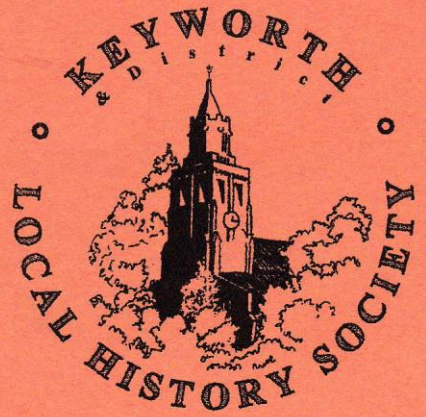
STRUCTURAL DEVELOPMENT IN ARCHITECTURE

AN INTRODUCTION

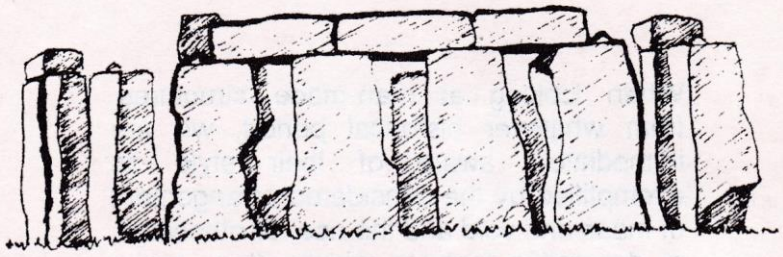


KEITH BARTON

AN INTRODUCTION TO STRUCTURAL DEVELOPMENT IN ARCHITECTURE

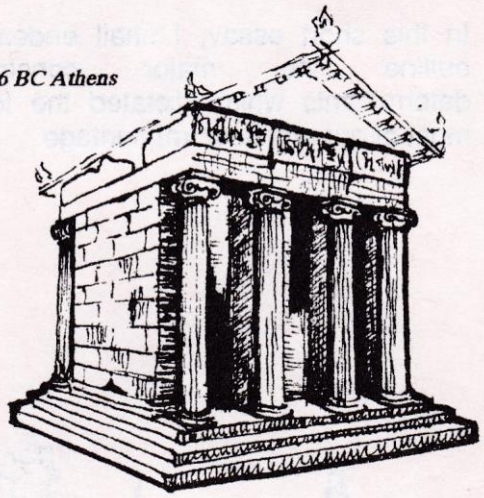
When looking at man-made structures, from whatever historical period, we are immediately aware of their style as exemplified by the considered arrangement of mass and void and the use, or otherwise, of decorative features which often make reference to an historical precedent. It is, however, less common for us as observers, to be aware of the constraints imposed by the materials used by the builders.

In this short essay, I shall endeavour to outline the major constructional determinants which dictated the forms of most of our architectural heritage.



1500 BC Britain

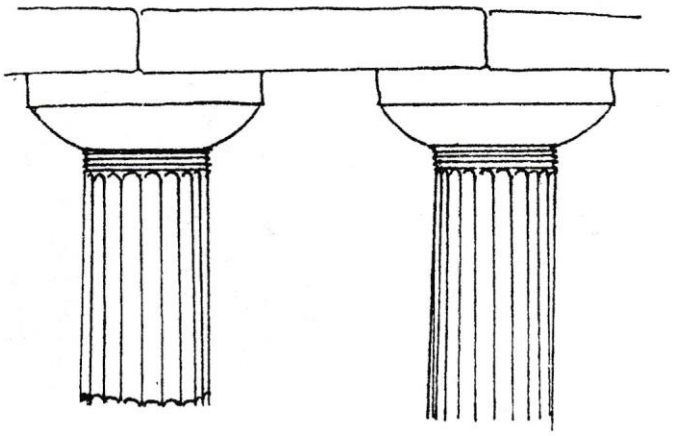
426 BC Athens



The earliest structures were almost certainly of wood. These wooden structures have long since disappeared and their existence can only be detected by careful observation of stains in the soil and the presence of post holes. On the other hand, there are many monuments in stone,still standing, which demonstrate the skill and ingenuity of man in his quest for shelter, or even immortality.

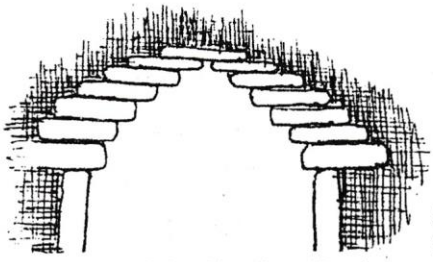
Throughout the known world we find impressive edifices which can reasonably be dated back to the third millennium BC, most of which utilised the simplest structural technique, itself derived from a timber predecessor: the Beam and Lintel.

But, in striving for permanence, the builder faced a major problem: the effects of stress on a brittle material. This resulted in severe limitations on the type of structure which could be created. Spans had to be short and any additional weight on the horizontals had to be applied above the columns. Stonehenge and the temples of ancient Greece demonstrate this style in its simplest and most developed form. In both, the columns are close-set and additionally, the Greek column was surmounted by a cushion whose purpose was to reduce still further the unsupported span of the lintel.

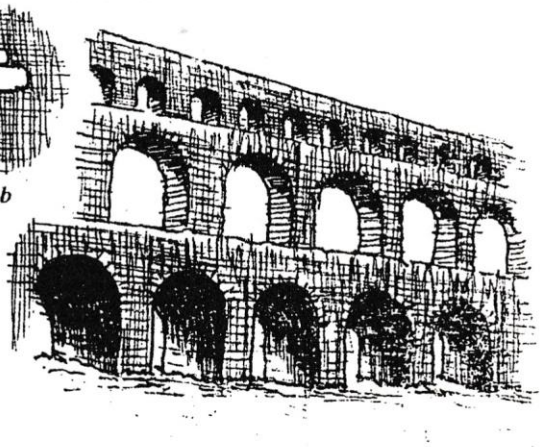


However, there were cultures, both in the Mediterranean and elsewhere in Europe, which developed a part-solution to the problem, by the use of overlapping or stepped horizontal slabs to create a crude arch, thus leaving a much wider void beneath. Just such a structure can be seen in the beehive tombs of Mycenae and, in an even more refined form, in the barrel vaults at Thebes. It should be remembered that trade in goods and ideas took place from the earliest times and that Britain was part of this interchange. It is not surprising therefore, to find that a development in building techniques emanating from the Mediterranean should appear in similar structures in Ireland or the more remote areas of Scotland; as for example, the Megalithic passage grave and tomb chamber at Newgrange, County Meath, Eire.. That these have been preserved is because of their remoteness from subsequent social, agricultural, industrial and urban development, which has been responsible for so much destruction of our historical record.

Moving forward in historical time, the Etruscans developed the barrel vault as a major constructional feature and the Romans,(who were very good at taking an idea and developing it beyond the dreams of its originator), applied the engineering principles of the semicircular arch to all manner of projects, from great aqueducts and viaducts to simple hypocausts beneath their houses.



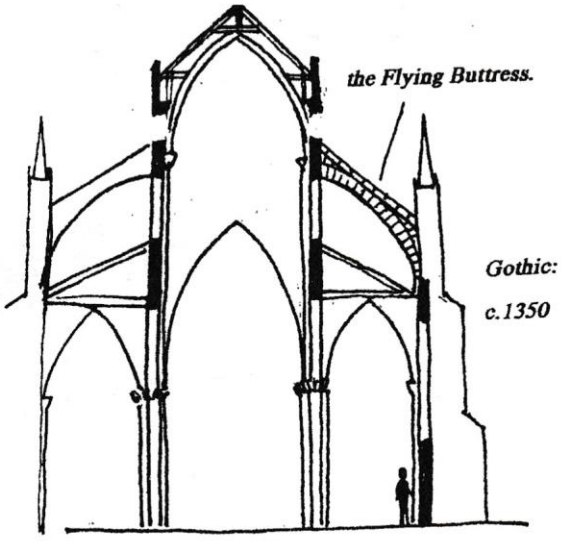
Section: Megalithic Chambered Tomb
County Meath, Eire



Pont du Gard: Nimes. AD14

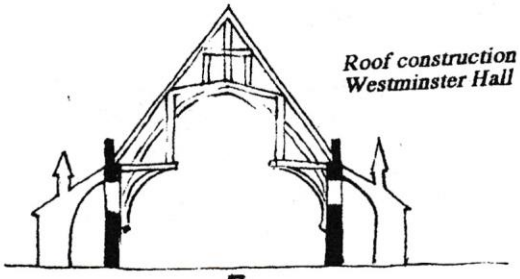
The semicircular arch was still the principal element of stone building when William of Normandy came to Britain and it was not until the twelfth century AD that the limitations imposed by the semicircle were overcome. By utilising opposing quadrants to make a pointed arch it became possible to develop the complex building structures such as we now see in the later Gothic cathedrals. These magnificent buildings represent the apogee of the use of stone as a structural material. Walls became thinner and less important as stress could be transferred to the ground directly via external arches (flying buttresses). This also meant that windows could grow in size, so spawning a whole new industry in the production of stained glass.

Norman. c.1180



Gothic: c.1350

In certain situations, wood was preferred; it was cheaper,lighter and had greater tensile strength, which is clearly demonstrated by the number of surviving medieval timber-framed buildings and especially complex roof structures over barns, halls and churches.



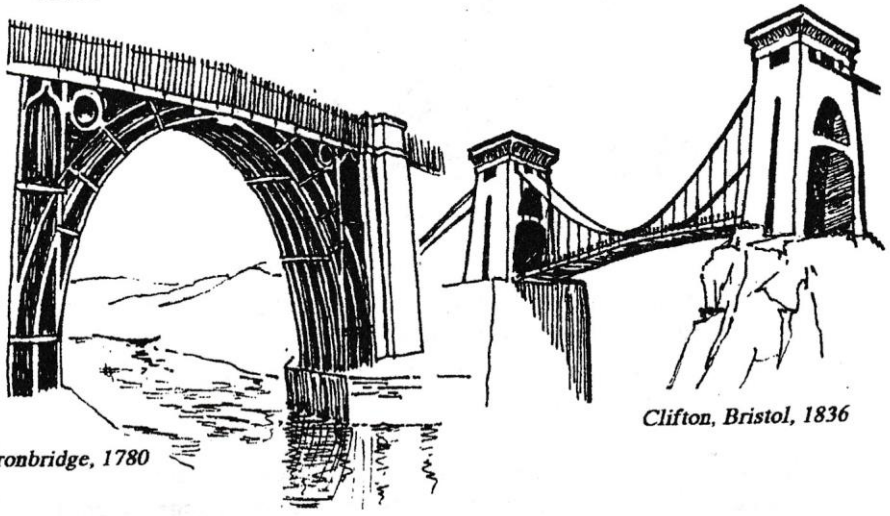
Roof construction Westminster Hall

Brick came into general use in the late fifteenth century (ignoring the fact that the Romans had used it!), but this material had the same inherent disadvantages as stone, with some additional ones of its own. Therefore it is safe to say as a generalisation that buildings built largely of brick had to be of relatively simple construction and usually had wooden framed interiors resting on a brick outer shell.

Brick was also combined with stone, used either as a decorative feature, or as a protective outer skin. Many town centres can show how important this material was, either alone or in brick/stone combination, to town planning and street design; in much the same vein, the majority of our great 18th century country houses use brick and stone in an imaginative and often exciting way, sometimes completely enclosing an earlier (and therefore 'unfashionable') family seat.

Town Street facade, c.1770
Brick with stone dressing.

The Industrial Revolution introduced many exciting new materials and techniques and by 1780 the new cast iron bridge at Ironbridge pushed the frontiers of this technology still further. Within fifteen years a number of these bridges had been built; chief among their designers was the father of canal and road builders, Thomas Telford, whose elegant and delicately poised spans are still in use. In parallel with these arched bridges, Telford revived the suspension bridge of antiquity with the Menai Strait bridge in 1818. But it is in railway stations, especially the major termini, market halls and factory interiors that we must look for the imaginative (and decorative) use of this material. Once again it was the brittleness of the material that was limiting and Isambard Kingdom Brunel took things a stage further by using wrought iron, which had more tensile strength, when he designed the Clifton suspension bridge for Bristol in 1836.

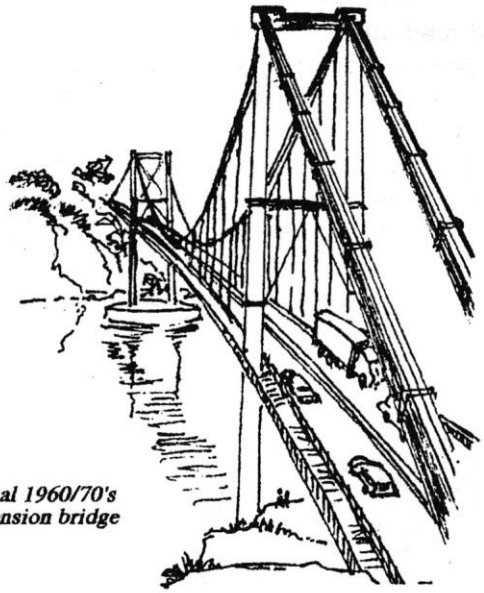


Ironbridge, 1780

Clifton, Bristol, 1836

The railway enthusiasm proved to be the creative spur to designers and builders using the new material: see, for example, the Forth Rail Bridge.

It was not until the introduction of high tensile steel in the twentieth century that further advances in bridge design became possible and out of which came the suspension bridges typified in Britain by those over the Humber and the Severn.



Typical 1960/70's Suspension bridge

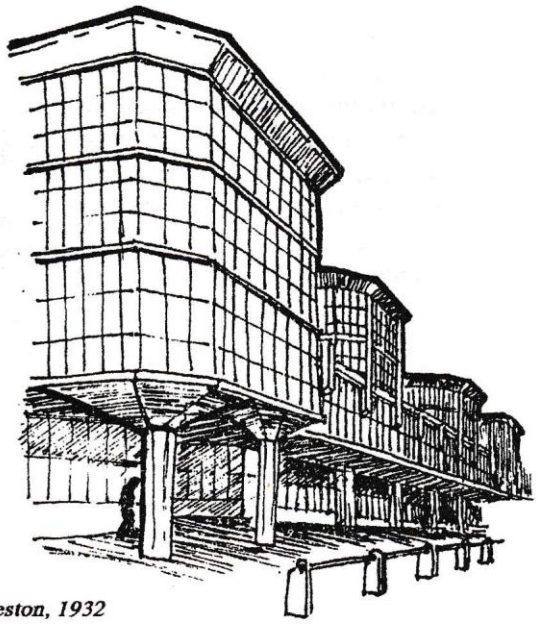
Throughout the nineteenth century, all available materials were used in a variety of ways and much of the look of our towns and cities now was established during this period. Nottingham's Lace Market area is a well-preserved example of these important developments.

Computer Aided Design has allowed the creation of more adventurous structures, using a variety of compression/tension themes, such as we see at the new Waterloo terminal and some futuristic designs for sports stadia, especially those provoked by competition for staging the Olympic Games.

Cast and reinforced concrete have been used throughout this century and there are many elegant and innovative buildings and other structures which testify to the constant desire to push any material to its limits. However, just as with stone,wood and cast iron, the material itself is self-limiting and some of the problems now being faced are caused by the rusting of steel reinforcing as the expanding oxide forces the cement coat apart. Blocks of flats and motorway bridges seem to be the major sufferers. Not only does the porosity of concrete cause problems with reinforcing, it also stains badly and many initially attractive buildings have lost their appeal as the combined effects of weather and air-borne pollution take their toll.

Nottingham's new industrial sites offer many worthy examples of the use of modern and traditional materials. Here we may see timber, stone, brick, concrete, cast, rolled and drawn steel and most recently, plastic, used to excellent and even prize-winning effect. It will be interesting to see whether the replacement for the now-demolished Boots and Allen's buildings on the island site at the end of London Road, will be as innovative as was the Boots factory at Beeston in 1932.

Keith Barton
March 1996



Boots, Beeston, 1932

GLOSSARY

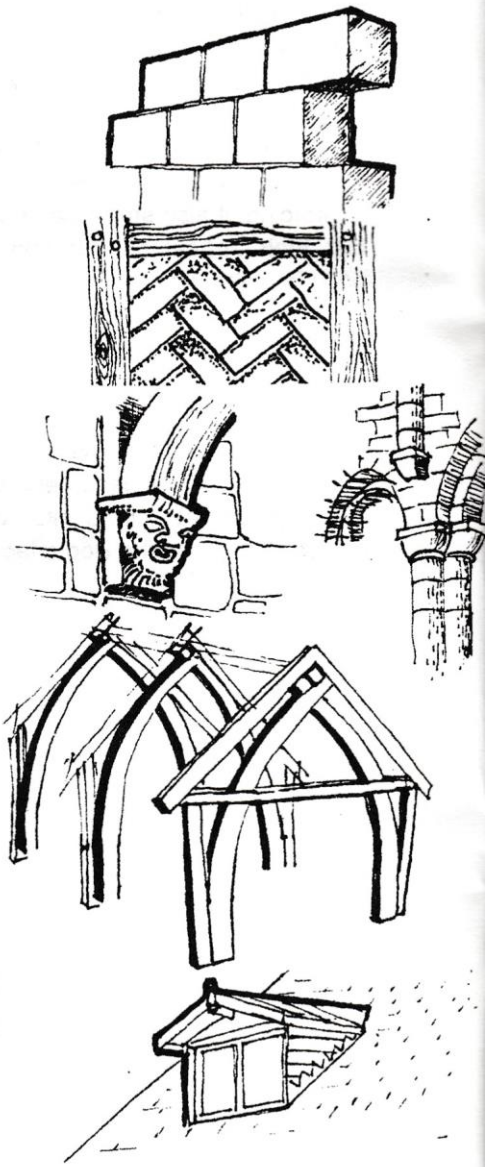
Ashlar
Carefully cut blocks of masonry used to give even courses with vertical joints.

Brick Nogging
A method of infilling the spaces between timbers in timber-framed buildings. Often laid in 'herringbone' pattern.

Corbel
A projecting support for internal roof structures, frequently carved, especially with human faces.

Cruck Blade
A curved brace which, in pairs, forms the principal support for the roof ridge, repeated as often as necessary, according to the length of the building. Usually only found in the smaller timber-framed dwellings of all periods up to the end of the 17th cent.

Dormer
A window projecting from a roof to light a sleeping area - hence the name.

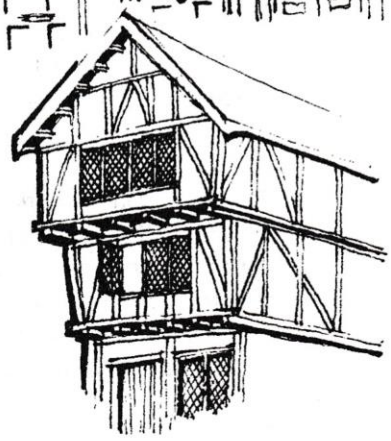


Eaves
Roof edge which projects beyond the wall: designed to throw rainwater clear to the ground below.

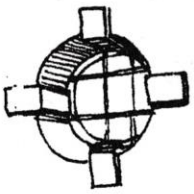
Fanlight
Glazed space above a door: gives light to the area behind. Often decorative: most common in Georgian houses and later.

Gable
The upper section of a wall at the end of a pitched roof.

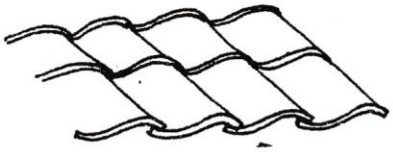
Jettying
Often found in timber-framed buildings. A method of increasing floor space, where an upper storey projects beyond a lower. Most frequently used in towns where building land was at a premium.



Oriel Window
Also called 'Bull's Eye': a circular window frequently found in Georgian buildings. Also a similar, more elaborate form is to be found in the window tracery of Gothic churches.

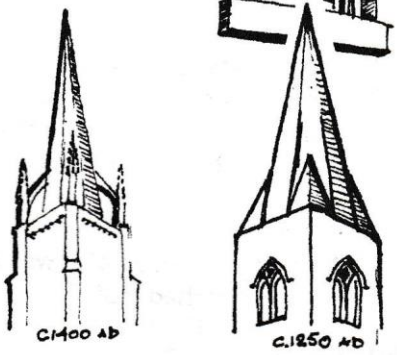


Pantiles
Rooofing tiles with a curved s-shaped section.

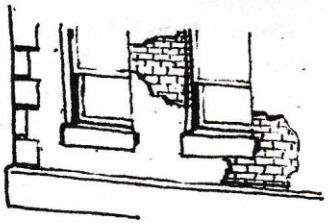


Sash Windows
A system of opening windows where frames slide over one another in either horizontal or vertical grooves.

Spire
A tall pyramidal structure usually polygonal, rising from a tower or roof. Its use created particular problems both visually and structurally when placed on a square tower. Had religious and aesthetic significance.

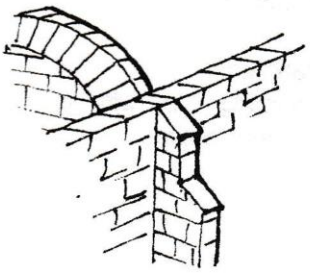


Stucco
External plasterwork, generally smooth. Often enabled builders to utilise cheaper brick in construction or to use colourwash. Sometimes inscribed to imitate the joints in an ashlared wall.

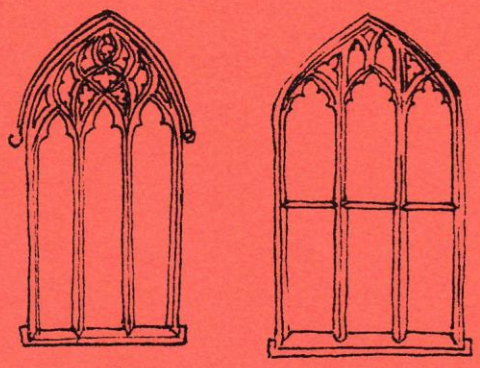


Terrace
A row of attached houses built as a single unit - eg. at its best,the Royal Crescent, Bath or, of course, any Victorian or Edwardian street.

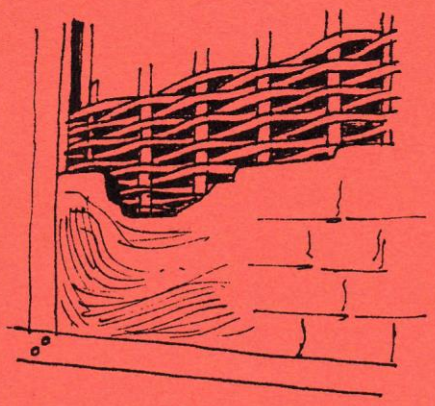
Thrust
An outward force created by the abutment of a wall, arch or vault against a vertical structure.



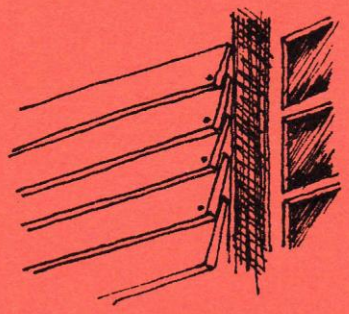
Tracery
Intersecting stonework used decoratively in medieval windows. Reached its apogee in the late 14th early 15th centuries.



Wattle and Daub
A method of thin wall construction, where woven hurdles of wood were plastered over with mud or clay, often reinforced with cow or horse hair. Made a good base for limewash to colour and protect. In general use as a cheap infill from Anglo Saxon times to the end of the 18th cent. Was used for both internal and external walls until the general introduction of brick and stone for all housing.



Weatherboarding
A method of facing external walls using overlapping horizontal boards similar in technique to the clinker-building of boats.



OCCASIONAL PAPER NO 2

PRICE £1.00

First published and printed in 1997
By Keyworth & District Local History Society

c/o Keyworth Library
Church Drive
Keyworth
Nottingham