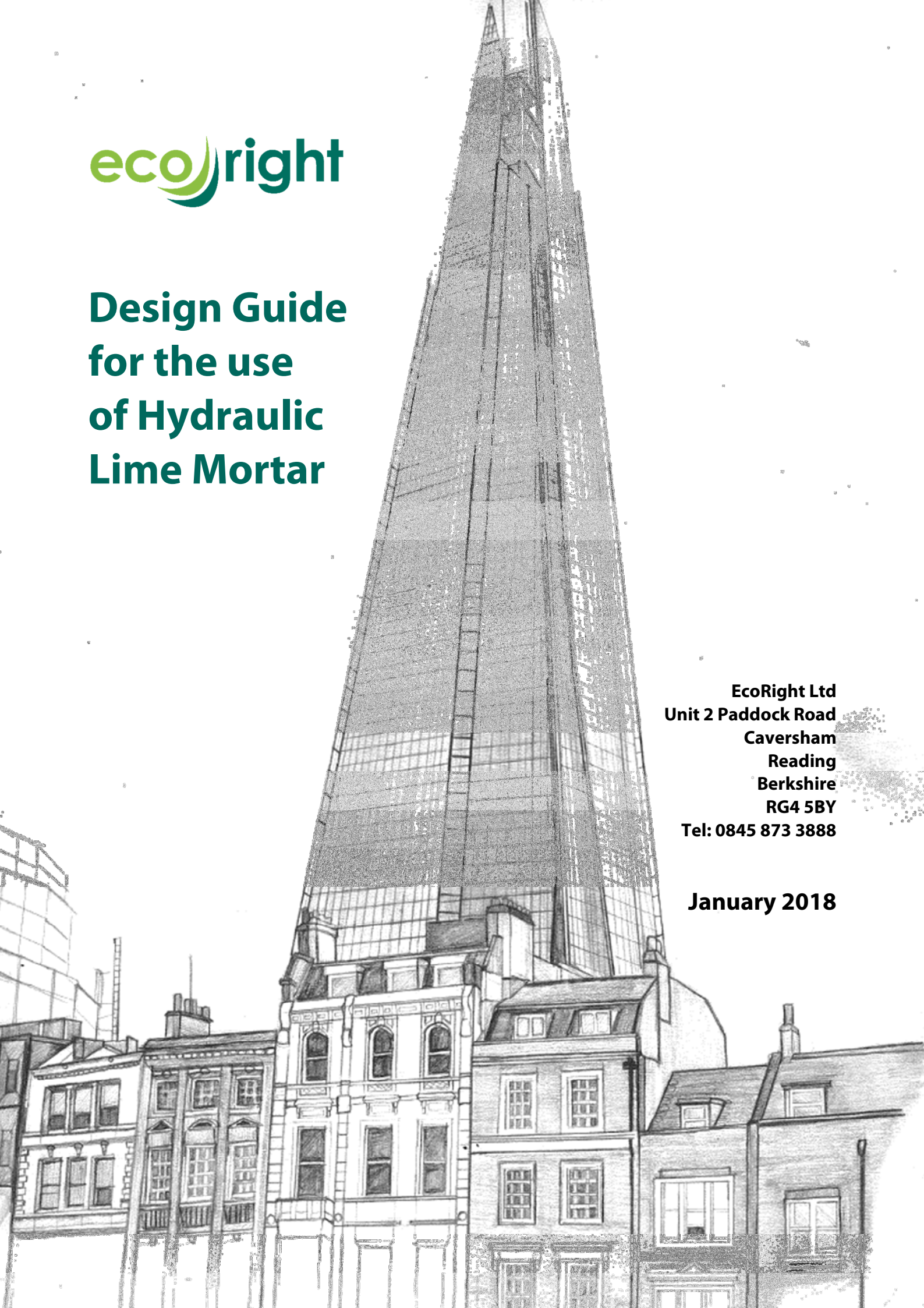
# Design Guide for the use of Hydraulic Lime Mortar



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January 2018

EcoRight Ltd, part of the Owlsworth Group of Companies, 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.

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

**1.3** 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.

**1.4** This guide applies to all building types with masonry walls, loadbearing or non-loadbearing and also where lightweight steel framing forms the inner leaf. Given the number of permutations of masonry types, loading and wall geometry that are possible, it can only provide general guidance.

**1.5** 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.

## 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 5628-1, 'Code of practice for use of masonry*** for the structural design of masonry. BS 5628-1 is now superseded but its replacement, BS EN 1996-1 does not include information for the use of lime mortars, so BS 5628-1 should continue to be used.

**2.2** Paul Livesey, recognised as a leading industry expert, looks at the development in the use of lime as a building material in ***"Building limes in the United Kingdom"***. The book also examines its use today focusing on mix designs, aggregate types and durability.

**2.3** For further details on the range of lime mortar products available from EcoRight Ltd, visit our website www.ecoright.co.uk or telephone 01189 469 153 or email info@ecoright.co.uk.

## 3. MATERIALS

### 3.1 Identification

The dry mortar is available in 25kg bags, 1 tonne bulk bags 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 30 tonnes of dry mix (due to weight restrictions the maximum initial delivery is 15 tonnes). 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 bulk bags which can be then mixed in a conventional drum mixer.

EcoRight mortars are suitable for use in blocklaying and stone masonry work and also as a backing or final coat render/plaster.

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 3:2001. 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: 2002 |
| Natural Hydraulic Lime (NHL) | BS EN 459: Part 1: 2001 |
| Calcium Lime (CL90) | BS EN 459: Part 1: 2001 |
| Pigments | BS EN 12874 |

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**
This is known as an **eminent** mix with the following proportion 1:2. EcoRight Eminent 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 |
|---|---|---|---|---|---|
| Eminent hydraulic | 1 : 2 | (iv) at 28 days<br>(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 |
|---|---|---|---|---|---|
| Moderately hydraulic | 1 : 2½ | (iv) at 28 days<br>(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).

## 5. DESIGN CONSIDERATIONS

### 5.1 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

### 5.2 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.

### 5.3 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 GUIDE

### 6.1 Design Benefits

The use of lime mortar allows any movement to be accommodated in the bed joints, therefore reducing the requirement for vertical movement joints. There is greater tolerance to movement, particularly in high buildings/structures (see 6.2).

Improved breathability allows moisture vapour to move freely through the mortar joint, reducing the likelihood of frost damage in the brickwork.

In the manufacturing process lime produces less carbon dioxide than cement as it is burnt at lower temperatures, saving on fuel consumption and emissions of pollution and greenhouse gases. $CO^2$ emissions are around 20% lower than in cement manufacture. Lime mortar will also absorb $CO^2$ during the hydration process (carbonation) and over a period of time become carbon neutral. Changing to a lime based mortar will make a significant contribution in reducing $CO^2$ levels in the UK.

Due to lower bond strength, the bricks/masonry can be easily cleaned and recycled at the end of the building's life.

### 6.2 Movement Joints

The movement in a masonry wall can be accommodated in the bed joints, therefore reducing the need for vertical movement joints.

Traditional masonry work did not use expansion joints, which actually made building much simpler and aesthetically more pleasing

6.2.1 Lime mortars have an inherent flexibility to accommodate minor movements in brickwork, allowing movement joint spacing to be increased or avoided altogether. Movement is accommodated in the individual bed joints.

When movement occurs in a building, hairline cracks will form in the mortar joints, but due to the autogenous healing properties of lime mortar through carbonation, any micro cracks are sealed. This is the result of movement of rainwater through the surface and dissolving the free lime.

6.2.2 In general, movement joint spacing can be increased by 2 ½ times the standard requirement for a cement based mortar application, 30m for brickwork and 15m for blockwork. Reduced spacing will be necessary near to corners or in areas with many openings.
In very large masonry panels without openings it is possible to increase the spacing further, depending on the length to height aspect ratio.

6.2.3 As significant movement can occur at the corners of buildings due to the brickwork sliding on the damp proof course (DPC), bed joint reinforcement can be installed to counteract the movement.

6.2.4 Joint spacing needs to be considered on a project by project basis, giving due consideration to fully utilising the benefits of designing masonry using a lime mortar.

## 7. WALL TIES

The selection and spacing of wall ties is dependent on various factors. These include type of masonry, cavity width, height of structure and location. Refer to Eurocode 6 Design of Masonry Structures (BS EN 1996 -1-1 2005) for guidance.

**7.1**
Wall ties for use with lime mortars should be stainless steel and types 1, 2, 3 or 4 depending on design loading. Spacing is the same as for cement based mortars. In large panels, differential movement can occur between the inner and outer leaf of a cavity wall construction. In this instance it is preferable and advisable to use flexible wall ties, to allow this movement and avoid cracking.

## 8. 8.0 BUILDING WITH LIME

### 8.1 Rate of Laying

There is very little difference in the build rate between a cement based and lime based mortar. Daily lift heights of 1.5m are possible. This applies for masonry units with an absorption of around 12-15%. For bricks with much lower absorption rates of 2-5% such as engineering bricks, there is a restriction on height generally as low as 2-3 courses per day. Consideration should be given on any temporary loading that may affect the build rate.

### 8.2 Pointing

Whenever possible, avoid recessed joints as they are likely to encourage water trapment in the bed joints and lead to potential joint failure. To allow rainwater to be shed the preferable option is flush pointing.

### 8.3 Winter Working

Working with lime mortar can proceed in winter providing adequate protection is given, as frost damage is very possible in the fresh mortar. In general, ***mortar should not be used if the temperature is at 5°C and falling or 3°C and rising.*** At below 5°C lime mortars will not harden until the temperature has increased above this level. It is therefore important to protect from the risk of frost attack.

### 8.3 Adverse weather conditions

Lime mortars do build up strength much slower and in extreme weather of direct sunlight, driving wind and rain, protection should be provided during the setting process.

### 8.4 Frost attack

Should frost damage occur in the freshly laid mortar then leave in place until weather conditions improve and simply rake out the joints and re-point. Under no circumstances should anti-freeze admixtures be used.

**8.5 Sulphate attack**

Due to the lower burning temperatures in the manufacture of hydraulic limes, there is an absence of Tri-calcium aluminate (C3A). As a result, lime mortars are less susceptible to sulphate attack