CI/SfB (41) Se5
March 2002

Cladding by BURLINGTON

This brochure describes the use of Burlington stone as external wall cladding and internal wall lining to achieve a natural finish which will last the lifetime of a building.

Stone by Burlington was formed by the progressive deposition of fine silt during the Silurian age. The deposits were metamorphosed by intense heat and pressure within the earth's crust, creating a totally waterproof non-porous material with a fine compact texture and great strength.

For over three hundred years Burlington has quarried this natural metamorphic stone from the heart of the English Lake District. Architects and designers around the world have long taken advantage of its natural beauty, durability and adaptability to create classic weather-resistant details and surface finishes.

Benefits of natural stone

The richness and character of natural stone impart weatherproofing, durability and prestige to any building. With its great strength and natural beauty, Burlington natural stone offers unique advantages, it is:-

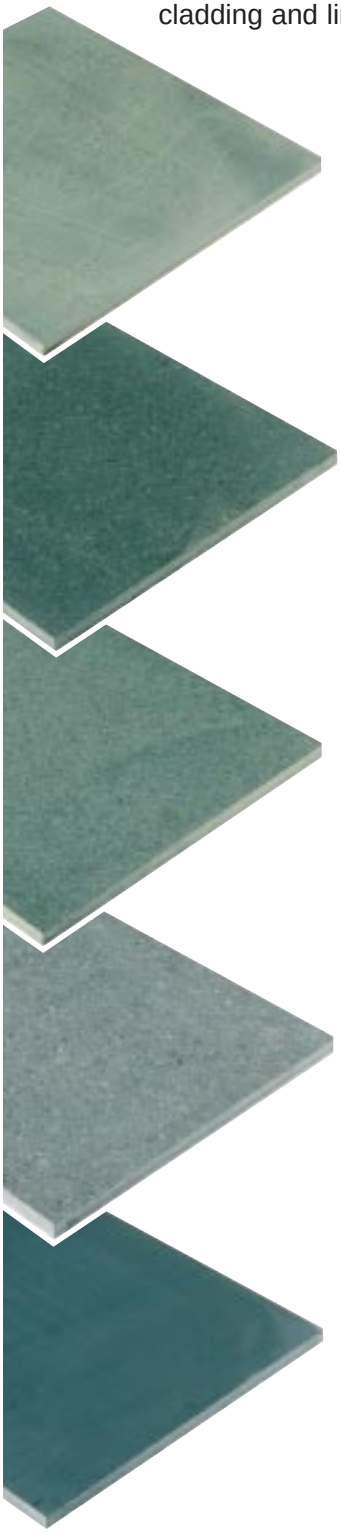
- of excellent appearance;
- hard, dense and very durable;
- impervious to water;
- resistant to frost, acid rain, salt attack and pollution, cycles of wetting and drying, and extremes of temperature;
- colour-fast – will not fade on exposure to UV light;
- chemically inert – compatible with all other building materials;
- resistant to (and will not support the growth of) mosses, lichens, algae or fungi;
- non-combustible;
- self-cleansing – very little maintenance required.

When correctly detailed and installed, Burlington stone cladding and linings have a service life in excess of one hundred years. The performance characteristics of the material have been determined by extensive testing and are given on separate Product Data sheets available from Burlington.

Cover photo: Aronoff Center for the Arts

STONE BY BURLINGTON

Burlington's quarries produce five distinctive types of stone, all of which are suitable for cladding and lining applications:



- Elterwater:
  a pale green stone;
- Bursting Stone:
  an olive green stone;
- Broughton Moor:
  a mid green stone;
- Brandy Crag:
  a silver grey stone;
- Blue Grey:
  a blue grey stone.

With the exception of Blue Grey, which is an even tone throughout, each stone is highlighted by contrasting veins which emphasise its natural origins and add character to any facing application. When combined in a single scheme the different types blend harmoniously, providing complement and contrast.

The variety of surface treatments which can be applied to each stone increases the range of options for any design scheme; those finishes include:

waterjet: the surface of the stone is worked with high-pressure water jets to give a non-slip matt finish;

honed: a smooth finish with a slight sheen, produced by using a polishing head;

sanded: sawn stone slabs are coarsely polished; this removes saw marks and leaves a semi-smooth, regular finish;

cleft: with this traditional treatment the stone is riven along its line of cleavage to reveal the natural grain; this gives an undulating surface with great character;

gritblasted: a high-pressure airline projects coarse-grained grit onto the top surface of the stone producing a finish similar to cleft, but available on slabs of greater size.

flamed: the top surface of the slab is burned off using a high temperature torch, giving an irregular textured finish;

textured: the top surfaces of sawn slabs are pneumatically tooled to produce a pitted or grooved surface.

Burlington are continually developing the range of treatments available. Sample cards showing materials and finishes can be supplied: please check the availability of a finish on a particular stone before specifying. If you require a specialised effect we will be happy to discuss with you how it can be achieved.

Burlington stone for cladding and lining is available in 20mm, 30mm and 40mm thicknesses, as described in Table 4 of BS 8298 1994: "Design and installation of natural stone cladding and lining" (MIA Design Manual IV*: 1", 1.25" and 1.5"). To meet individual project requirements, stone can be cut and shaped to other thicknesses and profiles if required.

* Whilst the principles for specifying and installing natural stone cladding are universal, codes and standards vary between countries. Where variations exist the specific requirements for the USA are given in brackets.

REALIZING THE POTENTIAL OF CLADDING

> "Stone is of the earth but, when it is worked, it receives the sky and becomes architecture."
>
> (Christian Norberg-Schulz)

The use of thin stone panels to *clad and *line buildings has a long history extending from the Roman period. Over the centuries architects have employed stone in this fashion to achieve buildings of grace and grandeur: stone has echoed the form of the building, emphasised structural elements such as columns and arches, and decorated interiors and exteriors.

***cladding** refers to an external veneer covering a structure: it may include both vertical and horizontal surfaces and carries no load other than its own weight;

***lining** refers to an internal wall covering which carries no load other than its own weight.

Advances in building technology over the last century have removed many of the structural constraints upon the use of building materials, giving designers greater freedom in the treatment of surfaces. Although cladding and lining are often regarded as two dimensional, stone remains a material with three dimensions, and this most basic of properties can be used to good effect.

Historically, the functional format of stone in compression revealed itself in the finished construction. In much the same way, the principles of masonry construction can be used as a starting point for developing attractive facing schemes. By referring to the functional requirements of masonry in the shaping of the stones, the coherence of the surface treatment can be increased and a sense of mass developed.

Facing set in bonded coursing recalls the original function of stone, allowing structural elements to be defined by the treatment of the facing. Other materials may be introduced to counterpoint the stone and the design can be further enhanced by variations in the finish of the panels. Plain butt joints will emphasise the continuity of the stone, whilst rebated or chamfered edges will give greater articulation to the facing.

Project: Miller Performing Arts Center, Alfred University

Architect: Kallmann, McKinnell & Wood

Splashback in honed Brandy Crag

Project: Central Library, Los Angeles

Architect: Hardy Holzman Pfeiffer Associates

Cladding to escalator in honed Elterwater

Project: McKenna and Cuneo, Washington DC

Architect: STUDIOS

Cladding to staircase in honed Broughton Moor

The use of quoins at corners, the development of columns or pilasters and the use of voussoir-like stones at openings are all references to traditional forms of loadbearing construction.

The formal and functional attributes of doors and windows can be accentuated with jambs and reveals, allowing components to be set back from the wall line, thus producing shadowing and articulating the elements. Introducing cills and string courses adds interest to openings and has the functional benefit of throwing rainwater away from the wall surface.

By contrast, stone cladding using modern technology may be used as a wrap-around skin which makes little reference to the underlying structure.

In rain screen cladding the joints between cladding units are left open and the cavity behind the cladding is ventilated to drain away and evaporate any moisture which penetrates the joints. Joints can be narrow and regular, they do not have to accommodate sealants.

Stone by Burlington is more than able to meet the exacting requirements of the modern construction industry, yet retains all the beauty of a natural material – a characteristic enhanced by sensitive detailing. The stone gives a practical, hard-wearing surface, which will maintain its appearance over centuries with virtually no maintenance, other than periodic cleaning.

The intrinsic beauty and quality of Burlington stone is clearly visible to building users and passers-by, enhancing the prestige and significance of any building.

All buildings undergo dimensional changes resulting from:

- settlement
- loading
- thermal effects

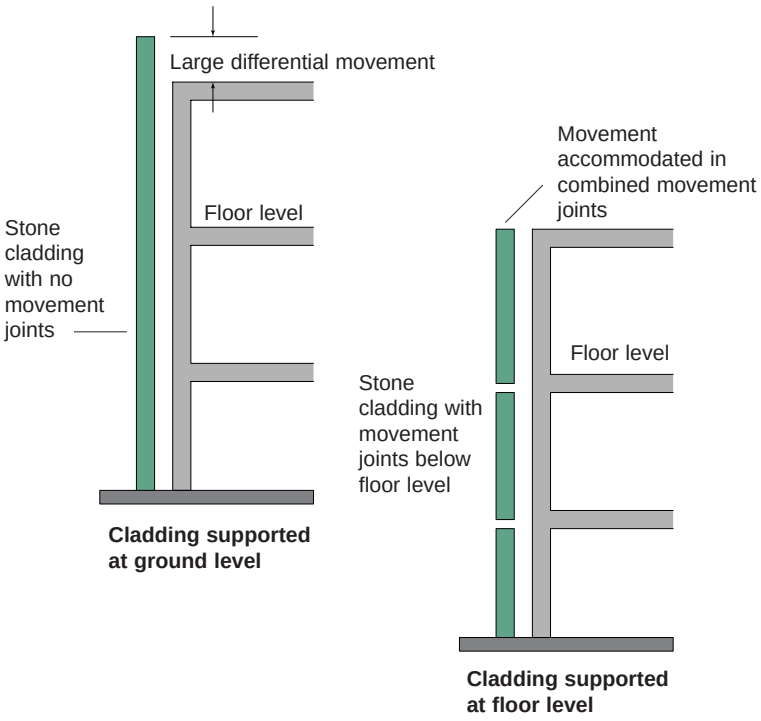
Because the physical characteristics and environmental exposure of the cladding differ from those of the substrate, dimensional changes produced in the one may not be matched by those in the other. This gives rise to differential movement between the cladding and the substrate which, if unrelieved, will produce stress, leading to distortion and/or damage.

The risk of damage can be eliminated by introducing flexible joints between cladding units. These break up differential movement into small amounts, the joints being wide enough to prevent units coming into contact as a result of differential movement. Guidance on how to assess the need for flexible joints to accommodate expansion and contraction of the structure is contained in BS 8298: 1994 “Design and installation of natural stone cladding and lining” and BRE Digest 223, whilst BRE Digests 227, 228 and 229 give details on how to calculate the extent of structural movement.

In principle, differential vertical movement requires flexible joints at each floor level and above openings, whilst the management of horizontal movement requires at least one flexible joint for every 6m (20') length of cladding: additional joints should be sited 1.5 - 3.0m from each corner.

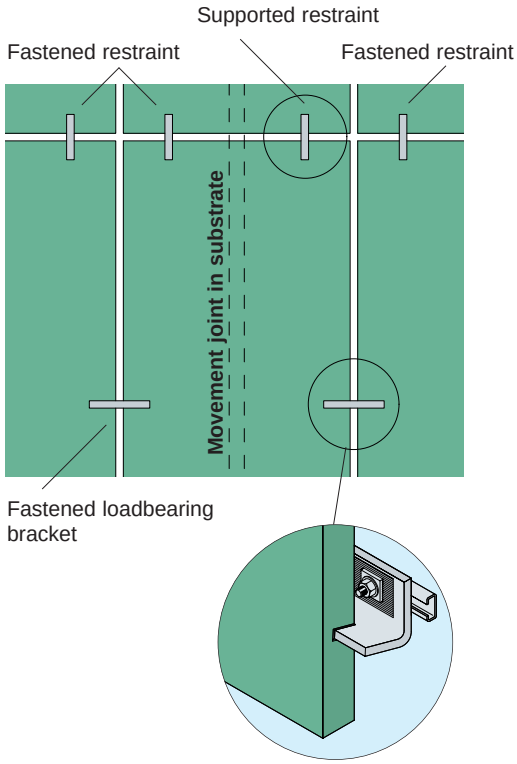
The recommended width for flexible joints accommodating vertical movement is 10mm (0.375"), whilst flexible joints accommodating horizontal movement should be 15mm (0.5") wide. Where necessary the exact dimensions of the flexible joints can be calculated by reference to the anticipated movement, which in turn depends upon the physical characteristics of the substrate and the cladding: stone by Burlington has a thermal coefficient of expansion of 10.4×10^{-6}m/˚C (a 3.0m length undergoing a 50˚C temperature rise would become 1.5mm longer). Burlington’s technical services can assist with calculations for individual projects.

Any movement joint provision made in the substrate must also be carried through the cladding and lining. Cladding units which span flexible joints must be fastened on only one side of the joint, and supported, without being fastened, on the other side.



Cladding supported at ground level

Cladding supported at floor level



Supported loadbearing bracket channel allows for lateral movement

Treatment of joints

Joints between cladding units can be treated in three ways:

- All joints left open, as in a rain screen system. The effect of wind and rain penetration upon the cladding and the substrate must be fully assessed and the ventilation and drainage of the cavity properly detailed.
- All joints sealed as soft joints with flexible sealant.
- Joints which do not accommodate movement sealed as hard joints and localised movement joints sealed as soft joints.

Hard joints may be pointed in mortar. For joints under 4mm ($^3/_{16}$") wide a 4:1 cement:sand mortar is suitable: above that width the mortar mix should be weaker to reduce risk of shrinkage cracks as the mortar dries. Lime gauged mortar may also be used: the longer curing time of lime gauged mortar will accommodate some initial movement and once set it will be stronger than cement mortar.

Sealants

The prime requirement of any flexible sealing material is that it retain its integrity across the entire range of changes of width of the joint. Identifying an appropriate sealing material involves matching the dynamic characteristics of the sealant (represented by its Movement Accommodation Factor) to the predicted maximum and minimum widths of the joints resulting from differential movements.

Sealants differ in their properties of **elasticity** (ability to recover size and shape after deformation) and **plasticity** (ability to be stretched continuously and permanently). Those with predominantly elastic properties are suitable for use with cladding materials with little thermal inertia which respond rapidly to changes in ambient temperature. More massive components, which react over days or weeks, require sealants with a combination of elastic and plastic properties.

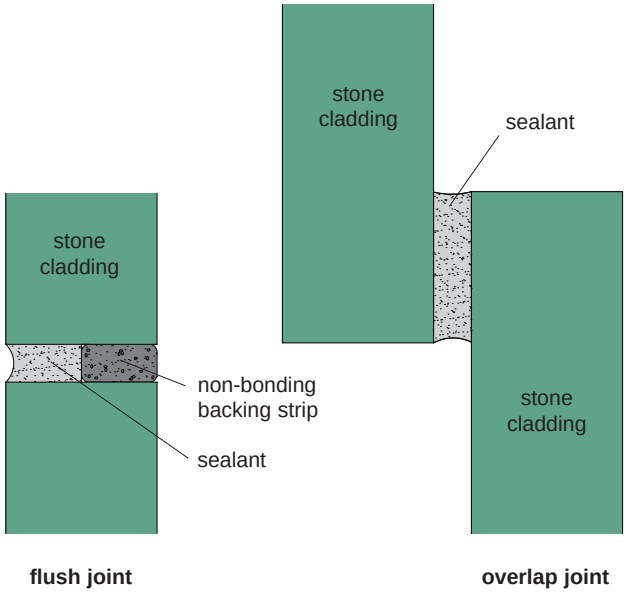
It is essential to provide a sealant backing strip for sealed joints: the backing strip assists in the correct application of the sealant by controlling sealant depth, prevents over-spill at the rear of the joint and provides a space into which the sealant can deform when compressed. Further guidance on the specification and installation of sealants is given in BS 6213: 1982 “Guide to selection of constructional sealants” (sealants for projects in the USA should comply with ASTM C920).

The choice of an appropriate sealant and its correct application are vital if sealant failure is to be avoided. A common cause of failure is migration of fluid from the sealant to the cladding, producing dark banding at joints or streaking on the face of the cladding. Whilst fluid migration initially affects the appearance of the cladding, it materially affects the performance of the sealant.

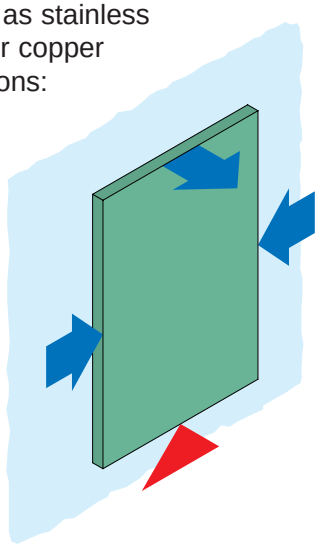
Burlington can advise on specific requirements for joint sealants.

Internal joints

Although there is no need to make them weathertight, joints in internal lining can be treated in the same way as those in external cladding. Where joints are narrow (1-2mm) and the anticipated movement is minimal, then they can be pointed with neat cement, tile grout or plaster of Paris.



Fixing components are the interface between the substrate and the facing. They may be formed of various materials such as stainless steel, phosphor bronze, or copper and have two main functions:



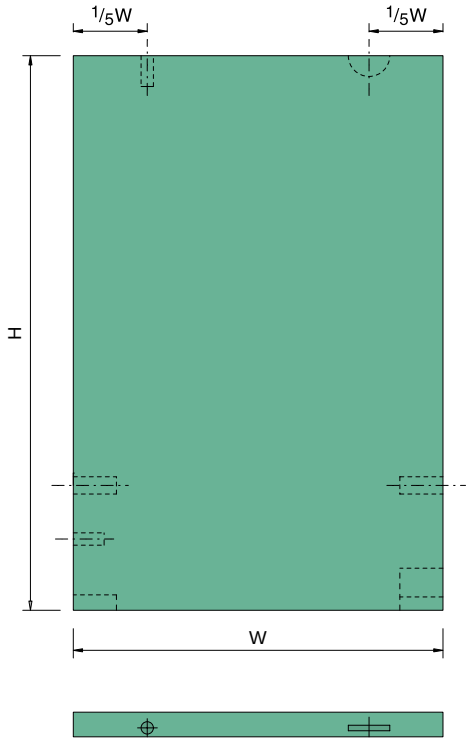
- **loadbearing:** to take the dead weight of the cladding or lining units:
- **restraining:** to hold the cladding or lining units in position and resist cyclic loads such as wind pressure and suction.

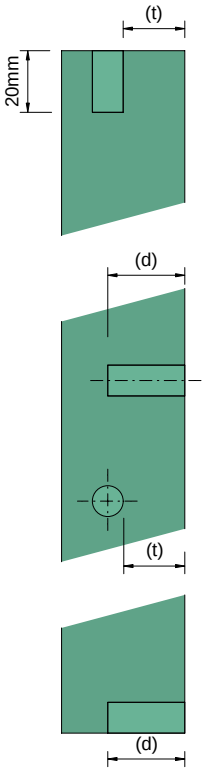
Fixings may be subject to direct, bending, shear and torsional stresses, all of which must be addressed at the design stage.

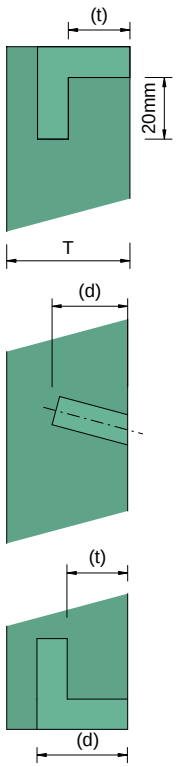
Recommended stone dimensions

	Stone Thickness T	Min. Thickness (t)	Min. Depth (d)
External cladding			
Less than 3.7m above ground or floor level and continuously supported	20mm (1")	7mm	N/A
More than 3.7m above ground or floor level	40mm (1.5")	15mm	25mm
Soffits	40mm (2")	15mm	N/A
Internal lining			
Less than 7m above ground and continuously supported	20mm (1")	7mm	N/A
Between 3.7 and 7m above ground or floor level, not continuously supported	30mm (1.25")	12mm	20mm
More than 7m above ground or floor level	30mm (1.25")	12mm	20mm
Soffits	40mm (2")	15mm	N/A

Sources: BS 8298: 1994 and (figures in brackets) MIA Design Guide IV.
Local building codes and standards may specify other dimensions.







Loadbearing

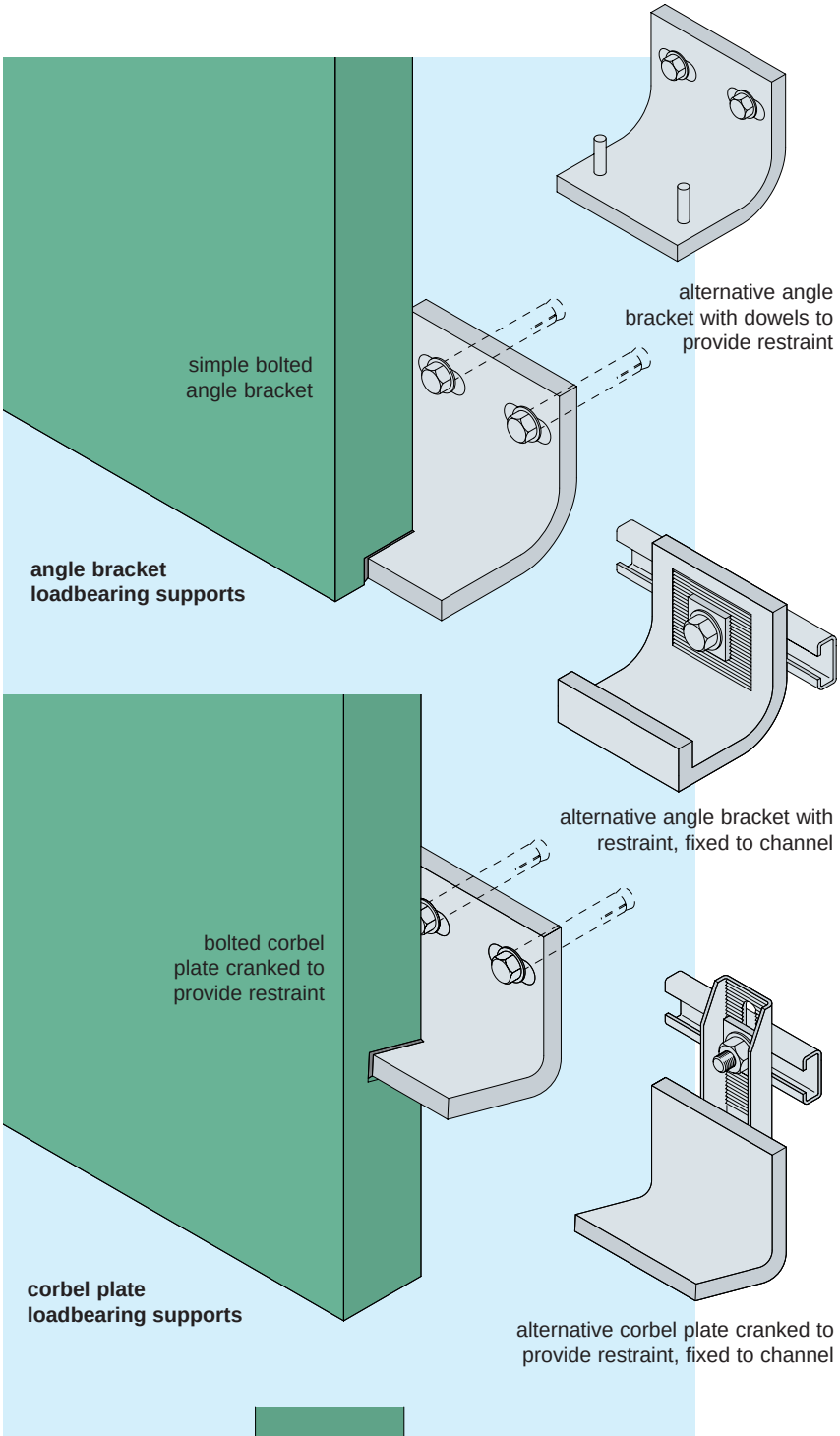
Loadbearing fixings must be provided at each floor level and over all openings in the structure or cladding. The load carried will depend on the thickness and area of the panels and the density of the stone. Cyclical or permanent water absorption can also affect the load, but Burlington stone's low absorption rate of 0.18% largely eliminates this consideration.

Loadbearing is commonly achieved using recessed angle brackets set at the bottom of the slab, or corbel plates projecting into mortices pre-cut into the back of the stone. The required depth of recesses and mortices is given in the table opposite.

Combination fixings

Design constraints may require fixings to be loadbearing whilst also providing restraint. This can be achieved by cranking the angle brackets or corbel plates, or by adding restraining dowels to angle brackets. Combination fixings should be fastened as close as possible to the bottom of the stone.

Undercut panel anchors may be employed where the cladding or lining is to be fixed to a steel support framework.



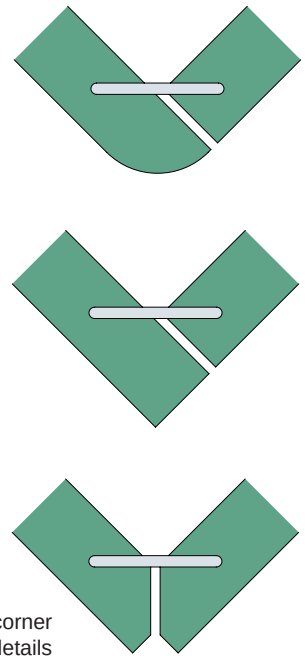
Restraint

Restraint fixings maintain facing stones in position by resisting the action of forces such as wind loading. The design of restraint fixings must eliminate or minimise permanent stresses upon the stones, fixings and substrate.

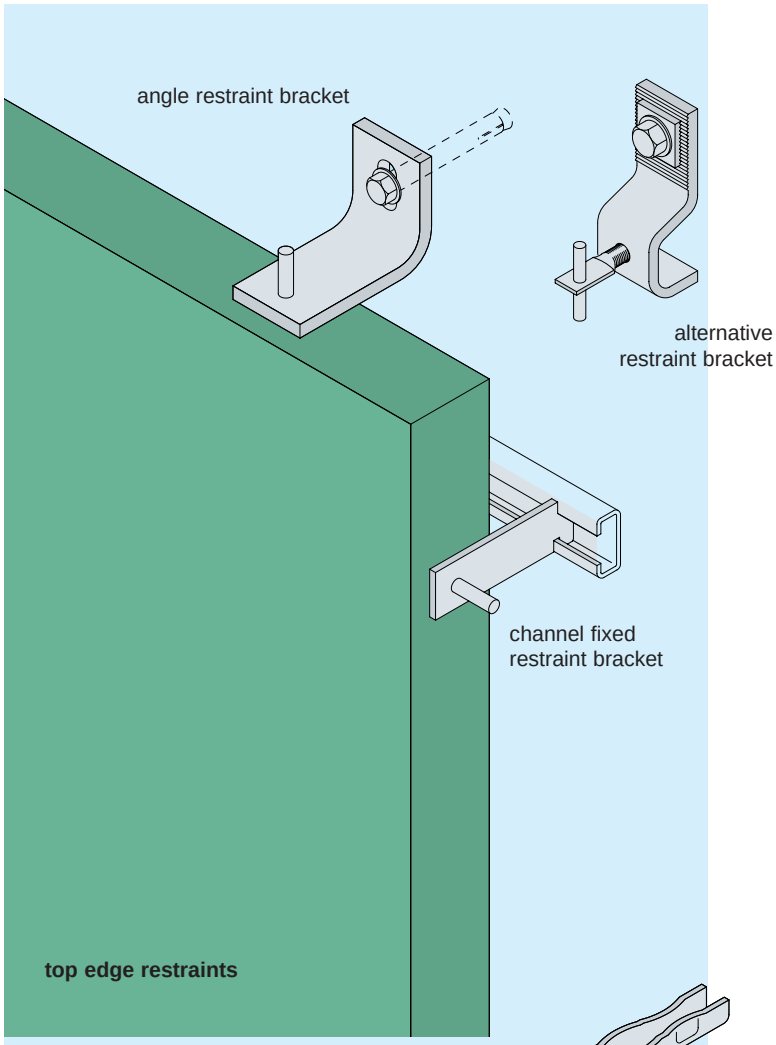
Each facing stone usually requires two restraint fixings at the top and two at the bottom, although for small stones one restraint fixing top and bottom may be sufficient. To maximise structural efficiency, restraint fixings should be sited at 1/5 points from each panel edge, or at least 75mm from the corner. The perimeter distance between fixings should not exceed 1200mm.

The commonest forms of restraint fixings are ties or cramps with dowels which project a minimum of 20mm into drilled holes in the slabs.

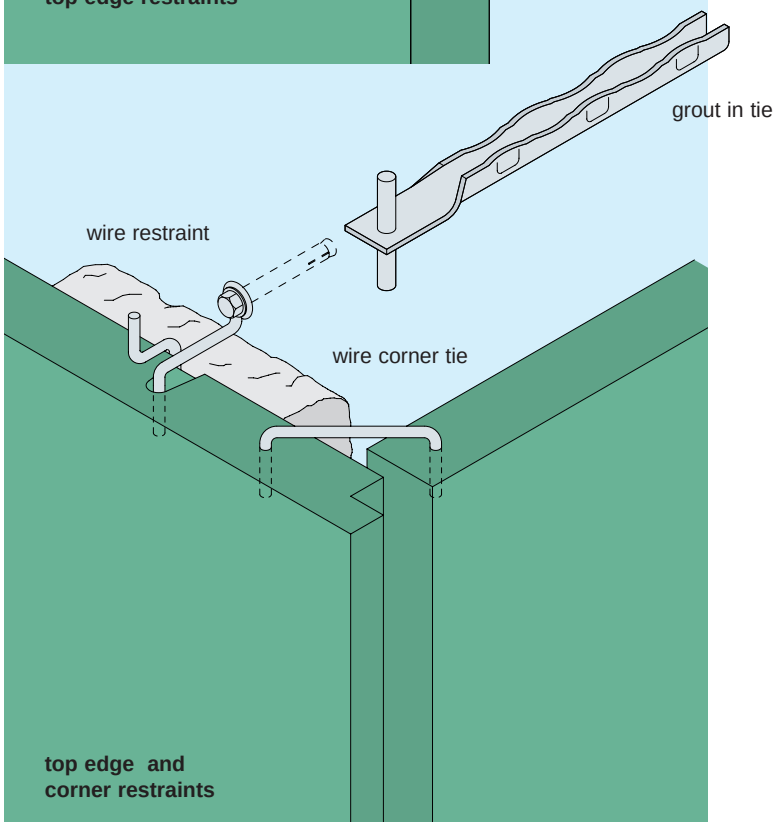
The required thickness of stone behind the dowel holes is given in the table on page 8. Wire ties, usually of stainless steel, may be used to restrain the thinner stones of fascias and linings.



alternative corner details



top edge restraints



top edge and corner restraints

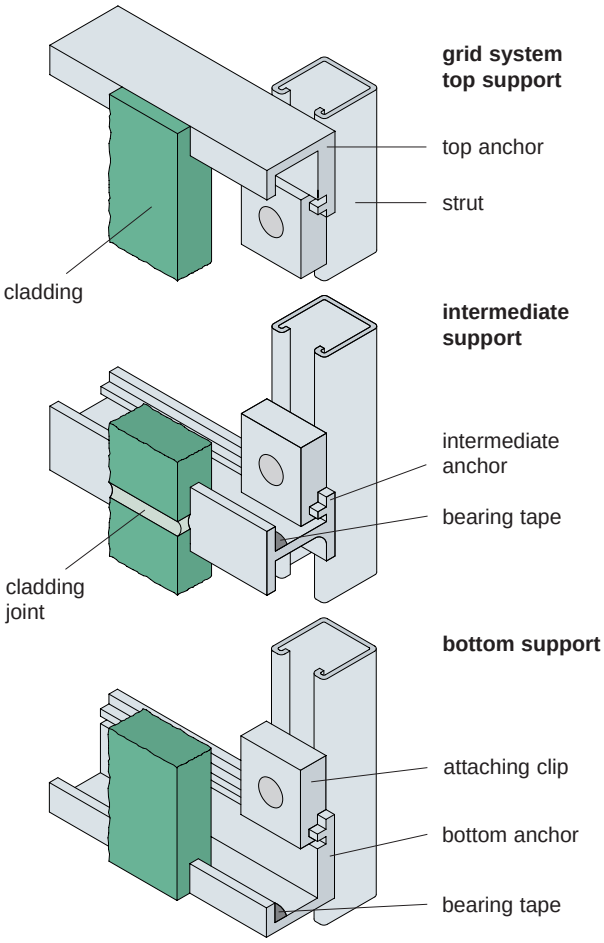
Structural fixing systems

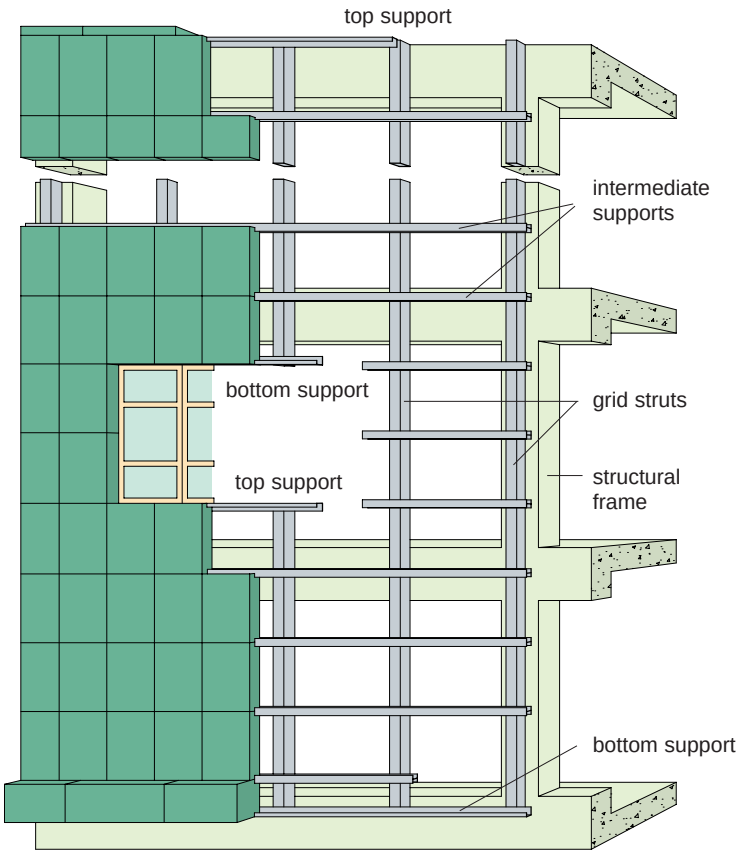
For large scale projects the use of structural fixing systems may be appropriate. These serve to integrate the cladding into the whole of the facade including the glazing and insulation panels.

Structural fixing systems may consist of:

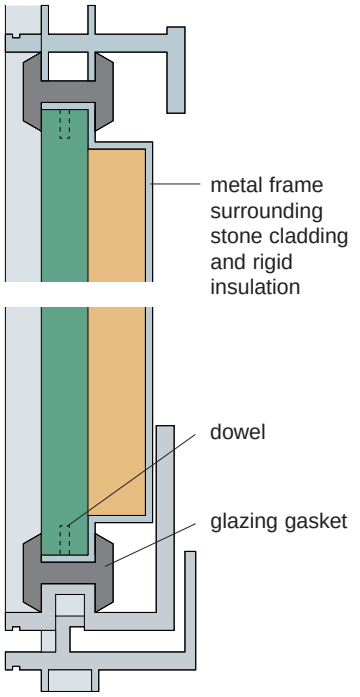
- Grid systems with the panels mounted on continuous steel bearings via rebates cut into the top and bottom edges of the stone.
- Stone cladding units installed in structurally glazed curtain walls in similar manner to glass.
- Stone cladding units installed in glazing channels of glazed curtain wall members, in similar manner to metal spandrel panels.

Specialist advice should be obtained to determine whether a proprietary system will be suitable for use with your project.





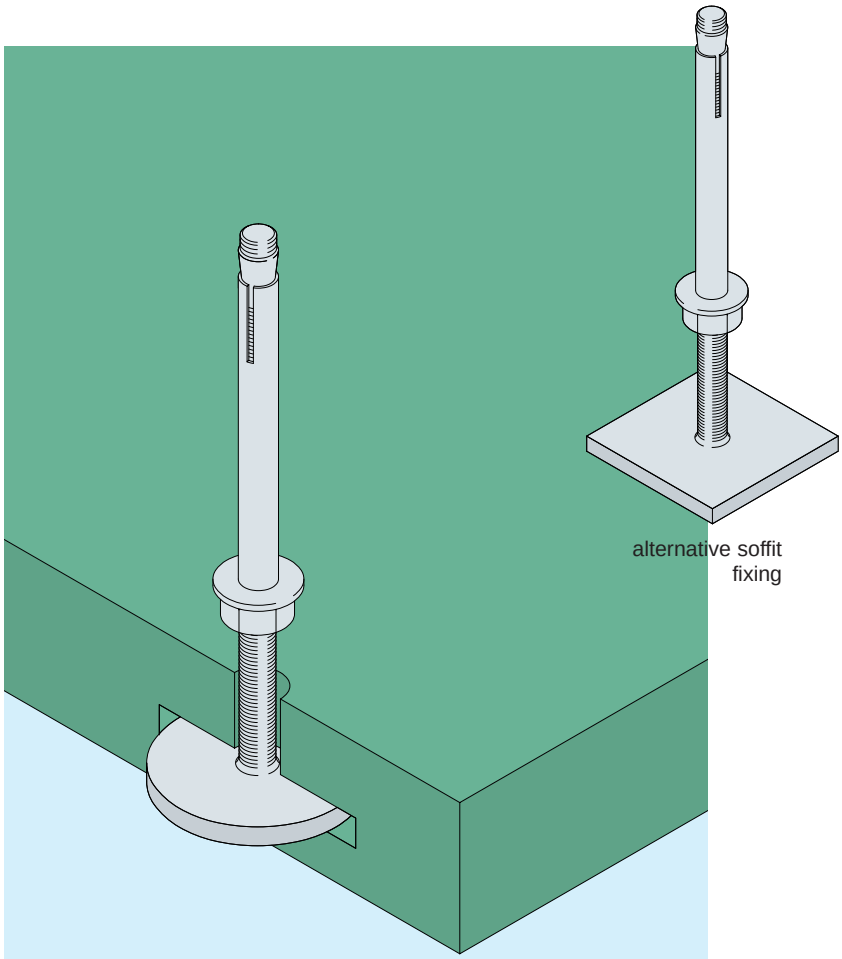
typical layout of grid system



structural glazing gaskets

Soffits

Fixings for soffits must bear the load of the stone and maintain alignment. Disc bolts located in mortices in the stones both support them and allow adjustment. Other fixing methods include the use of dowelled brackets, or face fixing with bolts passing through the stones.



soffit fixings

The attachment of fixings

The methods chosen for attaching fixings to the substrate will depend upon the nature of the substrate and the fixings specified. In all cases the fixings must allow for three way adjustment to enable the stones to be aligned and levelled correctly.

Individual fixings may be attached to concrete or blockwork substrates with expansion bolts or resin anchors, whilst ties may be grouted with mortar. Metal channels which are either cast into or bolted to the substrate may also be used; they are particularly suitable for restraint fixings, as the fixings can move to accommodate dimensional changes in the stone.

A steel substrate may require a secondary framework to provide sufficient attachment points; the risk of bi-metallic corrosion must be avoided through careful choice of materials and the use of isolating bushes and washers.

Project: Aronoff Center for the Arts, Cincinnati, USA

Architect: Cesar Pelli and Associates, New Haven in association with GBBN

Cladding to staircase in honed Elterwater

SPECIFICATION

The range of design and fixing options is too wide to allow us to offer a draft specification, but the project specification should cover the following headings:

- Location and extent of cladding or lining.
- Loading conditions.
- Nature of substrate, including supporting structure, cavity and insulation details.
- Supplier: BURLINGTON
- Stone: *Elterwater; *Brandy Crag; *Broughton Moor; *Bursting Stone; *Blue Grey.
- Finish: *waterjet *honed *sanded *cleft *gritblasted *flamed *textured.
- Dimensions of facing stones.
- Joints: dimensions, material.
- Flexible joints: locations, dimensions, building materials, treatment/primer/preparation, sealing material.
- Fixings: type and materials.

*delete as appropriate

Burlington's technical advice service can assist in the development of working drawings and advise on fixing plans; manufacturers of proprietary fixing systems can advise on any specific requirements.

Grooving and chasing of the stones must be done at the quarry, the stones reaching site fully prepared and ready for erection.

SITEWORK

Handling and Storage

As Burlington stone is a dense, heavy material, vehicular access should be provided to a storage area close to the point of installation.
Care must be taken on site to prevent damage to the material; when not crated it should be stacked on edge on timber bearers and protected with building paper or plastic sheeting.

Health and Safety

Burlington stone is an inert material and inherently safe if handled with due caution; safe lifting techniques should always be used. Wear protective clothing to avoid cuts from sharp edges. Wear eye protection when machining, drilling or cutting. Dust produced by dry machining contains silica which can be a long-term health hazard if inhaled in significant quantities for extended periods: use a suitable dust mask.

Installation

The type and number of fixings must be in accordance with manufacturer's instructions and relevant standards and building codes.
Ensure site work complies with the fixing schemes, otherwise the strength of fixings will be compromised.
Clean all dirt, dust and grease from jointing surfaces. Follow the manufacturer's instructions when applying sealants.
Clean down work on completion, using clean water and a bristle brush.

MAINTENANCE

Burlington stone is durable and when correctly fixed requires very little maintenance. Periodically check the effectiveness of compression and movement joints; renew sealants and pointing when they reach the end of their useful life.

Clean with water and mild detergent, finish off with a chamois leather. For more information refer to BS 6270: Pt1: 1982 "Code of practice for cleaning and surface repair of buildings" (MIA Design Manual IV: specification for slate: Part VI).

Prices and conditions of sale

Stone by Burlington is sold subject to our standard conditions of sale, a copy of which is available on request. We will gladly provide you with current details of availability and lead times and will be happy to provide firm quotations for individual projects on the basis of drawings and/or Bills of Quantities.

Supply, delivery

Burlington stone is normally crated and palleted: delivery in the UK is by our own road haulage vehicles, overseas deliveries will be by the most efficient available method.

References

Burlington stone has been used in numerous cladding schemes world-wide, including:-

- Corporate Headquarters, 55 Bishopsgate, London, UK;
- Marugame Museum, Japan;
- Canary Wharf, London, UK;
- Marriot Hotel, Glasgow, UK.

Note

Recommendations as to methods, use of materials and construction details are based on the experience and knowledge of Burlington Slate Limited and on British Standards: they are given in good faith as a general guide to designers, contractors and manufacturers.

Quality

Quality comes naturally with a material 400 million years in the making and in converting that material to modern building components Burlington operate an ISO 9002 Quality Assurance System.

Whatever the nature of your project, Burlington have the experience, the facilities and the expertise to provide the guidance, technical advice and delivery schedules essential to its success.

Technical support

We are always happy to provide technical advice on the specification of Burlington stone for new build or refurbishment projects. We offer in-depth project consultation and a wide range of support services including:

- a technical advice line: +44 (0) 1229 889 665; USA: (972) 985 9182
- estimating;
- computer-generated detailing;
- copies of relevant test results;
- product samples;
- help and advice on meeting national building regulations.

In addition, a range of technical support material is available on request; it includes:

- Product Data sheets for the stone from each of our five quarries.
- Sample cards for all stone tones and finishes.
- Application brochures for:
    - Flooring stone;
    - Interiors;
    - Cills;
    - Roofing;
    - Burlington Natural Slate Ventilators;
    - Landscaping;
    - Coping stone.

Our range of stone products is continually being extended. If you do not find your exact requirement in this brochure please call our technical advice line. We can probably supply a customised solution for you.

The applications shown in this brochure should not be treated as limits for the use of stone for cladding: at Burlington we are pleased to assist in developing innovative applications for our stone.

Project: McKenna and Cuneo, Washington DC

Architect: STUDIOS, Washington DC

Cladding to staircase in honed Broughton Moor

Project: Barthonia Forum, Köln, Germany

Architect: Luczak & Jurgensen

Cladding in honed and flamed Elterwater

Project: Canary Wharf, London

Architect: Cesar Pelli

Cladding honed in Elterwater

brochure designed by:
JPA Technical Literature, Newcastle upon Tyne
(0191) 281 8393

Soda Hall, University of California, Berkeley CA
Architect: Anshen and Allen in association with Barnes and Cavagnero
Cladding in flamed Broughton Moor

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