



BRICKWORK AND MODERN METHODS OF CONSTRUCTION



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INTRODUCTION

In construction there is a continuous desire to build projects to a higher quality, on a shorter timescale and at a reduced cost. The government's Construction Sector Deal challenges the industry to reduce construction cost by 1/3 and construction time by 1/2, whilst improving quality.

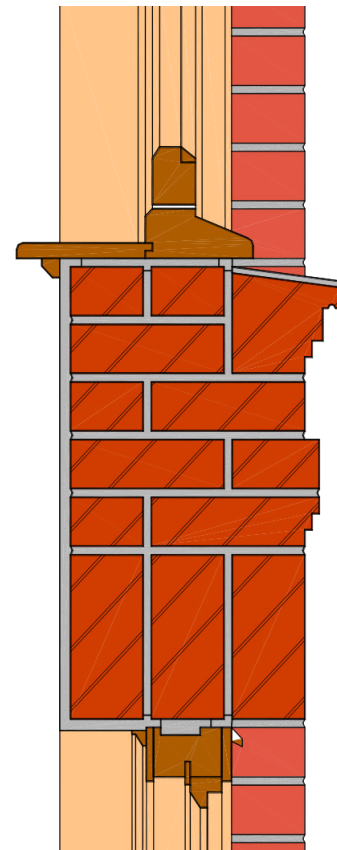
One of the key drivers identified to achieve these targets is the development and expansion of Modern Methods of Construction. Brick manufacturers have been at the forefront of developing MMC systems for several years.

Clay brick has undergone a dramatic transformation during the 20th century. From solid wall construction to the modern cavity wall, with improved levels of insulation and reduced water penetration.

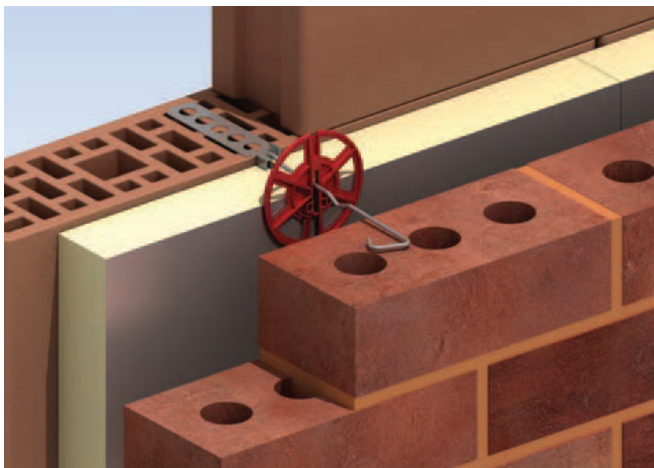
CAUTION REQUIRED

The sector needs to be mindful that during the push for quicker and cheaper we don't compromise the quality of what is built, as has happened with previous attempts to develop MMC. One of the principal benefits of hand laid clay brick is that it has a very long history of quality performance with a large and proven supply chain.

Assessing when it is appropriate to use a MMC system, to gain maximum benefits, has historically been a complex issue. Research from Richard Willetts at the Facade Engineering department of the University of Bath has made some substantial recent progress.



Traditional solid wall construction



Modern cavity wall construction







Traditional brick detailing

MMC DEFINITIONS

Historically the term **Modern Methods of Construction** has been used as quite a loose term to describe all different types of construction system, construction components and construction processes. MMC is not as well understood as the traditional construction trades.

The Government's Joint Industry Working Group on MMC have produced a definition framework to enable MMC within homebuilding to be better understood, with regularised terminology. The definition framework spans all types of pre-manufacturing, site based materials and process innovation.

 <p>CATEGORY DEFINITION</p>	 <p>1 Pre-manufacturing (3D primary structural systems)</p>	 <p>2 Pre-manufacturing (2D primary structural systems)</p>	 <p>3 Pre-manufacturing components (non-systemised primary structure)</p>
 <p>4 Additive manufacturing (structural and non-structural)</p>	 <p>5 Pre-manufacturing (non structural assemblies & sub-assemblies)</p>	 <p>6 Traditional building product led site labour reduction / productivity improvements</p>	 <p>7 Site process led site labour reduction / productivity / assurance improvements</p>

MMC definition framework produced by MHCLG Joint Industry Working Group.

BRICKWORK MMC OPTIONS

MMC is probably most widely understood as fabricating building components, in factories away from the site, but it can also cover a number of other systems and processes. The term 'pre-manufacturing' includes processes completed away from the final installed position, including in remote factories, near site or on-site 'pop up' factories. Brickwork solutions fall into a number of categories including:

Category 1 - pre-manufactured 3D primary structure with brick slips.

Category 2 - whole wall build up & brick faced pre-cast concrete sandwich panels.

Category 3 - pre-manufactured lintels & arches.

Category 5 - pre-manufactured chimneys, balconies, decorative panels & soffit systems.

Category 6 - site applied brick slip systems, panel systems & precast concrete panels.

Category 7 - brick laying robots

HISTORY OF BRICKWORK MMC

Brick making was introduced to the UK by the Romans and their process for making and laying bricks would be recognisable to a modern day audience. One of the great selling points for brickwork is the long established reputation for durability and robustness.

Throughout the history of the brick there have been examples of the 'traditional' brick unit being developed for specific purposes.

MATHEMATICAL TILES

The 18th and 19th century saw the use of mathematical tiles around Kent and East Sussex. These are essentially an overlapping brick slip system which would have been fixed to a timber frame and grouted to resemble brickwork.

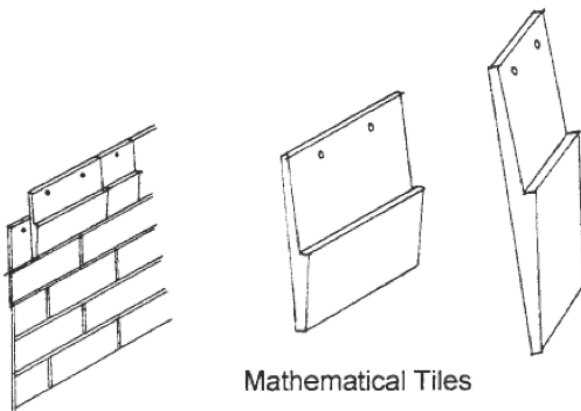
These systems can be seen as a precursor to modern day slip systems and share much of the same design reasoning.



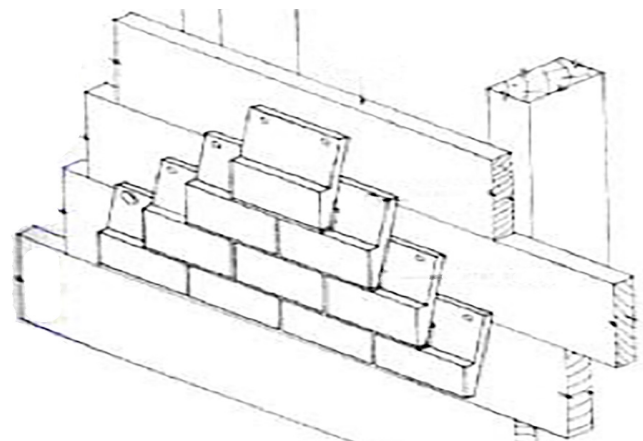
Timber framed property clad in mathematical tiles



Glazed finish on mathematical tiles



Stretcher and header units



Overlapping fixings onto timber frame

BRICK SLIPS - INDIVIDUAL SLIPS

INDIVIDUAL SLIP SYSTEMS

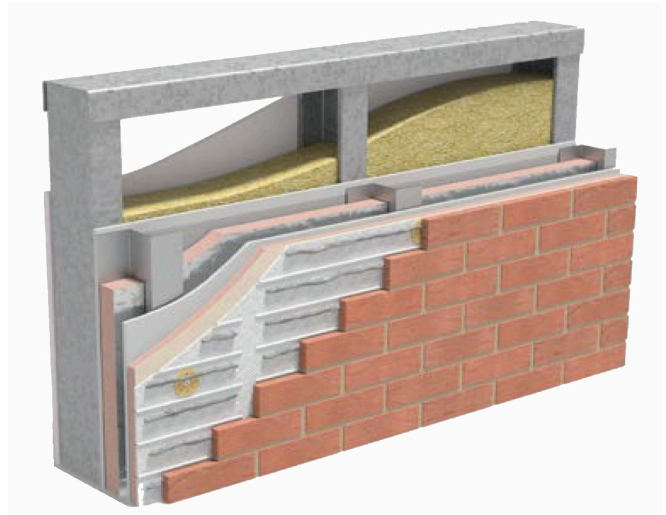
Individual brick slip systems can cover a wide range of different uses, depending on the required performance.

In the most simple scenario, brick slips can be used internally as a decorative finish. In this scenario the wall build up and adhesive will be similar to the application of tiles. To ensure that the slips replicate the effect of traditional brickwork it is important to follow the normal setting out, for bonding and coursing.

Slips are placed individually, which has the benefit of being able to accommodate construction tolerances but requires some skilled application.

Individual slip systems are also available for locations with increased performance requirements, including externally, where they are often used as an over-cladding. These systems will often include a backing board or track, which will improve adhesion and aid setting out.

Systems incorporating insulation can be used for new build applications, or for over-cladding existing buildings to improve thermal performance. The insulation is often supplied as part of a panel, pre-bonded to a track sheet to provide a grid for fixing the individual slips. Alternatively the slips may be bonded directly to the insulation.



Individual slips with track and insulation system



Mesh backing board to improve adhesion



Brick slips used internally

CATEGORY
DEFINITION

1 
Pre-manufacturing
(3D primary structural
systems)

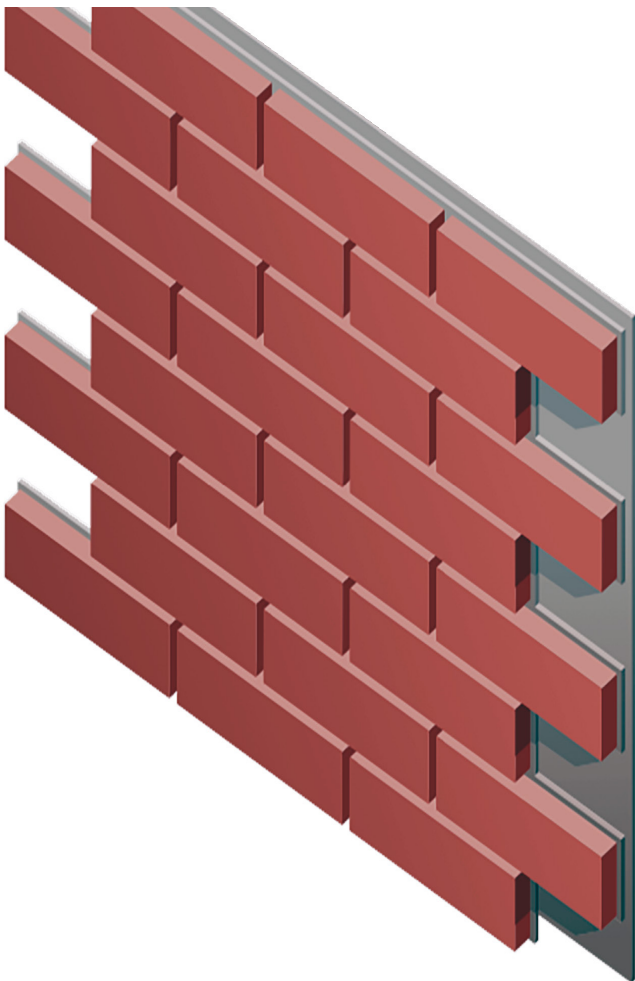
6 
Traditional building product
led site labour reduction /
productivity improvements

BRICK SLIPS - PANEL SYSTEMS

PANEL SYSTEMS

Panel systems are brick slips bonded to a rigid backer board or panel. Panel based systems are normally pre-manufactured and supplied with the brick slip already attached (sometimes pre-pointed). The main benefits are that brick bonding is completed under controlled factory conditions and speed of install is increased on site.

The specification of boards/backers used can vary significantly in terms of weather tightness, moisture absorption and fire performance, the panel shapes can be standard or bespoke and of varying aspect ratio and size; their design influences the handleability and installation on site. How panels are joined and aligned is also critical to the eventual finish, so construction tolerances must be co-ordinated.



Typical brick slip panel system



Panel system on 3D primary structure



Panel system corner profile

CATEGORY
DEFINITION

1 
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systems)

6 
Traditional building product
led site labour reduction /
productivity improvements

BRICK SLIPS - RAIL AND TILE SYSTEMS

RAIL AND TILE SYSTEMS

This is a group of systems where metal rails are fixed back to a supporting frame on site, and brick components are clipped or slotted into the rail. This can produce a mechanically retained slip, with no reliance on adhesive, which makes them non-combustible and therefore suitable for use on high-rise projects. The potential for performance variation is in the material the rail is made from, including any coatings applied, the design of the rail and the brick.

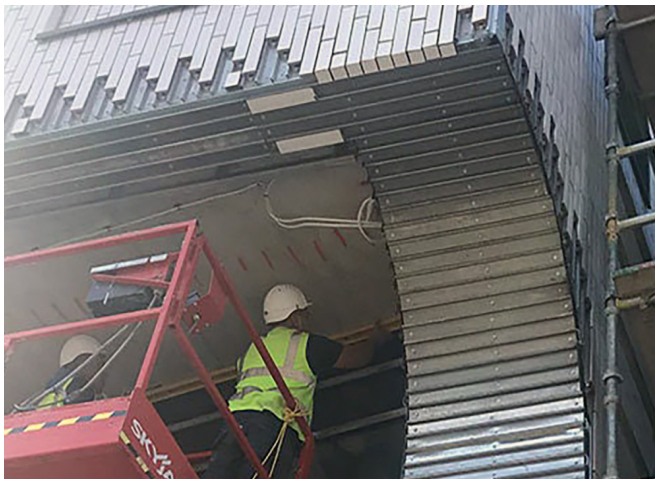
The decreased weight of construction and reduced wall thickness, when compared to hand laid brickwork, means that the benefits are enhanced as the number of storeys increases. These systems are typically used for high rise construction and specific details, such as balconies or dormers.



Window reveal detail



Rail system to achieve mechanical fixing



Curved profile

CATEGORY
DEFINITION

1
Pre-manufacturing
(3D primary structural
systems)

6
Traditional building product
led site labour reduction /
productivity improvements

PRECAST CONCRETE

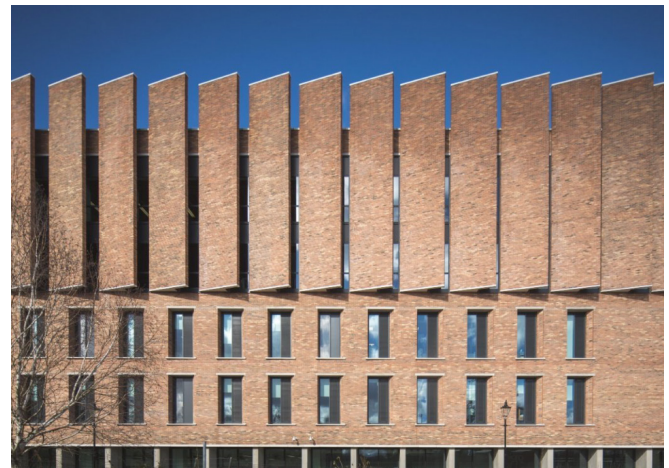
PRECAST CONCRETE

These panels are generally not considered to be a rainscreen system. Whole wall build-ups, including cavity and insulation are possible, which can dramatically speed up construction and benefit sites that suffer from challenging logistics. Although they create their own issues of increased design coordination and less flexibility for changes.

Precast systems can also be used to create details that would not be possible with hand laid construction, which has opened up a new language for brick architecture.



Precast panels with engineering bricks



Precast panels to create details unachievable in hand laid construction



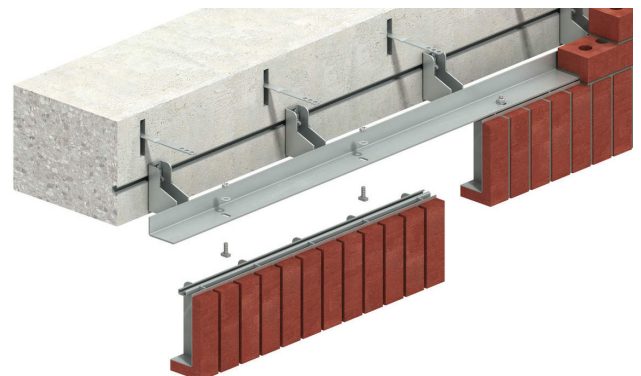
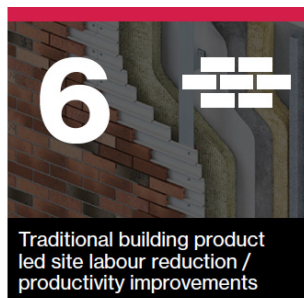
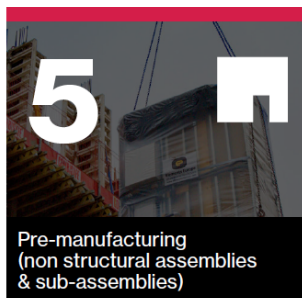
Panels can be fixed to a variety of frame types

PREFABRICATED COMPONENTS

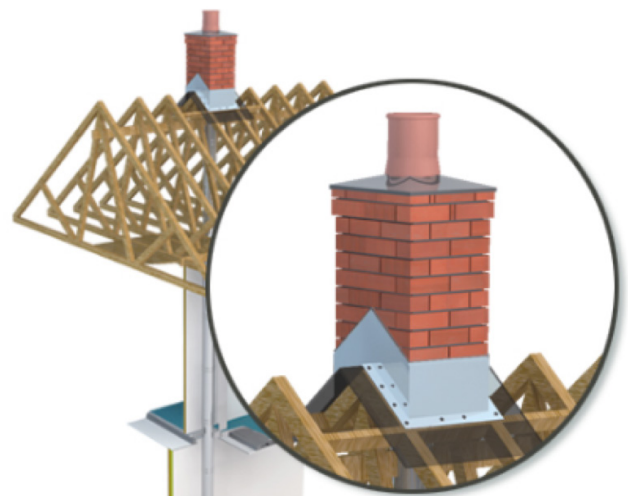
STRUCTURAL COMPONENTS

The most widely used structural components are lintels and arches. Sometimes these will be a single material but more usually they will be a composite of steel or concrete and brick slips. A more recent development is prefabricated brickwork wall panels. These are factory formed brick and mortar walls that can be craned and transported as a unit and then positioned on site, eliminating the need for bricklayers on site.

The use of structural components can reduce the complexity of construction required on site and the amount of formwork and falsework required for construction.



Brickwork soffit system



Pre-manufactured chimney

NON-STRUCTURAL COMPONENTS

Non-structural components tend to be used to reduce the complexity of construction required on site, but don't form part of the primary building structure.

The use of these components essentially shifts the construction time required on site to an off-site manufacturing location. Early engagement with a manufacturer is essential to ensure that construction time and quality improvements are realised.

Some of the most well known examples are pre-manufactured chimneys, which can be lightweight and allow quicker installation. The labour time for complex decorative panels can also be shifted off site if it is beneficial for the construction sequence.

Some non-structural components, such as soffit systems, enable new types of design solution.



Single skin prefabricated brickwork

ROBOTIC CONSTRUCTION

CURRENT SOLUTIONS

Bricklaying robots have been developed which can replicate some of the more repetitive elements of bricklaying. SAM 100 is one of the most well developed solutions available and consists of automated arm on a track, which places the brick with mortar already applied.

CATEGORY DEFINITION

7
Site process led site labour reduction / productivity / assurance improvements



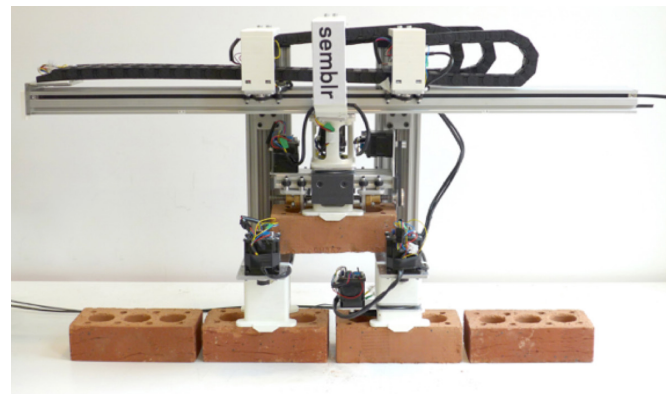
Sam 100 Bricklaying robot in action

ALTERNATIVE APPROACHES IN DEVELOPMENT

The currently available solutions have limitations to their widespread use due to the high capital costs and required enabling works. An alternative 'relative robotics' approach uses a smaller scale robot, which can move over the brickwork and build as 'swarms'. Both approaches require digital modelling of the project which can enable other benefits, such as reducing waste and optimising deliveries.



Developed prototype ready for site trials



Prototype for relative robotics

DESIGN AND SPECIFICATION

MMC SUITABILITY

Once the decision has been made to proceed with a brickwork design solution, the evaluation to determine whether a hand laid or MMC option is appropriate can begin. It is important that the evaluation is holistic and project specific including; cost, speed of construction and quality.

It is impossible to have a 'one size fits all' approach to projects and the most efficient solution may be a combination of hand laid and MMC.

INSTALLATION AND PROJECT LOGISTICS

One of the key principles of brickwork MMC is to increase the construction speed on site, by reducing complexity or transferring the process to an offsite location.

This is a potential benefit for projects with a time critical construction programme, such as schools.



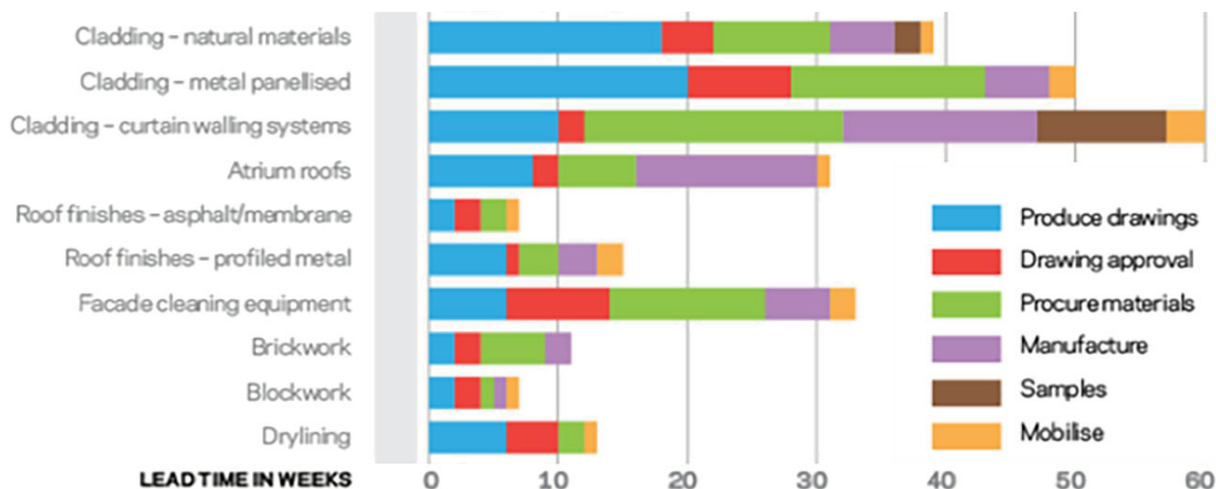
Holistic evaluation is required however, as interdependent factors such as delivery, storage, distribution, crane availability and the possibility to work on multiple construction activities concurrently will also impact the critical path and overall project performance.

Hand laid construction utilises the well-established supply chain of bricklayers, and whilst most MMC solutions can reduce the required installer skill, other MMC solutions require alternative specialist skill sets. The availability of appropriately skilled labour should be carefully considered.

LEAD-IN TIMES

Traditional hand laid construction typically has short lead-in times and ready availability compared to other facade systems. The installation time for MMC systems will often be quicker than hand laid construction however. The different lead-in time will vary the point at which capital outlay is required. Finally, the lead time will also impact when the design needs to be frozen.

For MMC solutions to be beneficial, the holistic time and cost benefits need to be greater than those achieved by hand laid construction.



DESIGN AND SPECIFICATION

PROJECT SCALE

Larger and more repetitive projects will typically maximise the benefits of using MMC. This is because the accumulated benefit of each element can be such that they outweigh the extra coordination required to move the fabrication/construction off-site.



COMPLEXITY OF DETAILING

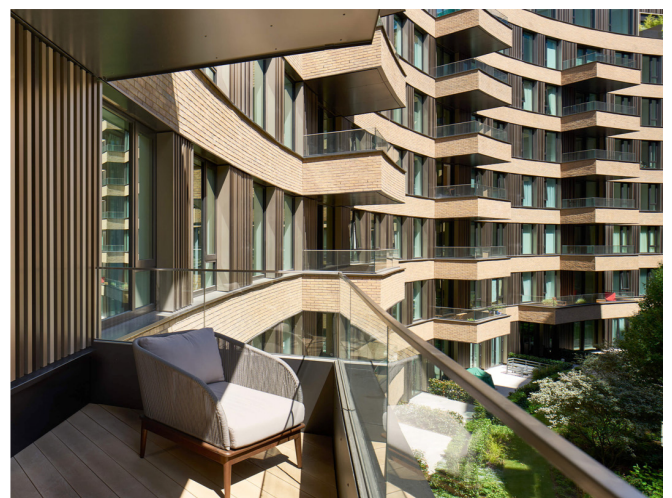
The complexity and the repetition of the brickwork detailing can influence whether MMC will be beneficial. Individual slip and panel systems will achieve the greatest time savings when the detailing is simple and repetitive.

Conversely if the detailing is complex and repetitive then precast or pre-manufactured components may result in a time saving over hand laid construction.

WEIGHT OF CONSTRUCTION

In particular areas, such as gable ends and balconies, reducing the weight of the construction can allow the primary structure to be reduced because less weight needs to be supported.

For these areas, individual slip systems and panel systems can reduce the weight whilst blending in with hand laid panels of brickwork.



DESIGN AND SPECIFICATION

THERMAL PERFORMANCE

For refurbishment and over-cladding of existing structures MMC slip systems can offer an effective solution.

Historic buildings have little or no insulation, so the use of a slip system incorporating external insulation can be a way of improving the facade performance, whilst retaining the attractive appearance of brickwork.



COMPLIANCE AND LIFESPAN

There are a number of different manufacturers producing MMC systems. It is important to ensure that the specified system is appropriate to the risk class of the project.

Third party assessment, such as BBA certification or BSI kite mark can be a useful indication. A positive factor for hand laid brickwork is the long life expectancy and minimal maintenance. Some MMC solutions will not match this long-term performance so care should be taken during specification to ensure that design life of the system is appropriate.

BRICK RETENTION

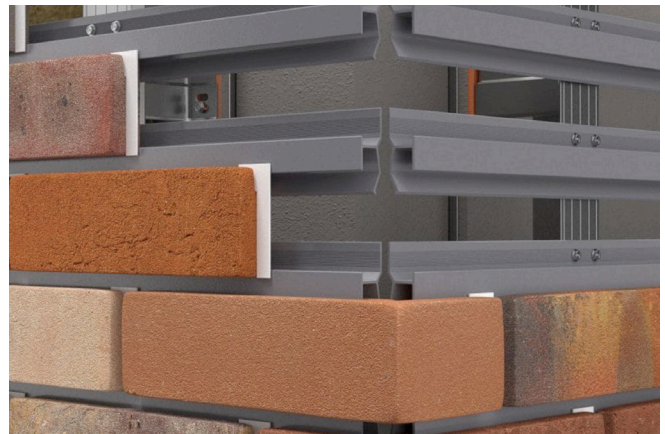
Generally this is not a risk for certified MMC systems. However for individual components and composite systems, it should be confirmed that they are suitable for use in the designed location.

Good installation controls are required to ensure that systems are installed as tested. Poor workmanship or installation in unfavourable weather conditions can affect the performance and appearance.

FIRE AND COMBUSTIBILITY

Brickwork MMC systems will need to comply with the ban on combustible materials above the regulated height threshold and not contribute to the spread of flame below this height.

All systems and components must be evaluated by a suitability competent person who understands the wider fire life safety design and construction strategy.



REFERENCES AND FURTHER READING

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