



ENGLISH HERITAGE

Building in Stone

INFORMATION FOR TEACHERS

This booklet introduces teachers to stone and how it has been used in the past for building. English Heritage properties as well as many other buildings can provide an excellent opportunity to understand and appreciate just how people have used stone to build a range of lasting monuments. These important parts of the built historic environment can be used to support different parts of the curriculum including history, geography, art, design and technology, science and RE.

Throughout human history, hills and mountains formed by the underlying rocks (geology), have been used as places to build safe and secure strongholds such as forts and castles. Stone has been used as raw material for building prehistoric homes and buildings including stone circles, Roman roads, towns and villas, medieval castles, abbeys, bridges and country and town houses throughout Britain. There are many different types of stone and these have been used in many different ways as part of the construction of buildings including walls, floors and roofing material, furniture and for decoration both inside and outside buildings. Although today little stone is used in the building of modern homes, it is still used in many important buildings and it is vitally important for repairing historic buildings.

To understand the importance of stone, there are many different aspects that can be investigated including the different types of



Hadrian's Wall, a World Heritage Site, provides an outstanding example of how a natural geographical feature has been selected for strategic purposes; in this case to mark the extremity of the Roman Empire in Britain. Here, the Romans took full advantage of the steep north-face of the ridge formed by the Whin Sill, an outcrop of a very hard igneous rock.

stone, how they are formed, the underlying geology, quarrying and transport, building materials and all the ways stone has been used.

Different types of stone and its formation

Since its formation 4.5 billion years ago, the Earth has been in a state of change. The continents and sea floors that form the surface of the Earth are part of the tectonic plates of the Earth's crust. Molten rock (lava) erupts around the edges of these moving plates, where plates are pushing together forming mountain ranges or where they are separating. Through this process the continents have been, and still are, in constant motion around the globe. Different types

of rocks are formed under different conditions, and are classified in broad types, which have specific characteristics and therefore used for different purposes.

Over millions of years as the continents moved in relation to the polar regions, the climate of the earth has changed, with extremes of heat and cold, wet and dry conditions. A record of these changes along with the life that evolved in these conditions is preserved in rocks and fossils.

Britain is unique in that it contains a more complete and varied record of these changes than any country of comparable size in the world. Although there are many gaps in the record, Britain has experienced a huge variety of

Rock type	Characteristics	Typical use
Igneous rock <i>is solidified magma, formed deep underground.</i>		
Granite	Dense, hard rocks with interlocking crystals of minerals such as quartz, mica and feldspar.	Road cobbles or setts, kerbs, polished slabs and buildings in Cornwall.
Metamorphic rock <i>has been altered by heat or pressure usually deep underground.</i>		
Marble	Fine-grained and soft, varying in colour from pure white to brightly coloured. Usually with a veined texture. Marble is not found naturally in Britain, it is imported mainly from Italy	White varieties used for statues. Coloured varieties for decorative features such as fire surrounds.
Slate	Extremely fine-grained, dense material, which can be split into thin sheets. Dark grey/purple and green in colour.	Most commonly seen as a roof covering. Cut and polished, it is also used for inscriptions or plaques.
Sedimentary rock <i>is formed from eroded igneous and metamorphic rock that has been deposited by rivers and seas. Rock is eroded or worn down by water from rain and rivers and extremes of temperature such as freezing.</i>		
Sandstones and Gritstones	Fine to coarse grained, composed of grains of sand (quartz). Colour includes light brown, red, yellow, grey/green. Some types of dense, hard fine-grained sandstone can be split into slabs and referred to as flagstones. Brown/grey in colour.	Quoins (corner stones), ashlar (cut blocks), rubble and coursed squared walling, mouldings and carvings. Paving, steps, window sills, coursed and dry stonewalling and roofing tiles.
Limestone	Rock that consists of calcium carbonate from the remains of shells and coral. It is often polished to look like marble. Colours include white (Portland stone), cream, grey and black. Fragments of coral, shells or crinoids (sea lilies) and ooliths (eggstones) may be visible.	Different grades including rubble stone, ashlar (cut stone) walls, stone carvings and internal decorations (fireplaces and monuments).
Tufa	Formed from calcium carbonate (dissolved limestone) deposited from springs. Used extensively in some areas, now mostly worked out. Easily worked, strong, light and porous.	Romans used tufa for example Chesters Fort (Hadrian's Wall). Used for vaulting in churches and cathedrals.
Chalk	Very fine-grained limestone, sometimes termed Clunch. White to grey in colour.	Some varieties durable enough for external walling or suitable for intricate carvings.
Flint	Nodule of flint (pure silica) occur in chalk. The best flint is black and very hard.	In some areas used as a building stone (Norfolk and Suffolk). Romans widely used flints as rubble wall-fill.

different conditions including volcanic eruptions, arid deserts, tropical seas and steaming swamplands. There have been several great mountain-building episodes and continual erosion of the land by ice (including major glaciers and ice-sheets), wind, rain, sea and river erosion. The landscape we see today has been moulded and shaped by these processes. Britain currently enjoys a temperate climate, undisturbed by the volcanic and earthquake activity that has

shaped it over millions of years.

The siting of most towns and historic sites relates to the underlying rocks and geology. Throughout history the natural landforms of England have been used to build in strategic locations, for example using high cliffs or ridges to site defensive castles, or flat open plains to show ceremonial sites such as Stonehenge to best advantage. Towns often developed away from areas that flood and near good farmland where the underlying

rock has improved drainage and helped provide good soils.

Building materials

A general rule for building is that the materials used are those that are cheapest and nearest. Timber was most frequently used for basic buildings such as houses, although mud, turf and reeds (for thatched roofs) were also used particularly in flat, lowland areas. However, these building materials have many disadvantages. They are susceptible

to damp, wood boring insects, fungal decay and especially to the effects of fire. Stone has the obvious advantage over these organic materials in that it is weather resistant, durable and fireproof, but it is also very hard, heavy and difficult to move.

The most easily accessible building stones, where a region is underlain by hard rock, are those that are found lying at the surface.

Before hard iron tools were available to shape and work them, stones were selected for their shape. Flat and elongated stones were laid in roughly horizontal layers (courses), with the stones of each higher layer placed to overlap the gaps or joints between the stones of the underlying one. This basic principle of building with stones or later with bricks provides greater strength than is possible using randomly placed stones. Buildings and structures made of unworked stone are limited in their size owing to the irregular nature of the stones. Walls also need solid foundations or the soil on which the walls stand will be washed out or compacted unevenly by the weight of the wall, with the result that the walls soon collapse. The Romans introduced technology that changed building in Britain. They smelted iron to produce tools that were sufficiently hard to cut stone into regular square shapes to build square and rectangular buildings. Lime mortar was used to bind the shaped stones together to form stronger walls that could be built taller. Although the Romans made these significant developments to stone buildings they also used concrete and bricks.

Quarrying and transport

The most common sources of building stones are the sides of steep-sided valleys and gorges, edges in upland areas or cliffs exposed along the coast. Through experience, the quarrymen learned to distinguish the best stones and



This artist's impression of Chysauster Ancient Village, Cornwall shows the use of unworked, irregular stone without mortar to build circular houses.

selectively quarried these. Stone was quarried and cut using hand tools, until the introduction of steam driven machinery in the eighteenth century. Once the soil, weathered bedrock and rubble was removed to expose good beds of stone, blocks were cut from the face with sharp picks and using a 'plug and feathers', a technique still widely used today. This uses pairs of curved steel wedges placed into a line of holes drilled into the exposed stone. A third wedge is

then hammered into place, to drive the curved wedges apart. By progressively applying stress along the line, the stone is eventually split from the quarry face into manageable size blocks. Blocks of roughly rectangular stone weighing over a ton could be manhandled using a variety of levers, wedges, rollers, and pulleys to the stonemason's bench, where it would be squared into building blocks.

In regions where there are outcrops of hard rock, every village

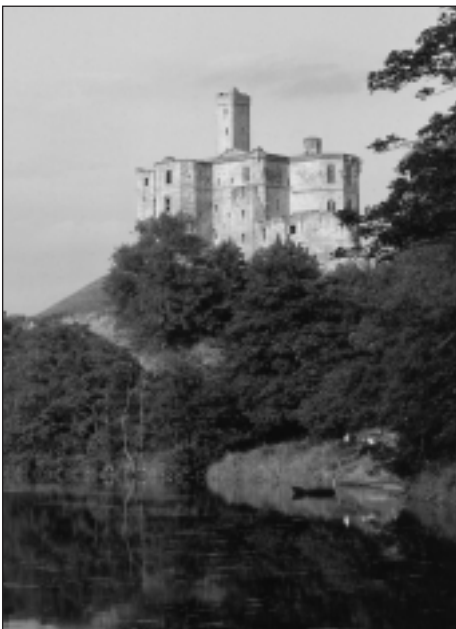


After centuries of national political strife following the Norman Conquest, attention turned to the defence of England from Spain, Holland and France and the threat of attack with ships loaded with cannons. All along the south coast, river estuaries, harbours and ports were protected by squat rounded fortresses, which presented a difficult target for enemy gunfire. At Hurst Castle, Hampshire, King Henry VIII built a stone fortress to command the narrow entrance to the Solent.



In the turbulent times after the Norman Conquest, the largest buildings were castles, built to defend strategic positions. Peveril Castle, in the Peak District, was one of the first of William the Conqueror's castles to be built using stone rather than having timber defences. The castle is set on the edge of a gorge, protected by steeply falling ground and is largely built out of the underlying limestone, a very hard, dense and brittle rock. The keep is the most important and heavily defended part of the castle and is built of Millstone Grit, a hard sandstone from at least 1.5km away in the Pennine hills. Millstone Grit can be cut into large, precisely squared blocks, but these stones would have been expensive to have quarried, worked and transported to the castle and so were only used for the outside of the keep. These valuable outer stones have largely been robbed or removed, revealing a core of lesser quality, rough disordered limestone rubble, set in lime mortar.

and town had its own quarry. The architectural style of the buildings often reflects the characteristics of the local stone particularly the size and shape of the individual stones.



The Normans used existing landforms building their castles on high, steep sided and easily defensible cliffs that commanded river crossings and established trade routes, such as Warkworth Castle, Northumberland.

Stone was usually transported short distances by wagons, sleds or packhorses. When larger quantities of stone needed to be transported further from the quarry a navigable river was vital, and in south and east England stone was transported from quarries in northern France (Caen Stone).

Building

Working stone or shaping it into square blocks is labour intensive, time consuming and therefore expensive and so the less important buildings in a settlement were built using unworked rubble stone. Irregular rubble stone was sorted and built up in roughly horizontal layers, with the stones held in place and levelled with a thick bed of lime mortar. Large blocks of dressed stone were used to reinforce the points of weakness in a building such as the corners and surrounds to doors and windows, enabling larger structures to be built. The strength and stability of

a building depends on it having good foundations. Where possible builders have always used the underlying bedrock or built a platform of stone.

Unlike early medieval castle walls, which follow the contours of the land, great churches and other buildings were built according to a planned geometrical design, usually rectangular or square, increasingly being based on precisely measured plans and drawings.

The master mason was an important figure in medieval society. He was responsible for the selection of the stone, supervision of the masons and also the design and the 'setting out' of levels, angles and dimensions of the building. In time, with increasing complexity of the buildings, the architect assumed responsibility for the design.



Monasteries were built in more peaceful circumstances compared to castles, which allowed the masons time to work more slowly, hoisting the stones to greater heights and developing stone carving skills. The west front of Castle Acre Priory, Norfolk demonstrates some of these skills.

Stone for decoration

The survival of historic monuments shows the durability of stone. However, different types of stone have also been highly valued for their decorative qualities as it can be carved into intricate sculpture or cut and polished to reveal a wide variety of very attractive colours, textures, fossils and minerals. Stone can be used to decorate both the inside and the outside of buildings.

A stone house such as Brodsworth Hall in South Yorkshire, built in the 1860s, can be used to study how the stone has been used both for weatherproofing and decoration. The walls themselves are built of precisely squared and regular sized blocks of limestone (ashlar). Large blocks of stone used in this way possess considerable strength. Unlike rubble or roughly coursed walls, which require large, strong stones to rein-



force the corners and arches or beams (lintels) to bridge openings, in an ashlar wall these are not so vital and the stonework can be used more decoratively. By looking at each side of the main building a variety of horizontal bands of stone, known as string courses, can be seen. These are designed to stop water flowing down the walls, preventing damage from damp and frost. The sloped or pitched roof, which is disguised behind the ornamental balustrade, is constructed from overlapping slate. The balustrade also hides the gutters, made from lead, that channel water away from the roof and walls of the buildings. Below the balustrade is the roof overhang or cornice, an exposed and vulnerable part of a building that is protected with lead and incorporates a drip moulding, a groove cut into the underside of the stone to stop water being absorbed into the masonry. Along with the string courses, above and below the ground floor, and the window sills, the cornice is both functional and decorative and is a prominent feature of buildings designed in a formal Classical style.

In many cases the finest stone carvings and mouldings have long since been removed, to be reused in later buildings or more recently placed in a museum, but there may still be patterns, inscription, heraldry or carved gargoyles to be seen. The stonework in churches, cathedrals, castles and abbeys was



Carved sandstone corbel from Rufford Abbey, Nottinghamshire.

often plastered or painted. Stone that can be highly polished is most often used inside a building for decoration such as wall panels, pillars, balustrades, fireplaces and floors, this includes types of marble, granite and limestone. Polished granite was not used until the nineteenth century because it is too hard to grind down by hand with fine abrasives (a similar process to sanding wood). However, the polished shelly limestone from the Isle of Purbeck on the Dorset coast was very popular from the thirteenth century particularly in churches and cathedrals where it was used for slender columns.

Weathering and erosion

All stone is subject to weathering and erosion, but some stone like granite only deteriorates very slowly. Rates of weathering and erosion vary depending on the type of rock and its physical and chemical composition. Weathering is a chemical process for example rainwater, a weak acid, slowly dissolves limestone. Erosion is a physical wearing away of rock for example the freez-



It is in interiors that polished stone is best seen, especially in the fireplaces, mantelpieces and hearths, such as in the Little Castle at Bolsover Castle in Derbyshire. Popular decorative stone includes coloured and veined limestones from Devon and dark grey fossil limestone from Derbyshire.

ing and expanding of water in the stone can cause it to shatter. The presence of mosses and algae, usually on the north facing parts of the building where they are not dried out by the sun are good indicators of the presence of water in the stone.

Archaeological investigation

It is rare for an ancient monument or historic building to be preserved as it was built. Like many modern buildings, it will have been repaired, altered and extended over the years. Often, as buildings changed hands from one generation to the next, the new owner

Carved and ornamental stonework, such as this carved stone head at Whitby Abbey, North Yorkshire, is more likely to become eroded because a much greater area of the stone is open to the atmosphere



(air and water). In urban or polluted environments, weathering is increased by the sulphurous chemicals in acid rain and is often associated with blackening of the stone.

would make changes according to domestic or political needs, or the fashion of the day. Such changes are recorded in the stones of a building the remains of earlier walls, decoration and the marks left by the mason's tools provide clues to the history of the building. This evidence can be observed, recorded and investigated using a variety of measuring and surveying methods.

EDUCATIONAL APPROACHES

Many sites can be used to study aspects of stone buildings, however a preliminary visit will be essential to plan your work. The following suggestions outline activities that can be undertaken before, during and after a visit to a site to help pupils see, investigate and understand some of the characteristics of different types of stone and the skills needed to build and work with stone. The QCA schemes of work for Design and Technology relate to the design of shelters and buildings and the use of different materials and to Key Stage 2 Science studying materials. Geography units at Key Stages 2 and 3 include looking at physical and human features in the environment and how they give rise to the distinctive character of a place, particularly the local area. As part of a history unit it is important to consider the skills and technology available and how people lived in the past and as part of a local history unit considering 'How this place has changed'.

Before your visit

Some activities can be used before your visit to help pupils to investigate a stone building in an area that they are familiar with. The skills used in looking at this building can then be used with an unfamiliar building during a visit to an historic building:

- pupils can help collect a box of

various rocks and stones to investigate similarities and differences. The following simple experiments can be tried: measuring or describing the stone, weight, texture (crumbly, smooth, rough) hardness (can you scratch them), changes when wet, can you draw with them (for example chalk) and colour

- pupils can research what different rock types look like. Local museums may have collections of local rock types or a small class collection of different types of rock could be used to classify rocks, particularly looking for differences and similarities. Pupils can collect words to describe the different characteristics of the rock that can be used during a visit to record descriptions of stone

- young pupils can be introduced to buildings and materials using stories for example The Three Little Pigs, the parable of the house built on sand

- research words and phrases used for different parts of a building (for example windows, doors, roof, and lintels) and build up a dictionary of terms. The school buildings or another building nearby can be surveyed to identify these different parts of the building and the materials used. A drawing or photograph of one side of the building can be annotated with information about the materials that have been used

- specific questions can focus pupils' investigations. How is the weather kept out of the building? How has the building been changed? This investigation can be used to practise the skills needed for a similar survey of an historic building

- look at local maps to identify local landscape features. Are there any rock outcrops or quarries marked? Are there ways that can

be used to transport stone using roads, rivers or railways? Are there any towns located in good positions. A geological map will help to identify the underlying rock types or those rocks outcropping nearby

- looking at an aerial photograph will also show some of the features, particularly when used alongside the maps.

During your visit

Stone can be used as a focus for a visit to a building or monument and there are many ways of exploring the different types of stone at a site and how it has been used both outside and inside the buildings. A preliminary visit is essential to plan the activities that are most suited to the building and where possible find further information about the types of stone and how it is used at the site. When your group arrives at a site it may be appropriate to introduce the pupils to the site and spend time investigating the whole site, looking for different types of stone and how stone has been used. The following activities suggest ways to investigate stone buildings:

Recording

Parts of the building or monument can be investigated to record how stone has been used:

- surveying and recording stone and how it has been used will enable pupils to further develop investigating and recording skills used in the preparatory activities. Parts of the site can be identified during a preliminary visit where pupils can record information about the type of stone used, how it is used and its condition using a stone recording sheet

- pupils can find and record marks left by stonemasons. These include tooling marks (to help decorative plaster to stick to the stone), or masons' marks (recording the work completed by different masons)

■ the types of stone used can be identified using a geological chart or a simple key.



Pupils can follow or develop their own stone trail for visually impaired visitors to the site, using a tape recorder. It may be appropriate for pupils to work in pairs exploring the texture of stone (check that touching the surface is permitted and safe). One pupil carefully leads the other, eyes closed to a location with an interesting texture. The 'blind' pupil feels and describes it using five words, which the other pupil records to use in the trail.

An investigation of the building

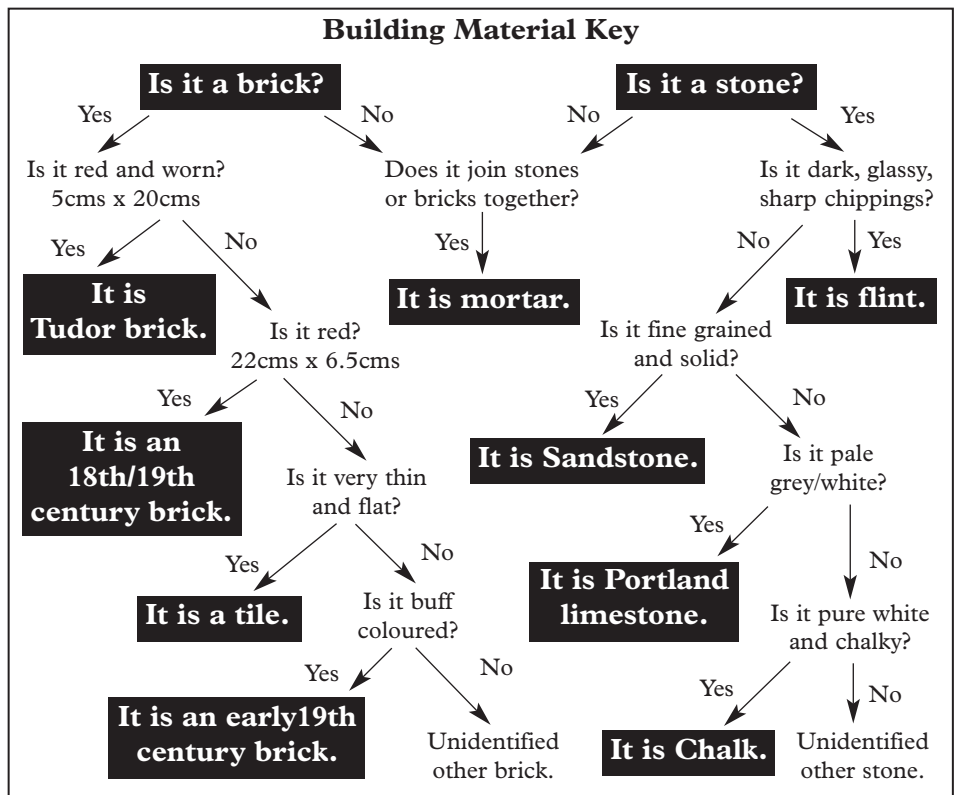
Pupils can undertake surveys of different aspects of the building to present as a report to the owners, perhaps with suggestions for work that is needed. The survey could include:

■ identifying different parts of the building such as walls, roof, steps, lintels, floor surfaces and chimneys. The different characteristics of the material, particularly different types of stone used for each of these, can be recorded using a plan of the building. Changes in the stone used can help identify when different parts were built

■ surveying the condition of the stone, annotating a picture or diagram of parts of the building, noting stone that looks like new, stone that has been replaced, stone that is badly eroded and stone where algae or lichen is growing

Stone recording sheet	
Building	Site 1:
The stone I can see is (circle words) Pure white, creamy white, grey, grey/green, black, brown, red/brown, shiny, dull, rough, smooth, gritty, sharp, crumbly. Add some words of your own.	
The stone has been used for strength/to keep the weather out/for decoration Other uses of this stone -	
I think the stone looks The same as when it was built/slightly worn or eroded/ very eroded	

A simple key can be used or further developed to help pupils identify different types of building materials.



EVALUATION SHEET: Subject						
	Materials	Function	Design	Decoration	Joins	Likes/dislikes
circle the appropriate words	wood	domestic	suits	plain	none	liked
	stone	military	function	fussy	glue	disliked
	glass	church	good	minimal	nails/screws	don't know
	concrete	decorative	bad	symmetrical	wooden pegs	beautiful
	brick	furniture	practical	moulded	welding	functional
	plastic	recreation	simple	handmade	mortar	useful
	metal	industry	complicated	carved	other (name)	decorative
	other (name)			other (name)		ugly other (name)

■ pupils can measure and draw their own plans of the building. This can include estimating or measuring the height of the walls, towers or other features

■ surveying the use of stone inside the building, if this is appropriate.

Evaluating the building

Buildings can be evaluated as part of a design and technology project. Pupils can discuss what they see at a site or building, their observations, their likes and dislikes.



Pupils can use the information collected about how stone was used in the existing building to design a new café extension. Pupils will need to consider whether it will blend in or contrast with the existing building, the materials to be used and decoration or ornamentation of the outside of the building.

MAKING A VISIT

All visits to English Heritage sites are free but must be booked through the regional office, for further details please refer to the Free Visits booklet. A small selection of sites for schools to visit are:

North East

Belsay Hall, compared to Belsay Castle weathering of stone and repair of mortar
Chesters Roman Fort
Dunstanburgh Castle, weathering texture caused by salt and wind

Yorkshire

Brodsworth Hall
Mount Grace Priory
Byland Abbey, site museum with examples of carved stone

North West

Furness Abbey, examples of problems of exposure of soft rock

Beeston Castle

West Midlands

Much Wenlock Priory
Kenilworth Castle
Wroxeter Roman City

East Midlands

Bolsover Castle
Rufford Abbey, sculpture and gargoyles

Eastern Region

Castle Acre Priory
Audley End House
Framlingham Castle

London

Chiswick House
Marble Hill
Rangers House, architectural study collection

South East

Dover Castle
Deal Castle

South West

Chysauster Ancient Village
Pendennis Castle

USEFUL RESOURCES

Barnes, J, *Design and Technology and the Historic Environment*, English Heritage, 1999, ISBN 1-85074-399-1.

Cooksey, C, *A Teacher's guide to Using Abbeys*, English Heritage, 1992, ISBN 1-85074-328-2.

Copeland, T, *A Teacher's Guide to Using Castles*, English Heritage, 1994, ISBN 1-85074-327-4.

Copeland, T, *Geography and the historic Environment*, English Heritage, 1993, ISBN 1-85074-332-0.

Corbishley, M, Darvill, T, and Stone, P, *Prehistory*, English Heritage, 2000, ISBN 1-85074-325-8.

Lockey, M & Walmsley, D, *Art and the Historic Environment*, English Heritage, 1999, ISBN 1-85074-651-6.

Keen, J, *Ancient Technology*, English Heritage, 1996, ISBN 1-85074-448-3.

Morris, R & Corbishley, M, *Churches, Cathedrals and Chapels*,

English Heritage, 1996, ISBN 1-85074-447-5.

Pownall, J & Hutson, N, *Science and the Historic Environment*, English Heritage, 1992, ISBN 1-85074-331-2.

Aerial photography Book/CD ROM English Heritage, 2001, ISBN 1-85074-780-6.

Building Stone Resources of the United Kingdom British Geological Survey (geological map and guide sheet) sales@bgs.ac.uk

A range of English Heritage videos for purchase or loan is also available, including The Master Builders in the construction of a great church. 23 mins, 1991.

English Heritage Education

English Heritage is the national leader in heritage education. We aim to help teachers at all levels to use the resource of the historic environment. Each year, we welcome over half a million pupils, students and teachers on free educational group visits to over 400 historic sites in our care. We also offer services to help access the National Monuments Record, our public archive. For free copies of our *Free Educational Visits* booklet, our *Resources catalogue*, and *Heritage Learning*, our termly magazine, contact:

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