Stone Testing

Checking its suitability – why do we do it?

Tim Yates, BRE

The Natural Stone and Building Conservation Conference 2011

17th March 2011, The Natural Stone Show, ExCel, London

Why should we test and which tests are appropriate?

- Failure mode effect analysis
  - What can go wrong?
  - What can we test for this?
  - How can we manage the risk?
- Is it safe?
- Will it last?
- Is it strong enough?

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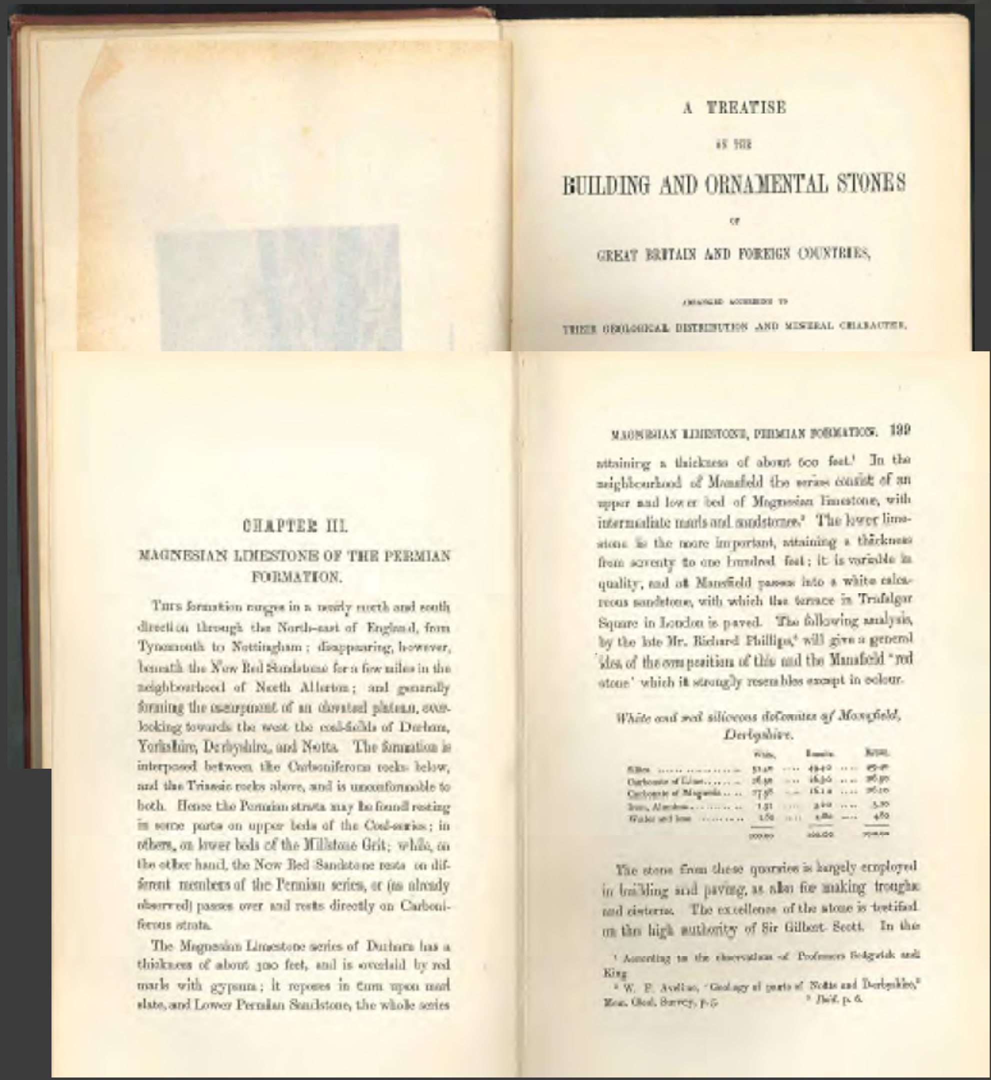
Some historic background…..

- Looking back to the 1860s
- New uses for stone…to be used on new types of structure
- Science and the stone industry
  - Geology - Edward Hull 1872
- Palace of Westminster



A TREATISE

ON THE

BUILDING AND ORNAMENTAL STONES

OF

GREAT BRITAIN AND FOREIGN COUNTRIES,

ARRANGED ACCORDING TO

THEIR GEOLOGICAL DISTRIBUTION AND MINERAL CHARACTER,

CHAPTER III.

MAGNESIAN LIMESTONE OF THE PERMIAN FORMATION.

This formation ranges in a nearly north and south direction through the North-east of England, from Tynemouth to Nottingham; disappearing, however, beneath the New Red Sandstone for a few miles in the neighbourhood of North Allerton; and generally forming the escarpment of an elevated plateau, overlooking towards the west the coal-fields of Durham, Yorkshire, Derbyshire, and Notts. The formation is interposed between the Carboniferous rocks below, and the Triassic rocks above, and is unconformable to both. Hence the Permian strata may be found resting in some parts on upper beds of the Coal-series; in others, on lower beds of the Millstone Grit; while, on the other hand, the New Red Sandstone rests on different members of the Permian series, or (as already observed) passes over and rests directly on Carboniferous strata.

The Magnesian Limestone series of Durham has a thickness of about 300 feet, and is overlaid by red marls with gypsum; it reposes in turn upon marl slate, and Lower Permian Sandstone, the whole series

MAGNESIAN LIMESTONE, PERMIAN FORMATION. 199

attaining a thickness of about 600 feet.[1] In the neighbourhood of Mansfield the series consist of an upper and lower bed of Magnesian limestone, with intermediate marls and sandstones.[2] The lower limestone is the more important, attaining a thickness from seventy to one hundred feet; it is variable in quality, and at Mansfield passes into a white calcareous sandstone, with which the terrace in Trafalgar Square in London is paved. The following analysis, by the late Mr. Richard Phillips,[3] will give a general idea of the composition of this and the Mansfield 'red stone' which it strongly resembles except in colour.

White and red siliceous dolomites of Mansfield, Derbyshire.

The stone from these quarries is largely employed in building and paving, as also for making troughs and cisterns. The excellence of the stone is testified on the high authority of Sir Gilbert Scott. In the

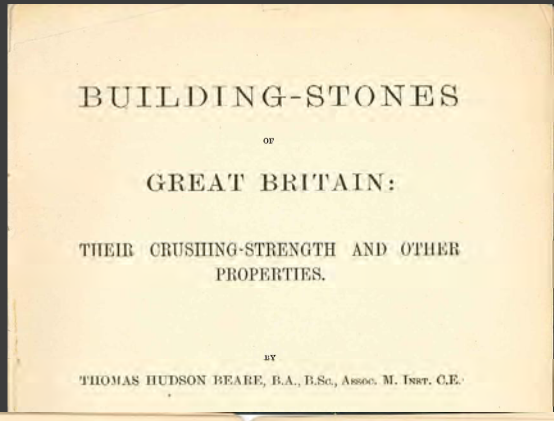
[1] According to the observations of Professors Sedgwick and King

[2] W. T. Aveline, 'Geology of parts of Notts and Derbyshire,' Mem. Geol. Survey, p. 5

[3] Ibid. p. 6.

Some historic background…..

- Looking back to the 1860s
- New uses for stone…to be used on new types of structure
- Science and the stone industry
  - Engineering - Thomas Hudson Beare 1892


BUILDING-STONES

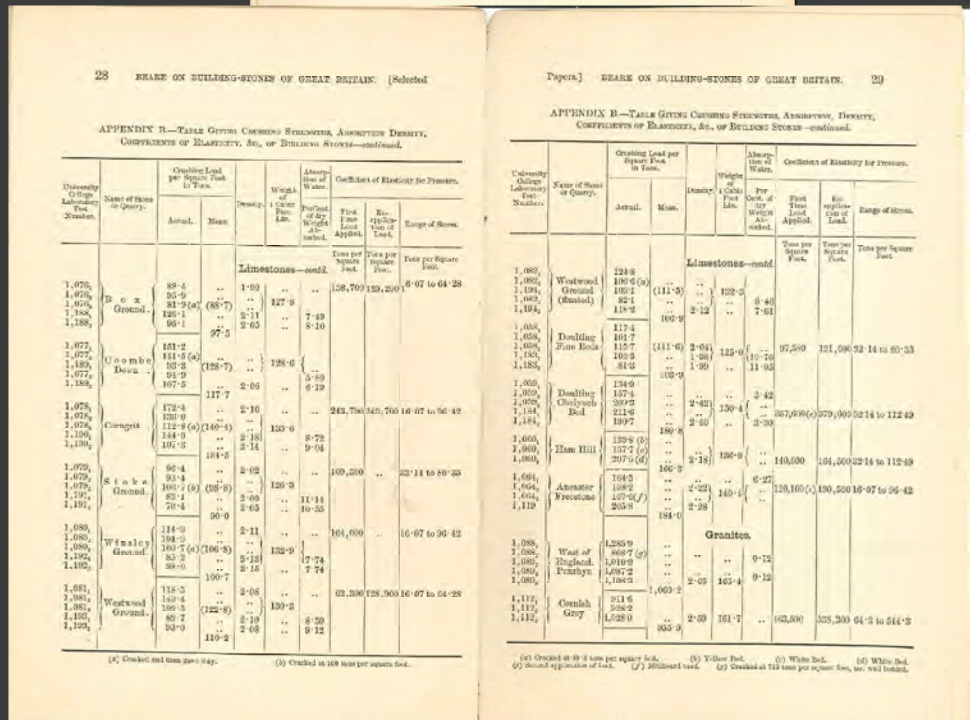
OF

GREAT BRITAIN:

THEIR CRUSHING-STRENGTH AND OTHER PROPERTIES.

BY

THOMAS HUDSON BEARE, B.A., B.Sc., Assoc. M. Inst. C.E.


28 BEARE ON BUILDING-STONES OF GREAT BRITAIN. [Selected

APPENDIX B.—Table Giving Crushing Strengths, Absorption Density, Coefficients of Elasticity, &c., of Building Stones—continued.

Papers.] BEARE ON BUILDING-STONES OF GREAT BRITAIN. 29

APPENDIX B.—Table Giving Crushing Strengths, Absorption, Density, Coefficients of Elasticity, &c., of Building Stones—continued.

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Some historic background…..

- Looking on – before and after the First World War
- Manual of stone testing for technical building work – Hirschwald 1911
- Modern Buildings – their planning, construction and equipment 1921
- The Stones of London – Elsden and Howe 1921


Handbuch

der

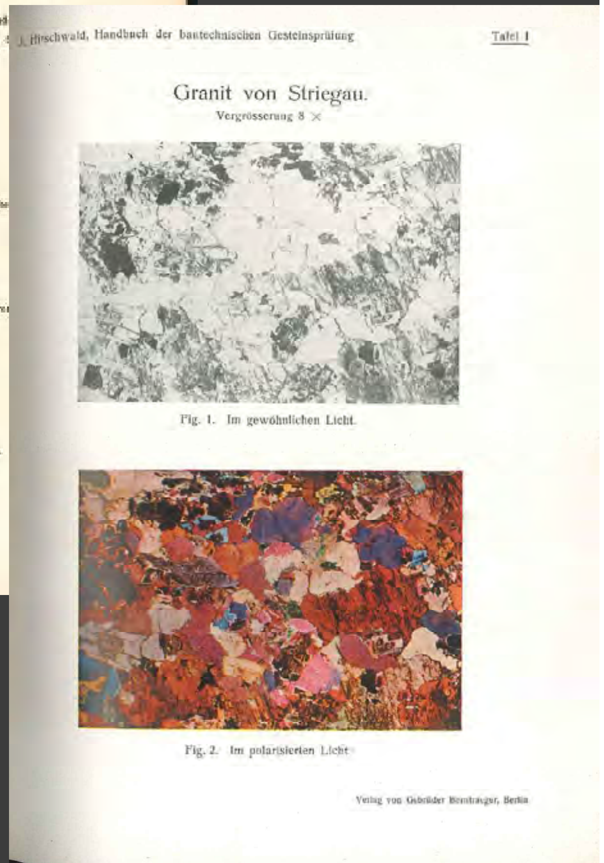
bautechnischen Gesteinsprüfung

Prof. Dr. J. Hirschwald

Berlin

Verlag von Gebrüder Borntraeger

1912


J. Hirschwald, Handbuch der bautechnischen Gesteinsprüfung Tafel I

Granit von Striegau.

Vergrösserung 8 ×

Fig. 1. Im gewöhnlichen Licht.

Fig. 2. Im polarisierten Licht

Verlag von Gebrüder Borntraeger, Berlin

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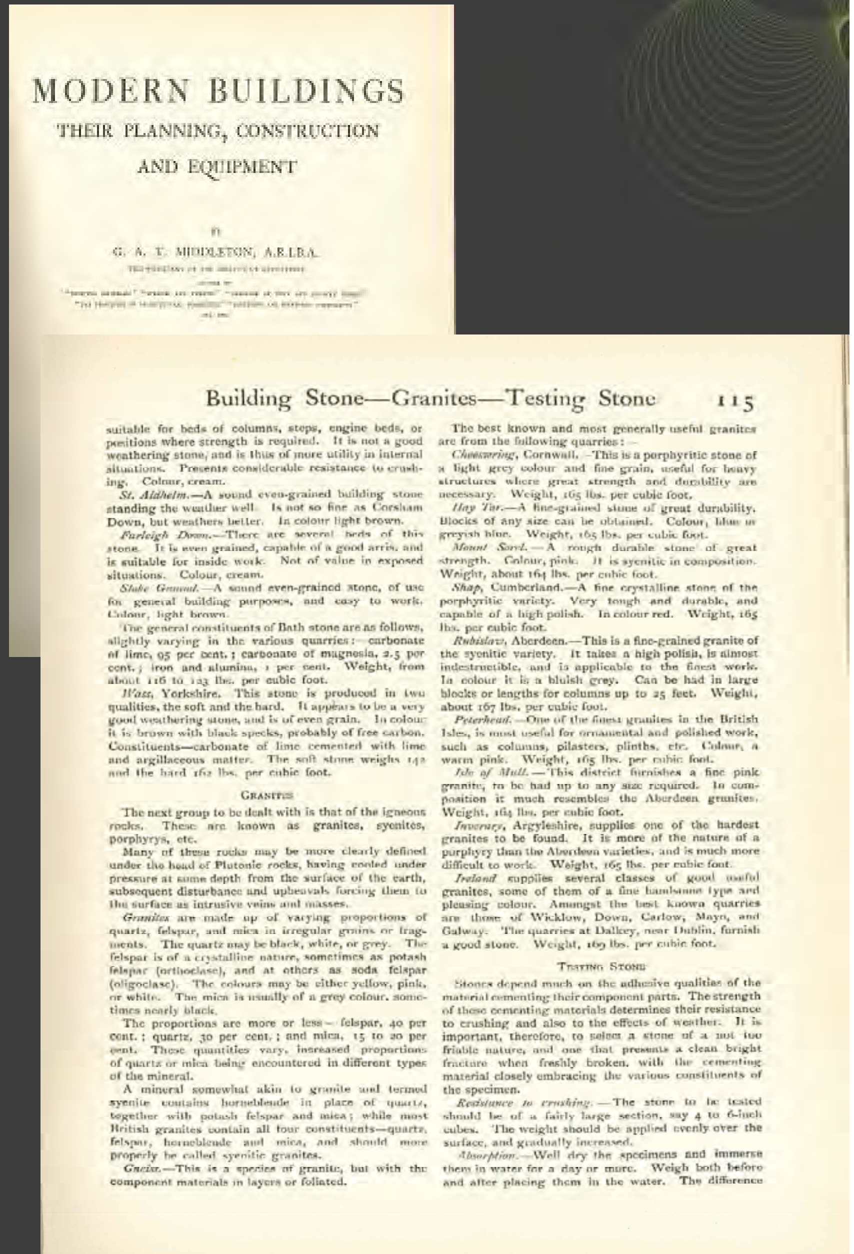
- Palace of Westminster


MODERN BUILDINGS

THEIR PLANNING, CONSTRUCTION AND EQUIPMENT

G. A. T. MIDDLETON, A.R.I.B.A.

Building Stone—Granites—Testing Stone 115

GRANITES

TESTING STONE

Different types of test (1)

- Index tests
  - **Petrographic description**
  - **Porosity, Density and Water Absorption**
  - **Saturation Co-efficient**
- Strength tests
  - Compressive
  - Flexural
  - Modulus of Rupture
  - Strength around a fixing
  - Point load

Different types of test (2)

- Durability tests
  - Freeze-thaw resistance
  - Salt resistance
  - Thermal Shock
- Safety
  - Slip and skid resistance
- Component tests
  - Wind loading
  - Fire
  - Impact

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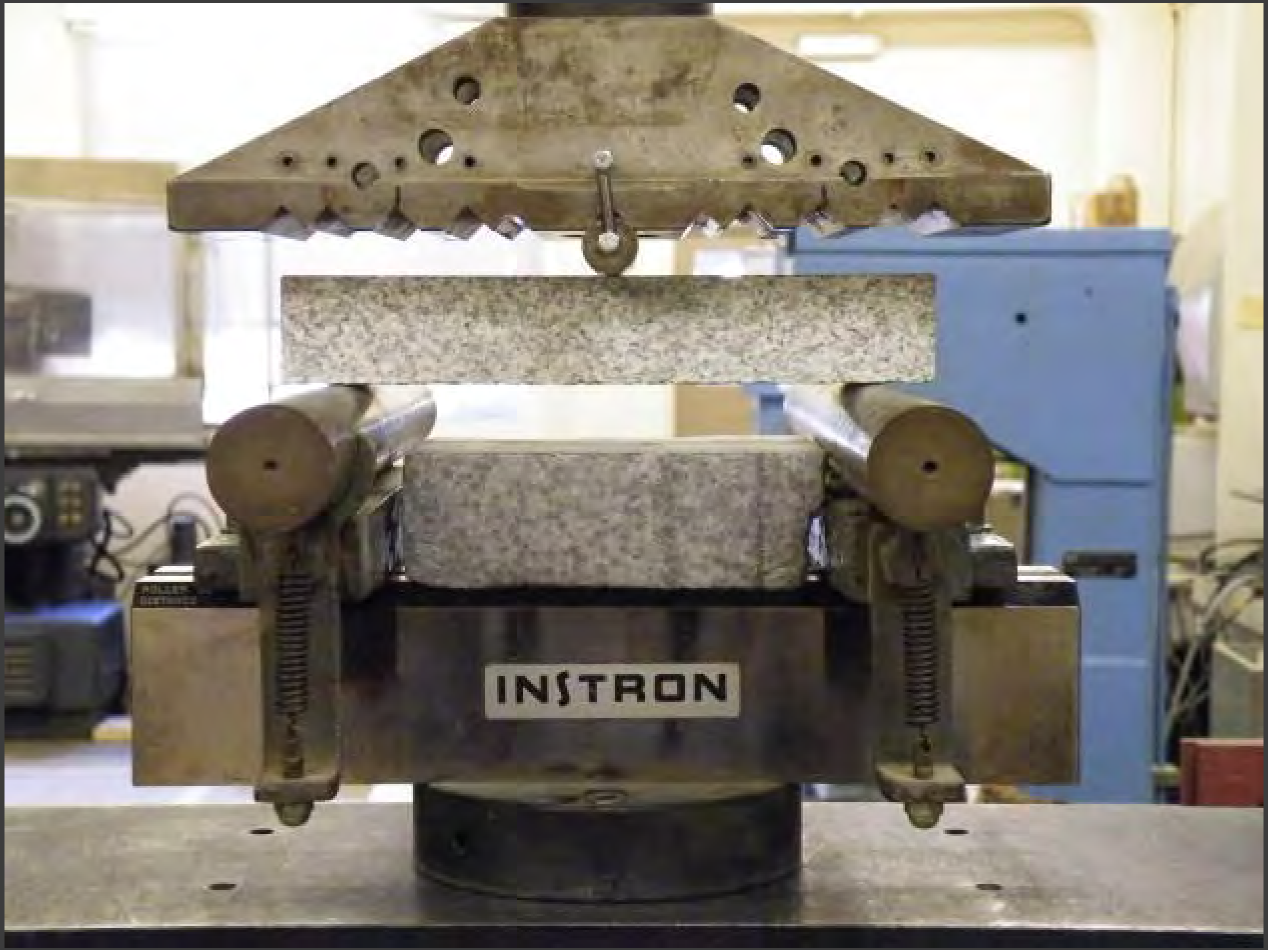
Different types of test -flexural



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Different types of test -flexural

bre

Different types of test - compressive

Different types of test – porosity

bre

Different types of test – slip

bre

Different types of test – salt

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Why should we test and which tests are appropriate?

- Failure mode effect analysis
  - What can go wrong?
  - What can we test for this?
  - How can we manage the risk?
- Is it safe?
- Will it last?
- Is it strong enough?

- **What's different about conservation?**

Philosophy

- Conservation
- Preservation
- Restoration

- Conservation Philosophy
  - *'Like for like'*
  - *Improvement*
  - *Best practical options*
    - (no excessive cost)

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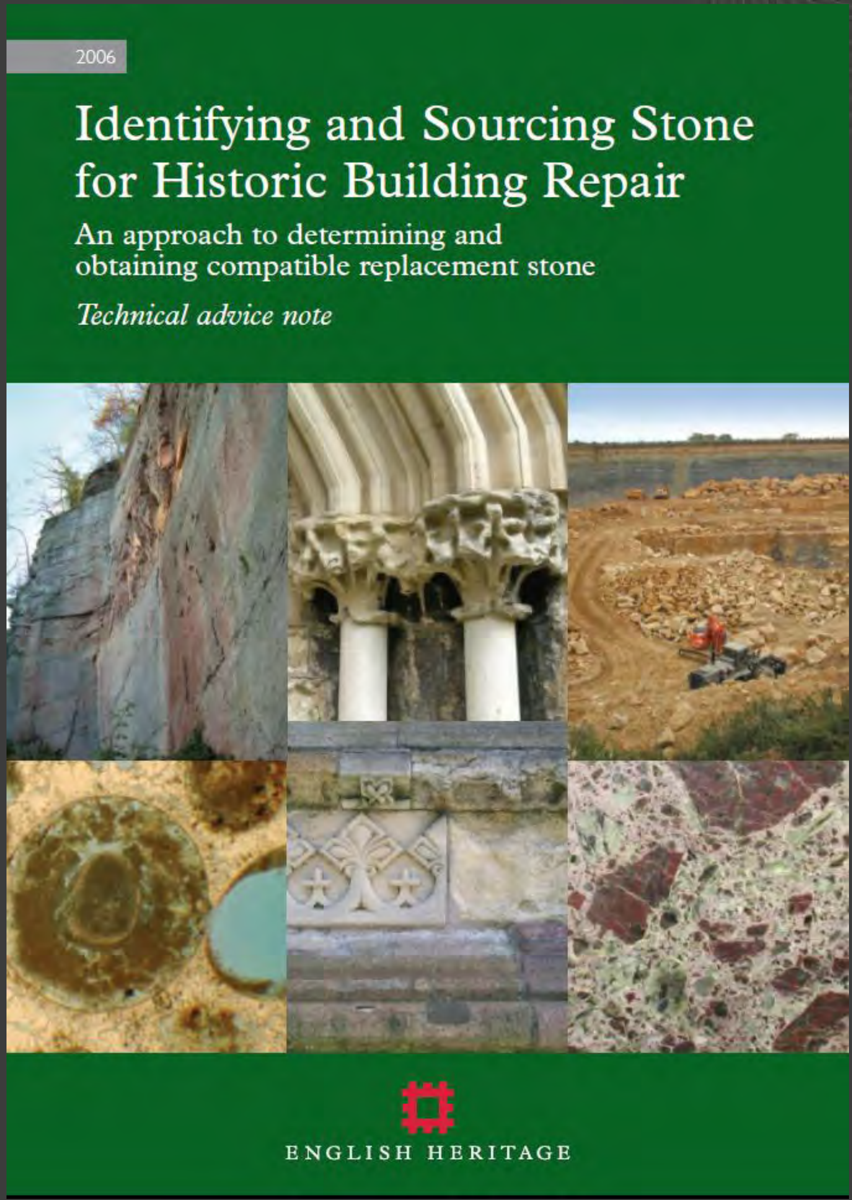
Limiting factors

- Analysis of existing materials
- Identifying the original sources
  - *Stone*
  - *Sand*
  - *Lime / binder*
- Identifying current sources
- Conservation guidance / listed building consent
- Funding – availability and associated restrictions
- Compromising

Guidance and Selection

4. Criteria for selecting replacement stone

- Petrography
- Chemical Composition
- Appearance
- Porosity
- Compressive Strength



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Case-studies

– Vimy Ridge Monument, France
    - *Crystalline Limestone*
– Albany Cathedral, New York State
    - *Sandstone*
– Gloucester Cathedral
    - *Oolitic limestone*

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Vimy Ridge Monument, France

- 1917: April 9, 100,000 soldiers of the Canadian Corps attacked Vimy Ridge
- 1922: the government of France gave 100 hectares of Vimy Ridge to Canada to be used as a memorial park.
- 1926: Work on the monument, designed Walter Allward, began

Vimy Ridge

- The twin ‘pylons’, each 67 metres in height, represent the countries of Canada and France. Twenty sculptured figures on the monument and the names of 11,285 Canadians missing in France are carved on the walls.
- 1936: The monument took ten years to build and was unveiled on July 29

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Vimy Ridge

- Original stone selection
- ‘Trau’ stone from the ‘Dalmatian Coast’
- Intended to last for many years
- Problems within 30 years
- Plans for a major restoration
- Preparation work – 2000 to 2002

Vimy Ridge – Selecting a replacement stone (1)

- Testing the stone
- Failure mode and effect
- Physical properties
- Colour and appearance
- Causes of failure
- Minimising future risks

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Vimy Ridge – Selecting a replacement stone (2)

- Identifying currently available stone
- Veselje Unito, Brac, Croatia

Vimy Ridge – Selecting a replacement stone (3)

- Finding the original quarry
- Seget, Trogir,Croatia

KANADSKI SPOMENIK IZ DALMATINSKOG KAMENA

KROZ KAMENOLOME U DALMACIJI — U SEGETU KRAJ TROGIRA

Vimy Ridge

- Located the original quarry
- Assessed the stone
- Hopefully a success story!

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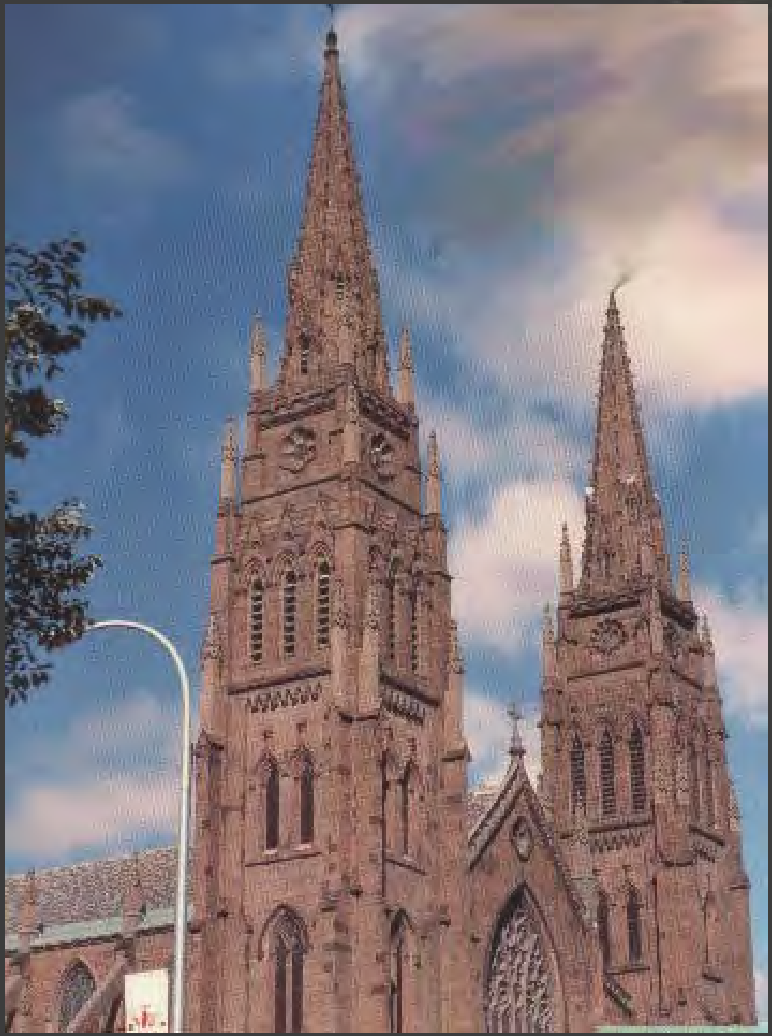
Cathedral of the Immaculate Conception, Albany New York State

- Initially constructed between 1848 and 1852
- Designed by Patrick Charles Keeley Inspired by Cologne Cathedral
- The north spire was constructed in 1862,The south spire in 1887.
- It was completed in 1892 with the construction of the sanctuary and sacristies at the west end.



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Albany Cathedral

- The cathedral is faced with Portland brownstone from the Connecticut River Valley.
  - Some of the first stone quarried in that area
- Now part of a major urban area
- Stonework decaying and in need of replacement
  - spires
  - clerestory

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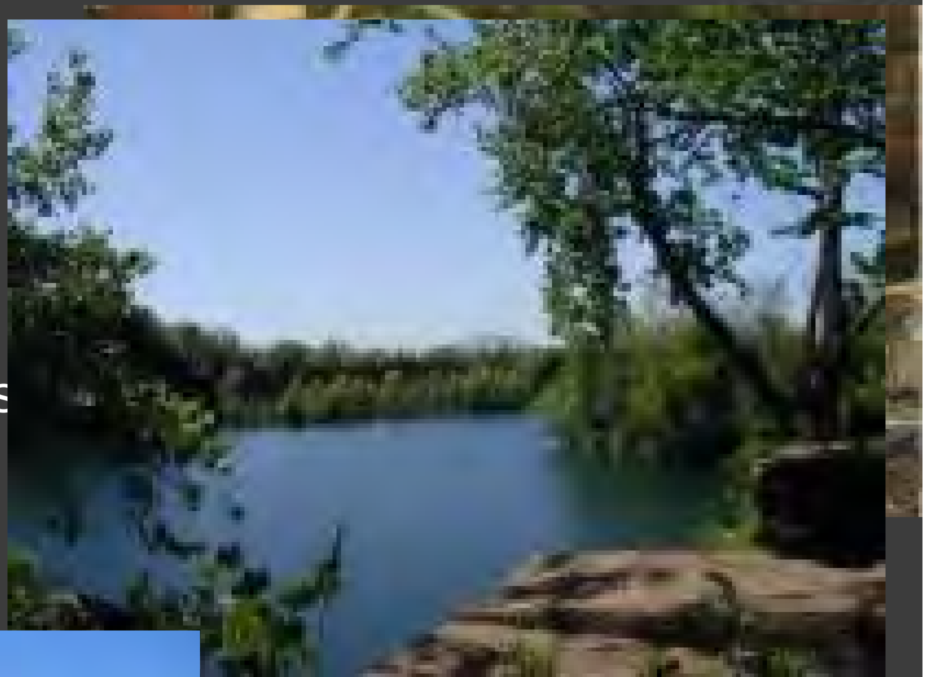
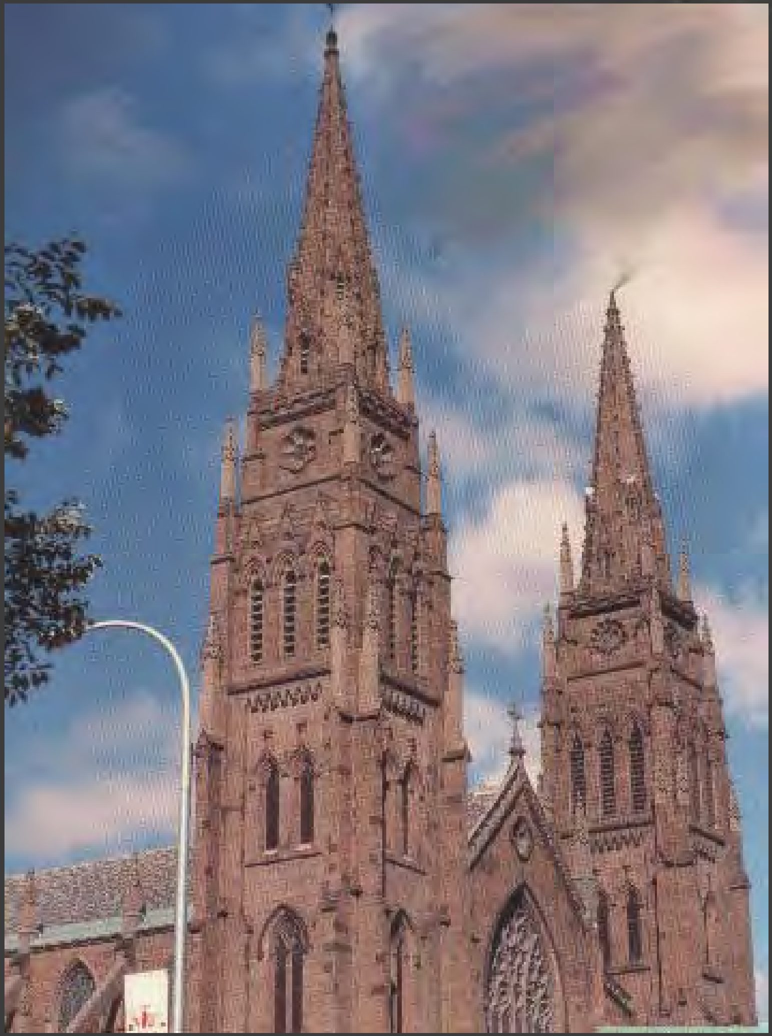
Albany Cathedral

- Original stone source known
- Brownstone Industry
  - Very active in 19th Century
  - Declined late 1920s – early 1930s
  - Devastating floods in 1936
  - 1993 limited working of quarries re-starts



Albany Cathedral

- Choosing a 'more durable stone'
- Range of alternatives
  - Brownstone (US)
  - Red St.Bees (UK)
  - Red Wilderness (UK)
  - Röttbacher (FRG)
  - Weserhartsandsteine (FRG)



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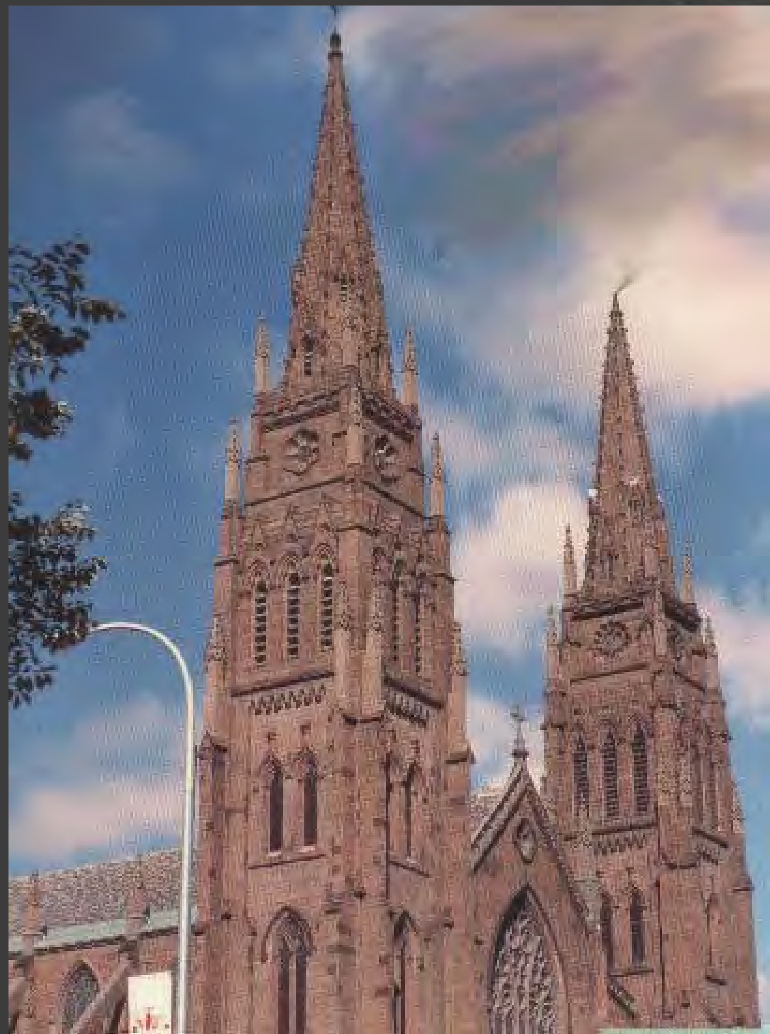
Albany Cathedral

- Physical Testing
- Emphasis on durability
  - Petrography / mineralogy BSEN12407 -
  - Porosity, saturation co-efficient, density and water absorption
  - Compressive strength BSEN1926
  - Sodium sulphate crystallisation test BSEN12372
  - Freeze/Thaw resistance BS EN 12371
  - Acid Immersion test (BRE In-house method based on BRE Report 141)
- 'Scoring system' to provide ranking



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Albany Cathedral

- Red St. Bees chosen
- Assess the quarry
- Long period of extraction
- Production Control Testing

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Albany Cathedral

- Maintaining ‘agreed quality’
- Managing risks
- Maximising service life

The Cathedral Church of St. Peter and the Holy and Indivisible Trinity, Gloucester, UK

- **1089** Abbey Church started
- **1373 - 1470** Extensive additions
- **1735-52** Major repairs and alterations to the cathedral.
- **1847-73** Beginning of extensive Victorian restoration work (F.S.Waller and Sir Gilbert Scott, architects).
- **1953** Major appeal for the restoration of the Cathedral; renewed
- **1989 - Present** : Continued restoration of various areas of 14th and 15th Century stonework

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Gloucester Cathedral

- Choosing a stone for repair and replacement
- Original quarries known but long since closed
- Re-opening an abandoned quarry
  - Why was it closed?
  - Assessing reserves
  - Additional costs
- Selecting a ‘match’ on the basis of colour and physical properties

Some final thoughts…….

- Testing can be useful ……even essential …but needs to be realistic and relevant!
- Conservation has the potential to bring added constraints and limitations
- Talk to those involved as early as possible in the project as getting the most appropriate stone can take a long time!

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