the stone collective

the stone collective

Pioneering stone as the 21st century's low-carbon, load-bearing building material

Introduction

The Stone Collective is a group of leading stone professionals dedicated to ensuring stone is recognised as the low-carbon, load-bearing building material for the 21st century. The Stone Collective aims to educate and inspire the built environment community on the use of load bearing stone.

The Stone Collective are:
Albion Stone
Hutton Stone
Lundhs
Paye Stonework and Restoration
Polycor and
The Stonemasonry Company

In the world of construction materials, stone stands as an enduring symbol of timeless beauty and strength. As one of the most planet-friendly choices available to builders, stone's low-carbon footprint is attributable to its fundamental nature – a material that is simply hewn from the earth and cut to shape. Unlike its counterparts in the construction industry, such as clay bricks and concrete, which release significant carbon emissions into the atmosphere, stone arrives at the construction site with its carbon footprint already minimised by the hand of nature.

Sculpted over aeons by geological forces, stone requires no energy-intensive manufacturing processes. There is no need for the relentless heat of kilns, the forceful crushing of raw materials, or the energy-consuming mixing of components. While other materials demand substantial energy inputs, stone's journey from quarry to construction site involves minimal processing. This inherent simplicity is the key to stone's low-carbon status.

Stone embodies the ethos of 'reduce, reuse, and recycle' from its very inception and can be repurposed in various applications for generations to come. As we navigate the challenges of a rapidly changing world, stone remains a steadfast ally in the pursuit of sustainable construction, reminding us that the most planet-friendly path is the one that simply allows nature to take its course.

The Stone Collective

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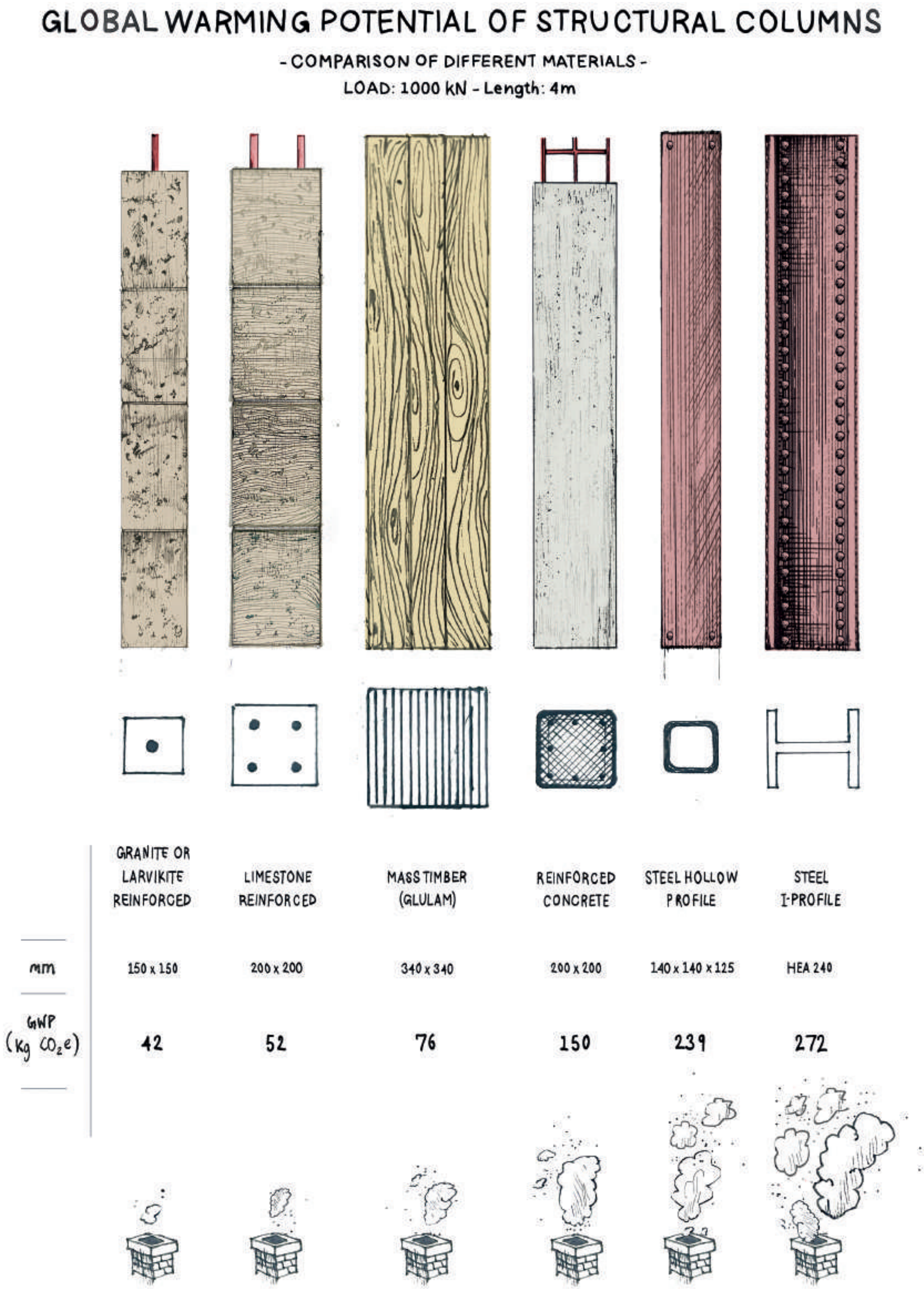
Relative carbon impact of related building materials



Calculated by **knippershelbig** according to EN 5804+A1

Sources: BECD, ICE University Bath

Stone, a commodity not a luxury; building a resilient future in stone

'Stone extracted in the morning, fitted in the afternoon' was the mantra of post-war French construction sites. Widely available, with new mechanical extraction methods, more efficient cutting saws and powerful cranes, stone became the most economical material for rebuilding the affordable housing stock in France.

In contrast, the art of building with structural stone in Britain was largely forgotten. With new regulations and codes favouring steel and concrete, stone has been deleted from the modern construction toolbox. Yet stone has much to offer; it is strong, slow to age, easily maintained, non-combustible and versatile. Importantly, stone has the ability to hugely reduce the carbon footprint of a new build. Sometimes referred to as 'natural concrete', limestone, granite and sandstone, if used structurally in solid pieces, is easy to repurpose, taking very little energy to reuse.

The biggest misconceptions surrounding stone include its perceived cost, potential challenges to specify, and that it is expensive to shape and labour-intensive to install. To make it more affordable, we must reconsider the modern understanding of stone, question rigid aesthetic selections, challenge demanding and unnatural structural conditions, as well as costly finishes and processing methods. By embracing the diversity of stone colours and textures, educating engineers on its mechanical properties, informing architects about its raw potential and engaging with quantity surveyors to clarify cost structures, stone can emerge as an optimal construction material.

Using prefabricated modules of stone, optimising these modules from specific quarries and designing your building accordingly, as well as developing bricks to make the most of the extraction site's output, we can make stone more relevant than ever. The conditions are right to expand the use of this versatile resource. With its increasingly efficient extraction, low use of water, and easy and efficient repurposing – any stone building is a quarry to be – we can embark upon a New Stone Age.

We hope this modest book will lay the foundations for a Renaissance in stone building.

A short history of the misuse of stone in the 20th century

The 20th century marked the decline of construction in stone, the victim of rising energy costs, wars that decimated a skilled and knowledgeable workforce, and the fashion for new materials. To understand this rapid decline and witness the change from structural to veneer, take a walk in the heart of the city of London.

The journey begins at Bank station, the site of architect Sir John Soane's 19th-century Bank of England building, understood to be his finest work. Soane's building, mostly demolished in the 1920s, is our reference for load-bearing masonry. The building was constructed in Portland Stone brought to the site on barges. Utilising the full strength of limestone, it showed a complete understanding and potential of the material by engineers, makers, and the architect.

27 Poultry Lane by Edwin Lutyens is another story. Built in 1924 with a steel structure, the engineers' material of choice in Post-War Britain, steel was seen as easy to specify and control during its manufacture. The stone is now a self-supporting structure acting as a screen with a classical vocabulary. Across the street stands the iconic Postmodern No. 1 Poultry by James Stirling, designed in 1985 and completed twelve years later, in 1997. Its pink and cream sandstone from Australia and the UK is only between 30mm and 50mm thick—a veneer hooked on stainless steel fasteners— a solid concrete shell embellished with a mineral make-up.

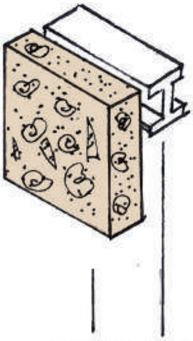
Lack of certification and codes ensures stone is left out of the materials conversation. During the late 20th century, architecture was not always concerned by the environmental impact or reuse of material. Across the road sits a behemoth of a building, the Bloomberg Headquarters by Foster and Partners completed in 2017, an exoskeleton of large Yorkshire sandstone pieces, patiently selected and fabricated off-site, then intricately connected to a structural concrete core. A tight embrace of two structural materials, leaving a legacy of wasted material and intensive fossil fuel use.

In the centre of London, Lutyens, Stirling and Foster wanted a heart made of stone, but built only a skin. However, their desire to use stone proves that architects and clients still want stone buildings as a symbol of authenticity, reassurance, and legacy.
In the story of structural stone, the material can either push the limits of new technological developments or fall victim to progress and fashion. As we move towards more responsible construction methods, being both frugal and conscientious, stone, the low environmental impact material of excellence, just might be the solution.

LUTYENS

No. 27 POULTRY

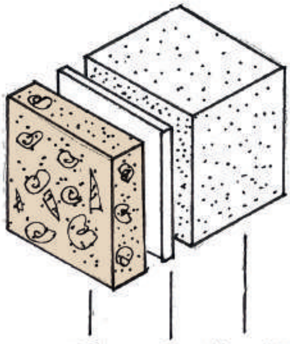
STONE IS WORKING ON IT'S OWN



STIRLING

No. 1 POULTRY

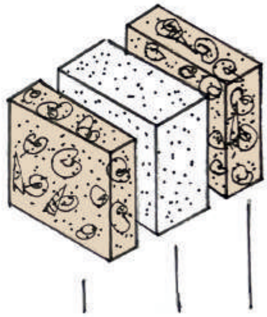
VENEER



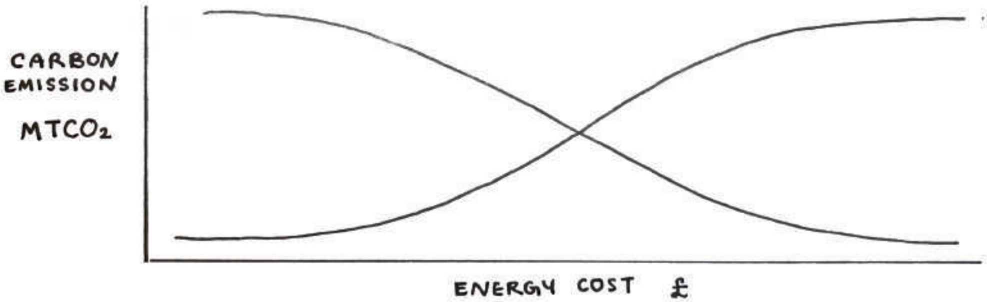
FOSTER

BLOOMBERG HQ

CLAD STONE CONCRETE, UNUSED STRENGTH



ENERGY COST VS. CARBON EMISSIONS: INVERSE RELATIONSHIP



From stereotomy to the digital age, new technology is central to stone engineering

From the cutting devices employed by 17th-century water mills to the cable wire cutting saws, steam-powered planers and industrial tip blades used to increase the speed of cutting granite and marble of the 1900s, the stonemason has never shied away from progress.

Stonemasonry was at the forefront of applied geometry with the use of stereotomy, the art of cutting volume through spatial geometry, producing some of the most daring vaults, bridges, and civil and military infrastructure. Stone design knowledge of the past compares to the most powerful parametric software used by stonemasons today.

Contemporary advanced scanning and imaging techniques allow quarry operators to map out their resources with unprecedented accuracy. This not only minimises waste but also ensures the responsible and sustainable use of precious stone reserves. Modern tracking and triage software ensures that a stone plant can develop a range of the most efficient modules, from large ashlars for quick building to bricks.

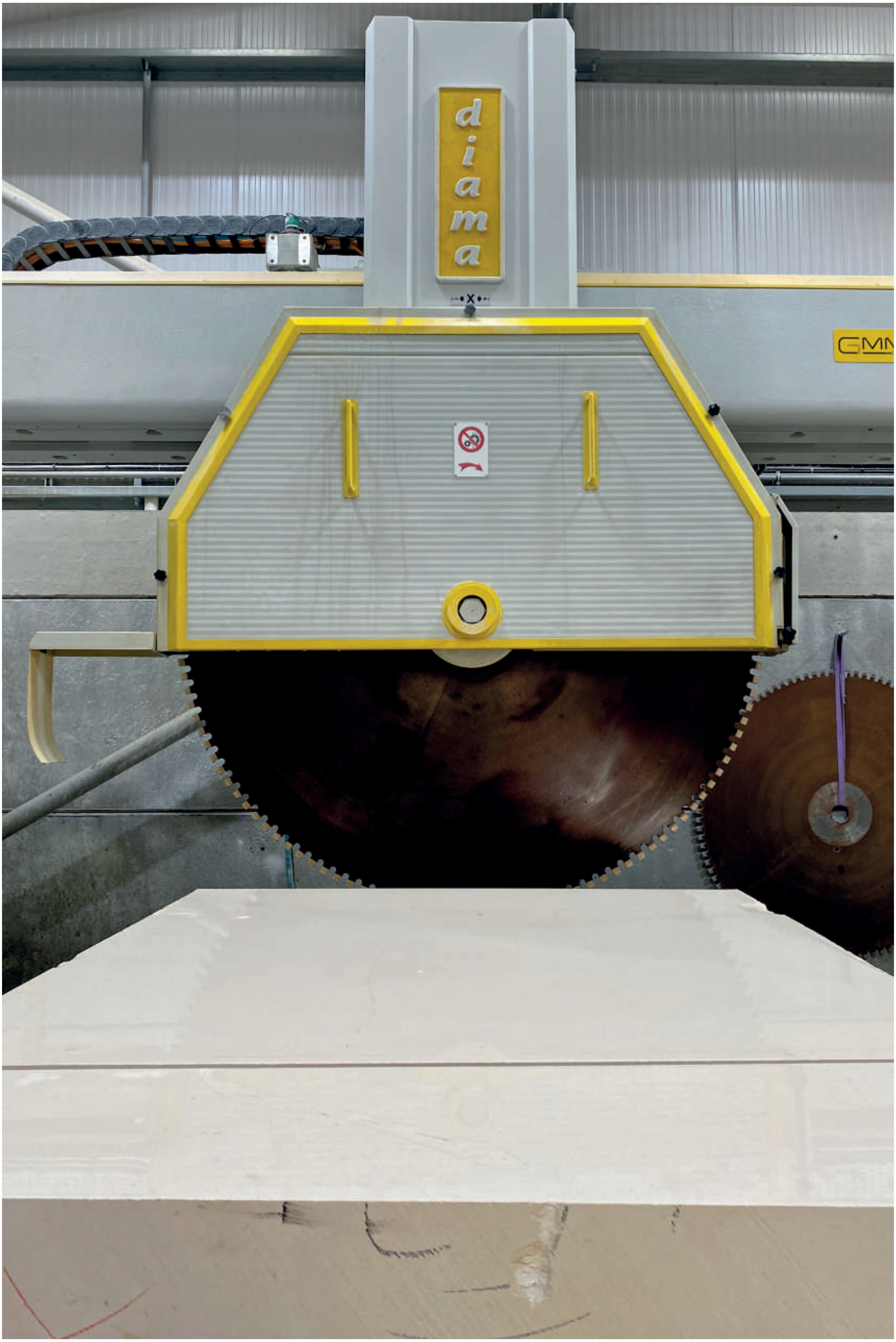
Testing technology, with more accurate instruments, can record and study in more depth how stone structures react to different conditions, from loadings in demanding structures to fire testing. Finite elements analyses help predict potential weaknesses in natural materials, allowing for more accurate and safe use. This non-destructive testing, coupled with the scanning of blocks, ensures the optimisation of material use from quarry to installation and maintenance. Ultrasound machines are currently being used to assess the structural integrity of stone blocks in certain projects. In the realm of stone extraction, technology has unlocked new possibilities.

Computer Numerical Control (CNC) technology has breathed new life into the age-old stone-cutting and carving craft. It offers unparalleled precision, allowing for the creation of intricate designs with a level of accuracy that was once unthinkable. From ornate facades to delicate sculptures, CNC has expanded the artistic horizons of stonemasons.

Automation and robotics have also entered the stone processing arena. These technologies streamline the cutting, polishing, and finishing processes, reducing labour-intensive tasks and enhancing efficiency. As a result, stone products can be manufactured more quickly and consistently.

The digital age has brought stone closer to architects and designers. Computer-aided design (CAD) software allows for complex 3D modelling and simulations, enabling professionals to visualise projects in detail before a single stone is cut. This fosters collaboration and creativity, pushing the boundaries of what can be achieved with stone.

Finally, emerging from the understanding that stone, with its high compressive strength, behaves like concrete, using cables and rebars for post and pre-tensioning creates endless possibilities, from prefabricated structural beams and columns to optimising walls and arches.



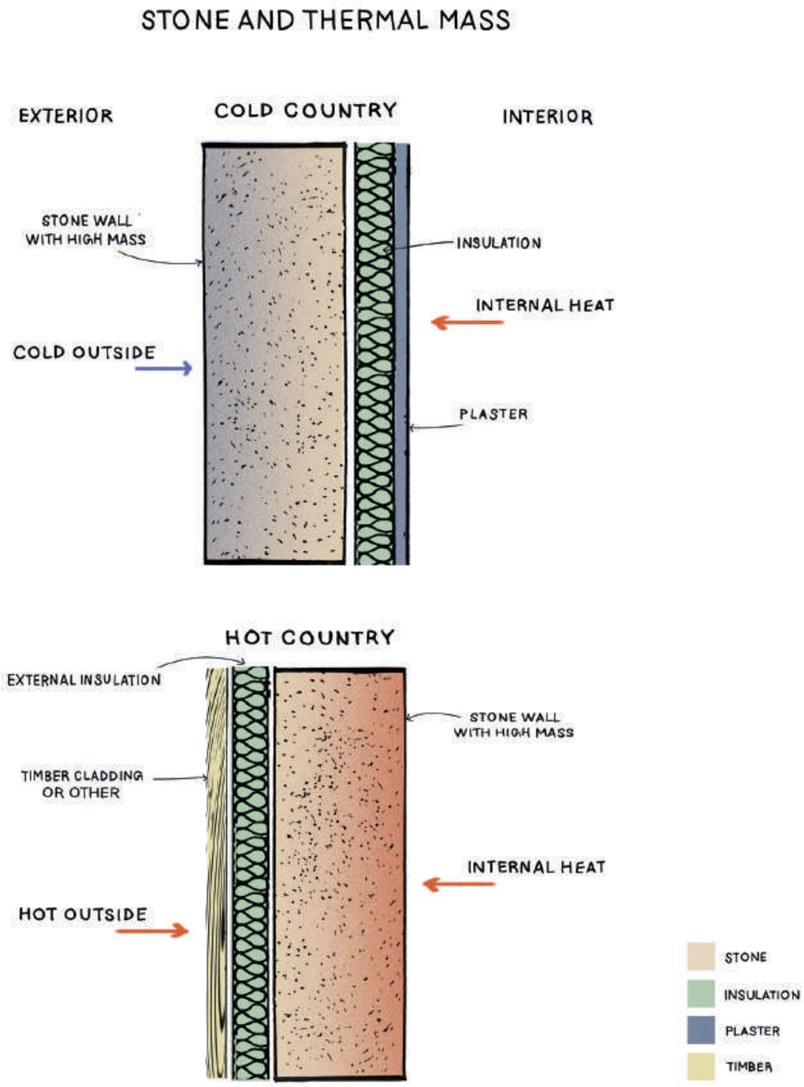
PIERRE BIDAUD

The natural inertia of stone

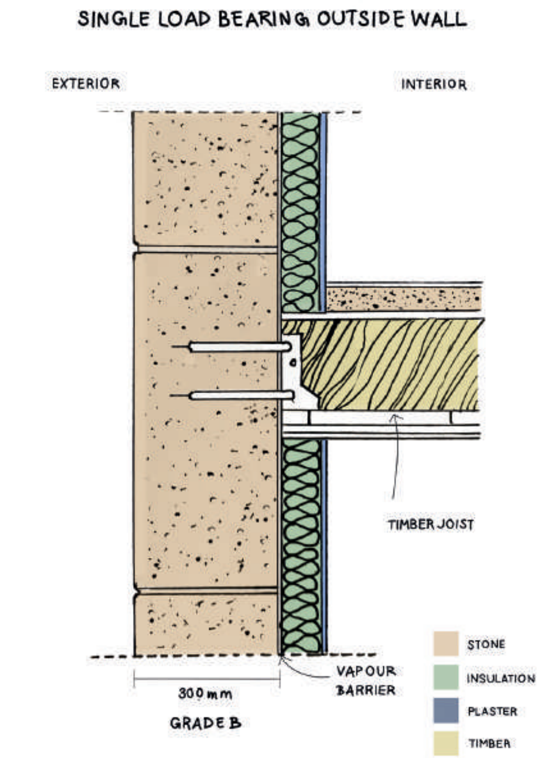
Natural stone has numerous advantages when it comes to thermal efficiency. However, depending on its porosity and density, its efficiency will vary. Generally, stones with a density similar to concrete will display the same thermal behaviour, absorbing and releasing heat in response to internal conditions.

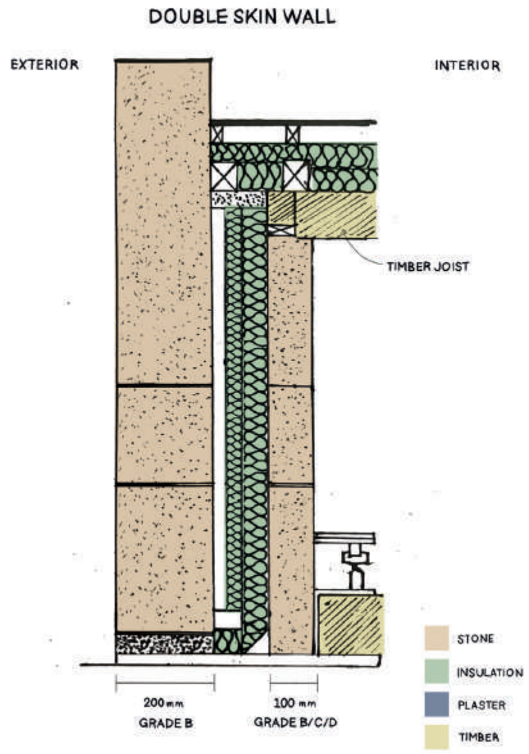
In hot climates, much of the unwanted heat gains will be absorbed by the thermal mass in exposed floors and walls, smoothing temperature fluctuations and cutting down overheating. Stone will store heat during the day in winter and redistribute it during the night.

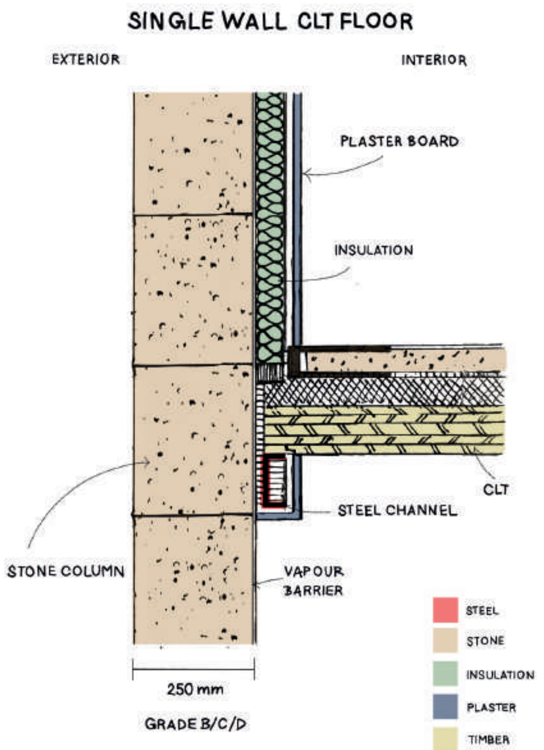
Stone, however, is not a great insulator. These sketches demonstrate two possible ways to deal with thermal mass in walls.

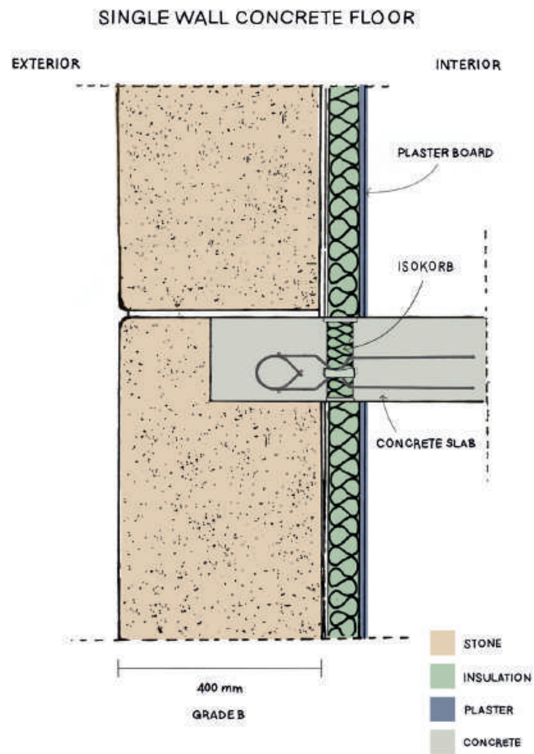


Resolving cold bridging in structural stone









MORTEN RAKKE PHOTOGRAPHY

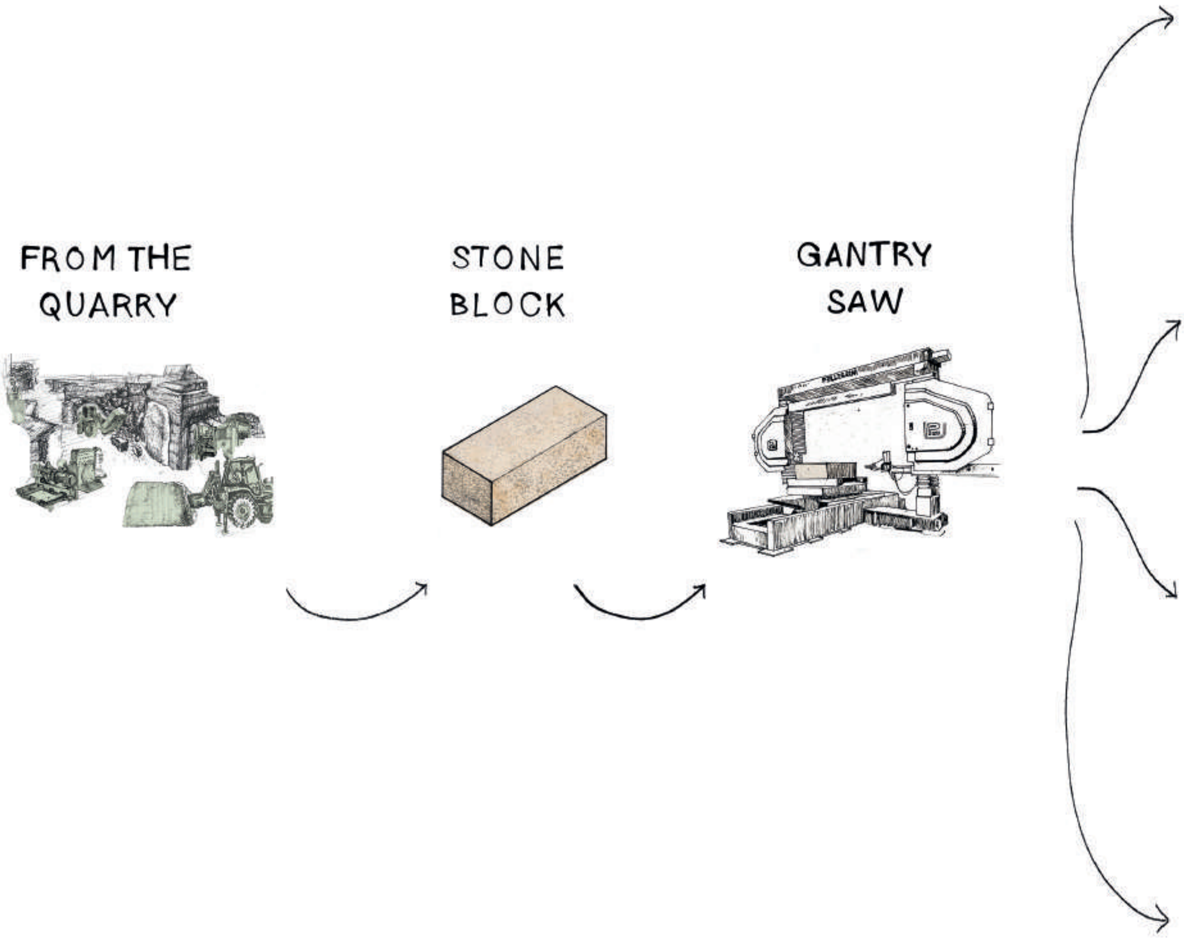
Digging deeper; respectful extraction in well-managed quarries

The world of stone extraction has undergone a remarkable transformation, dispelling the lingering misconceptions that once plagued quarries and mines. Dimensional Stone quarries – those dedicated to extracting solid, cubic stone – have emerged as the standard of sustainable practice, setting them apart from their massive clay or aggregate quarry counterparts. The stone industry has shifted its gaze towards innovative product utilisation. It now seeks to harness all of the stone's potential, from stone bricks and load-bearing stone to coastal defences and soil improvement applications. The result is the responsible and sustainable use of stone resources, leaving no waste behind.

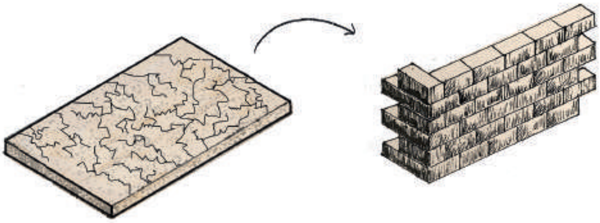
Technological advancements continue to play a pivotal role in this evolution. Advanced scanning and imaging techniques have empowered quarry operators to craft meticulous resource maps, minimising waste and ensuring the efficient management of stone reserves. Meanwhile, automation and robotics have revolutionised stone processing, streamlining tasks and enhancing product consistency.

The sustainability journey extends to quarry restoration. The extraction process is untainted by chemicals, ensuring zero contamination of the surrounding environment. Dimensional stone quarries are able to facilitate a rolling program of restoration. After the commercial life of a quarry concludes, restoration efforts breathe new life into the land. Examples from Sites of Special Scientific Interest designation to the proposed Eden Project in Portland show imaginative restorative land use.

As we look to the future, companies in the stone industry are not just redefining quarrying and processing; they are pioneering a sustainable legacy, bringing together industry and nature – marking the present as a transformative era for the stone sector.


FROM THE QUARRY
STONE BLOCK
GANTRY SAW

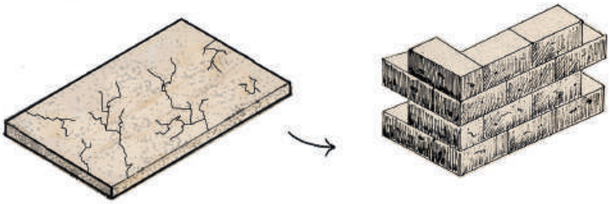
CRACKS — SMALL FORMAT



GRADE D

- MINOR CRACKS AND DEFAULTS
- MODULAR, HENCE FULL COLOUR, RANGE AND TEXTURE

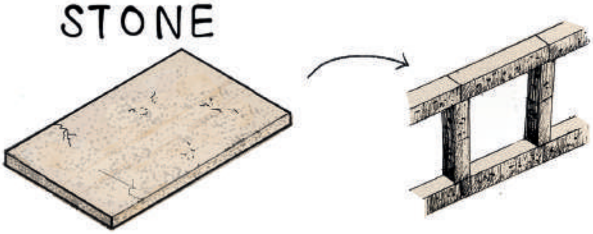
ASHLARS — LARGE FORMAT



GRADE C

- FULL COLOUR RANGE AND TEXTURE
- GOOD MECHANICAL PROPERTIES

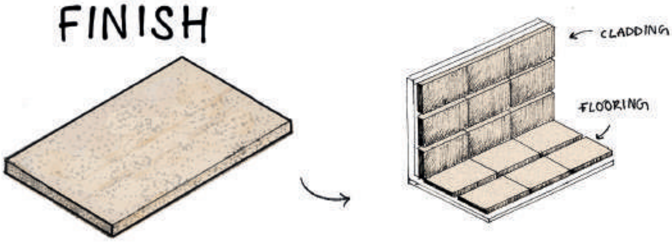
STRUCTURAL STONE — BEAMS & COLUMNS



GRADE B

- GOOD MECHANICAL PROPERTIES
- FULL COLOURS / TEXTURE BLEND

SURFACE FINISH — CLADDING & FLOORING



GRADE A

- FLAWLESS COLOURS AND TEXTURE

OFFCUTS GO INTO :

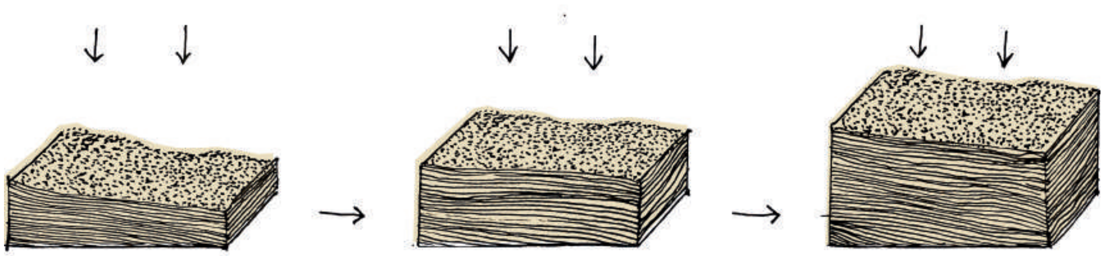
- AGGREGATE
- ADDITIVES FOR CHEMICAL USE
- FIELD NUTRIENTS

Keeping stone under pressure

If we had to label stone with one adjective, it would be strong. Stone is often pictured as the preferred material of the ancient builder. Due to its formation, minerals compacted over millions of years, stone lends itself to being in compression. Jurassic limestone has 40 to 50 megapascals (mpa) of compressive strength; for granite, this increases to 200 mpa, enough to support any heavy construction. By comparison, basic concrete and reinforced concrete starts at 50 mpa.

Stone is made of layers and should be positioned in the best way when placed under pressure, ensuring that the load is applied perpendicular to its layers. As stone was formed by minerals deposited in the Earth's mantle or on the floor of ancient oceans, unlike steel, it behaves poorly under tension. This is why stone buildings have always been designed with compression in mind.

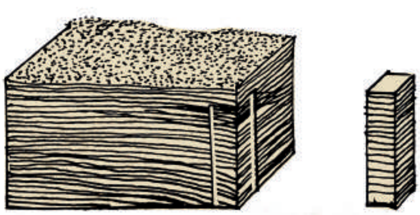
STONE IS FORMED BY DEPOSITION, GRAIN BY GRAIN, LAYER BY LAYER, IN WATER.



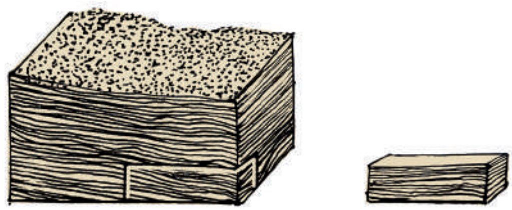
We found a recurrent issue with the modern design of structural stone: the lack of experience and knowledge in the field. The limited design guides on dimensional stone in the Masonry Eurocodes complicates matters. It is important to remember that much of the design process for stone structures can be addressed by applying basic engineering principles. Any gaps in knowledge can be bridged by low-cost and reduced-scale testing. Destructive compressive and flexural testing provided by testing specialists or quarry owners will provide valuable information on the stone's compressive and flexural capacities.

To find a stone's design strength, the characteristic strength used must be equal to the stone's lowest expected value (LEV), often up to 30% lower than the stone's mean strength. The design strength is obtained by dividing the characteristic strength by a high material safety factor, in many instances a figure of 2.3 is suitable. In a general scenario, the design strength of the stone ends up being approximately four times lower than its mean strength, leading to a safe final design with a very low utilisation factor. Engineering expertise leverages the intrinsic characteristics of stone to design structures that blend aesthetics, durability, and efficiency.

COLUMNS CUT FROM THE STONE IN ITS ORIGINAL ORIENTATION, BEDDING LAYERS WILL APPEAR HORIZONTALLY ACROSS THE COLUMN EDGES.



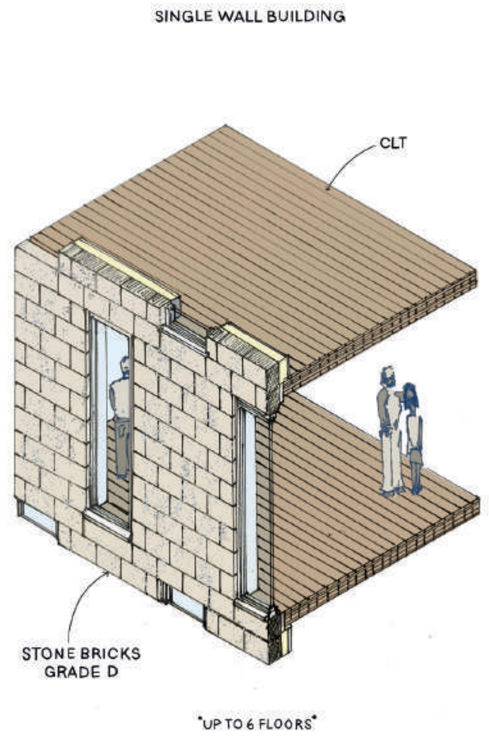
COLUMNS CUT FROM THE STONE HORIZONTALLY ACROSS THE ORIGINAL ORIENTATION, BEDDING LAYERS WILL APPEAR ALONG THE LENGTH OF THE COLUMN EDGES.

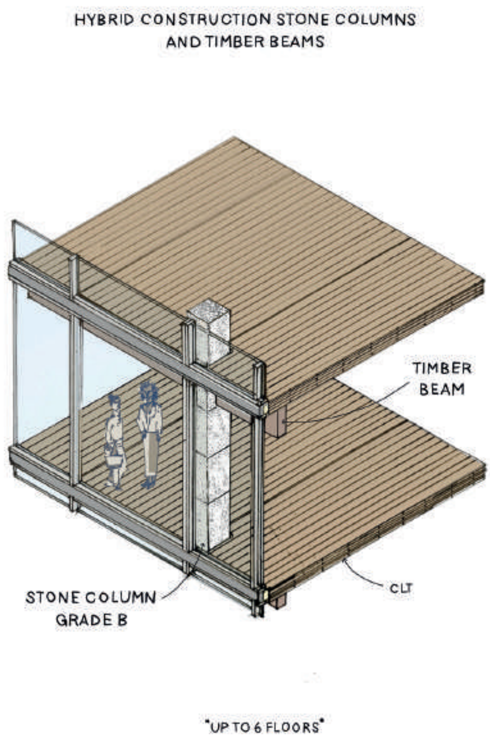


New structural stone typologies

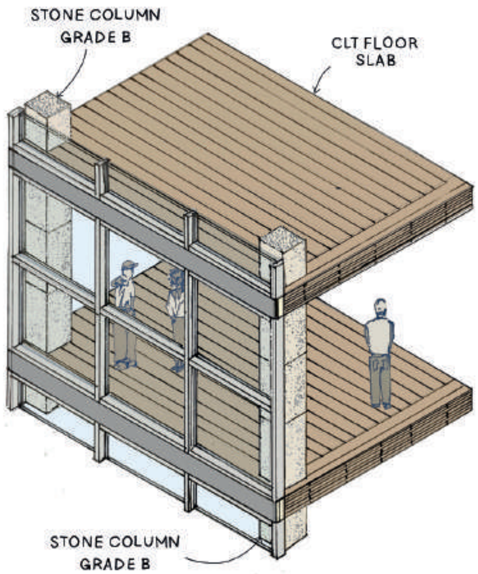
With new codes and regulations alongside advanced prefabrication technology, it's time to rethink stone building typologies.

New configurations in structural stone, as well as hybrid use with CLT and concrete, showcase the huge potential of stone.



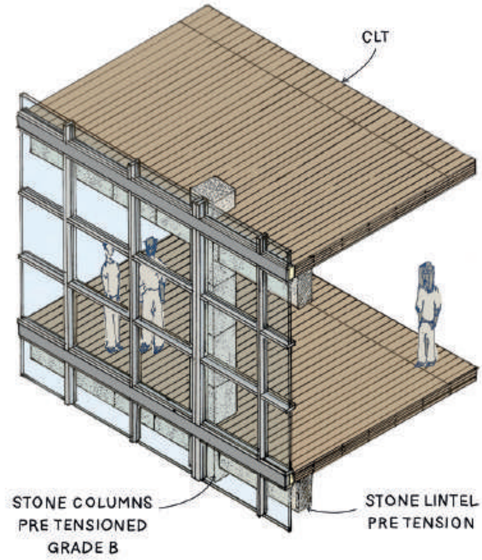


HYBRID CONSTRUCTION STONE COLUMNS
AND CLT FLOOR SLAB



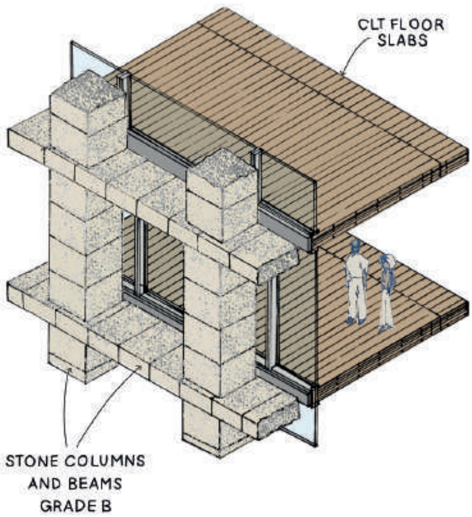
UP TO 6 FLOORS

HYBRID CONSTRUCTION STONE COLUMNS AND BEAMS



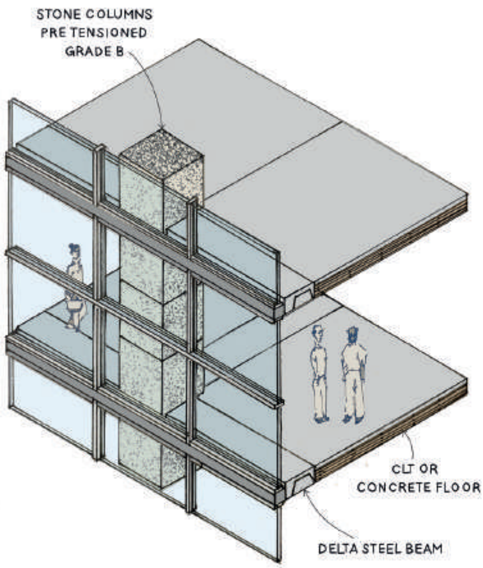
UP TO 6 FLOORS

FULL STONE FRAME CONSTRUCTION



UP TO 6 FLOORS

HYBRID CONSTRUCTION
STONE COLUMNS AND STEEL BEAM MEMBERS

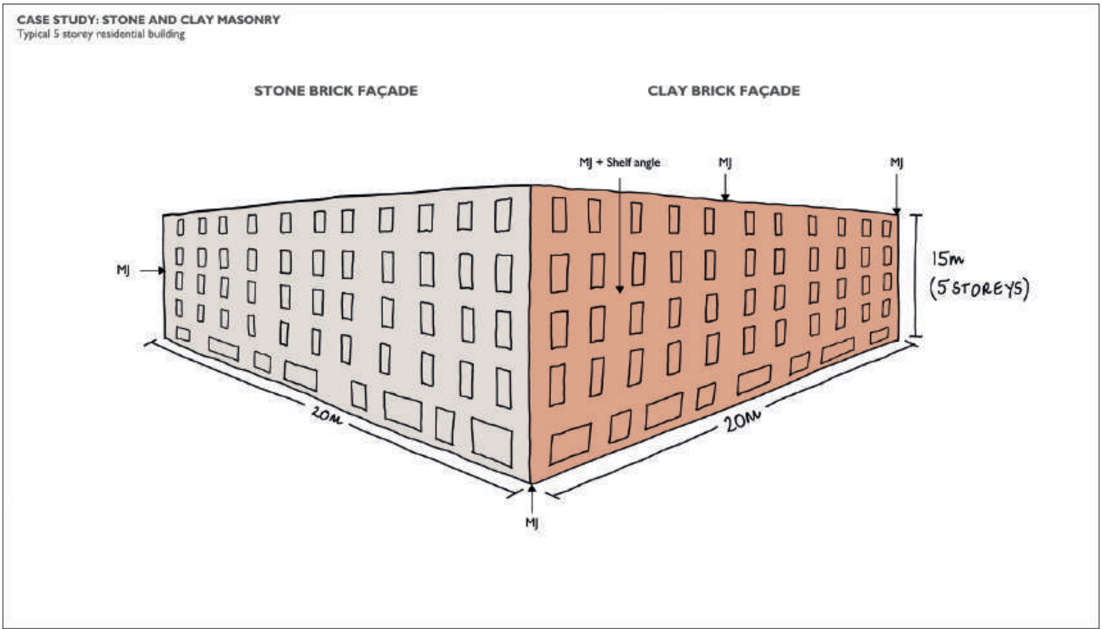


UP TO 6 FLOORS

The low-carbon stone brick; rethinking the future of construction

The low-carbon stone brick has emerged as a game-changer in the realm of sustainable construction with many advantages over traditional clay bricks. Its production process, characterised by cutting rather than firing, ensures remarkable environmental credentials, with carbon intensity reductions ranging from 55% to a staggering 86%. This innovative approach not only minimises the ecological impact but also introduces a cost-effective alternative to traditional brick manufacturing.

An outstanding feature of the low-carbon stone brick is its versatility in design and construction. Unlike traditional fired clay bricks, this stone variant allows for the creation of specialised bricks at a significantly lower cost. These bricks are sourced from historical quarries, providing an economically viable means of utilising stone for cladding at a fraction of the cost.



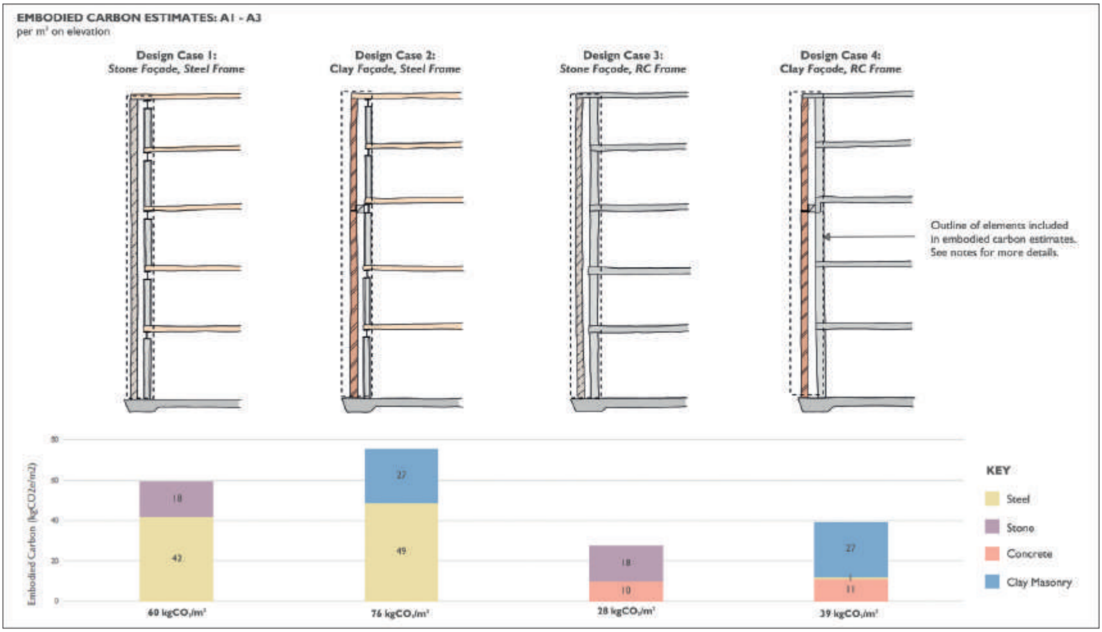
NOTES
1. Movement joints (MJ) are located at the corners of the buildings and at intermediate locations where necessary. The rules of thumb for movement joint spacing is as follows:

	Stone	Clay
Vertical	20m (8m from corners)	12-15m (8m from corners)
Horizontal	Up to 5-6 storeys*	Lesser of 4 storeys or 12m

* This needs consideration and is dependent on design and detailing.

Low carbon stone bricks are easily incorporated into construction projects without the need for extensive redesigns and are compatible with conventional bricklaying techniques. Beyond its cost-effectiveness, the low-carbon stone brick boasts exceptional strength, typically surpassing traditional clay bricks with a higher compressive capacity comparable to class B engineer bricks. Its tactile quality, warmth, and inherent protective properties add to its appeal, as does the varied grain, veins, and occasional fossils visible on each brick's surface.

As the construction industry addresses the urgent need for more sustainable practices, the low-carbon stone brick proves that creating low-carbon buildings can be achieved at a reasonable cost. With the possibility of local quarries supplying stone bricks, the construction sector now has the opportunity to source materials locally, further reducing its carbon footprint and ensuring a more sustainable future for construction.



NOTES

1. The carbon estimates include edge beams, slab downstands, columns, masonry cladding and masonry angles where applicable.

2. Foundations, ground floor slabs, floor structures and mortar are not included in the embodied carbon estimates.

3. Glazed areas and other architectural elements are omitted from the estimates. A glazing area of 20% is assumed.

Spolia; repurposing masonry

Spolia (from the Latin: ‘spoils’; singular: spolium) is the name given to a stone taken from an old structure and repurposed for new construction or decorative purposes. It results from an ancient and widespread practice whereby stone that has been quarried, cut and used in a built structure is carried away to be used elsewhere. This is an early example of what is now referred to as the circular economy.

More than half of the total material used to construct a building is attributed to the main structure and envelope. Reusing components from existing, soon-to-be-demolished, or already deconstructed structures significantly reduces the need for manufacturing new components, in turn reducing the carbon cost of the building.

As we start to see the financial cost of carving stone from new usurped by the carbon cost associated with its creation, the dismantling and repurposing of stone façades is becoming more common. The technology available to support the process of repurposing masonry has leapt forward, allowing us to provide a greater level of technical certainty.

The development in Light Detection and Ranging (LiDAR) and Ground-penetrating radar (GPR) survey accuracy allows for the overall volume of stone within a building to be determined. The existing building acts as a stone quarry, removing the expectation of building with new stone for all repurposing projects. However, an early understanding of the original construction is necessary for such a scheme to be successful.

The comparable commercial benefit of repurposed stone rather than new stone is bolstered when considering the substantial reduction in carbon emissions, the improved thermal performance of the external fabric, and the elimination of inherent steel frame corrosion risk defects. An optimisation strategy undertaken with GPR scanning makes it possible to calculate the external stone thickness of masonry facades, enabling all stones to be thinned down to a consistent depth. Reducing wall thickness provides space for thermal improvements such as a cavity construction and insulation or an increase in net lettable area.

ROBERT GREER

When reusing components from the building that have been exposed to weathering, they must be evaluated for suitability. In repurposing projects, the first survey confirms the performance of the stone, and a suite of tests will provide an assessment of the long-term durability and performance in line with current expected test standards.

A coordinated strategy for deconstruction needs to be planned jointly by the demolition contractor and the masonry specialist. This ensures that the timing of each step aligns and that the strategy for removing masonry can be synchronised with the demolition requirements, including the lifting and logistical aspects.

It is widely understood that products should be used for as long as they remain functional and reused or repurposed to the greatest extent possible when they reach the end of their service life. Masonry is designed to be durable and long-lasting and can be removed when a building is renovated or demolished, allowing for repurposing.

Spolia is a key component in recognising the importance and value of reclaiming materials to challenge waste and create a robust and climate conscious circular economy.

Case studies

30 Finsbury Square
New office block
London EC1

Architect
Eric Parry Architects

Client
Scottish Widows plc

Year completed
2003

Stone supplier
Albion Stone

Stone type
Portland Stone:
Bowers basebed

Residence, Thropton
Private Residence
Thropton,
Northumberland

Architect
Simon Beeby &
Potton Homes

Year completed
2022

Stone supplier
Hutton Stone

Stone type
Darney Sandstone
Dressings and
Mixed Buff/Grey
Random Walling

GEOFF LOVE

ROBERT GREER

1 Eagle Place

Mixed use, retail and office
London

Architect
Eric Parry Architects

Client
The Crown Estate

Year completed
2013

Stone supplier
Paye Stonework and Restoration

Stone type
Jordans Whitbed & Grove Whitbed

PETER JEFFREE

CHRISTOPHE AUBERTIN

Municipal Covered Market

Civic Building
St Dizier, France

Architect
Studiolada. France

Client
St Dizier Town hall

Year completed
2023

Stone supplier
Rocamat (Polycor France)

Stone type
Euville Limestone

15 Clerkenwell Close
Mixed use, residential and commercial
London

Architect
Groupwork

Year completed
2016

Stone supplier
The Stonemasonry Company Limited

Stone type
Chomerac

TIMOTHY SOAR

MORTEN RAKKE PHOTOGRAPHY

Hobekkseter tunnel
Infrastructure
Vestfold, Norway

Design & construction:
Hæhre Entrepenør

Year completed
2017

Stone supplier
Lundhs Real Stone

Stone type
Larvikite

The future of Stone

The future of stone lies in its past and its contemporary rediscovery.

The perennial use of stone in modern buildings depends on the commitment of the architectural world to tackling the climate emergency and freeing themselves from highly processed materials. With its short processing time, energy efficiency and frugal use of grey water, quarried stone has the potential to decrease the use of highly polluting artificial solutions. As we strive to lower the construction industry's carbon footprint, natural stone emerges as a superior choice.

In a society where regulation and codes are the bedrock of safe growth, the stone industry needs to reassure and educate the construction profession to prove once more that solid dimension mineral has a crucial role to play. The stonemasons and quarry professionals must help engineers and architects reconnect with a material with incredible mechanical characteristics, informing them how to design lasting buildings in stone.

Stone is continuously regenerating within the Earth's deep continental crust. Used in its fullness, from a structural standpoint, we can show respect to our environment by going back to the principle of 'borrowed earth'. The solid stone buildings of today are the urban quarries of tomorrow. Embracing the diversity of stone's colours and texture, its faults and imperfections to make full use of the output of the quarries will result in a more efficient way to build and save material.

The stone industry is scaling up operations, recognising its capacity to meet the escalating demand in response to the climate crisis. We need to argue for its use in well suited sectors at the right scale; community centres, schools and housing, alongside infrastructure projects such as bridges.

For thousands of years, stone masons were at the forefront of construction innovation; we need to adopt their forward-thinking approach and leverage new technologies, be it software or steel reinforcement. The stone industry needs to offer more standardised and prefabricated product lines to simplify the specification process and decrease both time and cost during on-site construction.

The future of stone is in our hands. It is up to us to transform this ubiquitous, ordinary material and make it purposeful and potent.

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Quote

'Stone extracted in the morning, fitted in the afternoon', from: *L'industrie de la Pierre et du Marbre* by René-Michel Lambertie. Published by Presses Universitaires de France 1962

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