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UNITED KINGDOM
CAST STONE ASSOCIATION ®

# Technical Manual for Cast Stone

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CAST STONE & CONCRETE PRODUCTS

**This manual has become the construction industry's standard reference for cast stone. It has been produced to assist industry professionals in the design, specification and use of cast stone building components. Now revised and updated, the manual is laid out to allow you to easily access information on cast stone relating to various stages of the building process right from material description to aftercare. We have included a short glossary of terms to assist you. You will also find useful project information and news on our web site www.ukcsa.co.uk and you can also contact the Association via email on info@ukcsa.co.uk**



March 2011

When correctly designed, manufactured and installed, cast stone can provide a durable, long lasting product which can match the appearance of many quarried stone profiles and finishes.

The material is recognised in NHBC Standards and the use of features made from cast stone should comply with the latest version of BS1217 or, better still, the higher standard adopted by UKCSA members.

While supporting BS1217, the UKCSA recognises that a key issue for cast stone is the material's durability and weathering characteristics. As the result of research carried out by the University of Dundee, the UKCSA has produced its own standard, with a mix design of 35 MPa. This is at least 40% above the British Standard and ensures strong cast stone with outstanding durability and site handling. The UKCSA standard includes a rigorous regime of product testing and third party verification, the results of which must be logged with UKCSA.

This latest edition of the Technical Manual will be a worthwhile and long-lasting aid to architects, builders and others who are new to cast stone, and will be a very useful prompt for even the most experienced of designers. This publication will provide valuable guidance to all those wishing to capitalise on the attractive finishes, versatility and longevity of cast stone and covers all aspects of cast stone design, manufacture and use.

The NHBC is pleased to see this new edition of the 'Technical Manual for Cast Stone.'

Peter Crane,
Head of Technical Standards

NHBC

The National House-Building Council

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# 1.0 Introduction

## Cast stone has been a familiar and much-used alternative to quarried natural stone since Georgian times. It evokes a sense of timelessness which fits in with any form of massive construction.

Cast stone is comparable to quarried natural stone as a building material in both appearance and performance, yet it is readily available and provides a cost effective alternative on projects from simple domestic housing to complicated schemes such as commercial buildings and cathedrals. It can be formed to almost any shape and size the designer wishes and can equal, or even surpass, the technical capabilities of quarried natural stone in terms of strength, moisture penetration, colouring and textural consistency. Stratification is never a problem and it is free from imperfections. Suitable for period and contemporary styles, it is ideal for both new build and refurbishment work particularly in areas of sensitive planning constraints or where stone is a predominant building material.

Cast stone is a special form of simulated stone, defined by UKCSA as any product manufactured with aggregate and cementitious binder intended to resemble and be used in a similar way to natural stone. Cast stone is either homogenous throughout or consists of a facing and backing mix.

Cast stone is produced by one of three processes: firstly as a semi-dry process which gives components a slightly open textured face, similar to sawn quarried stone; secondly as a wet cast process which gives a much closer face texture and allows large components and those with complex reinforcement to be produced; and thirdly as fibre reinforced cast stone, a process incorporating alkali-resistant extruded fibre reinforcement that allows thin and lightweight sections to be produced. Many UKCSA members continue manufacturing traditions dating back to before the turn of the century whilst incorporating modern production techniques to both reduce costs and provide a superior product. Many units are hand crafted to ensure a high quality finish.

| Classification | Applications |
|---|---|
| Architectural Stonework | Balustrading, parapet screening, columns and pilasters, pavilions, door surrounds, heads and cills, keystones, window surrounds, quoins, string courses, plinths, plaques, brackets, corbels, steps, gate piers, balls etc. |
| Architectural Masonry | Ashlar masonry. |
| Landscaping Ornaments | Urns, vases, jardinieres, bowls, baskets, boxes, troughs, pedestals, plinths, bird baths, sundials, statuary, finials, seats, tables, pool surrounds, fountains, wall masks, obelisks, dovecote, bollard, edging, paving etc. |
| Interiors | Table supports, table lamps, smoker stands, chimney pieces, door surrounds, Staircases, balustrading etc. |
| Custom-Made Stonework | Specially designed products especially ornate or highly detailed units for refurbishment, large section and structural application. |

## About the United Kingdom Cast Stone Association (UKCSA)

**An independent trade association formed in 1991, UKCSA acts to establish and maintain the highest standards of product quality, usage and social responsibility and represents the manufacturers that lead the field in their discipline. The Association also promotes the merits of cast stone to the market.**

The Association defines strict levels of technical performance for material produced by its members and many of these were incorporated into the current British Standard BS 1217: 2008 and its predecessor. The UKCSA was closely involved in producing the previous standard for cast stone and its update.

However, many cast stone manufacturers operate without adequate quality assurance or testing regimes and may not be operating to proper standards. These issues prompted UKCSA to produce a new generic specification for the material, The UKCSA Specification (see Appendix 3), which tackles the need for high product strength and high operating standards including independently verified testing regimes and reporting. The UKCSA Standard ensures that cast stone supplied by UKCSA members will be of consistent

high quality and gives specifiers and users confidence in the material. Moreover, cast stone produced by UKCSA members is at least 40% stronger than the requirements of the British Standard for cast stone.

This manual is intended to give general advice on the use of cast stone components. It covers the broad areas associated with manufacture, design, detailing, specification, installation and site practice. Each UKCSA member can give in-depth guidance and assistance relating specifically to their products and the particular units required.

All current information relating to the UKCSA Standard and Specification and use of cast stone can be found on the UKCSA web site at www.ukcsa.co.uk

## Sustainability and Corporate Social Responsibility

**In terms of sustainability, cast stone performs well in both production and within its life cycles. The material is highly durable, non-toxic, re-usable and requires virtually no maintenance or repair over its long lifespan. It can also contribute to thermal mass.**

The scale of its demands on raw materials will never compete with conventional building materials. The base materials are essentially the by-products of industrial processes or are readily available.

All members of UKCSA have an environmental management system in place and several are certified to ISO 14001. One member was the first company in the world to achieve BES 6001 for responsible sourcing and others have followed.

All UKCSA members are committed to environmentally responsible sourcing, primarily through the use of alternative recycled and secondary materials. A range of cementitious solutions are used to minimise the carbon footprint of products while enhancing their performance and durability. Some UKCSA members are actively pursuing recycled aggregates, including crushed glass, and less than perfect cast stone can be crushed and re-used as aggregate.

UKCSA members are equally committed to improving energy efficiency in the production of cast stone, minimising waste and preventing and reducing accidents. Between 2006 and 2008 members' collective waste was reduced by 10% and the accident frequency ratio fell by 31%. Energy data covering electricity, gas and oil are also monitored to enable continuous improvement measures for the future.

In terms of whole life energy consumption, cast stone costs very little to look after once it becomes part of a building. Its embodied energy becomes insignificant over time. Furthermore the carbonisation of cast stone captures carbon dioxide from the air. Concerns about carbon miles dog many natural building materials such as stone and timber, which are sourced from all over the world. In contrast, cast stone is made and distributed in the UK, often in localised markets. This provides a minimal carbon footprint and maintains UK employment.

UKCSA members are committed to ethical trading and as an Association supports the principles of the UN Global Compact and ETI Base Code.

# 2.0 Manufacture

## Cast stone is finding growing favour with both designers and users as a high-quality facing material which looks good and performs well at a realistic cost. This special form of concrete calls for particular skill and care and application of technology in its production.

Major advances have been made in mix design, batching, manufacture and curing. The manufacturer's aim is to produce a material, which resembles quarried natural stone products as closely as possible. The colour and texture of most stones can now be matched using crushed rock fines and/or carefully selected and graded natural sands, usually mixed with white cement. The range of shades can be extended by the use of grey cement and pigments.

Correct curing of all types of cast stone is essential both for the resistance to damage during transport and construction as well as durability and appearance over time. BS 1217:2008 states *"Cast stone should not be transported or installed before it is 14 days old unless accelerated curing processes allow a reduction of this time"* and this period may need to be extended for structural units. However, some UKCSA members employ enhanced curing techniques to significantly reduce the timescale required from production to site, and all UKCSA Members are required to achieve a minimum level of curing as a condition of their membership.

## 2.1 Semi Dry Production

The semi-dry method, as the name implies, involves the use of a low water content or “earth-moist” mix. Semi-dry products can either be manufactured using a through (facing) mix or employing a backing and facing mix. Facing mix is used for the complete element if the shape is complex, or if the units are typically less than 75mm thick. The facing material determines the long term performance of the cast stone and requires careful design. It must include carefully selected aggregates, graded such that thorough compaction is attainable thus yielding a strong (35-50 MPa) dense product. It must also incorporate an integral waterproofer, usually a metallic stearate to ensure low absorption and long term performance.

Compaction of the semi-dry material is usually achieved using either pneumatic or electric sand rammers. The efficiency of this process is very important in determining the final quality. Standard ashlar units can be manufactured using hand- operated compression machinery or, for very large contracts, fully automated plant.

Units are generally cast face down to ensure maximum compaction of the finished surface. In two-part casting the facing mix is compacted to a minimum thickness of 20mm. The layer is scratched to form a mechanical key for the backing concrete, which is immediately placed and compacted in successive layers. Inter-diffusion is an alternative mechanism for ensuring satisfactory bond between successive layers of materials and is dependent upon successful diffusion of two loosely filled layers under force from the compacting hammer. Both methods ensure that the product is effectively homogeneous.

After compaction the products are often demoulded immediately. Subject to complexity it is possible to produce up to 80 units per day from one single mould reducing mould commissioning costs and lead times.

In general, dry cast units need no surface treatment after de-moulding. If a more pronounced or “grainier” texture than the stone like, as-struck finish is called for, this can be achieved after de-moulding. If the designer or user requires to replicate a natural stone “tooled” finish i.e. striated, rock-faced etc. this can be achieved by reproducing the pattern in rubber or epoxy resin and then manufacturing the cast stone elements from the pattern.

It is essential that the initial cure is carried out in a controlled environment. This environment must be protected from direct sunlight and drying winds. An effective curing regime determines the development of strength and long term durability. It will also reduce surface shrinkage and therefore crazing and improve resistance to weathering and abrasion.

BS 1217:2008 states *“Cast stone should not be transported or installed before it is 14 days old unless accelerated curing processes allow a reduction of this time”* and this period may need to be extended for structural units. However, some UKCSA members employ enhanced curing techniques to significantly reduce the timescale required from production to site, and all UKCSA Members are required to achieve a minimum level of curing as a condition of their membership.

The semi-dry process is most suited to traditional sized products such as cills, heads, string courses, cornice, copings etc. Structural items can be produced so long as the reinforcement requirement does not inhibit compaction. The ability to reinforce dry cast stone offers a distinct advantage over natural stone.

## 2.2 Wet Cast Production

This process uses a higher water content mix than semi dry production resulting in a dense product with a typical cube strength of 35-50 MPa. This is generally a through mix of the finished face material which can be produced in a wide range of shades.

The mix generally will have a slump of up to 100mm and compaction is achieved using conventional wet-casting techniques i.e. table-vibrator, poker or in some cases vacuum casting. Many UKCSA members use sustainable self-compacting concrete, requiring no additional energy as the need to vibrate the mix is obviated. Vacuum casting is only suitable for relatively small elements (up to 250kgs) and is extremely effective in producing high quality surface finishes, although this is mainly a function of correct mix design.

The wet-cast process generally only yields one cast per mould per day. This is an aspect of wet-casting that both user and specifier should be aware.

Wet casting requires significant work before a satisfactory stone like finish is achieved. This is due to the formation of a layer of cement laitance typically 0.5-1.0mm thick against the mould face. This laitance requires removal if a consistent stone like finish is to be achieved. It is normally removed by chemical etching although other mechanical methods are used such as hand-rubbing, grinding and polishing. Its removal reveals the constituents of the mix and therefore quality of aggregate and control of batching is essential if uniformity is to be achieved throughout a particular project.

The product requires a controlled initial cure protected from direct sunlight and drying winds. As with all cast stone the product should normally be cured for a minimum of 14 days prior to despatch.

## 2.3 Fibre Reinforced Cast Stone Production

This process incorporates fibre reinforcement into a higher water content mix that can be either poured or sprayed into moulds, from which the product is demoulded the following day. A dense product with a close face texture is achieved which can be varied by the use of secondary surface treatments. Often the units are produced in thin sections which reduces the weight and associated manual handling issues, and offers the opportunity – through careful design and use of fixings – for retrofitting to the structure.

## 2.4 At a Glance Guide to Manufacturing Method Properties

| Property | Semi-dry | Wet cast | Fibre reinforced |
|---|---|---|---|
| Cube strength | Typical range 35-50 MPa | Typical range 35-50 MPa | Typical range 35-50 MPa but with enhanced tensile and bending strength |
| Size | More common to traditional units such as cills, heads, string courses, cornices etc. | Also suitable for large and structural units | Suitable for thin wall units and for traditional units where increased tensile strength is required |
| Colour | Highly authentic stone shades | Highly authentic stone shades | Highly authentic stone shades |
| Handling | As natural stone | As concrete | As concrete |
| Appearance as supplied | Slightly open texture, similar to natural Portland and Bathstones | Dense close texture with option of secondary finishes. | Dense close texture with option of secondary finishes. |
| Appearance on Weathering | Weathers in a similar manner to natural Portland and Bathstones | Retains supplied appearance for a longer period | Retains supplied appearance for a longer period |
| Product Strength | Function of unit geometry. Structural units can be both semi dry or wet cast. For structural requirements reference should be made to BS EN 1992 and BS EN 1996 | | Function of unit geometry. Thin wall units can be produced due to the the increased tensile and bending strength. For structural requirements reference should be made to BS EN 1992 and BS EN 1996 |
| Product Output | Highly cost effective through multiple use of same mould | Requires greater mould investment or longer lead times | Requires greater mould investment or longer lead times |

## 2.5 Summary of Main Finishing Methods for Cast Stone

| Finishing methods | Description |
|---|---|
| Rubbed Finish (Wet Cast only) | Dry rubbing is usually carried out with an abrasive pad or sandpaper block to remove surface laitance. Wet rubbing produces a clean smooth surface and can be of some help in delaying evaporation during the early curing period. |
| Simulated Tooled Finishes | Highly detailed designs can be achieved by taking mould plates from natural stone masters. Semi dry units also allow a limited amount of post production reworking using traditional tools. |
| Acid Etching | A good simulation of rubbed limestone can be achieved by the use of a solution of hydrochloric or another suitable acid applied carefully to a previous well-wetted surface. A further improvement is possible by wet rubbing down with an abrasive pad following the acid treatment. |
| Sand and Grit Blasting | This is a popular method of removing surface laitance and exposing to a controlled degree the underlying aggregate/cement matrix. |
| Wet Ground Finishes (Wet Cast only) | This is a method of finishing by which the surface of the units is removed to depth varying, according to requirements, from a nominal 1mm to a maximum not usually exceeding 3mm. In the same way as for natural granite or marble, cast stone can be given a full polish, subject to the mix ingredients. |

*Extract from research report produced by the Concrete Technology Dept at Dundee University*

# 3.0 Uses & Applications

**Cast stone is an extremely versatile material and offers the designer an outstanding flexibility when designing features and structural elements on projects in both traditional and modern styles.**

## 3.1 Comparison of Properties of Semi Dry, Wet Cast and Fibre Reinforced Cast Stone

The following sections carry information on aspects which may significantly affect the performance of cast stone components:

| Semi-dry Cast Stone | Wet Cast Stone | Fibre Reinforced Cast Stone (FRCS) |
|---|---|---|
| Close match in colour and texture and favoured by planning authorities as an alternative to quarried natural stone. | Close match in colour and texture to quarried natural stone with optional secondary finishes. | Close match in colour and texture to quarried natural stone with optional secondary finishes. |
| 28 day cube strength in excess of 35 MPa. | 28 day cube strength in excess of 35 MPa. | 28 day cube strength in excess of 35 MPa with enhanced tensile and bending strength. |
| Low porosity with weathering characteristics of quarried natural stone. | Very low porosity. Retains supplied appearance longer. | Very low porosity. Retains supplied appearance longer. |
| Method of manufacture restricts size to traditional products such as cills, heads, string courses, etc. | Unit size restricted only by crane and transport limitation. | Unit size restricted only by mould manufacturing and fixing considerations. |
| Process of tamping-in material makes complicated reinforcement difficult to place in mould. | No problems in casting around even the most complicated reinforcement cage. | The product includes fully integrated alkali resistant fibre reinforcing. |
| Can be cast as a through mix or with facing and backing mixes. | Generally cast as through mix. | Cast as through mix. |
| Durability similar to quarried natural stone with sharp arrises requiring careful on site handling. | Durable in respect of impact damage but still requiring careful on site handling. | Very durable in respect of impact damage but still requiring careful on site handling. Normally produced as thin walled products with the reduction in weight assisting with site and manual handling considerations. |
| Cost effective production combined with a short lead time is seen as the major benefit of semi dry cast stone. The method also offers the user and specifier a product which resembles and weathers as quarried natural stone at much lower cost. | This method of production can be used for the manufacture of larger units such as beams or cladding panels where a combination of mass concrete and structural reinforcement eliminates the use of the semi-dry technique. It offers the specifier another dimension to what is achievable in cast stone. | When manufactured as thin walled units this method of production is particularly suited for retro fit and refurbishment projects, and where the total weight of units is a consideration, or it can be used to give additional tensile strength when full sized units are produced. |

# 4.0 Design & Detailing

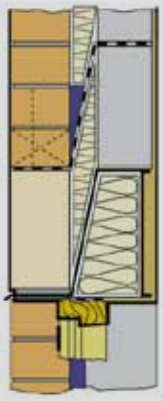
## All UKCSA members work closely with specifiers right from the design stage to ensure that the optimum solutions are achieved on all types of project from housing to major commercial developments.

It would be true to say that cast stone has a place on any project under consideration either as a main construction element or as detailing to improve the appearance and appeal of the property.

Good building practice is essential when considering the design and use of all building materials including cast stone. General guidance can be found in the relevant British Standards such as BSI Standards Publication PD 6697: 2010 Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2. See Appendix 4 for associated publications.

All UKCSA members are able to offer detailed information on the cost effective application of cast stone for each individual project. Benefits can include:

- Time savings at design and construction stages
- Early completion of production drawings to minimise disruption to the building programme
- Reduction of manufacturing costs
- Reduction of construction costs
- Minimisation of wastage



Typical detail of non-loadbearing cast stone lintel construction

Typical detail of self-supporting cast stone lintel construction

Typical detail of loadbearing cast stone lintel construction

## 4.1 Structural Considerations

Cast stone is often used for structural elements within a building. The inherent strength and density of both semi dry and wet cast material often exceed requirements by a comfortable margin. However the structural characteristics of cast stone produced by different manufacturers will vary and the supplier should be contacted at an early stage of the project.

As a general guide, cast stone components can be in compression or tension. Products intended for use in compression e.g. quoins, string courses, ashlar and columns are generally not classed as structural units. Items such as lintels, which are subjected to both compressive and tensional forces should be specified with care. Lintels can be supplied as either non loadbearing components (i.e. decorative), or load bearing (i.e. structural). With decorative heads it is important that they are used in conjunction with a steel support or lintel as they are not able to carry additional loads other than their own self weight. With structural heads, the loadbearing capacity will be specified by the manufacturer. In cases of uncertainty, the manufacturer's advice should be obtained.

Steel support lintels are normally used below the decorative head to support the head itself and the entire brickwork load above. There are however, cases where it is desirable to fit the support lintel over the decorative head so that the head is self supporting while the lintel carries only the load of the brickwork from above. This should not be done without first consulting the UKCSA manufacturer.

## 4.2 Building Movement

The control of movement should be assessed at the design stage since all building materials are subject to dimensional change during and after construction, due to moisture movement, cyclic thermal movements, and chemical action ( i.e. carbonation). Deflection under load, ground movement or differential settlement may also have to be accommodated. This in general can be overcome by the use of movement joints, bed joint reinforcement and the correct specification of the mortar.

To reduce the problems with movement, ideally the designer should only specify mortars of strength classes M4 and M2 [designation (iii) and (iv)] (see NA to BS EN 1996-1-1: 2005, Table NA.2). Strong mortars, wherever possible, should be avoided as these can introduce too much restraint into the masonry panel which could induce cracking.

*For further information please refer to NA to BS EN 1996-1-1: 2005 and Section 6.5 Mortars.*

Any settlement that occurs can put increased loads on some elements of the building, in the case of cast stone this would apply for example to one piece cills and built-in thresholds. It is good building practice to bed only under the stooled ends of these units and to point up the remainder of the open bed joint at a later date with a mortar of the same strength. Alternatively, where practical, temporarily bed the cills in a lime:sand mix until the walls are completed, loaded and any initial settlement has taken place.

*Further reference should be made to BSI Standards Publication PD 6697: 2010 and BS 5642: Part 1:1978.*

### 4.2.1 Differential Movement

Due regard should be given to the possible effects of differential movement between

various types of building materials. Cast stone products in general experience long term shrinkage, conversely, clay bricks suffer from irreversible moisture expansion and so these materials should be separated because their movements are different in both magnitude and direction. To reduce the potential for movement it is also important that the units are correctly bedded on a full bed of mortar, except one piece cills and thresholds. DPC's should always be sandwiched in the joint so that they are bedded on both sides. Under no circumstances should cast stone units be laid dry on top of DPC's.

Where two differing materials are used together in the same construction, then consideration should be given to the use of a slip plane. Slip planes should be designed to allow parts of the construction to slide, one in relation to the other, to reduce tensile and shear stresses in the adjacent elements. Often these details double up as DPC cavity trays. The slip plane may need to contain two layers of smooth incompressible sheet material or an applied coating to form a separating membrane. In principle all details should be checked to ensure that any potential movement is accommodated without adversely affecting the stability and/or performance of the elements and the structure as a whole.

*Please refer to BSI Standards Publication PD 6697: 2010.*

### 4.2.2 Movement Joints

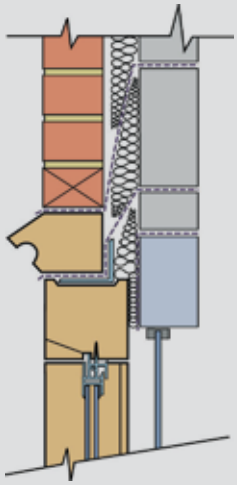
The risk of cracking in buildings can be minimised by incorporating movement joints according to British Standard recommendations. With cast stone masonry, movement joints should be no more than 10mm wide and positioned at a maximum of 6m centres. In external walls with openings, the movement joints may have to be more frequent or bed joint reinforcement included to restrain the masonry. Around openings, bed joint reinforcement should be positioned in the two courses directly above the opening and in the first and third course below the opening. The reinforcement should project at least 450mm either side of the opening. Whilst additional tensile and flexural strength may be obtained by the use of bed joint reinforcement, the size of the bed joint may preclude it's use or effectiveness. In terms of walling materials such as ashlar, the risk of cracking increases where the length of a panel exceeds twice the height. Low horizontal walls such as spandrel panels are particularly vulnerable to damage.

Extra consideration should be given to the South and West facing elevations as these suffer more thermal gain. Movement joints should be positioned wherever there are changes in thickness or directions of walls. Lightly restrained details such as parapets or boundary walls will need extra thought as these are more prone to movement.

The designer should also consider that brickwork can have movement joints positioned at up to 15m centres. Slip planes will therefore be necessary to separate the two materials. Always ensure that movement joints and slip planes do not impair the stability of the wall or its other functions. Use dowels or straps to provide lateral stability.

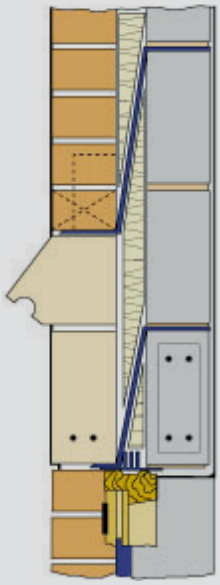
Movement joints are usually filled with an easily compressible joint filler of either polyethylene or polyurethane foam however, in narrow joints for cast stone they are usually formed butt jointed. Optimum performance in butt joints is obtained when the depth to width ratio of the sealant is in the range of 2:1 or 1:1 for two part polysulphide sealants.

*Further advice on the design and construction of movement joints can be found in BSI Standards Publication PD 6697: 2010, BS 6093: 2006 and BS 6213:2000.*



DPC used as a slip plane

# 4.3 Prevention of Moisture Penetration



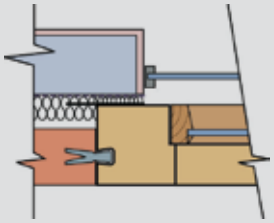
Position of DPC at head with dual supporting lintel

In cavity wall construction, the location of DPC's should be based on the assumption that rain water will penetrate the outer leaf and, more often that not, run down the internal face of the external leaf. Damp proofing measures are essential in controlling the ingress of rain through locations where the cavity is bridged and where there is a potential for moisture to track across these areas to the internal leaf. Careful attention to design and detailing, combined with good site practice, is essential in the elimination of damp penetration.

**The materials for the damp proof courses and cavity trays are varied. However they should all comply with the requirements of relevant British Standards:**

| | |
|---|---|
| BS 743: 1970 | Specification for materials for damp proof courses |
| BS 8000: Part 3: 2001 | Workmanship on building sites – Code of practice for masonry |
| BS 8215: 1991 | Code of practice for the design and installation of damp-proof courses in masonry construction |
| BS 6398: 1983 | Specification for bitumen damp proof course for masonry |
| BS 6515: 1984 | Specification for polyethylene damp-proof courses for masonry |

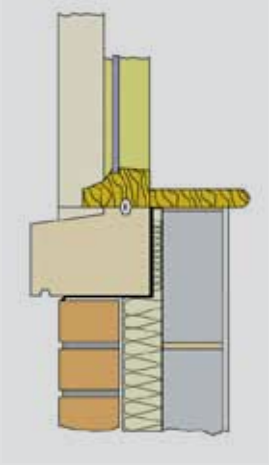
Alternatively, they should be supported by an Agrément Certificate.



Position of vertical DPC

DPC's should extend through the full thickness of the wall or leaf, at least 150mm above the external ground. It is good practice to overlap all DPC materials, by at least 100mm to prevent the upward transference of moisture. Where downward moisture movements occur, the DPC's should be lapped and sealed. Pitch polymers are generally favoured for masonry construction because they do not exude under load, have good bond characteristics and are not easily perforated. Using the appropriate adhesives, effective joints can be formed giving increased flexibility of use.

The risk of moisture penetration may be reduced by consideration of the following features.



Position of DPC at cill

### 4.3.1 Heads & Lintels

Cavity trays are vital in providing a watertight barrier which will channel and discharge water to the outside face of the masonry. Cavity trays with stop ends should be incorporated over all openings in external cavity walls and extend a minimum of 150mm on either side of the opening. The part of the tray that bridges the cavity should be adequately supported and this is particularly important at locations where the tray is to be jointed. The cavity tray should be bedded on both sides in fresh mortar. The tray should fall a minimum of 150mm across the cavity. Weepholes, positioned directly above the tray in the external leaf should be located at a maximum of 1m centres. There should be a minimum of 2 weepholes per opening and each weephole should be at least 75mm high. In locations where full cavity insulation is anticipated, the spacing of the weepholes should be reduced. The use of label moulding will

require additional trays. The cavity tray should over lap the vertical DPC at the jamb.

### 4.3.2 Jambs

To prevent the transmission of moisture, a continuous vertical damp proof course should be included behind jamb sections and this should extend at least 25mm into the cavity beyond the cavity closer. The DPC can be fixed to the window frame. Vertical DPC's at openings should be located so as to overlap the horizontal DPC at cill level, whilst being overlapped by the horizontal DPC at the head.

### 4.3.3 Cills

A horizontal damp proof course with stop ends should be provided in all jointed cills or sub-cills, for the full length and width of the cill bed. If the damp proof course is in contact with the inner leaf or cavity infill, the DPC should be turned up at the back and ends for the full depth of the cill. A cavity barrier/thermal barrier will be required to prevent cold bridging. Preformed cavity closers are available which provide both the damp proofing and thermal bridging requirements in one component.

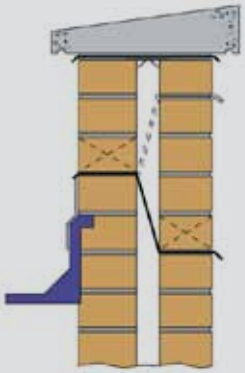
*Refer to BSI publication PD 6697 for full details.*

### 4.3.4 Cappings and Copings

BSI Standards Publication PD 6697: 2010 states that "Chimney terminals, freestanding walls, parapet walls and retaining walls exposed to the weather, should preferably be provided with a coping." Copings should have a drip on the underside, positioned a minimum of 40 mm from the face of the wall. Where for aesthetic or other reasons a capping is used, consideration should be given to the durability of the construction beneath which may be exposed to wetting. A coping with drips positioned as indicated may still not shed rainwater clear of the wall surfaces beneath. A continuous DPC, supported over the cavity, will be required below a capping or coping detail to prevent the downward transfer of moisture into the wall. This DPC should be bedded on both sides so that it is sandwiched in the joint and projecting 5 mm beyond each face of the wall below.

In parapet walls, a stepped cavity tray will be required which should fall a minimum of 150mm across the cavity. Weepholes, 75mm high are required at a maximum of 1m centres.

*Further reference should be made to BSI Standards Publication PD 6697: 2010 and BS 5642: Part 2:1983*



Position of DPC in parapet wall

## 4.4 Position of Water Bars

In cases of high exposure and to prevent water penetration through the joints in the cast stone, stainless steel water bars, bedded in polysulphide mastic, should be specified.

## 4.5 Cold bridging & Insulation

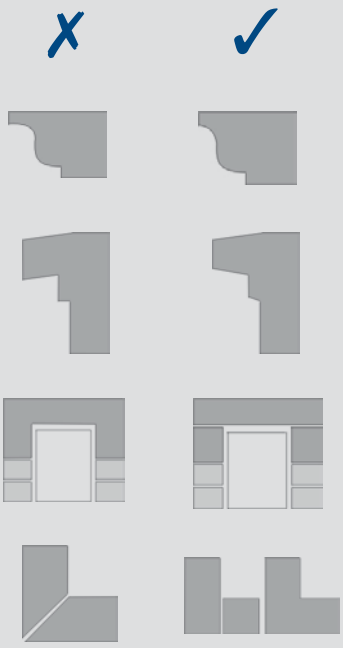
All external walls should be designed to meet the requirements of the relevant Building Regulations, in particular Approved Document Part L, and the general thermal insulation requirements of the building. The implication of cold bridging and risk of condensation, for example at exposed internal mullions, and window head and cill positions, should be considered and cold bridge paths should be avoided. Consult your UKCSA supplier for design information specific to the cast stone detailing of the project.

## 4.6 Prevention of Staining

Where the sectional profile allows it, all projecting components should be detailed with a drip groove in an attempt to shed water clear of the face of the structure and to reduce staining. However, as indicated in Section 4.3.4 the inclusion of a drip may still not shed rainwater clear of the wall surfaces beneath.

Lead or copper flashing over cast stone can cause staining. As an alternative, GRP or metal pre-formed flashings should be used. All flashing or weathering details should be bedded at least 25mm into the works and be provided with sealed joints and adequate overlaps. Attention to detail can prevent water from the flashing washing over the surface of the cast stone.

## 4.7 The Design of the Element




As many UKCSA members offer a bespoke service to customers, cost savings can often be achieved by discussing customised components at the design stage. The following comments are of a general nature only.

- Avoid slender projections from the unit. These increase the likelihood of damage on demoulding and do not enhance either the appearance or authenticity of the final units.
- Avoid negative rakes as these present difficulties in mould design.
- Avoid ‘U’ sections. These are very difficult to mould and less robust than creating the same effect using the jointed components.
- Avoid mitred joints. The use of quoins is traditional for wall construction and jointed returns are an alternative, much more robust solution.

Consideration should also be given to slenderness ratios when designing cast stone units to minimise the risk of cracking.

*Please refer to Section 8.4.5 for more information.*

## 4.8 Reinforcement

For structural elements consideration must be given to the design strength and the reinforcement detailing. Please refer to Section 8.4.6 of this manual for information. Reference should also be made to BS EN 1992 and BS EN 1996. Alternatively, advice should be sought from the individual manufacturer.

## 4.9 Lifting

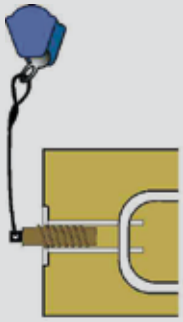
Cast stone has an advantage over quarried natural stone in that units can contain cast-in lifting attachments. These come as M16 or more delicate M12 cast-in threaded sockets or as proprietary lifting clutch systems, and assist the Specifier in meeting their CDM Regulations responsibilities.

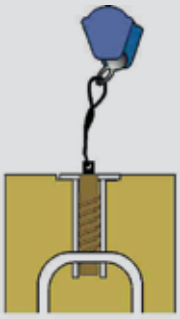
For delicate placement of large stones, a rope block-and-tackle system, suspended from a runway beam attached to the top of the scaffold, or even suspended from a crane hook, gives controllable, gentle adjustment. Chain blocks should not be used as they may mark the stone.

Materials used for lifting inserts depend upon the eventual position in the building, but in the great majority of applications where they are covered by subsequent construction and encased in an alkaline environment (i.e. mortar bed), BZP units are perfectly suitable and more cost-effective than stainless steel.

Safety of lifting operations has to be of paramount concern and relevant sections of HASAWA and Manual Handling Regulations should be observed, and Risk Assessments conducted before work commences. The following points should be considered:

- Where screw-in wire bond lifting loops are used, it is essential to ensure the threads are screwed fully home, and that a vertical lift is used – lifting capacity reduces very rapidly with angled lifts.
- When a threaded lifting eye has to be used at a right angle (e.g. a socket insert in the back of a panel) then articulated loops are available.
- With two point lifts, use a spreader beam to avoid angled slings.
- Snatch loading by cranes cannot be calculated for and must be avoided as it will damage both stones and lifters.
- Lifting stones directly with slings is unstable and can be unsafe.
- Webbing slings can damage unprotected arrisses.
- Wire rope or chain slings are completely unacceptable.




Unit should not be lifted with lifting eyes or loops at angles and always ensure that the eye loop is screwed fully home otherwise the thread can strip.


PIONEER
MPC
DATA

# 5.0 Supply & Site Practice

**Cast stone supplied by UKCSA members is manufactured to the highest standards and considerable care is taken to ensure that the units are handled and stored correctly prior to delivery. This section provides guidance on the transportation of cast stone units and their use on site.**

Health and Safety information e.g. Control of Substances Hazardous to Health [C.O.S.H.H.] data should be obtained directly from the manufacturer. Users should be also aware of Health and Safety requirements for handling of units. UKCSA manufacturers will generally have discussed handling requirements at the design stage to ensure that consideration is given to points such as the slenderness ratio of the product and it's characteristics i.e. it's profile and the ease of handling on site. This may include the incorporation of reinforcement and cast-in lifting sockets for the units.

Cast stone should be treated with care. The units must be handled and stored with care to prevent chipping, cracking or staining, especially those with finely detailed profiles. Long slender units should be handled in the plane they are designed to be installed, unless otherwise advised by the manufacturer. A typical example of a product which may not be handled in the same plane as it is installed would be a 65mm thick cill. Unless supplied in short lengths, this unit can suffer deflection cracks.

## 5.1 Transporting the Units

During transit the following points should be considered:

- A suitable vehicle e.g. rigid or articulated trailer preferably with air suspension should be used for transport.
- Units should be covered during transit to protect them from saturation and staining.
- Bearers should provide adequate support to prevent incidents of point loading of the units.
- Pallets should be designed to withstand the load which they are to carry
- Palletised deliveries of cast stone should be unloaded by the mechanism for which they were designed, either by grab or forklift, using suitable forks. Under no circumstances should scaffold poles, timbers etc. be used to carry or support the pallets.
- When using grabs, these should grip the pallet, not the product.
- Slings should not be used unless previously discussed with the manufacturer.
- Where slings are used to lift individual units, the arrises of the unit should be protected and the sling positioned to provide an even support.

## 5.2 Site Storage

Once the product is on site the following guidelines should be followed:

- Palletised products should be stored on flat, level, dry ground at a safe distance from other trades, roadways, etc. to prevent damage to the aesthetics and structure of the product. Runners should be used to support pallets on soft ground.
- Never stack pallets of products on top of one another.
- Individual units should not be stacked face to face without appropriate interface material (manufacturers packaging and protective materials should be used for this).
- Individual units should be suitably supported by timber or plastic bearers.
- Products should remain packaged until immediately prior to use.
- When unpacking the product, strapping/ packaging should be carefully cut, not ‘burst open’. Ensure that care is taken when cutting the packaging so that the face of the stone is not damaged by the knife blade.
- It is important that opened packs of cast stone are covered with polythene sheeting to prevent the ingress of water, dirt or dust.

The UKCSA has produced a cartoon-based site poster for the safe handling of cast stone. It can be downloaded from www.ukcsa.co.uk

# 5.3 Site Handling

The safe handling of cast stone components is essential in order to ensure that they remain undamaged. Where handling information is not clear, contact the supplier for further recommendations.

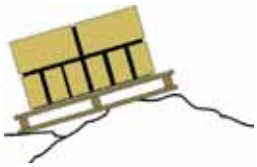
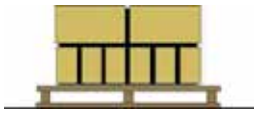
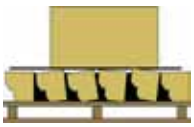
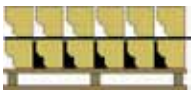
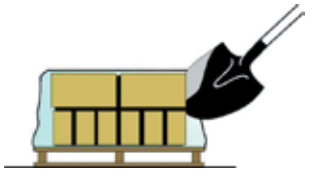
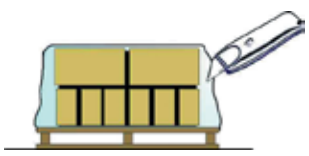
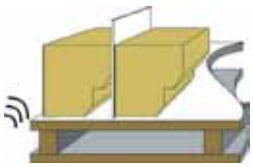
- A manual handling assessment should be carried out before the units or pallets are moved.
- Where units are supplied with lifting sockets or eyes these must be used. Avoid side loading to sockets by using a lifting beam where necessary.
- Always use suitable plant for moving the product around site and ensure wherever possible that units are delivered to the work area before any obstructions are put in the way.
- Units should be adequately supported to ensure ease of handling. Care must be exercised not to drop the product.
- Re-use interior packing to protect faces, arrises etc. during site handling.
- Care should be taken not to slide the units across each other.

Don't store pallets on sloping or uneven ground. Make sure storage area is flat, level and dry

Never stack pallets and large units on top of each other

When unpacking products, do not burst open the wrapping either by hand or with site tools. It should be cut open with a knife, taking care not to damage the faces.

When moving pallets of cast stone units, always re-use interior packing to prevent damage to faces, arisses and profiles.

| | ✗ | ✓ |
|---|---|---|
| Don't store pallets on sloping or uneven ground. Make sure storage area is flat, level and dry. |  |  |
| Never stack pallets and large units on top of each other. |  |  |
| When unpacking products, do not burse open the wrapping either by had or with site tools. It should be cut open with a knife, taking care not to damage the faces. |  |  |
| When moving pallets of cast stone units, always re-use interior packing to prevent damage to faces, arrisses and profiles. |  |  |

# 6.0 Installation

## This section provides guidance on protecting cast stone during construction, laying, bedding, joining, cutting, the recommended grade of mortars for cast stone products, and casting-in any required fixings.

Cast stone units should only be installed by suitably qualified personnel. During construction, the units should be protected at the end of each day and it is advisable to protect finished work.

The fixing of cast stone should be considered at the design stage so that any required fixings can be cast-in during production. Your UKCSA supplier will be able to advise on the most cost-effective solutions.

Cast stone units should be designed to minimise on site cutting. They are typically designed to be fixed with joint sizes of between 5-10mm and should be laid and adjusted to final position while the mortar is still plastic. It is vital to specify the correct mortar designation, which is often different to that used for the surrounding brickwork. Mortars containing lime give a stronger bond than those containing air-entrainment.

## 6.1 Protecting During Construction

Protect the units at the end of each day with polythene sheeting to prevent contamination and use edge protectors to prevent impact damage to the arrises. Allow an air space to let air circulate within the polythene sheeting, to prevent condensation forming.

## 6.2 Laying

Cast stone should only be installed by masons or suitably experienced personnel. Below are some general precautions that should be observed.

- During construction it is advisable to protect finished work using appropriate gauge polythene sheeting. This prevents mortar drops, mastic, paint and other construction materials staining or adhering to the cast stone.
- Mortar stains can be removed by using a dilute hydrochloric acid (typically 7-10%) solution. The masonry should be wetted down with water to reduce the initial suction by the cast stone. Under no circumstances should the masonry be saturated. The stain should be agitated with a nylon brush to break up the surface of the mortar stain. The acid should then be washed from the surface of the masonry. Care should be taken to ensure that the acid washings are collected and conveyed to a safe place for disposal. Protective equipment will be required by the operatives and this will include goggles, rubber gloves and protective overalls.
- Brace constructions to prevent damage to freshly assembled materials. It is also advisable to limit the height and number of courses constructed in any one day, depending upon the width of the wall, mortar strength, exposure, unit density and weight. Typically, individual lifts should be limited to 1.2m in any one day unless restrained.

## 6.3 Bedding and Jointing

Typically, cast stone products are designed to be fixed with joint sizes of between 5-10mm between the units. All units should be laid and adjusted to final position while the mortar is still plastic. Mortar exuding from joints should be cut away without smearing the face of the unit. Use load shedding (plastic) spacers to support heavy stones and to prevent the mortar being extruded until it has cured sufficiently. Locating holes for dowel joints should be completely filled with either mortar or resin.

- Do not leave pockets that could collect water. Protect all unfinished masonry with polythene.
- During hot dry weather, the faces to be jointed should be lightly sprayed with clean water to reduce initial suction and to prevent the cast stone from removing too much moisture from the mortar. If this does occur, there may be insufficient water left in the mortar to fully hydrate the mix and this will result in a dry, powdery joint which may be substantially weaker than anticipated in terms of bond strength,. However, it should be noted that the use of water reducing admixtures or other water resistant additives, introduced into the cast stone during manufacture may reduce the effectiveness of spraying the joint with water. Ideally, the correct designation of mortar should be specified in the first instance, to suit the environmental conditions.

## 6.4 Cutting

Cast stone units should be designed to minimise on-site cutting. If it is unavoidable on site, units should be cut with a diamond tipped masonry blade which should ideally be water fed. Once cut, all units should be washed down to remove any excess dust. Due regard should be given to protecting the operative in accordance with the current Health & Safety requirements.

# 6.5 Mortars

It is vital that the correct mortar designation is specified when using cast stone products. The designer should note however that this is often of a different designation to that used for the surrounding brickwork. Failure to allow for this, particularly where the mortar is stronger, can result in cracks appearing in long units as a result of concentrating the effects of differential movement. The cracks are usually of little structural significance but are unsightly. The reason is that too much restraint is offered by strong mortars and that this can cause distress to the cast stone by preventing the shrinkage process taking place. The cracks will occur both in the cast stone and in the mortar below onto which the units are bedded. This can cause debonding of the unit from the mortar and hence instability. If strong mortar is used for the jointing/pointing process then damage may occur to the arrises as the strong mortar shrinks away, perhaps pulling some of the arris with it. Strong mortars shrink considerably and also have a higher bond strength.

- Sand and cement mortars are not recommended because they lack the required workability to allow the masons to lay the units at an economic rate.
- Mortars should be able to resist frost and develop durability fairly quickly. However, as has been stated earlier, the strongest mortars are not always the best. Where a mortar of a stronger strength is required for durability reasons, reference should be made to Table NA.2 of NA to BS EN 1996-1-1: 2005.
- Mortars containing lime give a stronger bond than those containing air-entrainment and are particularly useful because the improved bond increased flexural strength and better resistance to rain penetration. Air-entrained mixes tend to be more resistant to frost damage, particularly when the mortar is at an early age. With mortars containing lime however, there is also the added advantage of a certain self healing action, known as autogenous healing. This has the effect of sealing small cracks (often caused by movement) which occur in the mortar. Free lime in the form of calcium hydroxide, which is formed during the hydration of the cement, is washed from the cement matrix when the joint becomes wet. As the free lime washes to the surface of the joint, it reacts with the carbon dioxide to form calcium carbonate which is non-water soluble. This self seals the fissure and in time makes the joint more water proof.

To improve the water repellent quality of the joint in exposed conditions, proprietary water-proofers are often added to the mortar. However, the most commonly used water proofing additives such as Styrene Butadiene, which is a co-polymer latex emulsion (SBA or SBR) cannot typically be specified because they are only suitable with either a designation (i) or (ii) mortar, which is too strong for cast stone components.

*For further information please refer to NA to BS EN 1996-1-1: 2005.*

The recommended grade of mortars are:

| Types of Mortar | Binder Constituents | Designation |
|---|---|---|
| Cement:Lime:Sand | A Portland cement and lime with or without an air entraining additive | (iii) 1:1:5 to 6<br>(iv) 1:2:8 to 9 |
| Masonry Cement:Sand | Masonry cement containing Portland cement and lime in the approximate ratio 1:1 and an air entraining additive | (iii) 1:3.5 to 4<br>(iv) 1:4.5 |
| | Masonry cement containing a Portland cement and inorganic materials other than lime and an air entraining additive | (iii) 1:4 to 5<br>(iv) 1:5.5 to 6.5 |
| Cement:Sand (plasticised) | A Portland cement and an air entraining additive | (iii) 1:5 to 6<br>(iv) 1:7 to 8 |

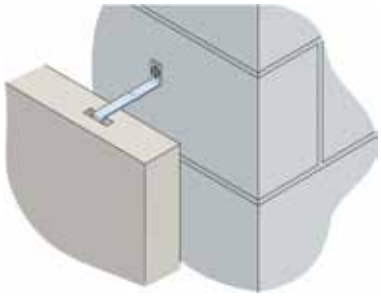
*All proportions by volume*

# 6.6 Fixings

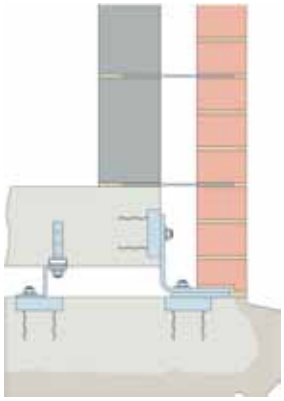
Consideration should have been given to the fixing of cast stone at the design stage so that any required fixings can be cast-in during production. This will facilitate easy installation and reduce unnecessary costs and delays. Your UKCSA supplier will be able to advise on the most cost effective solutions to the requirements.

Here are some typical examples of fixing solutions.

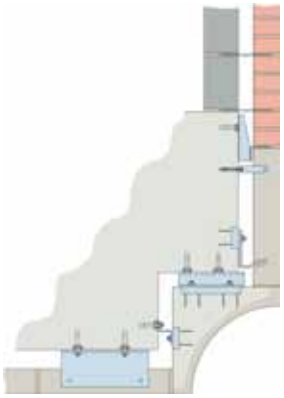
*Illustrations used courtesy of Ancon Building Products*



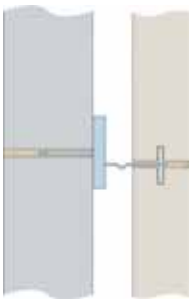
Tie fixed to blockwork restraining the top of a cast stone unit



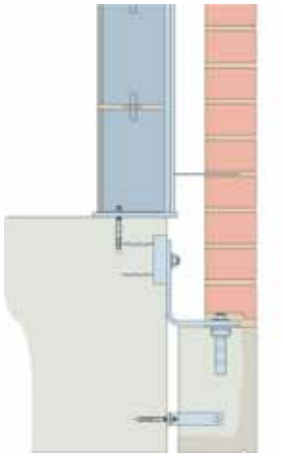
Continuous angle supporting brickwork above and cast stone units



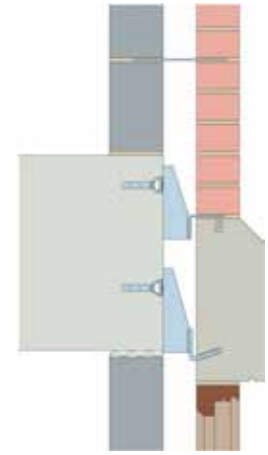
Support unit with special angles and channels for soffit and feature stones



Proprietary channel used with tie for stonework



Continuous angle supporting brickwork above and cast stone units



Units supporting various materials

Support with restraint dowels for cornice

# 7.0 Aftercare & Surface Effects

**High quality cast stone is a highly durable material, and if correctly installed will last for many decades with minimal care and maintenance.**

## 7.1 Prevention

Every effort should be taken to protect the cast stone units from contamination. Care taken in transit, storage, fixing and protection during construction virtually negates any requirement for additional work.

Cast stone should not, in the natural course of events, require any maintenance over many years. The product will weather in a similar way to natural stone and consideration should be given to prevailing climatic conditions at design stage.

However, routine maintenance of other elements of the building fabric is important and such examples are keeping gutters, roof coverings, flashings and hoppers in good working order. Joints should be kept properly pointed, excessive vegetation removed or controlled, ferrous metal painted and judicious cleaning undertaken when necessary.

## 7.2 Cleaning

Cleaning is most frequently undertaken for aesthetic reasons. However, sometimes there are sound practical grounds for removing dirt when, for instance, decay is taking place around encrustations and cracks or open joints are being obscured.

Before undertaking any cleaning of cast stone there are several important considerations to review.

- Cast stone behaves in a similar way to natural stone and the precautions required for cleaning the natural material should be adopted with cast stone.
- Any cleaning will expose the underlying cast stone and various elements of the structure may have weathered differently causing changes in colour. The effect after cleaning may be a patchy finish.
- Although cast stone elements may get dirty, this is usually unlikely to cause any particular problem unless the encrustation of dirt is causing decay to the surface, or staining the underlying stone, especially at street level. In these cases some remedial action may be appropriate.

### 7.2.1 Precautions

Before the application of any treatment to cast stone it is recommended that the supplying UKCSA member is contacted for advice. Any subsequent treatment should be tested on a small sample area in an inconspicuous place prior to any major application.

### 7.2.2 Pointing

Particular attention should be paid to the condition of the joints prior to the commencement of any cleaning programme. These should be inspected to ensure that the pointing is in a sound condition.

### 7.2.3 Health & Safety

- In all cases of cleaning professional advice and/or the advice of the individual manufacturer should be sought prior to the commencement of any treatment.
- Always use experienced operatives for the cleaning process and follow the cleaning material manufacturer's instructions.

- Any company undertaking cleaning processes must complete a full risk assessment in accordance with Regulation 3 of the Management and Safety at Work Regulations and comply with the control measures necessary to fulfil their statutory obligations.
- Information on protective measures contained within this manual is given only as a guide and should not be assumed to meet all requirements indicated above.

## 7.3 Repair Work

In many cases it is possible to repair chips etc., but the recommended techniques vary from manufacturer to manufacturer and their advice should be sought. It should be noted that repair work is normally carried out with mixes very similar to those used in the original product and will therefore take time to weather to the colour of the item.

## 7.4 Weathering

Research commissioned by UKCSA and carried out by the Concrete Technology Unit of University of Dundee on semi-dry cast stone, confirmed that the material weathered in a similar way to original natural stone control samples when both were exposed to identical atmospheric conditions.

# 7.5 Efflorescence

Rain Dampens Surface

Slowly soluble salts dissolve and migrate towards the surface as the stone dries

This leaves minute white/ colourless crystas at the surface (known as Efflorescence)

Optical properties conceal the crystals when they are wet

Efflorescence, also known as lime bloom, may appear as a white deposit covering part or all of the surface of products containing cement. The result of light deposits is the lightening of the surface colour the heavier the deposit the lighter the colour. Except in very severe cases the phenomenon disappears completely when the unit is wet and reappears at it dries out. The phenomenon is temporary and will, with time, disappear as a result of normal weathering. The length of time will depend on many factors such as rainfall, atmospheric pollution etc.

### 7.5.1 Occurrence

Efflorescence is a temporary, naturally occurring phenomenon that occurs to a varying extent on all items containing cementitious binders. Mortar is particularly prone to efflorescence in the form of lime staining and this can contaminate other products (e.g. cast stone, bricks etc).

It is formed by soluble salts from the cement migrating to the surface where they react with the atmosphere to produce the white powder (calcium carbonate) known as efflorescence. Individual crystals are very small and are not firmly fixed to the surface.

The smallness of the crystals linked with their optical properties causes them to become invisible when wet. As they dry out they become visible and are unchanged. Products are more susceptible to efflorescence under damp conditions as this aids the movement of the soluble salts.

Efflorescence in no way affects the structural integrity of the cast stone.

### 7.5.2 Prevention

The risk of occurrence of efflorescence will be reduced by protection on site before and during installation.

### 7.5.3 Treatment

Whilst it is better to allow the phenomenon to disappear naturally, it may, however, be removed chemically by using a proprietary acid washing agent (e.g. dilute hydrochloric acid). The product should first be thoroughly soaked with clean water followed immediately by the application of the commercial acid washing material (which is generally available from most builders merchants) in accordance with the manufacturer's instructions and Health and Safety Guidelines.

A small trial area in an inconspicuous place is recommended to be treated prior to any major application. As the efflorescence dissolves there will be some frothing and once it has finished the whole surface should once again be thoroughly rinsed with clean water. In the vast majority of cases one treatment should be all that is necessary, but in severe cases retreatment may be required.

The cast stone manufacturer should be consulted before applying any chemical compounds to its products.

# 8.0 UKCSA Standard

**This standard has been developed by the members of the United Kingdom Cast Stone Association and surpasses the requirements of the current British Standard BS 1217:2008.**

## 8.1 Scope

This Standard covers the materials that can be used, the acceptable tolerances and minimum performance in terms of strength and durability for cast stone.

## 8.2 Definition

For the purposes of this Standard the following definitions apply:

**Cast stone:** Any material manufactured with aggregate and a cementitious binder that is intended to resemble the appearance of, and be used in a similar way to natural stone. Cast stone is either homogenous throughout or consists of a facing material and a backing material.

*For other definitions of concrete materials, reference should be made to BS 6100.*

## 8.3 Materials

### 8.3.1 Binders and Binder Constituents

Cast stone shall be made by using one of the following binders complying with the appropriate standard:

| | |
|---|---|
| BS EN 197-1: 2000 | Specification for Portland cement |
| BS EN 197-4: 2004 | Specification for low early strength blastfurnace cements |
| BS 4027: 1996 | Specification for sulphate-resisting Portland cement |

The binder shall be used either by itself or, for cements complying with BS EN 197-1, in combination with one of the following;

| | |
|---|---|
| BS EN 15167-1: 2006 | Ground granulated blast furnace slag for use in concrete, mortar and grout |
| BS EN 450: 2005 | Fly ash for concrete |

### 8.3.2 Aggregates

Aggregates used, apart from grading requirements, shall conform to the appropriate standard as follows:

| | |
|---|---|
| BS EN 12620: 2002 | Aggregates for concrete |
| BS EN 13055: 2002 | Lightweight aggregates for concrete, mortar and grout |
| BS EN 15167-1: 2006 | Ground granulated blast furnace slag for use in concrete, mortar and grout |
| BS EN 450: 2005 | Fly ash for concrete |
| BS 3892-2: 1996 | Pulverised-fuel ash to be used as Type 1 addition |

### 8.3.3 Additives

There are a variety of additives which may be used as an integral part of the cast stone mix. The two main uses of additives are to improve the plasticity of the mix and to reduce permeability of the finished product. Self compacting admixtures can be used in the wet cast process.

Plasticisers tend to be chemicals based on compounds of Formaldehyde or Lignosulphate and improve the workability of the mix and aid compaction. Water proofers can either be a surface treatment or an integral part of the mix.

Surface treatment water proofers tend to be based on acrylics, silicones, silanes or siloxanes that can either penetrate the surface to form a chemical bond within the substrate imparting hydrophobic/ hydrophilic properties or form a water impervious surface.

Integral water proofers work by either filling the pore structure to block the further penetration of water i.e. hydrophilic or imparting a charge to the pore surface to repel water particles i.e. hydrophobic.

Metal stearates have been used as an integral water proofer for over 50 years. These stearates are hydrophobic and are typically blended with other materials to obtain good dispersion within the cement matrix.

Calcium stearates are used primarily as damp proofers, where an electrostatic charge is imparted into the walls of the capillaries of the cast stone mix. By the very way in which these stearates are produced, they also have the added advantage that they act as water proofers by sealing the voids within the macro texture of the material.

### 8.3.4 Pigments

Metallic Oxide pigments used in the manufacturing process should conform to BS EN 12878: 2005 Specification for Pigments for the colouring of building materials based on cement and/or lime.

## 8.4 Requirements for Units

The declaration of the properties of the units called for in this Standard will assist the designer in correctly designing the construction works.

All requirements for testing of products detailed within this section are further defined in Appendix 1 & 2.

For Internal Quality Control, other test methods may be used provided that:

- A relationship can be shown to exist between the results from the standard test and those from the alternative test, and
- The information on which the relationship is based is available for inspection.

### 8.4.1 Two Part Mixes

When cast stone is made from separate facing and backing mixes the facing shall have a minimum thickness of 20mm at any point. A bond between the facing and backing mixes shall be made either by a mechanical key or by inter-diffusion.

### 8.4.2 Surface Finish

Surface finishing techniques may be employed in the manufacture of cast

stone. The surface finish shall, unless otherwise specified, exhibit a texture similar to that of natural stone. The colour and texture of the exposed (when installed) face of cast stone should be agreed between the supplier and the purchaser. The supplier should on request supply a sample of an agreed size for approval of the purchaser. It is important that finishes are discussed with the manufacturer, particularly where very smooth surfaces are being considered, as the type of finish will significantly influence the overall appearance.

### 8.4.3 Linear Dimensions

The actual dimensions of individual regular units should conform to the declared work dimensions subject to the tolerances given below. Individual manufacturers may specify tolerances that are tighter than those in the table following page.

| Dimension (mm) | Tolerance (mm) |
|---|---|
| up to 600 | +/- 2 |
| 601 – 1000 | +/- 3 |
| 1001 – 2500 | +/- 4 |
| 2501 – 4000 | +/- 5 |
| over 4000 | +/- 6 |

### 8.4.4 Flatness of Plane Surface

Where the surfaces intended to be exposed in the finished cast stone are declared by the manufacturer to be plane, they shall not deviate from a plane by more than the values given below. The units shall be tested in accordance with Appendix 1.

Maximum permitted variation from plane = 0.3 % of the maximum dimension of the item or 2 mm whichever is the greater.

### 8.4.5 Slenderness Ratio

Slenderness ratio is equated by using the diameter of either an inscribed or superscribed circle on the section of the product, determined by the supported plane, and the length of the product.

The slenderness ratio $S_R$ is given by the equation: $S_R = \frac{L}{d}$

where $L$ is the product length in mm and $d$ is the diameter of the circle.

The slenderness ratio should be less than or equal to 15 for wet cast units or less than or equal to 12 for semi-dry units.

Alternative ratios may be used subject to agreement between manufacturer and purchaser and slenderness ratio is not relevant in the case of thin walled Fibre Reinforced Cast Stone (FRCS) units with their enhanced tensile and bending strength.

### 8.4.6 Reinforcement

Untreated low carbon high yield steels shall have a minimum cover of 40 mm when measured from any installed exposed face and 30 mm from any protected face.

Galvanised steels shall have a minimum cover of 30mm when measured from any installed exposed face and 20mm from any protected face.

Stainless steels shall have a minimum cover of 10mm or twice the bar diameter whichever is the greater, when measured from any exposed face.

For other reinforcement materials the specification is as given in BS 1217: 2008. A variety of other reinforcement materials such as basalt fibre or fibre reinforced polymer product are available and their use will be drawn to the clients attention prior to manufacture of the units.

Weathered section showing typical inscribed circle

Cut ends of galvanised steels must be coated before use.

Where units are made from two-part mixes, reinforcement shall neither be placed within 10 mm of the interface nor across the interface of the facing and backing mix, unless the cementitious binder used in both mixes is identical.

Reinforcement may be required either for structural or handling purposes only. Other metal components may be required for fixing or restraint purposes. These may or may not be considered as part of the reinforcement.

### 8.4.7 Compressive Strength

The average crushing strength of three cubes tested to BS EN 12390-3 shall not be less than 35 MPa @ 28 days old. No individual cube is to have a strength of less than 28 MPa.

The figure of 35 MPa represents a 40% increase in compressive strength over that indicated in the British Standard and is as a result of research carried out by The University of Dundee. Note:1MPa is equal to 1N/mm$^2$.

### 8.4.8 Capillary Absorption Test (CAT)

When sampled and tested in accordance with Appendix 2 with an immersion time of 10 minutes, the mean coefficient of water absorption due to capillary action of the three samples shall not exceed 1.0 mg/mm$^2$ with no individual value exceeding 1.3 mg/mm$^2$.

It should be noted that the recent research project undertaken in conjunction with The University of Dundee has identified that the overall durability of a product is more likely to be indicated by the compressive strength than the CAT figure. The CAT figure is more useful in determining whether a water proofing/ damp proofing additive has been included.

### 8.4.9 Sulphate Resistance

Where sulphate resistance is required (normally in unprotected ground or ground containing natural sulphates) the suitability of the units shall be based on the cement type and content.

### 8.4.10 Thermal Conductivity

When requested by the customer, the manufacturer/supplier shall declare the thermal resistance of the units. The value shall be established either by testing or from recognised tables.

### 8.4.11 Fire Properties

Units manufactured in accordance with this Standard are non-flammable, non-combustible, do not give off toxic gases and can provide a barrier to the spread of smoke and flame. Standard values should be referred to for the fire resistance of walls made from units complying with this Standard.

### 8.4.12 Sound Insulation

The sound insulation provided by cast stone built with units to this Standard is predominantly influenced by mass per unit area. The density of the units will be declared by the manufacturer on request to enable mass calculations to be carried out.

Other factors such as the shape of the units and the air-tightness of the wall also have an influence. In general, the sound insulation of a cavity wall is affected by the width of the cavity, the type and spacing of the wall ties.

# 8.5 Sampling

### 8.5.1 Cube Crushing Test

Compliance testing shall be demonstrated by the testing of three cubes of either 100 mm or 150 mm size made from the facing mix and also from the backing mix where applicable. The three cubes shall be made from a single batch of mix and shall be compacted in the same way as the finished cast stone. Compliance testing shall be carried out on a minimum of a weekly basis.

### 8.5.2 Capillary Absorption Test

Select three samples of cast stone (when tested these must be at least 17 days old). The sawing of specimens shall not be permitted. Capillary absorption testing shall be carried out on a minimum of a quarterly basis.

### 8.5.3 Marking

The following particulars shall be clearly marked on the delivery notes, drawings or supplier's certificate supplied with a consignment of cast stone products:

- The name trade mark or other means of identification of the manufacturer.
- Product reference and/or description.

To comply with BS 1217: 2008 the manufacturer must also clearly state the weathering class i.e. either CAT and/ or ISAT and the number and date of the British Standard (i.e. BS 1217: 2008).

# Appendix 1- Flatness of Plane

The equipment required to perform this test shall be:

- Straight edge of equal or greater length to the maximum dimension over which the flatness is to be measured or 1.5 m whichever is the lesser.
- Feeler gauges (two sets).

**Method**

**Concave Surfaces:** Place the straight edge on the surface of the item to be tested. Insert a feeler gauge blade between the straight edge and the surface of the cast stone. Measure the deviation from the straight and compare with the value given in 8.4.4.

**Convex Surfaces:** Place the straight edge on the surface of the item to be tested. Insert two feeler gauge blades of identical size, one at each end of the straight edge such that contact is made between the feeler gauge blades the straight edge and the stone. Measure the deviation from the straight and compare with the value given in 8.4.4.
*NB The deviation from the straight is the thickness of one feeler blade not the sum of both.*

# Appendix 2 – Capilliary Absorption Test

Measure the visual face of each product by suitable means and record the area of each in square millimetres to the nearest 10mm$^2$. Record as $A_1$, $A_2$, $A_3$.

At not less than 14 days old, dry the three products in a well ventilated oven or ovens at 70±5°C for at least 72h and allow to cool to room temperature 15-25°C in an air-tight enclosure. Weigh and record the mass of each unit to the nearest 0.1% of the product weight and record as $W_1$, $W_2$, $W_3$.

Place each product, supported on suitable spacer devices, into a try and fill with cold water so that the visual face under test is under a maintained 5±1mm head of water. After 10±0.5min, remove each product; remove excess water with a damp rag and within 30s of the removal, reweigh and record the masses as above, Record as $X_1$, $X_2$, $X_3$.

Calculate the capillary absorption $C_1$, in mg/mm$^2$, to the nearest 0.1 mg/mm$^2$:

$$C_1 = \frac{1000\ (X_1 - W_1)}{A_1}$$

Similarly repeat the calculation for the other samples $C_2$ and $C_3$ substituting the relevant values of $X$ and $W$.

Finally calculate the mean value $C$ (in mg/mm$^2$) as:

$$C = \frac{C_1 + C_2 + C_3}{3}$$

Record the mean value to one decimal place.

# Appendix 3 – The UKCSA Specification

- Cast stone units:
  - Manufacturer: Member of the United Kingdom Cast Stone Association (UKCSA).
    *(See www.ukcsa.co.uk/membership.php for a list of current members)*
  - Manufacturing process: In accordance with the UKCSA Operating Standard
  - Method of manufacture: Wet cast *
    Semi-dry cast *
    Fibre reinforced cast stone *
    *(* include the method of manufacture required as appropriate)*
  - Product references: To approved details
  - Absorption: To BS 1217: 2008, CAT method
  - Compressive strength: To BS 1217: 2008
    Cube strength testing to be carried out on a minimum of a weekly basis
    Cubes cured in accordance with BS EN 12390-2
    Cubes crushed in accordance with BS EN 12390-3
  - Average cube strength: Minimum 35 MPa (35 $N/mm^2$)
    Single cube strength: Minimum 28 MPa (28 $N/mm^2$)
  - Finish: To approved sample
  - Colour: To approved sample
- Mortar: To BS 5628-3: 2005
- Joints: Flush pointed
  - Width: 6 mm **
    10 mm **
    *(** include the joint width required as appropriate)*
- Other Requirements: None

# Appendix 4 – British Standard References

The following British Standards give guidance and information on various aspects of the design and construction of masonry structures:

It is strongly recommended by UKCSA that all concerned are acquainted with the relevant aspects of the Standards prior to commencing on a project. UKCSA members will be able to advise clients with particular reference to cast stone materials and components.

| | |
|---|---|
| BS 743: 1970 | Specification for materials for damp proof courses |
| BS 1217: 2008 | Cast stone. Specification |
| BS 1881-208: 1996 | Testing concrete. Recommendations for the determination of the initial surface absorption of concrete |
| BS 3892-2: 1996 | Pulverized-fuel ash. Specification for pulverized-fuel ash to be used as Type 1 addition |
| BS 3892-3: 1997 | Pulverized-fuel ash. Specification for pulverized-fuel ash for use in cementitious grouts |
| BS 4027: 1996 | Specification for sulphate-resisting Portland cement |
| BS 5642-1: 1978 | Sills and copings. Specification for window sills of precast concrete, cast stone, clayware, slate and natural stone |
| BS 5642-2: 1983 | Sills and copings. Specification for copings of precast concrete, cast stone, clayware, slate and natural stone |
| BS 6073-2: 2008 | Precast concrete masonry units. Guide for specifying precast concrete masonry units |
| BS 6093: 2006 | Design of joints and jointing in building construction. Guide |
| BS 6100-0: 2010 | Building and civil engineering. Vocabulary. Introduction and index |
| BS 6100-1: 2004 | Building and civil engineering. Vocabulary. General terms |
| BS 6100-6: 2008 | Building and civil engineering. Vocabulary. Construction parts |
| BS 6100-9: 2007 | Building and civil engineering. Vocabulary. Work with concrete and plaster |
| BS 6100-11: 2007 | Building and civil engineering. Vocabulary. Performance characteristics, measurement and joints |
| BS 6213: 2000 +A1: 2010 | Selection of construction sealants. Guide |
| BS 6398: 1983 | Specification for bitumen damp proof course for masonry |
| BS 6515: 1984 | Specification for polyethylene damp-proof courses for masonry |
| BS 8000 Series | Workmanship on building sites |
| BS 8000-3: 2001 | Workmanship on building sites. Code of practice for masonry |
| BS 8104: 1992 | Code of Practice for assessing exposure of walls to wind driven rain |
| BS 8215: 1991 | Code of practice for design and installation of damp-proof courses in masonry construction |
| BS 8221-1: 2000 | Code of practice for cleaning and surface repair of buildings. Cleaning of natural stones, brick, terracotta and concrete |
| BS 8221-2: 2000 | Code of practice for cleaning and surface repair of buildings. Surface repair of natural stones, brick and terracotta |
| BS 8900:2006 | Guidance for managing sustainable development |
| BS 8902:2009 | Responsible sourcing sector certification schemes for construction products. |
| BS EN 197-1: 2000 | Cement. Composition, specifications and conformity criteria for common cements |
| BS EN 197-2: 2000 | Cement. Conformity evaluation |
| BS EN 197-4: 2004 | Cement. Composition, specifications and conformity criteria for low early strength blastfurnace cements |
| BS EN 450-1: 2005 +A1: 2007 | Fly ash for concrete. Definition, specifications and conformity criteria |

| | |
|---|---|
| BS EN 771-1: 2003 | Specification for masonry units. Clay masonry units |
| BS EN 771-2: 2003 | Specification for masonry units. Calcium silicate masonry units |
| BS EN 771-3: 2003 | Specification for masonry units. Aggregate concrete masonry units (dense and light-weight aggregates) |
| BS EN 771-4: 2003 | Specification for masonry units. Autoclaved aerated concrete masonry units |
| BS EN 771-5: 2003 | Specification for masonry units. Manufactured stone masonry units |
| BS EN 771-6: 2005 | Specification for masonry units. Natural stone masonry units |
| BS EN 772 Series | Methods of test for masonry units |
| BS EN 845-1: 2003 +A1: 2008 | Specification for ancillary components for masonry. Ties, tension straps, hangers and brackets |
| BS EN 845-2: 2003 | Specification for ancillary components for masonry. Lintels |
| BS EN 845-3: 2003 +A1: 2008 | Specification for ancillary components for masonry. Bed joint reinforcement of steel meshwork |
| BS EN 1991 Series | Eurocode 1. Actions on structures |
| BS EN 1992 Series | Eurocode 2. Design of concrete structures |
| BS EN 1993 Series | Eurocode 3. Design of steel structures |
| BS EN 1994 Series | Eurocode 4. Design of composite steel and concrete structures |
| BS EN 1995 Series | Eurocode 5. Design of timber structures |
| BS EN 1996-1-1: 2005 | Eurocode 6. Design of masonry structures. General rules for reinforced and unreinforced masonry structures |
| NA to BS EN 1996-1-1: 2005 | UK National Annex to Eurocode 6. Design of masonry structures. 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 |
| NA to BS EN 1996-1-2: 2005 | UK National Annex to Eurocode 6. Design of masonry structures. General rules. Structural fire design |
| PD 6697: 2010 | Recommendations for the design of masonry structures to BS EN 1996-1-1 and BS EN 1996-2 |
| BS EN 1996-2: 2006 | Eurocode 6. Design of masonry structures. Design considerations, selection of materials and execution of masonry |
| NA to BS EN 1996-2: 2006 | UK National Annex to Eurocode 6. Design of masonry structures. 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 |
| NA to BS EN 1996-3: 2006 | UK National Annex to Eurocode 6. Design of masonry structures. Simplified calculation methods for unreinforced masonry structures |
| BS EN 1997 Series | Eurocode 7. Geotechnical design |
| BS EN 1998 Series | Eurocode 8. Design of structures for earthquake resistance |
| BS EN 1999 Series | Eurocode 9. Design of aluminium structures |
| BS EN 12620: 2002 +A1: 2008 | Aggregates for concrete |
| BS EN 12878: 2005 | Pigments for the colouring of building materials based on cement and/or lime. Specifications and methods of test |
| BS EN 12390-2: 2009 | Testing hardened concrete. Making and curing specimens for strength tests |
| BS EN 12390-3: 2009 | Testing hardened concrete. Compressive strength of test specimens |
| BS EN 13055-1: 2002 | Lightweight aggregates. Lightweight aggregates for concrete, mortar and grout |
| BS EN 15167-1: 2006 | Ground granulated blast furnace slag for use in concrete, mortar and grout. Definitions, specifications and conformity criteria |
| BS EN 15167-2: 2006 | Ground granulated blast furnace slag for use in concrete, mortar and grout. Conformity evaluation |
| BS EN ISO 9001:2008 | Quality management systems. Requirements |
| BS EN ISO 14001:2004 | Environmental management systems. Requirements with guidance for use |

# Appendix 5 – Acceptability Guidance

The following minor blemishes to cast stone on structures are considered acceptable by UKCSA:

### Chips, Scuffs, Blemishes, Hairline Cracks, Crazing.

Shall not be obvious under direct daylight illumination from a distance of 6m.

### Cracking

Minor hairline cracking can seal itself through the action of autogenous healing and as such is unlikely to be a major problem.

However, a live crack, one that is continuing to move due to external forces, is unlikely to heal quickly as the walls of the crack will be moving and the crack width changing.

The cause of the cracking may be a more important factor than the crack itself. For instance, cracked cills are usually caused by incorrect installation, eg fully bedding the cills instead of just bedding under stools, the cills not being able to move independently to the brickwork around and being pulled apart by the brickwork movement at the opening. In this instance the incorrect installation should be dealt with rather than the result ie the cracked cill, and a replacement cill should be correctly installed.

### Colour Variation

Cast stone items are manufactured with natural products and colour variations are inevitable and should not be a cause for rejection.

Cast stone is trying to replicate the appearance and character of quarried stone with it's inherent variations in both colour and texture.

Initial colour variations can often be down to the age of the products. There could be 6-8 weeks differences in the age of the products when initially installed, leading to colour differences due to inherent moisture content, weathering etc. These will all equalise in time when the pieces are installed and subject to the same water content, weathering and sunlight conditions.

Colour differences can also arise due to the water content of individual castings. This may simply be due to the position on the building which allows one piece to get wetter than another during normal weather conditions, or may be due to problems with the waterproofer in the castings. In the latter case, this should be dealt with as a failure of the stone to comply with the British/UKCSA Standard, rather than a colour acceptability issue.


### Colour Variations (due to Efflorescence)

Lime bloom, or efflorescence is a temporary, naturally occurring phenomenon that occurs to varying extents on all items containing cementitious binders. It will, with time, disappear as a result of normal weathering. The length of time will depend on many factors such as rainfall, atmospheric pollution etc. The bloom can also be removed by the judicious use of a mild brick cleaner.

### Surface Texture Variations

All surfaces intended to be exposed to view shall exhibit a texture approximately equal to the approved sample when viewed under direct daylight illumination from a distance of 3m.

### Surface Texture Variations (Wet Cast)

All surfaces intended to be exposed to view shall have no air voids greater than 0.8 mm and the density of such voids shall be less than three occurrences per 25 mm square.

### Repairs

Repairs to cast stone shall be acceptable if the repairs conform to the other requirements above.

Repairs can range from minor filling of blemishes through to a reconstruction of the piece with a full surface coating. Significant differences in colour may exist between the properly repaired areas and the original castings when the time elapsed between the date of manufacture and the date of the repair is great. The repaired areas should be left alone and should blend in over time due to the action of curing, natural weathering and sunlight, as mentioned under Colour Variations.

### Dimensional Requirements

Shall be in accordance with the British/UKCSA Standard.

# Glossary

**Acid Etching** Process of applying a solution of hydrochloric or muriatic acid to the exposed surface of cast stone in order to remove the laitance from the aggregates, thus achieving a fine grained finish which simulates natural cut stone.

**Anchor** Metal device used for securing cast stone to a rigid structure.

**Arris** The sharp edge at the junction of two adjacent surfaces of a cast stone unit.

**Ashlar** Masonry constructed of stones to a rectangular shape and laid in courses, as opposed to rubble work which is uncoursed masonry of random shaped stones.

**Backing Mix** Concrete, normally sand, gravel, and grey cement: used for the unexposed portion of cast stone.

**Bed Joint** The joint which the stone sits on. It is normally filled with mortar.

**Capping** Cast stone unit intended to protect the top of a wall, balustrade or parapet as well as adding aesthetic value to the wall, but not necessarily designed to shed rainwater clear of the surfaces beneath.

**Cast Stone** Any material manufactured with aggregate and a cementitious binder that is intended to resemble the appearance of, and be used in a similar way, to quarried stone. Cast stone is either homogenous throughout or consists of a facing mix and backing mix.

**Colouring** A process of (or material used for) tinting the hue of cast stone. It is normally achieved through the use of aggregates or inorganic iron oxide pigments.

**Coping** Cast stone unit intended to protect the top of a wall, balustrade or parapet as well as adding aesthetic value to the wall, and designed to shed rainwater clear of the surfaces beneath.

**Crazing** A series of hairline cracks, normally less than one millimetre in depth, in the outer surface of a concrete product. Crazing does not normally affect the life of a concrete product.

**Curing** The process of hydrating the Portland Cement in cast stone to a specified age or compressive strength.

**Dowel** Round (usually non-corrosive) metal pin used in anchoring and aligning cast stone.

**Dressings** Brickwork or stonework flanking a wall opening or adjacent to a corner, treated distinctly from the remainder of the wall face.

**Drip** Continuous groove cut or cast into the bottom of the projecting edge of cast stone in order to disrupt the path of the water to the wall below.

**Efflorescence** Also known as lime bloom, may appear as a white deposit covering part or all of the surface of products containing cement. It is a temporary, naturally occurring phenomenon that disappears as a result of normal weathering.

**Exposed Face** Any face which is not bedded or otherwise protected in the works (e.g. with mortar or bitumen). Visual Faces are Exposed Faces but not necessarily vice versa.

**Facing Mix** Materials used for both homogenous cast stone and, when a backing mix is used, the visual face of cast stone.

**Fibre Reinforced Cast Stone**
A wet cast manufacturing process incorporating alkali-resistant extruded fibre reinforcement. Allows thin and lightweight sections to be produced.

**Fines** Aggregates passing 6mm sieve.

**Finish** Final exposed surface of cast stone. It is independent of colour, but it will control the colour intensity. Acid etching is a cast stone finish.

**Full Bed** A horizontal joint completely filled with mortar.

**Grout** Mortar of pouring consistency.

**Head** A unit spanning an opening but not necessarily intended to carry the weight of the construction above.

**Homogenous** A single continuous mix throughout the section of the unit.

**Insert** A metal device cast into a unit normally used for anchoring or handling.

**Jamb** The vertical side of a door or window frame or opening.

**Joint** Gap between masonry units filled with mortar or backer rod and sealant.

**Jointing Scheme** The jointing pattern shown on contract documents.

**Lift Socket** A metal device embedded into the cast stone for the purpose of lifting and/or anchoring.

**Lintel** A unit spanning an opening and intended to carry the weight of the construction above.

**Monolithic** Of, say, a column when it is made of a single block of stone.

**Mortar** A blend of cement, lime, sand and water which is applied at a pliable consistency to bond masonry units.

**Mould** A form in which cast stone is shaped. It can be constructed from wood, rubber, fibreglass and other materials.

**Operating Standard** The UKCSA Operating Standard lists the minimum manufacturing processes and control requirements that all manufacturing members must comply with as a condition of membership.

**Precast** A concrete product not poured in place.

**Quoins** Masonry blocks placed to give emphasis to the corner of a building.

**Rebar** A deformed steel bar used for reinforcing cast stone.

**Rebate** A continuous groove cut or cast into a cast stone unit.

**Reinforcing** Rebar, basalt fibre composite reinforcing bars, or alkali-resistant extruded fibre placed into a cast stone unit during the manufacturing process to augment the unit during handling or to enable it to carry a structural load (ie lintel).

**Return** The side or face of a surface or moulding at right angles to the main face.

**Reveal** The return of a wall surface into a door or window opening, normally at right angles to the main wall face.

**Rustification** Masonry of stone, brick or stucco with the joints between the blocks recessed with V-joints or other profiles imparting additional emphasis and visual strength to the wall.

**Semi Dry Cast Stone** A manufacturing process giving components a slightly open textured face, similar to sawn quarried stone.

**Shop Drawing** The drawing which the cast stone manufacturer submits for approval, showing the shape of pieces, exposed faces, jointing, anchoring, reinforcing and unit cross section.

**Soffit** The underside of a projecting element such as a cornice, or any flat underside.

**Splay** A large-scale chamfer, such as a door or window reveal, wider at the wall surface than at the frame.

**Slip Cill** A cast stone window sill that fits within the masonry opening.

**Tolerance** Allowable deviation from specified dimensions.

**Tooled Finish** A finish obtained by texturing the cast stone eg bush hammering or needling.

**Trowel Finish** A finish normally given to the back or unformed side of cast stone. This finish may look slightly different than the moulded sides of the piece.

**Visual Face** Any face or part of a cast stone unit visible after completion of works. Visual Faces are Exposed Faces but not necessarily vice versa.

**Wet Cast Stone** A manufacturing process giving a close face texture and allowing large components and those with complex reinforcements to be produced.

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