedrooms, except where the WC is an ensuite serving that bedroom.

Proprietary partitions

Proprietary partitions should be independently assessed or tested for 'sound transmission' performance in compliance with Technical Requirement R3.

Sound insulation of SVPs and soil pipes in floor voids

All soil pipes running horizontally through a floor void above or below a habitable room should be wrapped in at least 25mm of mineral wool (10kg/m³ min) and be adequately supported to avoid contact with the floor decking or ceiling.

Sound insulation should be provided to soil pipes passing through homes by an encased boxing, using lining materials (minimum 15kg/m²) and wrapping the pipe with a minimum 25mm of unfaced mineral fibre (10kg/m³ minimum). The insulation should be continued through the thickness of each sound-insulating floor).

11.3.7 Differential movement

Also see: Chapters 6.2 and 6.10

Buildings formed using volumetric systems shall account for differential movement between the frame and other building elements or supporting structures.

Where volumetric units connect to surrounding construction and differential vertical movement is expected, consideration should be given to:

- the design of joint details and accommodation of differing floor levels at thresholds, staircases and lift shaft enclosures
- service entries and risers
- design and provision of suitable weather resistant and durable joints
- interface of self-supporting cladding and cladding attached to the unit
- design of connection brackets, anchors, and ties to accommodate movement.

Timber frame volumetric

Where the primary structure of volumetric units is timber, it will shrink as the timber dries out, reducing the overall height. In some cases the expected shrinkage can be greater than that of traditional platform framed timber buildings due to the form of construction. The extent of the differential movement increases with the number of storeys, and the design should allow for differential movement between the volumetric units and other parts of the construction, including:

- door and window openings
- eaves and verges
- balconies (including Juliet balconies)
- service entries, risers and fixed vertical external services
- openings for drive throughs
- staircases and lift shaft enclosures (where they are not timber framed)
- the interface of the timber volumetric unit with any other construction at each floor level where cladding is fixed to the unit.

For timber frame volumetric structures the shrinkage and associated gap sizes to accommodate differential settlement should be subject to specialist calculation.

Where claddings are factory installed and supported by the volumetric unit, consideration should be given to interfaces with self-supporting cladding.

Refer to Clause 6.2.8 for guidance on how to accommodate differential movement in traditional platform timber frame construction.

Light steel frame volumetric

The design for differential movement in light steel frame volumetric structures should be in accordance with the System Manual. Also see Clauses 6.10.20 and 6.10.21.

11.3.8 Protection from moisture

Also see: Chapters 5.1, 6.1, 6.2, 6.10 and 11.1

Volumetric systems shall be adequately protected from the effects of moisture. Details of volumetric systems at low level shall fully consider the durability of materials, protection of the building from moisture ingress and condensation as a result of thermal bridging. Issues to be taken into account include:

- 1) cavities in external walls
- 2) protection at low level
- 3) DPCs, DPMs and cavity trays
- 4) junctions between adjoining units.

Guidance on temporary weather protection can be found in Clause 11.1.5. Guidance on moisture management strategies for structural timber buildings can be found in Structural Timber Association publication 'Moisture management strategy'.

11.3.8.1 Cavities in external walls

A clear cavity in accordance with Table 1 should be provided between the cladding and insulation.

Table 1: Minimum cavity widths

Cladding	Cavity width
Masonry	50mm
Render on board background	25mm
Vertical tile hanging ⁽¹⁾ where a breather membrane is provided and fixed to sheathing	Dependant on batten support layout and spacing ⁽¹⁾
Other cladding ⁽¹⁾	See Chapter 6.9 Curtain walling and cladding

Note

1. See Chapter 6.9 Curtain walling and cladding.

Cavities should be:

- drained (for light steel frame backing walls)
- extend at least 150mm below DPC
- drained and vented (for timber frame backing walls)
- be kept clean, free from obstructions and capable of draining freely.

Timber frame backing walls

Cavities to volumetric units with a timber frame backing wall should be in accordance with Clause 6.2.10.

Light steel frame backing walls

Cavities to volumetric units with a light steel frame backing wall should be in accordance with Clause 6.10.16.

11.3.8.2 Protection at low level

Timber frame walls

The lowest timber should be a minimum of 150mm above finished ground level. This may be reduced to 75mm in situations where the site is not subject to a high-water table or where the cavity will not have standing water.

DPCs should be installed below the sole plates of ground floor walls and internal partitions.

Where external ground levels are raised locally to accommodate accessible entrances, consideration should be given to the following:

- appropriate drainage installed along the perimeter or ground falling away from the building
- adjacent surface finishes which do not promote splashing
- additional cavity ventilation either side of raised ground levels
- use of a 'kerb' to raise level of timber frame elements.

Light steel frame walls and floors

The base rail of LSF should be kept a minimum of 150mm above the external ground level (or waterproofing layer of a flat roof, balcony, or terrace) and cavity fill.

DPCs should be installed underneath the full width of the lowest section of framing, eg all ground floor walls and internal partitions, to protect the steel from corrosion due to moisture.

Locally raised ground levels (up to the internal floor finish) to less than 15% of the external perimeter (of an individual building, eg row of terraced homes, apartment blocks and detached garages, measured on plan) to accommodate level thresholds can be accepted. The cavity should be kept clear and allow drainage. Wall insulation should overlap the base rail by a minimum of 150mm.

Where the base rail or lowest steel is less than 150mm above ground level:

- light steel frame should be in accordance with Clause 6.10.16b
- hot rolled steel components should have a factory-applied protective coating system in accordance with Clause 6.5.3.

11.3.8.3 DPCs, DPMs and cavity trays

Damp proofing should:

- be installed correctly to provide a physical barrier to the passage of water, and to ensure water is directed to the outside
- use only appropriate tapes and sealant (but not solely rely on sealant) in accordance with the design and manufacturer's recommendations
- use DPCs/DPMs where necessary, including junctions between systems and any other component or systems.

DPCs

The following materials are acceptable for use as DPCs:

Bitumen-based materials	BS 6398, BS EN 14967
Polyethylene (except as cavity trays in walls, below copings and in parapets)	BS 6515, BS EN 14909
Proprietary materials	Technical Requirement R3
Thermoplastics and Elastomers	BS EN 14909

DPMs

Where DPMs are required, they should be linked with any DPCs in the supporting structure, in order to provide continuous protection from moisture from the ground or through the supporting structure.

DPMs should be properly lapped in accordance with Chapter 5.1 Substructure and ground-bearing floors.

Suitable materials for DPMs include:

- 1,200-gauge (0.3mm) polythene sheet
- minimum 1,000-gauge (0.25) polythene sheet where assessed in accordance with Technical Requirement R3
- bitumen sheet to BS 6398
- proprietary materials assessed in accordance with Technical Requirement R3.

Cavity trays

Cavity trays should be provided at all interruptions to the cavity (eg window and door openings and air bricks) and abutments unless otherwise protected (eg by overhanging eaves) or alternative means of protection are provided (eg profiled metal flashings) such as part of a proprietary cladding system.

Clause 6.1.17 contains further guidance on the installation of cavity trays in masonry cladding.

The following materials are acceptable for use as cavity trays:

- plastic and rubber to BS EN 14909 and hold satisfactory assessment by an appropriate independent technical approval's authority accepted by NHBC
- proprietary materials as part of a cladding system holding satisfactory assessment by an appropriate independent technical approvals authority accepted by NHBC.

11.3.8.4 Junctions between adjoining units

At junctions of volumetric units or between volumetric units and surrounding construction, particularly where they incorporate factory installed external claddings, consideration should be given to:

- providing suitable access to install breather membranes and achieve minimum laps
- providing suitable access to adequately link DPCs and DPMs in the substructure
- use of appropriate tapes and sealant (but not solely rely on sealant) in accordance with the design and the manufacturer's recommendations
- design of suitable cladding joints in accordance with the manufacturer's recommendations
- interaction of cavity barriers and cladding joints
- use of damp proofing materials which are compatible with adjoining components.

Connections between volumetric units and between volumetric units and surrounding construction should be designed to avoid the risk of fixing through and thus puncturing or damaging AVCLs or breather membranes.

11.3.9 Insulation

Also see: Chapters 6.2 and 6.10

Insulation shall be suitable for the intended use, correctly installed, and be of a suitable material and thickness to comply with Building Regulations and reduce the risk of surface and interstitial condensation.

Insulation should be:

- in accordance with the design
- installed correctly to minimise the risk of thermal bridging, surface, and interstitial condensation
- installed in accordance with the manufacturer's recommendations.

The System Manual and design should include control measures to mitigate risk of slump of non-rigid insulation during transport and site installation.

Where insulation is to be installed to the external/cavity face of the frame, workmanship and tolerances of external walls, particularly at panel joints, should be maintained to minimise:

- reducing the width of clear cavities
- gaps between insulation boards
- ledges between insulation boards forming moisture traps.

Timber frame backing walls

Insulation to volumetric units with a timber frame backing wall should be in accordance with Clause 6.2.15.

Light steel frame backing walls

Insulation to volumetric units with a light steel frame backing wall should be in accordance with Clause 6.10.17.

11.3.10 Junctions and interfaces

Also see: Chapters 6.2 and 6.10

Junctions and interfaces shall be suitably detailed, built to appropriate tolerances and provide satisfactory performance.

The use of volumetric units, particularly where finished linings or claddings are installed will introduce junctions and interfaces between adjoining units that are not common in traditional construction.

The junctions of volumetric units should be designed with appropriate tolerances to avoid excessive deviation:

- to external faces of adjacent units, which may impact cavity widths, installation of insulation and cladding as well as performance of cavity barriers or fire-stopping
- to internal faces of adjacent units, which may impact continuity of acoustic or fire-resisting linings or installation and fit of surrounding construction (eg staircases).

Spatial tolerances are critical for the performance of joints, details, and interfaces. The design should:

- include dimensions and the permissible deviation clearly indicated in the System Manual and on relevant drawings
- allow for adjustability to accommodate the tolerances for manufactured units and range of deviation in site construction in the form of levelling bolts, bracket systems and detailing allowing horizontal and vertical adjustment.

The manufacturer and designer should consider:

- guidance on jointing methods for structures, claddings, openings, and services passing through building elements given in BS 6093
- undertaking of mock-ups or trials to ensure satisfactory fit and tolerances can be achieved.

Foundations

Foundations should be installed to tolerances in accordance with the System Manual. The foundation tolerances should consider:

- level of foundation
- straightness of foundations
- dimensional tolerance
- level between foundation and substructure brickwork
- squareness of foundations.

Floors

Interfaces of floors at unit junctions should be designed to achieve necessary tolerances to allow installation of floor coverings. Interfaces of floor decking may either be designed as a butt joint or by using a transition piece to accommodate minor tolerances between decking finishes.

Floor interfaces should:

- have a nominal 3mm gap at decking joints
- filled with an appropriate gap filler or covered with a cover strip
- be kept clear of debris
- not exceed 2mm level difference between floor decking at any position.

11.3.11 Cladding

Also see: Chapters 6.1, 6.2, 6.9, 6.10 and 9.1

External claddings shall be suitable for their intended purpose, have suitable junctions and interfaces to resist the penetration of water and wind, be suitably durable and have an acceptable finished appearance.

Issues to be taken into account include:

- 1) junctions and interfaces between cladding types and adjoining units
- 2) movement
- 3) continuity of insulation, breather membranes and AVCLs
- 4) tolerances
- 5) finished appearance.

Masonry external cladding should be in accordance with Chapter 6.1 External masonry walls.

Lightweight external claddings, whether factory or site installed, should be:

- in accordance with Chapter 6.9 Curtain walling and cladding
- compatible with the framing system
- supported by systems assessed in accordance with Technical Requirement R3 which ensure that cladding design loads are effectively and safely transferred to the building structure.

Further guidance on render onto board backgrounds can be found in Clause 6.11.8.

The design and construction of cladding to external walls should consider:

- durability
- cavity drainage
- differential movement
- restraint
- performance in relation to fire.

Timber frame backing walls

Further guidance on the use of masonry and lightweight claddings with timber frame walls can be found in Chapter 6.2 External timber framed walls.

Light steel frame backing walls

Further guidance on the use of masonry and lightweight claddings with light steel frame walls can be found in Chapter 6.10 Light steel framed walls and floors.

11.3.11.1 Junctions and interfaces

Junctions and interfaces, including those between factory installed lightweight cladding systems to adjoining units, and those between lightweight cladding systems and other elements of the building, should be carefully designed and detailed to be weather resistant, and prevent moisture reaching parts of the wall it could adversely affect.

The design should take account of:

- differing profile characteristics
- movement
- design of suitable interfaces between differing cladding types
- tolerances and deviation
- the erection sequence.

For lightweight cladding finishes applied to an insulation backing, the use of small infill pieces at unit junctions or differing types of backing insulation (eg to form cavity barriers or fire-stopping at compartment lines) should be detailed in accordance with the manufacturer's recommendations and within the scope of certification by an independent technical approvals authority acceptable to NHBC.

11.3.11.2 Movement

Movement joints to masonry cladding should be in accordance with Clause 6.1.3. Refer to Clause 6.2.8 for further guidance on accommodating movement in masonry cladding to timber frame structures, and Clause 6.10.20 for masonry cladding to light steel frame structures.

Lightweight claddings

Where lightweight or self-supporting cladding is used movement joints should be provided where required by the design.

Movement joints should be:

- formed in accordance with the cladding system manufacturers' recommendations
- positioned to accommodate calculated movement
- continued through the depth of the cladding.

Accommodation of differential movement should be made at floor zones between lightweight cladding.

11.3.11.3 Continuity of insulation, breather membranes and AVCLs

Junctions and interfaces of adjoining units or units with surrounding construction should be carefully designed and detailed to ensure continuity of insulation, breather membranes and AVCLs.

The design should:

- ensure adequate laps of membranes or provision for suitable method of sealing in accordance with manufacturer's recommendations
- make allowance for secure fixing of insulation, including at panel junctions, to the support frame or wall.

11.3.11.4 Tolerances

Where factory installed lightweight claddings extend to the edges of units, the cladding interfaces should meet the following tolerances unless specified otherwise by the design:

- be adequately straight in elevation, with a maximum $\pm 6\text{mm}$ deviation from nominal design width in any unit edge width or height up to 3m (see Figure 1)
- a maximum deviation of 6mm in plan or section between faces of adjoining units (see Figure 3)
- a maximum deviation of 6mm in elevation between in-line edges across a transverse or cruciform interface joint (see Figure 4).
- a maximum deviation of 5mm in plan or section between faces of adjoining units (see Figure 2)
- a maximum deviation of 6mm in elevation between in-line edges across a transverse or cruciform interface joint (see Figure 4).

Figure 1: Straightness of interface joint widths

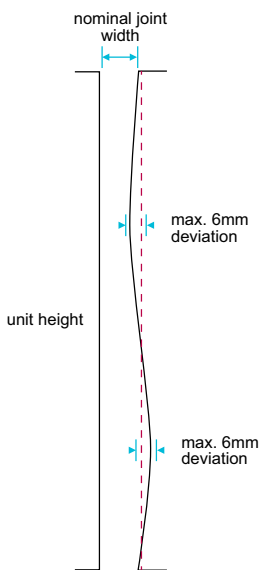


Figure 2: Taper of interface joints

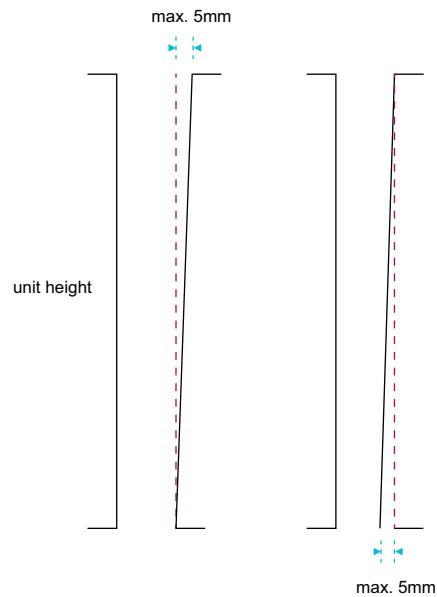


Figure 3: Offset of cladding faces

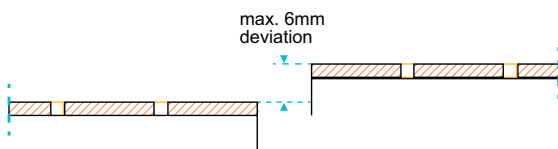
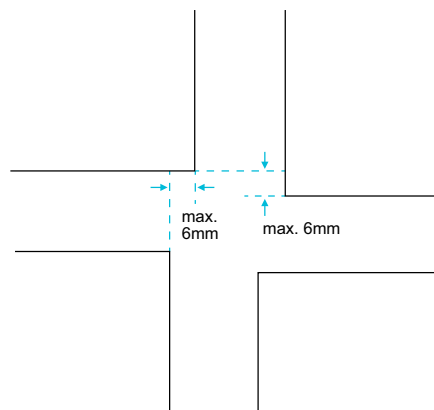


Figure 4: Accuracy of cruciform interface joints



11.3.11.5 Finished appearance

Tolerances and finishes for factory installed external claddings should be in accordance with Chapter 9.1 A consistent approach to finishes.

Brick slip cladding

Factory installed brick slip claddings should be set out to co-ordinate with adjacent units and surrounding construction to avoid:

- cutting of brick slips, particularly in the storey heights, at corners, around openings, and at panel edges except when it is essential
- irregular or broken bonds of brick finishes, particularly at openings
- small cuts of brick finishes
- broken bond and out of line joints at junctions of panel and junctions with surrounding construction (eg substructure brickwork).

Care should be taken to ensure the finish specification of mortar used for site installed brickwork is the same as used for factory installed brick slip claddings to avoid variation in the texture, finish, and colour.

Weatherboard cladding

Factory installed weatherboard cladding should be set out to co-ordinate with adjacent units and surrounding construction to avoid:

- cutting and notching cladding boards around window and door openings
- misaligned cladding boards at panel junctions.

11.3.12 Doors, windows, and glazing

Also see: Chapter 6.7

Doors, windows, and glazing shall comply with the Technical Requirements and be designed and specified to ensure adequate in-service performance.

Doors, windows, and glazing should be designed, specified, and installed in accordance with Chapter 6.7 Doors, windows and glazing.

The specification of fixings for doors and windows should be adequate to resist the effects of vibration and loads imposed during storage, transport and installation.

Adequate protection against damage should be provided to factory installed doors and windows, particularly where protruding from the face of the unit.

11.3.13 Staircases

Also see: Chapter 6.6

Staircases shall comply with the Technical Requirements and be designed to ensure adequate safety and performance.

Staircases should be designed, specified, and installed in accordance with Chapter 6.6 Staircases.

Wall linings should be continuous behind the string of staircases.

Fixing connections should be coordinated to ensure fire protection continuity and structural adequacy.

Where staircases are factory installed into volumetric units, consideration should be given to construction tolerances and the potential for differential vertical movement when designing connections to upper units. Landings should be framed to provide full support and solid fixings for the tops of flights, nosings, newels, apron linings, etc.

Suitable access should be provided to facilitate final installation of staircases and connection to upper units on site, including any necessary fixings or supports required.

The top nosing of staircases should be:

- level with the floor decking
- fixed firmly.

11.3.14 Air and vapour control layers

Air and vapour control layers shall be designed and installed correctly to restrict the passage of water from within the home to the structural frame.

Where they are provided, AVCLs should be:

- 500g polyethylene sheet, vapour control plasterboard, or material assessed in accordance with Technical Requirement R3
- in accordance with the design
- overlapping the base rail
- fixed on the warm side of the wall insulation and frame
- placed to cover the external wall, including base rails, head rails, studs, lintels, and window reveals
- taped or sealed in accordance with the manufacturer's recommendations and punctures made good
- sealed around service penetrations.

Air and vapour control layers should be:

- stapled at 250mm centres to the top and bottom of the frame, at laps and around openings to closed panel timber frame
- fixed with double-sided tape or adhesive as a temporary fixing before the wall board is fixed to closed panel light steel frame backing walls.

Joints in air and vapour control membranes should:

- have 100mm minimum laps
- be located on studs or noggings.

Where vapour control plasterboard is used:

- joints between sheets should be positioned on studs or noggings
- joints should be filled, taped, and finished
- care should be taken not to displace the vapour control material when cutting vapour control plasterboard.

The junctions of volumetric units, particularly where the junction includes back-to-back internal walls, should be carefully designed to ensure the continuity of air and vapour control layers.

Where internal linings are factory installed to volumetric units, provision should be made to allow adequate access to achieve correct lapping and sealing of air and vapour control layers at unit junctions when installed in the final position on site.

Light steel frame backing walls

A high resistance air and vapour control layer should be provided, unless a condensation risk analysis shows that it is not necessary, and the air and vapour control function is being provided by another solution compliant with NHBC Technical Requirements. Modelling where appropriate should be undertaken in accordance with BS EN ISO 13788 or BS EN 15026. The following boundary conditions should be used for the purposes of calculation to BS EN ISO 13788:

- at 21°C internally
- at -2°C externally
- >60% internal RH.

Multiple layers of AVCL-type material through the thickness of the element should be avoided, except where condensation risk analysis shows it to be acceptable.

11.3.15 Breather membranes

Breather membranes shall be correctly installed to protect the sheathing and frame from external moisture, and capable of allowing vapour to pass into the cavity.

Breather membranes should be:

- vapour resistant to less than 0.6MNs/g (0.12 Sd) when tested in accordance with BS EN ISO 12572 using the set of conditions C and using five test specimens
- at least Class W2 to BS EN 13859-2 with no water leakage during testing. In areas of very severe exposure (see Clause 6.1.6 for classification of exposure zones) or where liquid water penetration of the cladding is anticipated, for example open-jointed cladding, Class W1 should be used. When open-jointed claddings are used or the membrane likely to be left exposed during construction for a duration longer than normally to be expected (also see the membrane manufacturers recommendations on exposure times), performance should be based on artificial aged behaviour in accordance with BS EN 13859-2. Where a vented and ventilated cavity with full rainscreen and no gaps, for example masonry or rendered board claddings, are used, performance should be based on artificial aged behaviour in accordance with BS EN 13111
- self-extinguishing
- fixed so that vertical joints are staggered where possible, and at regular intervals, to prevent damage by wind
- installed so that each joint is protected, and moisture drains outwards
- lapped so that upper layers are over lower layers to ensure rain runs away from the sheathing
- lapped to a minimum of 100mm at horizontal joints and a minimum of 150mm at vertical joints
- fixed at a maximum spacing of 600mm horizontally and 300mm vertically
- fixed at a maximum spacing of 150mm around openings
- marked with stud positions for wall tie fixing
- applied using austenitic stainless-steel fixings
- repaired or replaced before proceeding with the cladding, if damaged
- durable and adequately strong when wet, to resist site damage
- capable of resisting water penetration.

Only tapes and sealants in accordance with the design and the manufacturer's recommendations should be used for sealing of membrane joints.

Light steel frame backing walls

Breathable membranes should be used to protect sheathing boards and insulation. Breather membranes may be omitted where water resistant insulation boards with taped joints are used. Tape should be of a type recommended by the insulation manufacturer, breathable to allow water vapour to move freely and resist water penetration. Suitable taping should be applied at the lintel interfaces and other penetrations to direct water outside.

11.3.16 Sheathing boards

Also see: Chapters 6.2 and 6.10

Sheathing boards shall be durable and suitable for their intended purpose.

Where they are required, sheathing boards should be:

- of a suitable strength and quality
- attached using suitably specified and durable fixings.
- compatible with the frame

Sheathing boards contribute to many functions critical to the performance of the system and building and cannot be easily replaced, so should comply with Technical Requirement R3.

Timber frame backing walls

Sheathing boards to volumetric units with a timber frame backing wall should be in accordance with Clause 6.2.7.

Light steel frame backing walls

Sheathing boards should be appropriate for the exposure of the building and suitable for use in humid conditions.

Sheathing boards to volumetric units with a light steel frame backing wall should be in accordance with Clause 6.10.20.

11.3.17 Wall ties

Wall ties and fixings shall adequately connect the cladding to the frame.

Wall ties and their fixings should be:

- compliant with BS EN 845-1
- fixed to studs and not the sheathing
- in accordance with and of the type specified in the design
- of austenitic stainless steel or assessed in accordance with Technical Requirement R3
- kept clean and free from mortar droppings
- inclined away from the sheathing so that the slope is maintained following differential movement
- capable of accommodating differential movement
- installed at a minimum density of 3.7 ties/m² for masonry cladding, eg spaced at a maximum of 600mm horizontally and 450mm vertically
- spaced at jambs of openings and at movement joints at a maximum of 300mm vertically and within 225mm of the masonry reveal or movement joint; additional studs may be needed
- spaced within 225mm of the top of the wall, including at gables.

11.3.18 Services

Also see: Chapters 6.2, 6.10 and 8.1 to 8.6

Internal services shall comply with the Technical Requirements and be in accordance with statutory requirements. Issues to be taken into account include:

- 1) installation
- 2) recording of factory testing and commissioning
- 3) access for site connections, inspections, and commissioning.

All service installations should be designed and installed in accordance with Part 8 Services.

The design and System Manual should clearly define:

- how design, manufacturing and installation tolerances are accommodated
- which services are factory installed and which are site installed
- designer responsibilities for factory installed and site installed elements and overall coordination.

Service mains and service outlets should be:

- designed to ensure the fire resistance of walls and floors is not impaired
- designed to ensure that the required sound insulation of walls and floors is maintained
- installed in accordance with the design
- on the warm side of the insulation
- designed to accommodate differential movement where required.

Careful positioning of service pop-ups and entry points is required to align with service entry points and factory installed services to volumetric units. A pre-installation survey should be undertaken prior to installation of units.

11.3.18.1 Installation

Prefabricated wiring systems should be tested and installed in accordance with BS 8488. The manufacturer should provide details of whether any or all of the connectors within the prefabricated wiring system should be accessible for inspection, testing and maintenance.

Timber frame walls and floors

Services installed in volumetric units with timber frame walls and floors should be in accordance with Chapter 6.2 External timber frame walls and Chapter 6.4 Timber and concrete upper floors.

Light steel frame walls and floors

Services installed in volumetric units with light steel frame walls and floors should be in accordance with Clause 6.10.22.

11.3.18.2 Factory testing and commissioning

The method of testing and commissioning of factory installed services should be detailed in the System Manual.

Pressure testing of factory installed water supply, gas supply, heating and waste pipework should be undertaken where practicable. Exposed ends of all pipework should be sealed to prevent contamination and protected to prevent damage.

Appropriate performance and safety testing should be undertaken to factory installed prefabricated wiring systems in accordance with BS 8488.

Written records should be provided for testing undertaken to factory installed services and included in system verification documentation.

11.3.18.3 Access

Where access is required to connect service mains through walls or floors, a suitable method should be detailed in the System Manual for making good the access point in accordance with the design to maintain the fire, sound, air, thermal, and moisture resistance of the structure.

Consideration should be given to:

- providing adequately located and sized access points to install, test and commission service connections on site
- provision of suitable information in the handover file where access points are to be permanently sealed (such as behind a tiled wall), to allow future users access in the event of a fault or for routine maintenance.

Consideration should be given to providing access for inspection or maintenance or a leak detection system where concealed riser voids contain water supply pipework.

11.3.19 Further information

- *Structural Timber Association — Moisture management strategy*



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