Design Guide

The use of Hydraulic Lime Mortar in Masonry with Lightweight Steel Framing

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Design Guide

EcoRight Ltd, part of the Owlsworth Building Group, manufactures a comprehensive range of lime based building products.
In a choice of natural earth tone colours for our hydraulic lime mortar range, we are able to achieve a solution for every lime building application.
The highest quality materials are used in our pre-blended products to ensure a consistency is achieved on the finished works.

EcoRight Ltd is a member of ***The Building Limes Forum***, a charitable organisation which works internationally to promote research and education and to encourage expertise and understanding in the use of building limes.

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Forward

Lime is one of the world's oldest building materials having been in use for centuries, dating back to the Romans, and many historical buildings are still in evidence today.
The use of lime mortar declined in the early part of the 20th Century, particularly after World War 2 and with the development of Portland cements. Revival of lime-based mortars requires the re-assessment in the construction of buildings or structures to take into account the characteristics and properties of modern factory blended lime mortars.

In the last 35 years, there has been a renaissance in the use of lime mortars as designers are now appreciating the benefits and applications in their design.
Lime mortars in the UK have stood the test of time from our Victorian heritage through to the modern commercial and residential buildings we see today.

1. INTRODUCTION

1.1 This guide has been prepared to assist Architects and Structural Engineers in utilising the benefits of EcoRight® natural hydraulic lime mortars in the design of external non-loadbearing masonry cavity walls with an outer leaf of lime mortar masonry and an inner leaf of lightweight steel framing. It applies to all building types where lightweight steel framing forms the inner leaf.

1.2 Given the number of permutations of masonry types, loadbearing and wall geometry that are possible, it can only provide general guidance.

1.3 Users of this guide will be experienced in the structural design of masonry to current British Standards & Building Regulations using cement-based mortars.

1.4 This document is for guidance only and the designer must satisfy themselves that this guide is applicable to their particular project/application. It is the designers' responsibility for the overall design of the building.

1.5 A draft specification is attached as guidance only (section 8)

1.6 Specialist advice may need to be sought for unusual arrangements. Should any project not be covered by this generic guidance then please contact EcoRight Ltd to discuss the project further.

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2. BACKGROUND

2.1 Lime has been used as a traditional binder for centuries and generally we associate its use with historic building renovation or conservation.

There is now an increased interest in the use of natural hydraulic lime mortars in modern construction, enabling designers to appreciate the benefits of its use, not just for the repair of historic structures but also for new-build construction.

More research is now available, providing information on the properties and performance of lime mortar, so that standards can be set and design codes written with confidence. There is much published information available to assist the designer. ***'The use of lime-based mortars in new build' by the NHBC Foundation*** gives design data on mortar strengths for direct use in ***BS 5628, 'Code of practice for use of masonry*** for the structural design of masonry. BS 5628-1 is now superseded but its replacement, BS EN 1996 does not include information for the use of lime mortars, so BS 5628 should continue to be used.

2.2 The lateral strength of a traditional cavity masonry wall panel is calculated by taking the sum of the lateral strengths of each leaf. The deflection of each leaf is similar, due to the similar stiffness of the two leaves.

2.3 There is no codified guidance on the design of thin masonry veneers in conjunction with lightweight steel framing.

2.4 With an inner leaf of lightweight steel framing there is a disparity between the stiffness of the steel framing system when compared to the stiffness of a masonry panel. Analysing a sample masonry panel backed with lightweight steel framing suggests that approximately 80% of the wind load will be carried by the masonry. The masonry cannot sustain this load and therefore the panel must be considered as a cracked section, to enable the wind load to be transferred to the inner leaf of lightweight steel framing.

2.5 Lightweight steel framing systems have been in popular use for a limited time and therefore not all buildings where it has been used will have experienced the full design wind loading. The effects of the cracked section on the long-term durability and weather resistance of those buildings that have been subject to full design wind loading are not known. However, currently there are no reports in the industry of the system failing.

2.6 Manufacturers of lightweight steel framing will generally design their system to have sufficient strength to take the full design wind load, ignoring any contribution from the masonry outer leaf. However, the manufacturer may limit the amount of deflection at full load to only height/360 or even as much as height/180. Deflection at these levels may cause cracking and such framing is not considered stiff enough to provide adequate restraint to masonry.

2.7 Issues of stiffness of lightweight steel framing systems is not limited to their use with walls using lime mortar. Concerns with brick leaf cracking are equally applicable for walls using cement mortars.

3. MATERIALS

3.1 Identification

The dry mortar is available in 25kg bags, IBC's or silo options.

For large, individual projects and building developments, mortar can be supplied in silo form, which can hold up to 22 cubic metres or 35 tonnes of dry mix. The Silo is fitted with a control panel and "high-shear" mixer that regulates water input and mix flow, producing a consistent mortar at the touch of a button. For smaller projects the mortar is available in 25kg or IBC's which can be then mixed in a conventional drum mixer.

EcoRight mortars are manufactured under factory conditions using natural hydraulic limes (NHL5 and NHL3.5) and a blend of well graded sharp sands.

All mortars are produced to EcoRight mix design recipes and marketed under the EcoRight brand - your assurance of quality and consistency

3.2 Authority

EcoRight mortars comply with the durability requirements of BS5628: Part 3:2005. Mortar strengths are measured at 91 days as opposed to 28 days, as lime mortars gain strength more gradually compared to Portland cement-based mortars.

Materials used conform to the following standards:

Sand	BS EN 13139: 2013 Aggregates for Mortar
Natural Hydraulic Lime (NHL)	BS EN 459: Part 1: 2015 Building Limes
Calcium Lime (CL90)	BS EN 459: Part 1: 2015 Building Limes
Pigments	BS EN 12878: 2014

Water added on site should be clean and free from impurities.

3.3 General Advantages

EcoRight mortars offer several mix advantages:

- Consistent mix proportions
- Consistent quality of mortar
- Correct choice of sands
- Mortars can be re-worked for up to 24 hours
- Reduction in wastage
- Increased productivity as there is no need to allocate one individual for mixing.

4. PRODUCT DATA

4.1 Manufacture

EcoRight mortars are manufactured using factory batching techniques.

Raw materials and end products are subject to regular quality control procedures and testing. The materials are weighed and mixed with rigorous quality control procedures.

Although mortar is traditionally specified by volume, it is generally accepted that batching by weight produces mortar of a greater consistency.

4.2 Mortar Mix Proportions

EcoRight Hydraulic Lime Mortar M5
A class M5 mix with the following proportion 1:2. EcoRight Hydraulic Mortar will reach HLM5.0 (class III) at 28 days and HLM5 (class II) at 91 days (high resistance to freezing & thawing, high resistance to sulphates).

Mortar class	Lime : sand (vol/ vol)	BS 5628 Mortar mix Durability Designation	Hydraulic lime Mix designation	Typical Compressive strength (N/mm2 @ 91 days)	Mortar Durability Class
M5	1: 2	(iv) at 28 days (iii) at 91 days	HLM5.0	5.0	7-8

EcoRight Hydraulic Lime Mortar M2.5
This is known as a **moderate** mix with the following proportion 1:2¼. EcoRight Village Moderate Hydraulic Mortar will reach HLM1 (class IV) at 28 days and HLM2.5 (class III) at 91 days (good/high resistance to freezing & thawing, high resistance to sulphates).

Mortar class	Lime : sand (vol/ vol)	BS 5628 Mortar mix Durability Designation	Hydraulic lime Mix designation	Typical Compressive strength (N/mm2 @ 91 days)	Mortar Durability Class
M2.5	1: 2½	(iv) at 28 days (iii) at 91 days	HLM2.5	2.5	5-6

The above is meant as a guide only; if you wish to discuss a specific application in further depth, please call our sales office.

4.3 Performance

EcoRight mortars are more flexible than Portland cement-based mortars, allowing for increased movement joint spacing or avoiding movement joints altogether.

EcoRight mortars offer excellent vapour permeability, enabling buildings to" breathe", preserving the brickwork.

EcoRight mortars are formulated to meet strength and durability requirements. Strength of lime mortars are normally specified at 91 days (see 5.3).

DESIGN CONSIDERATIONS

4.1 Limitations

5.1.1 This guide applies to designs that meet the following criteria:

(i) Masonry panels subject to lateral wind loading and vertical self-weight only.

(ii) Masonry panels restrained on two or more sides.

(iii) Masonry panels tied back to a concrete or steel frame. The steel frame may be fabricated from hot rolled or lightweight cold rolled steel.

(iv) Masonry panels with an inner leaf of cold formed lightweight steel framing.

5.1.2 This guide relates primarily to clay masonry as there is very little information on the use of lightweight steel framing systems with facing blocks or stonework. Advice should be sought from the manufacturer of these materials as to their suitability for use with lightweight steel framing.

5.2 Considerations

Consideration on the use of lime mortar needs to be early in the design and planning stage and allow for the "constraints" of the material to be fully utilised as benefits, which are:

- More tolerance to movement
- Movement within the walls is accommodated in the bed joints therefore reducing the requirement for vertical joints
- Improved breathability – absence of condensation and dampness
- Capable of self-healing
- Less susceptible to sulphate attack
- Cold weather working
- Slow rate of strength gain
- Speed of construction

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5.3 Mortar classification

Classification of mortar type to be used is dependent on exposure conditions and/or loading (contact EcoRight Ltd for further guidance).

In general, an M2.5 moderately hydraulic lime mortar will cover most applications for cavity wall construction, solid brick, blockwork and stonework.

If a higher level of durability is required such as parapets, chimneys or below dpc, then an M5 eminently hydraulic mortar should be used.

5.4 Mortar strength

Cement based mortars achieve their target strength and are tested at 28 days, however, for hydraulic lime mortars the strength development is much slower and design strength isn't achieved until 91 days.

Masonry constructed using a lime-based mortar will develop sufficient strength and resistance to vertical loading.

Consideration should be made if excessive lateral loadings are expected. Single skin brick or blockwork will have sufficient resistance to vertical loads.

6 DESIGN GUIDANCE

6.1 The stiffness of the lightweight steel framing needs to be sufficient so that the deflection under full design loading is limited, to ensure that the masonry remains un-cracked.

6.2 To limit the risk of cracking the outer leaf of masonry the horizontal and vertical deflection of lightweight steel framing should be limited to panel height/500 and panel length/500 at full design load. Cantilever panels such as parapets should have the horizontal deflection limited to height/250.

6.3 Lightweight steel framing should be designed with sufficient strength to support the full design loads, ignoring any contribution from the masonry.

6.4 Stud spacing should be limited to 400 centres maximum horizontally.

6.5 Consider the aspect ratio of the panels. It is recommended that this does not exceed 4 lengths:1height.

6.6 Mortar to be EcoRight Class M2.5 (HLM 2.5) or EcoRight Class M5 (HLM 5) as required by EN BS 5628. Lime putty mortar should not be used.

6.7 The frequency of wall ties should be increased with ties provided at 400mm centres horizontally and 300mm centres vertically.

6.8 Wall ties to be Type 1.

6.9 Movement joints should generally be placed at closer spacing than for other masonry walls constructed with lime mortar. It is recommended that movement joints be spaced at a maximum of 18m for straight walls and 9m from stiff returns. Joints may need to be at closer centres for panels with openings, of large aspect ratio, parapets and large changes in section, in accordance with normal practice.

6.10 Plasterboard or other board of at least equivalent strength should be screwed onto the inside face of the lightweight steel framing to increase the overall stiffness of the wall panel.

7 CONCLUSION

7.1 Masonry laid in lime mortar can be successfully constructed with lightweight steel framing as an inner leaf, provided that the steel framing has sufficient stiffness.

7.2 To achieve the required stiffness, it is recommended that the deflection of the lightweight steel framing system is limited to height/500 or length/500. Deflection of cantilever parapets should be limited to height/250.

7.3 The strength of the steel framing should be sufficient to carry the full design loading on the masonry panel, ignoring any contribution from the masonry.

7.4 This design guide will be updated at intervals and the design process will continue to evolve as new data becomes available.

8 DRAFT SPECIFICATION

Draft Performance Specification for Lightweight Cold Formed Steel Framing System (SFS)

1.0 Introduction

1.1 (*Insert brief description of where the SFS is to be used)*. For the exact location and setting out of all SFS systems and size of masonry panels and openings, reference should be made to the relevant Architect's drawings.

1.2 This performance specification refers to the use of the (*Insert manufacturer's name and product reference*) Steel Framing System; however, the contractor may propose a similar system by an alternative manufacturer. Any alternative system shall meet this performance specification and be approved by both the Architect and Structural Engineer prior to its use.

1.3 The purpose of the Steel Framing System is to provide lateral restraint to the external masonry against wind loads. The loads shall be transferred from the masonry through the SFS back to the main superstructure. The dead load of the masonry shall be supported by the structure.

1.4 The SFS shall be designed by the specialist supplier in accordance with this specification. Detailed calculations for wind loading/stud design and panel layout shall be submitted to the Structural Engineer and Architect for comment prior to fabrication/erection.

1.5 The SFS system shall be erected by a SFS approved installer.

1.6 This specification is with regard to the structural performance only, for all insulation, lining and masonry refer to the Architect's details.

2.0 Loading and Design Criteria

2.1 The system shall be designed to withstand wind loads as described within BS 6399: Part 2; 'Loadings for Buildings. Code of Practice for Wind Loads'. Wind loads shall be determined from the building plan, height, orientation and local topography utilising the following coefficients;

Building Type Factor	K_b = *(project specific)*
Ground Roughness Category	*(Town/ Country)*
Size effect factor	C_a = 1.00
Seasonal Factor	S_s = 1.00
Probability Factor	S_p = 1.00

The ground floor altitude of the site shall be taken as *(project specific level AOD)*.

2.2 Specific wind load calculations for each block shall be submitted to the Structural Engineer forcomment.

2.3 The maximum serviceability lateral deflection of each stud shall be limited as follows:

Maximum stud lateral deflection for studs restrained at top and bottom = H / 500
Maximum stud lateral deflection at top of cantilever studs = H / 250

where H = clear storey height or height of cantilever.

2.4 Specific stud calculations shall be submitted to the Structural Engineer for comment.

2.5 Studs shall be located at maximum 400 centres.

3.0 General Specification

3.1 Products

3.1.1 All Studs, joists and accessories shall be of the type, size, gauge and spacing as determined by structural calculations and as shown on the drawings, and shall be supplied by (*Insert manufacturer's name, address and contact details and product reference*) (*or a similar approved specialist)*

3.1.2 All structural members shall be designed in accordance with BS5950-5:1988 – Structural use of steelwork in building, Part 5 'Code of Practise for Design of Cold Formed Thin Gauge Sections'.

3.1.3 All framing members shall be formed from hot dipped galvanised steel Z35 quality with yield of 350 N/mm^2.

3.2 Fabrication

3.2.1 Prior to fabrication of framing, the Contractor (or SFS manufacturer) shall submit typical details and panel drawings to the Architect or Structural Engineer to obtain comments.

3.2.2 Any prefabricated panel shall be square, with components attached in a manner as to prevent racking and to minimise distortion while lifting.

3.2.3 All framing components shall be cut squarely for attachment to perpendicular members, or as required for an angular fit against abutting members.

3.2.4 Insulation equal to that specified elsewhere shall be provided in all boxed sections not accessible after erection.

3.2.5 Fastening of components shall be with self-drilling, self-tapping screws to approval by SFS manufacturer. Screw size and pattern shall be as determined by the structural calculations and shall always be of sufficient size to ensure the strength of connection. Wire tying of components will not be permitted.

3.3 Erection of Studs

3.3.1 Runners shall be securely anchored to the supporting structure as determined by the structural calculations and as shown on the specialist's drawings.

3.3.2 Complete, uniform and level bearing support shall be provided to the bottom runner.

3.3.3 Abutting lengths of runner shall be securely anchored to a common structural element.

3.3.4 Studs shall be plumbed, aligned and securely fixed to runners in accordance with SFS manufacturer's design.

3.3.5 Framing of wall openings shall include headers, lintels and supporting studs as shown on the specialist's drawings.

3.3.6 Temporary bracing will be provided where required until the completion of erection.

3.3.7 Resistance to bending and rotation about minor axis shall be provided by bracing and strapping, as shown on the specialist's drawings.

3.3.8 Splices in studs shall not be permitted.

3.4 Erection – General

3.4.1 All screw fixings are to be drawn perpendicular to the surfaces to be fixed. Skew fixings will not be accepted.

3.4.2 Distortion of the metal to achieve connections will not be accepted.

3.5 Brick Ties

3.5.1 Brick ties shall be stainless steel Type 1 to suit cavity and insulation type at maximum 400mm centres horizontally and 300mm vertically.

3.5.2 Brick ties shall be provided at 225mm vertical centres immediately adjacent to openings (at jambs/ cills and head members).

3.5.3 Brick ties shall be provided at 400mm centres horizontally and 225mm vertically within a zone 1.5 metres from the corner of a building.

3.6 Inspection

3.6.1 Prior to the installation of any lining board or cladding, the SFS shall be inspected by the SFS manufacturer. The manufacturer shall provide written confirmation that the system has been installed in accordance with their designs and drawings.

3.6.2 Prior to the installation of any lining board or cladding, the Structural Engineer shall be notified. The Structural Engineer shall be provided with the opportunity to inspect and comment upon the installed system.

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