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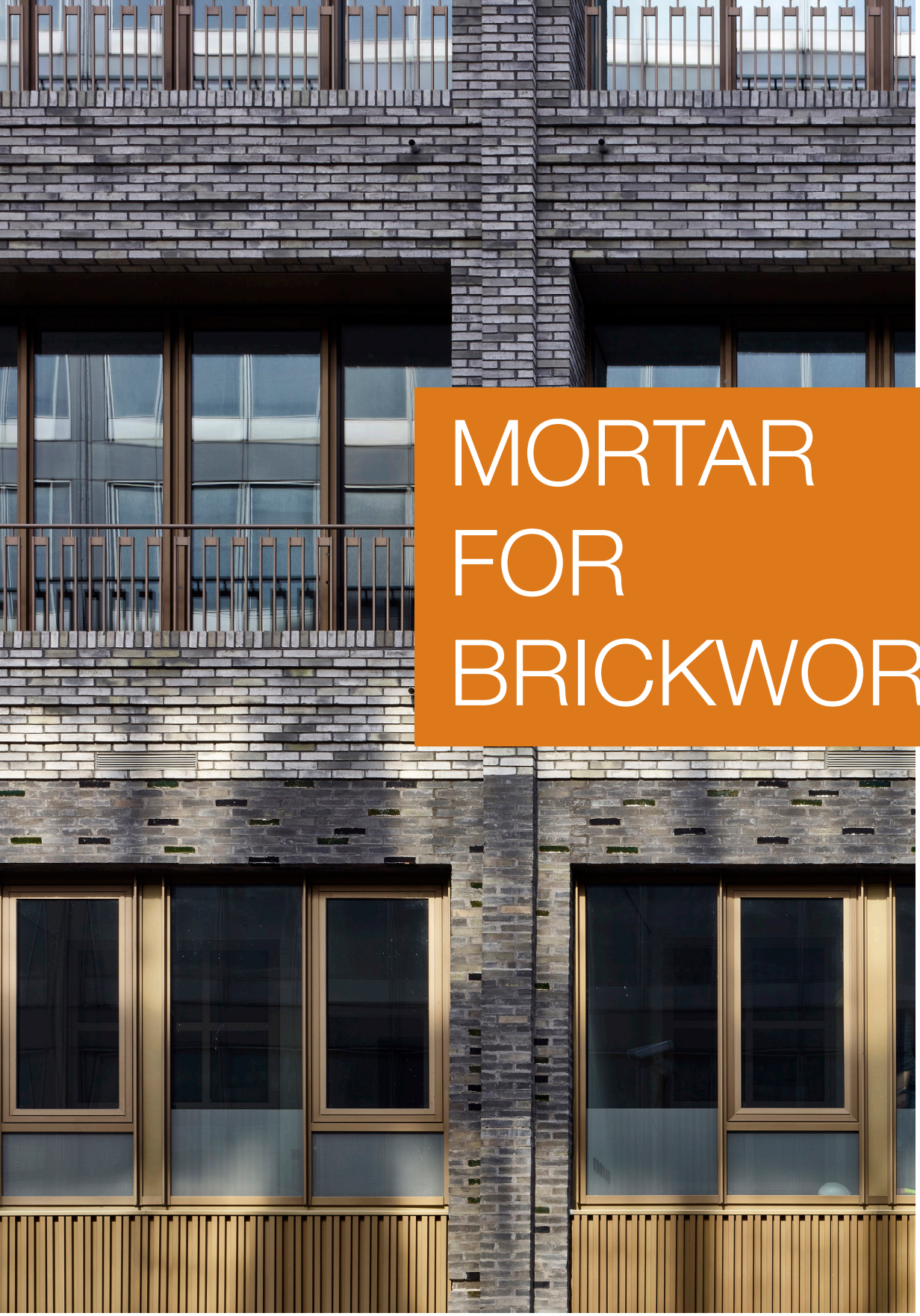


# MORTAR FOR BRICKWORK

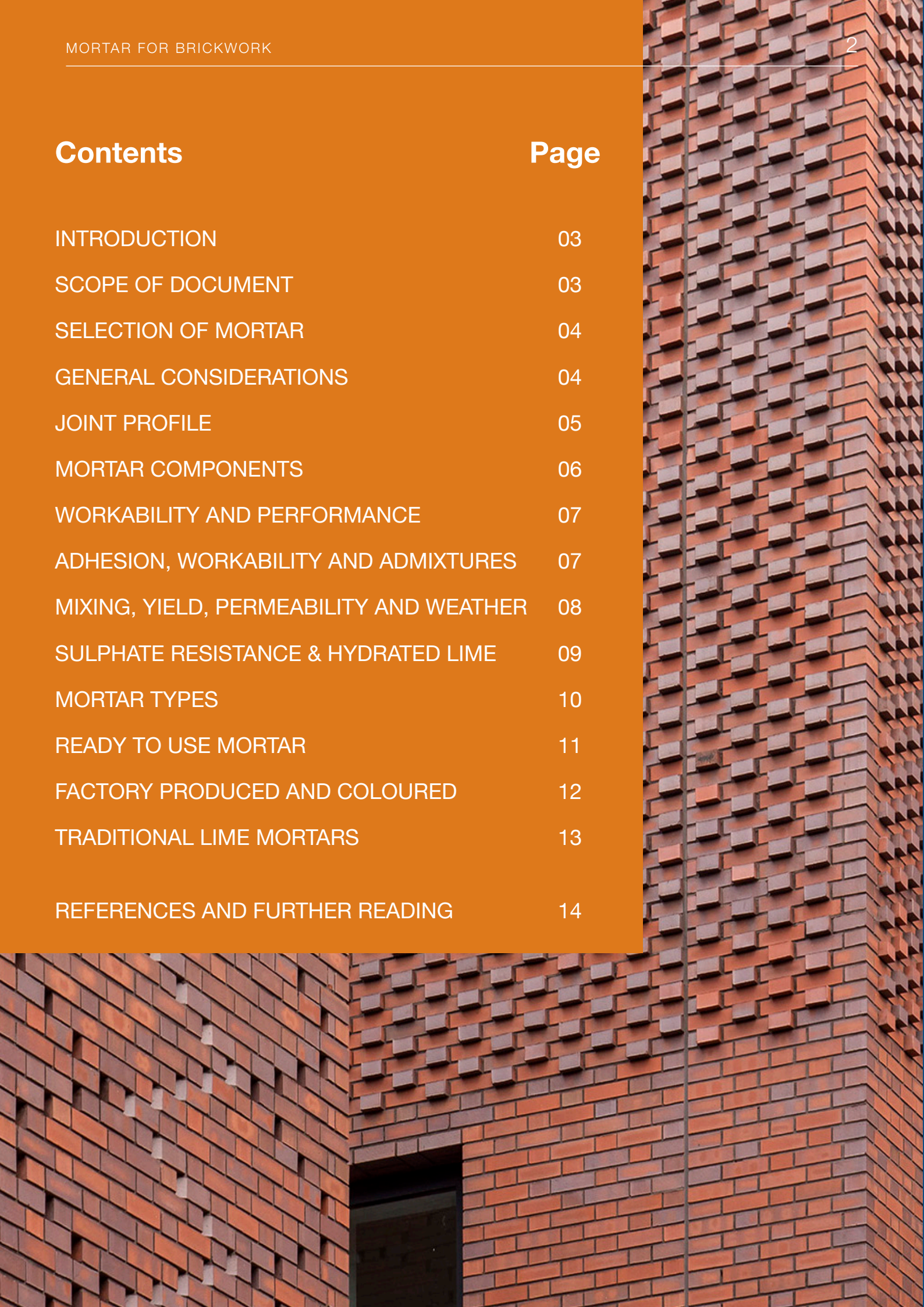
Brick Development Association

www.brick.org.uk

BRICK DEVELOPMENT ASSOCIATION

## Contents Page





# INTRODUCTION

Mortar is a workable paste used to bind bricks and other masonry units together.

A mortar joint acts as a sealant, a bearing pad, the glue that sticks the units together yet keeps them apart and, in this sense, performs as a gap-filling adhesive.

Its role is also to seal irregular gaps between masonry and provide a barrier to the passage of moisture.

The correct designation of mortar is vitally important in providing not only strength to the wall construction but also durability against water ingress.

**Amsterdam residence. Levs Architecten**

# SCOPE OF DOCUMENT

This document provides an overview of considerations and options when selecting mortars, including the joint profiles.

There is also a summary of the constituent parts of mortar and the different factors which can affect workability and performance.

Finally there is an explanation of the available mortar types , including traditional lime mortars.

**Hospital Auditorium. Dehullu Architecten**

**Scottish Water. Reiach & Hall**

# SELECTION OF MORTAR

Mortar accounts for approximately 17.5% of the brickwork built in stretcher bond and therefore it is important to consider the correct selection of mortar, which can be designed or prescribed in accordance with BS EN 998-2, Specification for mortar for masonry.

## GENERAL CONSIDERATIONS

When selecting mortar, the designer should give careful consideration to the following characteristics:

- Appearance - joint profile and colour
- Structural requirements
- Type of construction and position in the building
- Degree of exposure
- Compatibility between brick and mortar strength
- Reference to table 15 in PD 6697 and Annex B.2 BS EN 1996-2

**Mortar being delivered to site**

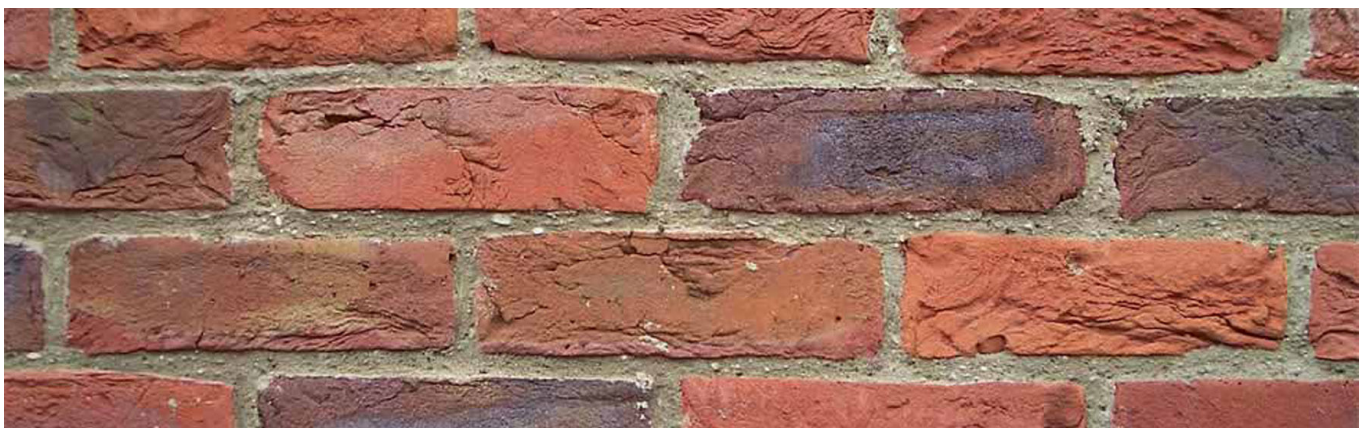
Mortar for brickwork can be divided in to two groups; designed mortars and prescribed mortars.

## DESIGNED MORTARS

The composition and manufacturing method is selected by the producer to achieve specified properties. Designed mortars are classified by their compressive strength.

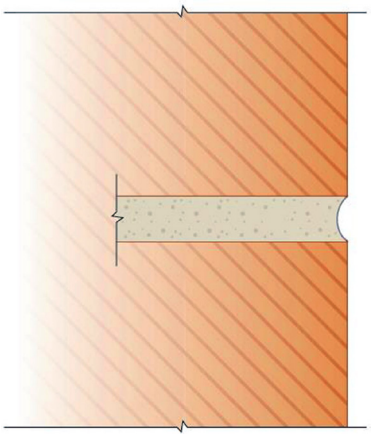
## PRESCRIBED MORTARS

Prescribed mortars are made in pre-determined proportions, the properties of which are assumed from the stated proportions of the constituents and are classified by designations. It is difficult to state categorically that the proportions can be equated to the strength intimated in Table 1 on page 10 but it is sufficient as a guide.



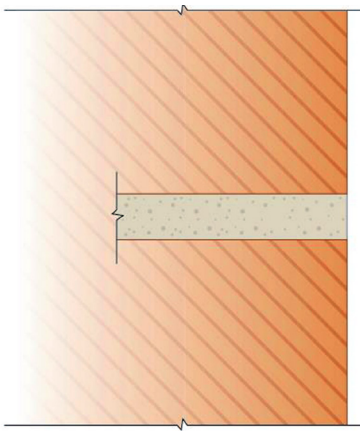
**Mortar choice can have a big visual impact on brickwork**

# SELECTION OF MORTAR - JOINT PROFILE



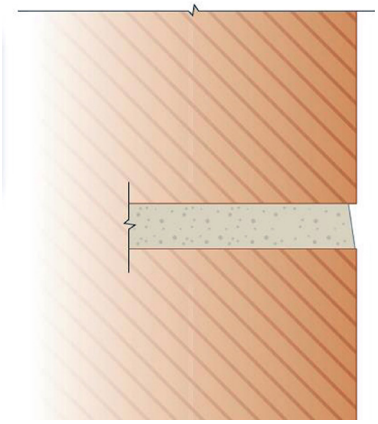
## BUCKET HANDLE JOINT

This type of joint is the most commonly used in which the face of the joint is compressed and provides the most durable profile.



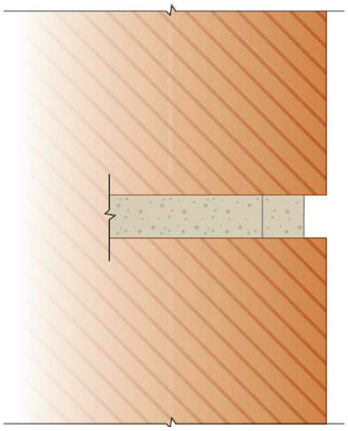
## FLUSH JOINT

This is the simplest but potentially least durable. As this joint has not been compressed by a finishing tool it should not be used in areas of severe exposure.



## WEATHER STRUCK JOINT

This joint is recessed at the top slightly sloping to allow for the dispersion of rainwater. It has excellent strength and water resistance. Perpends should also have this profile.



## RECESSED JOINT

The maximum depth of the recess should not exceed 4mm and should be ironed to compress the joint's surface. When using this joint profile consideration should be given to the exposure of the wall and brick type.

# MORTAR COMPONENTS

## SAND

Sand is the major component in mortar and correct choice of well graded sand in the correct quantity is important. A good quality building sand should always be used. Sand with a high percentage of fine particles or containing clay/silt will require additional water in the mortar mix, produce a weak mortar, provide reduced durability and may result in shrinkage of the mortar.

**Sand is the major component in mortar**

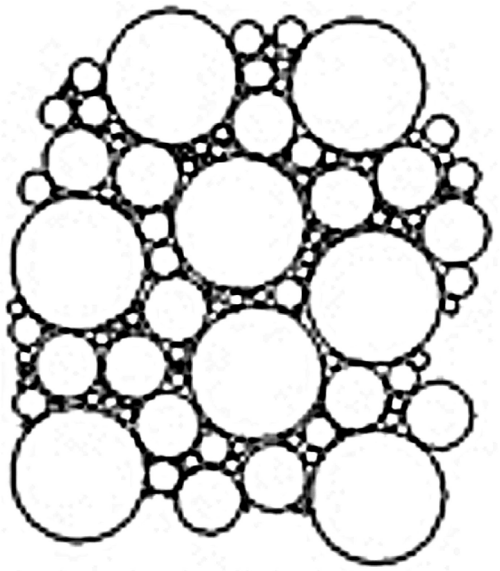
## CEMENT AND/OR LIME TO FILL THE AIR SPACE

The air space between sand grains represents approximately one third of the volume. The types of binder used to fill that air space alter the strength and physical properties of mortar.

For example, 1 part cement to 3 parts sand will result in the sand voids (air spaces) being completely filled, producing a very strong but brittle mortar.

Alternatively 1 part cement to 1 part lime to 6 parts sand produces a well filled mortar, but with the extra adhesion and flexibility given by the lime, balanced by the strength of the cement.

Altering these proportions to suit the strength requirement, exposure level, and workability or weather conditions can be of considerable benefit to the durability of the final brickwork.



**Air between sand grains is roughly a third of the total volume**

## WATER CONTENT

Variations in the water suction rate of bricks can adversely affect bricklaying. The wetness of the mortar mix can be increased or reduced to maintain a consistent level of moisture whilst laying. Only with high suction rate bricks in warm weather conditions should dunking (or wetting) of the bricks be considered. If it is undertaken the bricks should not be soaked and only clean fresh water should be used to avoid soluble salt contamination.

# WORKABILITY AND PERFORMANCE

## MORTAR ADHESION

For good adhesion to brick, mortar must have good workability. Poor workability will result in air spaces between mortar and brick, preventing good bond formation, water ingress and durability issues.

Bricks with a rough textured bed face and medium suction rates will have greater bond performance with mortar than smooth textured low suction bricks.

Bricks with high initial suction rates may rapidly absorb moisture during laying (particularly in warm weather). If too much water is lost through this suction, repositioning bricks during levelling may become difficult as well as resulting in a poor bond. Laying shorter runs of walling will help along with a light wetting of bricks prior to application of mortar. Over wetting should be avoided as this will result in “floating” on the mortar bed and may contribute to excessive efflorescence and staining, such as 'picture framing'.

**Temperature will have an impact on the water content required**

## WORKABILITY

Mortars that contain only cement and sand tend to be coarse and have poor workability. If additional water is added to improve workability, this will have a negative effect on strength and drying shrinkage. The addition of lime will increase workability, reduce the water requirement and improve strength and resistance to shrinkage within mortar beds.

## ADMIXTURES

There are a number of different types of commercially available admixtures that can be added to mortar to enhance workability and performance. All admixtures’ use should be strictly controlled and in accordance with the manufacturers’ instructions on dosage.

Primarily admixtures are used to retard the set of mortar when conditions require this or provide air entrainment to assist workability and prevent shrinkage within mortar joints. Air entrainment plasticisers are used to replace lime within the mix. Excessive use of this admixture will have a negative effect on durability weather-tightness due to increased porosity especially when used in pointing mortar. Air entrainment additives should not be used in conjunction with masonry cements which already contain lime as a plasticiser.

Washing-up liquids and any additives containing calcium chloride should not be used as they can weaken the mortar and contribute to efflorescence staining.

# WORKABILITY AND PERFORMANCE

## ON-SITE MIXING

Accurate gauging of mortar component materials is required to ensure the correct mortar designation and the desired performance. The use of a gauging bucket/box will provide accurate method of achieving this. Inaccurate gauging will affect structural performance, water demand, durability and resistance to movements and sulfates.

**Increased demands for accuracy means that site mixing is less common**

## QUANTITY YIELD

One tonne of ready mixed lime:sand, when gauged with the specified quantity of cement on-site will generally be sufficient to lay approximately 1000 bricks.

## PERMEABILITY

Cement rich mortars (strong) will provide better resistance to water penetration but offer less resistance to shrinkage within the mortar. Proper selection of building sand with good grading will reduce the amount of voids between the sand particles. However weak mortars containing less cement will not bond all the sand particle, therefore allowing water to penetrate more easily. Uneven mixing of mortar will also result in a poor distribution of cement in areas of the mortar mix and may lead to rain penetration under certain conditions of moderate exposure.

For further information on design considerations please refer to BDA document *Severely Exposed Brickwork.*

## WEATHER

Mortar should not be used in construction if environmental conditions are 2°C and falling. Water in the mix will freeze and result in poor strength and increased porosity (reduced resistance to the passage of water). Frozen mortar should be discarded and any unfrozen mortar should not be used on frozen bricks.

Mixed mortar as well as freshly laid mortar should always be protected from inclement weather and never “knock up” mortar once it has started to set.

For further information on workmanship please refer to BDA document *Good Site Practice and Workmanship.*

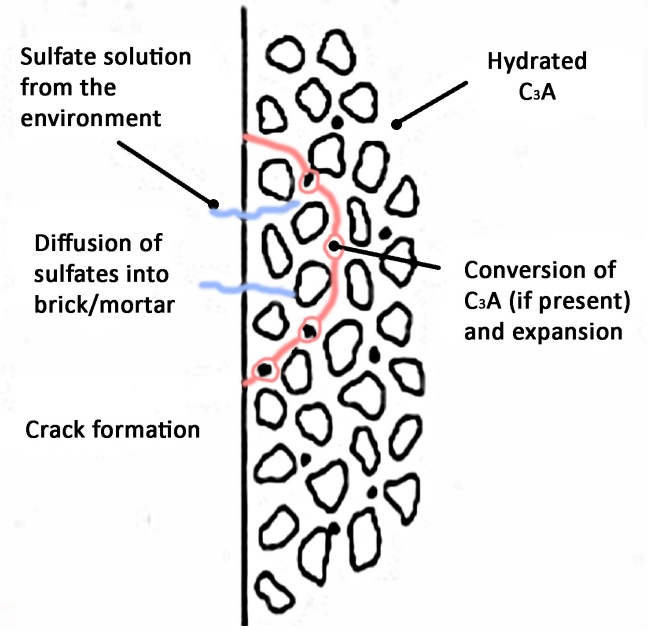
**Protecting mortar from inclement weather is essential**

# WORKABILITY AND PERFORMANCE

## SULPHATE RESISTING CEMENT

Sulfate attack on masonry is principally caused by the reaction between a component of cement (known as tri-calcium aluminate) and sulfate in solution that can derive from ground/soil water, bricks or cement. Non sulfate resisting cements contain between 3.5 -4.0% sulfate in the form of gypsum which is used to control the setting properties.

Sulfate resisting cement with a lower sulfite content and reduced levels of tri-calcium aluminate, should always be used in exposed walls and areas that are of risk of considerable water movement such as below sills, where effective dpc's have not been used, freestanding walls, earth retaining walls and where soils contain high levels of sulfate i.e. London clay.

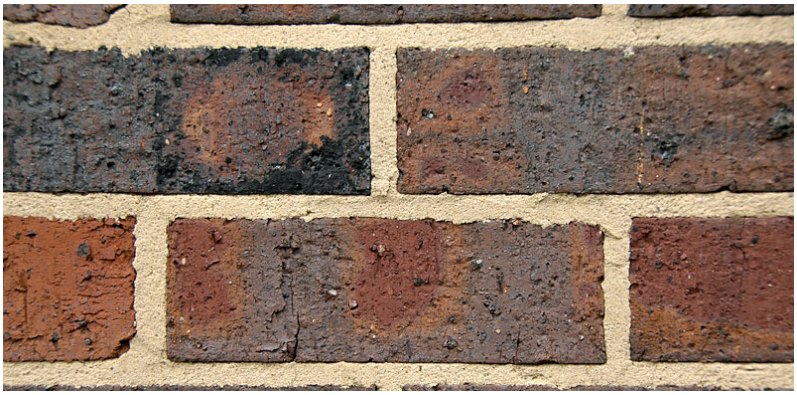



Mortars containing sulfate resisting cements will only be effective if used in the correct designation and must be accurately gauged. Robust design details should also be used to minimise water movement on and around the brickwork.

## BENEFITS OF HYDRATED LIME IN CEMENT MORTAR

The use of hydrated lime in cement mortars has a number of benefits;

- Excellent workability – assists flow of mortar onto bed and perp joints.
- Water retention – retains water in the mix, reducing the suction from bricks and therefore providing excellent bond. Strength development- the lime provides increased early strength and durability.
- Flexible/Self-Healing –small movements associated with new build can be taken up with no excessive hairline cracking.
- Reduction in efflorescence – by reducing the risk of hairline cracks within mortar, water penetration, required for efflorescence to occur, is minimised.



# MORTAR TYPES

For building mortars, one volume of cement is required for 3 volumes of sand to give a durable workable mix. However this strength of mortar is not always required. To maintain workability and performance of weaker mixes, the addition of lime or air entraining plasticisers should be used.

Care should be taken to follow manufacturers' instructions on dosage of plasticisers as overdosing will result in porosity and reduce the ability to resist water ingress.

| Mortar designation | Prescribed mortars (traditional proportion of materials by volume)[A] | | | | Mortar class that may be assumed | Suitable for use in environmental condition |
|---|---|---|---|---|---|---|
| | Cement[B] : lime : sand with or without air entrainment | Cement[B] : sand with or without air entrainment | Masonry cement[C] : sand | Masonry cement[D] : sand | | |
| (i) | 1 : 0 to ¼ : 3 | 1 : 3 | Not suitable | Not suitable | M12 | Severe(S) |
| (ii) | 1 : ½ : 4 to 4½ | 1 : 3 to 4 | 1 : 2½ to 3½ | 1 : 3 | M6 | Severe(S) |
| (iii) | 1 : 1 : 5 to 6 | 1 : 5 to 6 | 1 : 4 to 5 | 1 : 3½ to 4 | M4 | Moderate(M) |
| (iv) | 1 : 2 : 8 to 9 | 1 : 7 to 8 | 1 : 5½ to 6½ | 1 : 4½ | M2 | Passive(P) |

A When the sand portion is given as, for example, 5 to 6, the lower figure should be used with sands containing a higher proportion of fines, whilst the higher figure should be used with sands containing a lower proportion of fines

B Cements in accordance with NA.1.3 (except masonry cements), or combinations in accordance with NA.1.4

C Masonry cement in accordance with NA.1.3 (inorganic filler other than lime)

D Masonry cement in accordance with NA.1.3 (lime)

**Table taken from BS EN 998-2**

## CEMENT:LIME:SAND

This type of mortar provides good workability, water retention, adhesion and resistance to hairline cracking caused through drying shrinkage. It should be noted that all products containing cement will shrink to a certain degree during the drying phase. Sand should conform to the requirements of BS EN 13139 and be free of contaminants such as silt or clay deposits. Lime should be hydrated lime to the requirements of BS EN 459-1. Cements should conform to BS EN 197-1.

## MASONRY CEMENT:SAND

Masonry cement is manufactured using Portland cement, plasticisers and air entraining agents ground together. The additives include limestone and hydrated lime which provide increased workability and durability. As these additives are already being incorporated, any additional additives used at time of mix could lead to accidental overdosing of air-entrainment and have a negative effect on the durability against water ingress.

Manufacturer's instructions on both masonry cement and admixture packaging should be strictly adhered to.

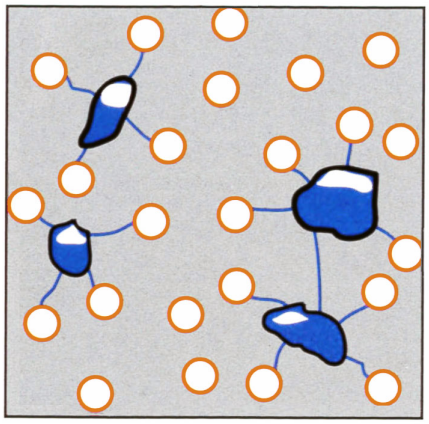
# MORTAR TYPES

## AIR ENTRAINED CEMENT:SAND

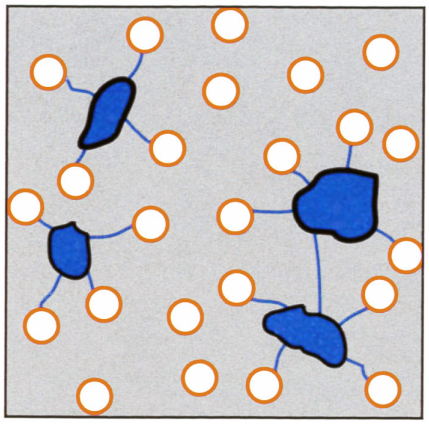
Air-entrainment admixtures in a mix provide an alternative to the use of lime to obtain improved workability in Portland cement: sand mixes.

## AIR ENTRAINED CEMENT:LIME:SAND

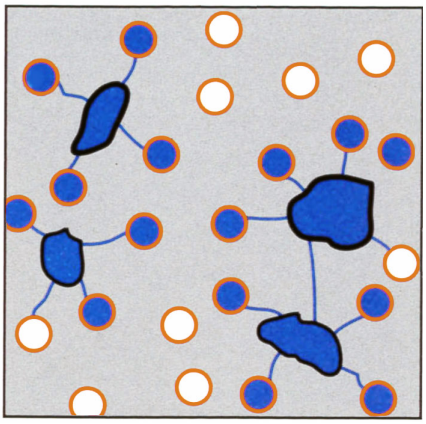
Air-entraining admixtures, when added to Portland cement:sand:lime mixes provide good durability and is suitable for a number of applications.



Air entrainment admixture creates pores in the mortar which are then filled with air.



During freezing, water in the capillary pores expands and moves towards the air-entrained pores.



Under pressure, the water will be pushed into the air entrainment pores and not crack the mortar matrix.

## READY TO USE MORTAR

These are made in factories under tightly controlled conditions and delivered to site, ready to use in either a wet or dry state. They have guaranteed mix proportions and overcome any potential problems relating to site mixing.

- Wet ready-to-use (retarded) mortar. These can be delivered to site in tubs or mixers. They include an admixture which delays the beginning of setting of mortar materials (usually 36 hours) extending the working life of the mortar. It is recommended that the mortar suppliers' recommendations are strictly followed when using ready to use retarded mortar.

- Dry ready-to-use mortars are stored dry in silos or bags.

No admixtures or other materials should be added to ready-to-use mortars other than small amounts of water to compensate moisture loss through evaporation on hot or windy days.

**Ready to use mortars can remove errors due to site mixing**

# MORTAR TYPES

## FACTORY PRODUCED SILO MORTAR

These offer a range of mix proportions and overcome many potential problems relating to site mixing. The silo, containing the dry powder mix, is delivered to site complete with integral mixer. Once power and water supplies are connected, mortar can be produced as required. The rate at which water is added can be controlled to achieve the required consistency.

Two-Compartment Silo – These are transportable silos with two sealed compartments that are filled by the producer with the required amounts of sand and cement. The mixing ratio is calibrated before delivery to ensure mix proportions are to the customer's requirements.

Liquid admixtures and pigment may be added to the mixer by means of a metered pump.

Single Compartment Silo – This is a single compartment transportable silo that is filled by the producer with dried sands, cement, lime if required and other admixtures, pigments or additives premixed to customer's requirements.

In all cases the use of admixtures should be in accordance with the recommendations of the mortar manufacturer.

## COLOURED MORTAR

A wide range of light-fast colours and shades is available and these are supplied by leading manufacturers. These materials are specified in BS EN 12878 Pigments for building materials based on cement and/or lime.

Even though the pigments are chemically stable and do not significantly change their hue, all cement based materials can change their appearance over time. Coloured mortars may be more conspicuous by these changes. For example, efflorescence or lime bloom will look far more noticeable on dark mortars.

The control of variables when producing consistently coloured mortars is important. The specification of factory produced mortars ensures minimal colour variation. Mixing on site requires care in mixture proportions and consistency of the base materials, both cement and the aggregate as well as the pigment. Often pigmented mortars can appear patchy until fully dried.

**Regulation of the mix proportions is essential to achieve a consistent colour**

# MORTAR TYPES

## TRADITIONAL LIME MORTAR

Also known as natural lime mortar, these types of mortars are made with sand using lime as the binder.

There are 2 basic types of lime for use in these types of mortars:

Non hydraulic limes- also known as lime putty, have a very slow setting process taking several weeks to gain a basic working strength. These are wet products whose setting is dependent on air not water. The lime reacts with carbon dioxide in the atmosphere to produce a hardened calcium carbonate. It can be stored for years in an airtight container or under water thereby preventing the reaction with carbon dioxide.

Hydraulic limes – are dry powders that react and set with water. They therefore must be stored in a dry environment to prevent setting before use due to reaction with atmospheric moisture.

Natural hydraulic limes (NHL), are classified in three ascending numerical grades of compressive strength at 28 days, expressed in $N/mm^2$ (Newtons per square millimeter), as:

| | |
|---|---|
| NHL 2 | - old classification 'feebly' |
| NHL 3.5 | - old classification 'moderately' |
| NHL 5 | - old classification 'eminently' |

## GAUGING NATURAL HYDRAULIC LIMES

When gauging natural hydraulic limes with sand to make a mortar it is important to understand that dry lime hydrates have different relative bulk densities (volume for a given weight) from sand (as do all powder binders) and therefore should ideally be accurately weighed. As weigh-batching is not commonly practiced on-site, most lime suppliers specify volumes of sand (usually to the nearest 10 liters) per full bag of NHL.

It is also important to remember that damp sand increases, or 'bulks', in volume (the amount being dependent on sand grading and moisture content). Allowance must be made for this when measuring the sand, so it can then be accurately volume batched with the lime to the specified ratio. It is important to discuss this and agree the correct procedure with the lime supplier.

Guidance on the use of traditional lime mortars is not covered in masonry standards and they are generally used in renovation projects. However, with increasing use of designs looking to maximise environmental and sustainability advantages, more designers are considering their use.

Hydraulic lime mortars are suitable for some modern masonry constructions and are capable of producing sufficient strength and setting properties for some thin brickwork (102.5mm thick) applications. Advice from both the masonry manufacturers and lime suppliers should be sought prior to use.

# REFERENCES AND FURTHER READING

EN 771-1, Specification for masonry units Part 1: Clay masonry units

BS EN 197-1: 2011 Cement. Composition, specification and conformity criteria for common cements.

BS EN 413-1: 2011 Masonry cement. Composition, specifications and conformity criteria.

BS EN 413-2: 2005 Masonry cement: Test methods

BS EN 459-1: 2015 Building lime. Definitions, specifications and conformity criteria

BS EN 459-2: 2010 Building lime. Test methods.

BS EN 459-3: 2015 Building lime. Conformity evaluation

BS EN 845-1, Specification for ancillary components for masonry – Part 1: Ties, tension straps, hangers and brackets

BS EN 845-2, Specification for ancillary components for masonry – Part 2: Lintels

BS EN 845-3, Specification for ancillary components for masonry – Part 3: Bed joint reinforcement of steel meshwork

BS EN 934-3: 2009 Admixtures for concrete, mortar and grout. Admixtures for masonry mortar. Definitions, requirements, conformity, marking and labelling.

BS EN 998-2, Specification for mortar for masonry – Part 2: Masonry mortar

BS EN 1990:2002+A1:2005, Eurocode – Basis of structural design

BS EN 1996-1-1:2005, Eurocode 6 – Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry

structures

BS EN 1996-1-2:2005 Eurocode 6. Design of masonry structures. General rules. Structural fire design

BS EN 1996-2:2006, Eurocode 6 – Design of masonry structures – Part 2: Design considerations, selection of materials and execution of masonry

BS EN 1996-3:2006 Eurocode 6. Design of masonry structures. Simplified calculation methods for unreinforced masonry structures

BS EN 12878: 2014 Pigments for the colouring of building materials based on cement and/or lime. Specifications and methods of test

BS EN 13139: 2002, Aggregates for mortar.

PD 6697:2010, Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2

PD 6678: 2005 (2012), Guide to the specification of masonry mortar.

BS 4551: 2005 + A2 (2013), Mortar. Methods of test for mortar. Chemical analysis and physical testing.

BS 8000-3, Workmanship on building sites – Part 3: Code of practice for masonry

BS 8103:2013, Structural design of low-rise buildings – Part 2: Code of practice for masonry walls for housing

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