TECHNICAL INFORMATION **A5**

Ibstock Brick

DESIGN & SPECIFICATION CONSIDERATIONS
BRICKWORK MORTARS

In January 2005 the existing BS mortar and associated test method standards were withdrawn and replaced by harmonised European Product Standards and common test methods. A new two-part harmonised product Standard for mortar was published in 2003.

BS EN 998-1: Specification for mortar for masonry: Part 1: Rendering and plastering mortar.

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

PD 6678: Guide to the selection and specification of masonry mortar.

These documents are applicable to all mortars; however, when applied to site mixed mortars they must be used in conjunction with the European Code 6 Design of masonry structures and PD6697 recommendations to the design of masonry structures.

MORTAR PERFORMANCE

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

Alternatively 3 parts sand to ½ part cement to ½ part lime produces a well filled mortar, but with the extra adhesion and flexibility given by the lime, balanced by the strength of the cement. This is a 1:1:6 mix.

Altering these proportions to suit the strength requirement, exposure level, and workability or weather conditions can be considerable benefit to the durability of the final brickwork. Variations in the water suction rate of bricks can adversely affect brickwork.
The wetness of the mortar mix can be reduced to maintain a consistent level of moisture whilst laying. Only when high suction rate bricks in warm weather conditions should dunking of the bricks be considered. If it is undertaken, the bricks should not be used to avoid soluble salt contamination.

ON-SITE MIXING

A recognised method of gauging is recommended to ensure that the correct designation of mortar is achieved. PD 6697 gives detailed guidance on batching materials and mixing mortars. Following these procedures will promote consistency of the mortar and thereby ensure that specified requirements for its performance and appearance are maintained.

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.

ADHESION

To achieve good adhesion a mortar must have good workability. Mortar of poor workability will not perform adequately and will allow air to be trapped between the mortar and the brick, thus preventing good bond formation.

A brick with rough bed faces and medium suction rates will have high bond characteristics because the mortar will key into the texture of the brick. Conversely, bricks with low suction rates and a smooth texture will have lower bond characteristics.

Highly porous bricks may rapidly absorb moisture during laying (particularly in warm weather), causing the mortar to become insufficiently plastic to allow repositioning of the bricks during levelling. It is possible in such circumstances that no adhesion will be obtained between bricks and mortar. Laying mortar beds in shorter lengths to reduce drying will help. Wetting may assist adhesion, but over wetting may lead to floating on the mortar bed and to excessive efflorescence and staining.

Workability

Workability is the behaviour of a mortar in respect of all the properties required during application, subsequent working and finishing. The operative's opinion of workability is greatly influenced by the flow properties of the mortar - its cohesiveness and retention of moisture against the suction rate of the clay masonry unit. THIS IS A CRITICAL ASPECT ON VERY LOW SUCTION RATE CLAY MASONRY UNITS AND ADVICE ON CORRECT MORTAR DESIGNATION MUST BE SOUGHT FROM IBSTOCK.

Bonding agents, waterproofing admixtures and air entrained mixtures conforming to BS EN 934-3 can all be added to mortars. However, their use must be strictly controlled and in accordance with the manufacturers' instructions, particularly to avoid over mixing. Washing-up liquids and admixtures containing calcium chloride should not be used.

SULFATE RESISTING CEMENT BINDERS

Sulfate attack on masonry is principally caused by the reaction between sulfate in solution with a constituent of Portland cement. Sulfate can derive from either the ground soil water or the units. The risk is greatly diminished by using suitable binders and/or additions e.g. sulfate resisting cement binder. Sulfate attack will only occur where there is considerable water movement through the masonry i.e. in freestanding walls, below sills where effective DPC's have not been provided, through earth retaining walls which are not water-proofed on the retaining face and external walls between ground level and DPC.

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PERMEABILITY

Strong mortars will provide better resistance to water penetration, but offer less resistance to differential movement. Rain penetration can be greatly reduced by good design and proper selection of the sand grading. Rich mortars (high cement content) will crack more easily than weak mortars. Weak mortars are more tolerant to movement but the voids between the sand grains will, however, contain less cement, allowing water to penetrate more easily. Uneven mixing of the mortar can result in a cement deficiency in some areas and rain penetration can occur under some conditions.

THE BENEFITS OF HYDRATED LIME IN CEMENT MORTAR

The benefit of using hydrated lime in cement mortar has been recognised by builders throughout the ages.

When correctly gauged with cement this mortar offers

- Excellent workability- flows easily assisting the filling of mortar bed and perpend joints.
- High water retentivity- reduction in the effect of suction from bricks ensuring complete contact between mortar and unit aiding water-tight joints.
- Strength development- early strength is produced with the continued carbonation of the lime giving increased strength and durability after.
- Elasticity- inevitable small movements of buildings during and after completion can be taken up without excessive cracking.

In certain conditions if minor cracks have appeared they can heal themselves by a process called 'autogenous healing'. Rain water takes a little of the lime into the void as a solution but the lime remains after evaporation of the water. Reaction with air turns the lime into calcium carbonate continually hardening as time passes. This provides improved resistance to wind driven rain.

- Efflorescence- in certain cases, hydrated lime containing mortars can reduce instances of efflorescence by minimising the amount of water that can enter the structure via hairline cracks in the mortar/brick interface.

EFFLORESCENCE AND LIME BLOOM ON MASONRY MORTAR

Aesthetically mortar takes up 17% of the face of a brick wall. It is important to get the appearance of the mortar joints correct to enhance the finished effect.

The main causes of unsightly masonry are;

- Constructional blemishes-marking bricks with mortar. Mortar splashes and clumps are usually cleaned up by use of a proprietary acid cleaner.
- Efflorescence-a transitory effect due to dehydrated salts deposited on or near the surface of the mortar. If left it should weather away.
- Lime Bloom- often mistaken for efflorescence but actually carbonated material derived from the free lime present in all types of cement (free lime in cement. This must be removed by use of a proprietary acid cleaner).

PREVENTATIVE ACTION

Design and plan- water must not be allowed to percolate into masonry and keep it in a damp condition. Pay attention to design features such as sills, copings and parapet walls.

Select the correct mortar- factory produced mortars offer the best, most durable product. Always gauge correctly.

Site care and workmanship- water can be the worst enemy on site. Always protect materials from inclement weather, covering newly laid brickwork and unused materials. Never 'knock up' mortar once it has started to set.

COLD WEATHER WORKING

It is inadvisable to proceed with the construction of masonry whilst the temperature is below 3 degrees centigrade and falling. If mortar freezes any frozen material should be discarded. Any unfrozen material should not be used on frozen bricks or blocks. Water present in fresh cement may freeze and expand forcing the material apart and breaking the bond.

Anti-freeze admixtures of the calcium chloride type should never be added to the mix. Their effect is minimal and they cause dampness and efflorescence.

WATER RETENTION OF MORTAR

This is the critical mortar property that resists water loss by absorption into the masonry units (suction rate) and/or to the air, in conditions of varying temperature, wind and humidity (particularly summer/winter working). Water retentivity is related to workability. A mortar with good water retentivity remains plastic long enough to allow the masonry units to be aligned and plumbed without breaking the critical bond between the mortar and the units. Low-absorption units in contact with mortar with high water retentivity may 'float' and move out of alignment and plumb. Therefore, water retentivity should be neither too low nor too high. Adjustments MUST be made by varying the amount of cement admixtures, lime, any entrained air and/or the amount/type of sand,. Loss of moisture due to poor water retentivity, in addition to loss of plasticity,will almost certainly greatly reduce the effectiveness of the bond to the masonry units. THIS IS A CRITICAL ASPECT ON VERY LOW SUCTION RATE CLAY MASONRY UNITS AND ADVICE ON CORRECT MORTAR DESIGNATION MUST BE SOUGHT FROM IBSTOCK.

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TYPES OF MORTAR

For building mortars, about one volume of binder is needed for 3 volumes of sand to give a workable mix, however, this mix is stronger than is necessary for most uses. The workability of mortars containing less cement is improved by the incorporation of lime, plasticisers and entrained air or a combination of these.

Adhesion to dry absorbent units can be considerably improved by a water retaining admixture. All factory-made masonry cement based mortars are air entrained.

CEMENT:LIME:SAND

This type of mortar possesses good working qualities, water retention and adhesion. Lime should be non-hydraulic to BS EN 459-1. Sand should conform to the requirements of BS EN 13139 and ideally be clean sand now known as fine aggregate. Cements should conform to BS EN 197-1

AIR-ENTRAINED CEMENT:SAND

Plasticisers which entrain air in a mix provide an alternative to lime for imparting improved working qualities to cement:sand mixes. Air bubbles increase the volume of the binder paste, filling voids in the sand improving working qualities. Admixtures should conform to BS EN 934-3

AIR-ENTRAINED CEMENT:LIME:SAND

Mortar incorporating both lime and air-entraining plasticiser has particularly good durability and is suitable for a wide range of uses both external and internal.

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 mortar- mortars are stored dry in silos or bags.

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 powder 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.

Note: Ibstock cannot control variables in any site supplied mortar. This must be clearly communicated with the mortar supplier at all times.

COLOURED MORTARS

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.

COLOUR CONSISTENCY

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.

Ibstock's Technical Services can give advice on toning mortars to suit most products in the Ibstock Portfolio

SELECTION OF MORTAR

The mortar selected is to be Designed or Prescribed mortar in accordance with BS EN 998-2.

Designed mortars- composition and manufacturing method is selected by the producer to achieve specified properties. They are classified by their compressive strength.
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 the table below but it is sufficient as a guide.

The designer should carefully select the mortar for an application by considering

- Structural requirements
- Type of construction and position in the building
- Degree of exposure
- Characteristics of the brick & general properties of the mortar.
- Mortar designation must be suitable to the brick's technical properties
- Reference to tables in PD 6697 and EC6

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Designed mortars (Not provided to a prescribed mix) Compressive Strength Class	**Exposure category**	**Prescribed mortars** (proportions of materials by volume) not tested for strength				
		Mortar designation	Portland cement or Sulfate resisting Portland cement and lime, with or without air entraining additive.	Masonry cement containing Portland cement and lime in approx 1:1 ratio, and air entraining additive.	Masonry cement containing Portland cement (min 75%) and inorganic materials other than lime, and air entraining additive.	Portland cement or Sulfate resisting Portland cement and an air entraining additive.
M12	Severe	(i)	1:0 to ¼ :3	-	-	1:3
M6	Severe	(ii)	1: ½ :4 to 4 ½	1:3	1:2 ½ to 3	1:4
M4	Moderate	(iii)	1:1:5 to 6	1:3 ½ :to 4	1:4 to 5	1:5 to 6
M2	Passive	(iv)	1:2:8 to 9	1: 4 ½	1: 5 ½ to 6 ½	1:7 to 8

Note 1:Proportioning by mass will achieve more consistent mortars than proportioning by volume.
Note 2:The range of sand volume noted for the mixes in this table is to allow for the effects of differences in grading of the properties of the mortar. The lower figure should be used with sands containing a higher proportion of fines.
Note 3:The addition of lime to a mortar designation is highly recommended and greatly increases workability and water retention.

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 mortars;

Non hydraulic limes - have a very slow setting process taking several weeks to gain a basic working strength. Its setting is dependant entirely on air and not water. It can keep for years in an airtight container or under water.

Hydraulic limes - chemically react with water to set. It must be kept stored dry to prevent setting by atmospheric moisture before use.

They can be subdivided in 3 categories, feebly hydraulic, moderately hydraulic and eminently hydraulic dependent on the relative content of impurities extracted with them from their natural deposits.

Prior to 1925 brickwork masonry was characteristically heavy, solid construction jointed with lime mortar. Wall thicknesses were frequently 2 bricks or more and never less than 215mm. Comparatively low stresses were developed in the masonry and were well within the capacity of the limited compressive strength of traditional lime mortars.

Following the second World War masonry construction changed profoundly using thinner cavity walls to economise on materials. Thin walls provide less plan area to support loads and therefore higher stresses are developed. Mortars for this type need to be stronger in both compression and flexure.

Guidance on the use of traditional lime mortars is not covered in EC6 or PD6697 and they are generally used in renovation projects. However, some designers are now attracted to the environmental advantages that are claimed for lime mortar.

Hydraulic lime mortars are suitable for some modern masonry construction and are capable of producing sufficient strength and rate of setting for some thin wall brickwork applications. A few producers are offering the technical advice necessary and also producing factory batched materials making it easier for potential users to achieve successful construction.

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