Graphic History of Architecture

John Hansbridge
EGYPT

THE ARCHAIC PERIOD

<table>
<thead>
<tr>
<th>Dynasty</th>
<th>I</th>
<th>II</th>
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<td>c.3200 B.C.</td>
<td>2980</td>
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THE OLD KINGDOM

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<th>III</th>
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<td>2789</td>
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First Intermediate Period

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<th>Dynasty</th>
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<td>2258</td>
<td>21134</td>
<td>1991</td>
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THE MIDDLE KINGDOM

The Feudal Age

Invasion of the Hyksos from Asia

Union of Upper and Lower Egypt
Capital: Memphis

The Age of the Pyramids
Capital: Thebes

MAP OF EGYPT AND WESTERN ASIA

Miles

500
The Egyptian Empire in Asia and Nubia
Capital: Thebes

Egypt was a narrow strip of highly productive soil, 8 to 12 miles wide, along the banks of the Nile, about one-fifth of the area of England and Wales. From pre-dynastic times sun-dried mud bricks were used for houses, but these have not survived: timber was scarce and hence arches were built without centering. There was however an abundance of limestone, sandstone and granite. The planning of irrigation canals and fields, necessitated by the annual inundations of the Nile, demanded a system of geometry (Gk land measuring). Believing in a life after death, the Egyptians thought that the body should be preserved in a lasting tomb; this became a geometric construction of great solidity and permanence.
Pit graves in desert cemeteries: sand heap A surrounded by circle of stones B over grave C. Pit graves transformed into tombs by brick lining and flat wooden or arched brick roofs. Walls of sun-dried brick. Beginning of stone masonry.

THE STEP PYRAMID, Saqqara, Dynasty III: Section looking west. Built by Imhotep, architect to King Zoser.
1 Begun as a mastaba-tomb. 2-5 Then successively enlarged, in limestone. Set within a complex of buildings (p.18)

THE PYRAMID OF MEDIUM, Dynasties III-IV: Section looking west, reconstructed
1 Centre core. 2 Successive layers added, at about 75°, each of local stone and cased with limestone.
3 Enlargement of the pyramid. 4 Steps filled in with a facing of limestone. 5 The tomb chamber

Stones on sledges, pulled up long earth ramps. The Rocker; pulleys were unknown. Suggested methods of hauling and lifting stones.
Built of local stone on a core of rock
Constructed of some 2,300,000 stone blocks, each weighing approximately 2½ tons. It is probable that for a period of twenty years 100,000 men were levied annually, during the three months’ inundation of the Nile (July to October), for transporting stone.
Also about 4,000 permanent skilled masons and attendant labourers were employed
EGYPT

THE OLD KINGDOM
Dynasties III-VI, 2780-2258 B.C.
The Age of the Pyramids

The Step Pyramid, Saqqara, set within a complex of buildings of local stone faced with limestone

Built by Imhotep for King Zoser, Dynasty III

The great Pyramid of Cheops, Giza, Dynasty IV

Funerary Temple of Mentuhotep I, Deir-el-Bahari (reconstructed), Dynasty XI

Pyramid of Neferirkara

Pyramid of Ne-user-ra

Pyramids of Abu Sir (reconstructed), Dynasty V

THE MIDDLE KINGDOM
Dynasties XI-XII, 2134-1786
COMPARATIVE BUILDINGS & PLANS

THE NEW KINGDOM
Dynasties XVIII-XX, 1570-1085 B.C.
The Age of the great Temples

Mortuary Temple of Amon, Deir-el-Bahari (reconstructed), Dynasty XVIII
Designed by Senmut and built for Queen Hatshepsut

The Great Temple of Amon, Karnak, Dynasties XVIII-XXXI (Foundations Dynasty XI)

The Temple of Amon, Luxor, Dynasties XVIII-XIX
Begun by Amenhotep III and added to by Rameses II

Temple of Seti I, Abydos, Dynasty XIX

Great Temple, Abu Simbel, Nubia, Dynasty XIX. Built for Rameses II

THE PTOLEMAIC PERIOD
332-30 B.C.
Revival of Temples

The Temple of Horus, Edfu, 237-212 B.C.
Begun by Ptolemy III

The Temple of Hathor, Dendera, 1st cent. B.C.

St Paul’s, London

Plans and buildings in black drawn to the same scale
A garden shrine from a painting in a tomb, Thebes, Dynasty XIX

Temple of Amenhotep III, Island of Elephantine, Dynasty XVIII (Destroyed A.D. 1822)
Pylons, Temple of Luxor, Dynasty XIX. Built by Rameses II

GREAT TEMPLE OF AMON, KARNAK

Built of sandstone
Begun Dynasty XII
1-4 Dynasty XVIII 5 Dynasty XIX
6 Ptolemaic period

7 Temple of Rameses III, Dynasty XX
8 Temple of Khonsu, Dynasties XX-XXI

Section

Hypostyle hall, a-a

hall filled with sand and roof-slabs lowered into position
Valley Temple built of granite: Pyramid of Cephren, Giza.

Dynasty IV

Rock-hewn tomb, Beni-Hasan,

Dynasty VII

PROTO-DORIC COLUMNS

Tomb 18, Beni Hasán

Dynasty XI

LOTUS COLUMNS

Tomb of Sahura, Abusir

Dynasty XIX

Palm Columns

Temple of Isis, Philae

Ptolemaic

Brick arch, el ‘Asaseef, Thebes

Vault of damp mud bricks laid in slanted courses without centering
Dynasty V
Mortuary Chapel of Ne-user-ra, Abusir

Dynasty XIX
Temple of Luxor

Dynasty XIX
The Great Temple of Amon, Karnak; Hypostyle Hall,

PAPYRUS COLUMNS

Temple of Hathor, Denderah, Ptolemaic

Temple of Isis, Philae

Ptolemaic

HATHOR-HEADED COLUMNS

Corbelled-stone pyramidal tomb, Abydos,

Temple-tomb Deir-el-Bahari

Corbelled-stone arches,

Temple of Seti I, Abydos

Dynasty XIX

Dynasty XI
SUMERIAN CITY KINGDOMS

Civilization in Western Asia began with city kingdoms in the rich alluvial plain between the lower Tigris and the Euphrates, an area about that of Wales (Map p. 14). Tower-temples or zigurrats were the centre of city life. There was no stone and little timber but clay was moulded into sun-dried brick. Buildings were faced with kiln-baked bricks, sparingly owing to lack of fuel.

ASSYRIA

Assyria was set on a high tableland of lime-stone, harder rock & alabaster, but the Assyrians continued to use sun-dried and kiln-baked bricks. Palaces of warrior-kings were built on large platforms of brick 30-50 feet high. Lower courses of walls were faced with slabs of alabaster 9-12 feet high and carved with bas-reliefs or covered with plaster and painted with bright colour. The arch was constructed for gateways, vaults and drains.

SECOND BABYLONIAN EMPIRE

Nebuchadnezzar (604-561 B.C.) rebuilt Babylon to a regular plan described in The Histories by Herodotus (484-406 B.C.). Buildings were of kiln-baked brick and bitumen.

PERSIAN EMPIRE

Palaces were built at the capital city of Susa, at Pasargadae and Persepolis, being constructed of stone which was abundant in Persia; whilst raised platforms and glazed coloured bricks were adapted from the Assyrians; also influences from Babylon, Syria and Egypt.

SECOND PERSIAN—SASSANID—EMPIRE

The capital city at Ctesiphon. Buildings were erected of kiln-baked brick, vaults and the earliest domes being built over square compartments, developed by the Byzantines.
INTRODUCTION - ASSYRIA

PALACE OF SAGON II
KHORSABAD
(restored)
772-705 B.C.

Both the platform, about 50 ft high and 25 acres in extent, and the palace built of sun-dried brick and faced with kiln-baked brick.
THE CITY OF BABYLON (reconstructed), as rebuilt by Nebuchadnezzar, 604-561 B.C., during the Second Babylonian Empire. Described in *The Histories* of Herodotus.
PERSIA

THE
PALLACES OF PERSEPOLIS
(reconstructed),
Built by Darius (521-485 B.C.) and Xerxes (485-465 B.C.)
Built on a platform 1500 ft by 1000 ft in area, and 40 ft above
the plain, part solid rock, part large blocks of stone, without mortar,
held by metal cramps. Buildings constructed of sun-dried brick and faced with glazed bricks.
Columns of stone and flat roofs of cedar wood

Hall of 100 columns, Darius
Palace of Xerxes
Hall of Xerxes
Propylae of Xerxes

Hall of the Hundred Columns

Assyrian pavilion motifs
adopted by the Persians
Bricks were laid to form a base A; against an end wall B wedge-shaped bricks were fixed with mortar C. To ensure adherence these were often laid in sloping courses D. An arch was constructed with little or no centering to complete the vault E. To facilitate work and to reduce pressure, vaults (and domes) had a high oval profile F. When completed vaults were often re-inforced by a second or more courses of brick G. Sassanid Persian buildings, vaults and domes were constructed of kiln-baked bricks laid with a mortar of lime and sand.

The Persians built domes with little or no centering. A dome is an arched construction both vertically & horizontally: each ring of brick or stone once closed in cannot fall if it rests adequately on the ring below.

The Persians were the first to erect circular domes on square plans with four angular corbelled semi-domes.

The Palace, Serbistan (exterior restored), c. A.D. 350.
DOMES - SECOND PERSIAN EMPIRE

The Palace of Chosroes, Ctesiphon, 6th cent. A.D.

The Palace, Firouzabad (exterior restored), c. A.D. 450
GREEK

AEGEAN

Minoan—Crete

1500 1184

Mycenaeans c.1500

1184

1500

The Greek invasions

Establishment of Greek city-states along the Mediterranean and Black Sea

Greek colonisation 8th-6th centuries B.C.

775/6 First Olympiad

650

Archaic period

500

1500

1184

Mycenaeans c.835 Homer

100 miles

Pompeii

Tarentum

Croton

Segesta

Selinus

Agrigentum

Syracuse

Byzantium

Troy

Neandria

Pergamum

Ephesus

Larissa

Priene

Miletus

Cnidus

Rhodes

Sparta

Corinth

Olympia

Teges

Aegina

Epidaurus

Halicarnassus

Gnossus

Phaestus
The Aegean Period. No records survive of the Minoan sea-kings of Crete except remains of palaces, e.g. Cnossus. The Mycenaean built massive citadels with Cyclopean masonry and domed tholos tombs on the mainland. The Aegean civilization fell before the Homeric Greeks.

The Hellenic Period. The Greeks called themselves Hellenes (Hellas was called Graecia by the Romans). They formed numerous small city states in which primitive houses surrounded a citadel and later a temple built on an acropolis or upper city. National unity was achieved by pan-Hellenic festivals held at Olympia, Delphi, Argos and Corinth every few years. The Hellenistic Period began with the Empire created by Alexander the Great when many new cities were founded with monumental buildings.

The Greek temple developed from the Mycenaean megaron built of sun-dried brick, stone and timber to house a deity and to be looked at from outside, not to contain a congregation within. The arch was known to the Greeks, but they based their temples on the column & beam. These developed from the 6th-4th centuries B.C., each with its own ratios of proportions established by experience. Columns were often placed closer than necessary to support the entablature in order to create a repetitive rhythm of solids and voids. Optical refinements displaying an appearance of vitality and strength have been measured in a number of them. Many architects wrote treatises about their buildings, cited by Vitruvius (1st cent. B.C.) who classified their plans and proportions.
The Palace of King Minos (restored), c. 1800-1600 B.C.
1 The King and Queen's apartments 2 Great staircase 3 Hall of the Colonnade 4 Hall of the Double Axes 5 Queen's Megaron or Hall 6 Construction: A timber framework B sun-dried brick or rubble masonry C gypsum slabs or D plaster painted with frescoes E plinth and floor of gypsum or limestone F ceiling beams 7 Cypress columns

'TIRYNS of the Great Hall' (Homer) (restored) c. 1400-1200 B.C. on a limestone ridge above the plain of Argos, wide ascribed to the Cyclops. The palace built of timber framework, sun-dried bricks and columns of wood.
1 Main gateway 2 Greater propylaeum 3 Lesser propylaeum 4 The men's Megaron or Great Hall 5 The women's Hall
MYCENAE (restored), c. 1350 B.C.
The citadel palace of Agamemnon,
Cyclopean walls of boulders weighing 5 to 6 tons were eased into alignment on pebbles.

MYCENAE, The Treasury of Atreus, 1330-1300 B.C. One of some 40 beehive or tholos tombs on the Greek mainland. Built of horizontal overlapping courses of lime-stone or corbelling without centering. The door-way flanked by 2 green sandstone half-columns with a relieving triangle above.
Stone beams of great span are liable to fracture, therefore columns were placed close together.

TIMBER to STONE ANTAE OR PILASTERS

TIMBER construction, c.620 B.C.
Doric temple of Apollo, Thermum.
Wooden entablature and columns

MARBLE construction, c.477-438 B.C.
The Parthenon, Athens
BUILDING METHODS

ERECTION OF A COLUMN

LIFTING DEVICES

METAL CRAMPS set in molten lead

MASTONRY
Fine squared ashlar bedded and jointed without cement

Stone left undressed to avoid damage in transport

ERECTION OF A COLUMN
The Heraeum, Olympia, c. 649 B.C.
Walls sun-dried brick. Stone replaced wood columns as they decayed. Gable roof with terracotta tiles.

Temple of Apollo, Syracuse, c. 575 B.C.
Monolithic stone columns.

Sanctuary of Thermum, Aetolia
Megaron A, c. 2000-1500 B.C.
Small stones carry walls of wood and clay, roof thatched with reeds.

Megaron B, c. 1000-800 B.C.
House or Temple. 18 posts formed the first known Greek peripteral temple scheme.

The Temple of Apollo, c. 600 B.C.
Built over Megaron B. Columns and entablature of wood.

Temple F, Selinus, c. 560 B.C.
Stone screens join the columns.

Archaic Temple of Artemis, Ephesus, c. 560 B.C. Burnt down and rebuilt, 356 B.C.
Designed by Chersiphron of Cnossus and his son Metagenes who wrote a work on the temple, now lost, cited by Vitruvius.
Appearance conjectural, columns of marble, walls of limestone faced with marble.
Temple of Zeus Olympius, Agrigentum, c. 480 B.C.
Built of coarse stone faced with marble dust cement; position of figures conjectural

Temple of Aphaia, Aegina, c. 490 B.C.

The Parthenon, Athens, 447-432 B.C.
Ictinus and Callicrates architects, Pheidias master sculptor; built of white marble

The Doric Temple of Athena Alea, Tegea, c. 353 B.C.
Designed by the sculptor Scopas, the interior had 14 Corinthian engaged columns

Doric temple of Apollo Epicurius, Bassae, c. 430 B.C.
By Ictinus, architect of the Parthenon, Athens.
The Corinthian order used for the first time
Built of fine-grained, brittle grey limestone;
details in marble, roof of thin marble slabs.

Ionic temple of Athena Polias, Priene, c. 334 B.C.
By Pythios, architect and sculptor of the Mausoleum, Halicarnassus, who wrote a book on the temple, since lost.
All the measurements are in multiples of the Ionic foot, i.e. 11.587 inches.
GREEK & ROMAN

DORIC

18.8'' = 11 modules
20 flutes separated by sharp 'arrises'

parts
0
15
30
lower 1/2 diameter = 1 module

The Theseion, Athens
Greek

Temple on the Ilissus, Athens
Greek

Roman

Theatre of Marcellus, Rome

Delos, c.6th cent. B.C.
Cyprus, c.6th cent. B.C.

Neandria, c.6th cent. B.C.

Ionic and Corinthian;
24 flutes separated by fillets

Thermae of Diocletian, Rome

Capital, angle column

Temple of Aphaia, Aegina

A method of setting out a volute

Greek

Temple of Demeter, Paestum

Ionic

Temple of Theatre of Marcellus, Rome

Neandria, c.6th cent. B.C.

14 8 3'' = 16M 14P

Greek

Roman

Theatre of Marcellus, Rome

Temple of Aphaia, Aegina

Thermae of Diocletian, Rome

Capital, angle column

A method of setting out a volute

Ionic

Greek

Roman

Theatre of Marcellus, Rome

Neandria, c.6th cent. B.C.

14 8 3'' = 16M 14P

Greek

Roman

Theatre of Marcellus, Rome

Neandria, c.6th cent. B.C.
THE FIVE ORDERS

CORINTHIAN

Egypt, Dynasty XIX

Tower of the Winds, Epidaurus, c. 334 B.C.

The Tholos, Athens, c. 360 B.C.

COMPOSITE

Roman Choragic Monument, Athens

Greek The Pantheon, Rome

TUSCAN

Roman Arch of Severus, Rome

Roman Vitruvius (iv, 7)

From "The Five Orders of Architecture" by Vignola (A.D. 1509-73)

Temple Fortuna Virilis, Rome

Erechtheum, Athens

Ilissus, Athens

The Olympicum, Athens, c. 174 B.C.

Temple Fortuna Virilis, Rome, 86 B.C.

The Arch of Titus, Rome, A.D. 81

Temple of Castor and Pollux, Rome, A.D. 16
distyle in antis
prostyle tetrastyle
peripteral hexastyle (surrounded by columns)
dipteral octastyle (2 rows of columns)
dipteral decastyle

Classification of column arrangements according to Vitruvius (11, 2)
THE TEMPLE OF APHAIA,
AEGINA, c.490 B.C.

Built of soft, yellow local sandstone, coated with a thin layer of stucco and coloured. Sculpture and tiles on pediments of Parian marble, other tiles of terracotta.
Between the Greeks' defeat of the Persians in 479 B.C. and the Peloponnesian War (431-404 B.C.), Athens rose to her zenith; under the leadership of Pericles, buildings were erected on the Acropolis:
1. The Parthenon
2. The Propylaea
3. The Erechtheum (restored)

The Parthenon, 447-432 B.C. Doric temple dedicated to Athena. Ictinus and Callicrates, architects; Phidias, master sculptor. Optical refinements p. 38
BUILDINGS ON THE ACROPOLIS

THE ERECHTHEUM, 420-406 B.C.
A. Sanctuary of Athena Polias
B. Sanctuaries of Erechtheus and Poseidon

Possible architect Mnesicles. The caryatids and column capitals may have been designed by Callimachus, inventor of the Corinthian capital. Built on 4 levels, irregular in plan to preserve places sacred to Athens; built of white marble.
Little is known of Greek city planning before Hippodamus laid out his native city Miletus c.479 or 466 B.C.

and 'discovered the method of dividing up cities' (Aristotle Politics)

The Telesterion or Hall of the Mysteries, Eleusis

A house or temple, c.8th cent. B.C.

after a terracotta model from Argive Heraeum

Megaron, c.500 B.C.

Peristyle, c.450 B.C.

Section of the 9 superimposed 'cities' of TROY
II Prehistoric citadel, c.2600-2300 B.C.
VI Homeric Troy, 1900 B.C.; sacked c.1200 B.C.

Plan of selected buildings, Troy
II Prehistoric citadel VI Homeric Troy

Scheme of (restored),

Plans showing additions to a palace, Larissa (restored)
PLANS, BUILDINGS AND HOUSES

HELLENISTIC

Dynamic planning
Upper citadel,
PERGAMUM,
c. 241-159 B.C.

City state of
PRIENE,
c. 350 B.C.;
about 5000
inhabitants

Temple of Athena
gymnasium
council hall
agora

Agora
or market
place, Priene
(restored)

council hall

The
Bouleuterion
or Council Hall,
Miletus (restored),
c. 175-164 B.C.

House, Priene, c. 350 B.C.
Built of stone and sun-dried bricks (restored)

House,
Built of stone
(restored) Introduction

Delos,
c. 250 B.C.
of the Peristyle
Entasis (Gk: distension) designed to counteract the illusion of the outline of a column curving inwards.

Exaggerated diagram of the rising curvature of the stylobate and inward inclination of the columns. Angle columns look thinner seen dark against light and are thickened by \( \frac{1}{2} \) in.

OPTICAL CORRECTIONS, THE PARTHENON, ATHENS

1. The Parthenon as seen
2. Without optical corrections
3. The front with inclined axes of columns and with convex stylobate and entablature producing the result seen at 1

Proportions of height, thickness & distance apart of columns according to Vitruvius (III, 3)
The Tholos, Epidaurus, c. 360 B.C. by the sculptor-architect Polycleitus the Younger; built of sandstone and marble.

The Choragic Monument of Lysicrates, Athens, c. 334 B.C. Podium of limestone, upper part white marble, Corinthian order used externally for the first time.

The Tower of the Winds, Athens, c. 50 B.C. Clock-tower built of marble.
Early Rome, with its Republican magistrates, town-council (senatus) and town-meetings (comitia), by a series of systematic conquests created an Empire round the Mediterranean consisting of different nationalities accepted as allies. The Roman Empire became a fusion of the practical Western idea of one universal society in which all men might live in conformity with Roman law and the Oriental conception of an Emperor-God with a throne-altar demanding a common worship and loyalty. This union between the West and the East was a continual source of weakness and led to the ultimate division of the Empire.

The Romans built roads and bridges for swift communication, military camps with a simple set plan (later incorporated in many city-plans) for speed of construction, and government and civic buildings, which were both useful and symbolic of Roman law and order.

Greek Hellenic Period

775/6

429/8 — Plato — 347
384 Aristotle 322
342 — Epicurus — 270
326 — Zeno — 264 (Stoicism)
During the Republic kiln-baked bricks and stone blocks with or without mortar were used in building. The invention of concrete revolutionised construction in the Empire. Concrete was used with a facing for protection and a surface finish, & there is a sharp distinction between the art of the engineer constructing arches, vaults and domes and the applied art of decoration with columns and pilasters, marbles and mosaics.

The Romans invented all possible variations in the plans of buildings which were copied by later architects. *The Ten Books on Architecture* by Marcus Vitruvius Pollio, a Roman architect and engineer who lived in the 1st century B.C. was widely read in the Renaissance and later.
THE FORUMS.
ROME (restored)


The Thermae of Caracalla, Rome, c. A.D. 212-217
Stands on a platform 20 ft high containing store-rooms, furnaces, hypocausts and hot-air ducts; room for more than 1600 bathers

1. Main entrance
2. Apodyteria—undressing rooms
3. Tepidarium—tepid bath
4. Calidarium—hot-air bath
5. Warm baths
6. Hot baths
7. Frigidarium—open-air cold bath
8. Palaestra, peristyles
9. Lecture halls and libraries

The Pantheon, Rome, A.D. 120-124

Palaces of the Emperors on the Palatine Hill, Rome, A.D. 3-212

1. Palace of Augustus, 21 B.C.-A.D. 14
2. Palace of Domitian, A.D. 81-96
   a. Triclinium or Banqueting Hall.
   b. Peristyle.
   c. Temple of household gods.
   d. Basilica or Hall of Justice.
   e. Tablinum or Throne Room
The Romans developed the arch as a constructive principle and added the Greek column and entablature as decoration.

Wooden centering supported on piles P or on the impost I.

Ribs of baked brick set on wooden centering to receive concrete.

Methods of constructing stone and concrete vaults.
Constructions of arches on piers with non-constructional facing of columns and entablature.

Arch and dome of the Pantheon, Rome, A.D. 120-24.

Thermac of Diocletian, Rome, A.D. 302.

Brick ribs in concrete cross-vaults.
CONCRETE
used by the Romans from the 2nd century B.C., consisting of sand, gravel, pebbles, chippings of stone, mixed with a cement of lime and water and spread over a temporary wooden or permanent brick centering, to solidify into the required shape - arch, vault or dome. The dead weight rested upon supporting walls or piers without exerting an outward thrust. Pozzolana, a volcanic rock found near Rome, made a concrete of great hardness and durability. Concrete surfaces were faced with stucco, brick or marble for protection and finish.

MASONRY
The Romans copied the Greek technique, building courses of dressed blocks, held by through stones laid dry without mortar or with iron cramps and dowels set in molten lead. The space between the courses was left empty or filled with undressed stones, earth or concrete.
Opus testaceum with brick from c.78 B.C.

Cross-vault built of brick ribs and filled in with concrete. Villa Sette Bassi, near Rome, c.A.D. 123-134

Concrete dome with a framework of brick ribs. Temple of Minerva Medica, Rome, c.A.D. 260

Method of fixing marble facing

A. marble slab
B. plinth
C. cement
D. iron clamps

The Basilica, Shakka, c.A.D. 175-200

The Pretorium, Musmiyeh, c.A.D. 180

Syria: buildings of dressed stone continued in the period of Early Christian architecture in the 5th to 7th centuries.
The Pantheon, Rome, A.D. 120-24. Erected by Hadrian

Concealed brick arches link together 8 massive brick piers supporting the dome

The Temple of Vesta, Tivoli (restored), 27 B.C.-A.D. 14
The Colosseum, Rome, A.D. 70-82
Temple of Bacchus, c.a.d. 120-200

Temple of Jupiter, from c.a.d. 10

Court, c.a.d. 200

TEMPLES, BAALBEK, SYRIA (restored), c.1st-2nd centuries a.d.; built of hard local sandstone

Temple of Bacchus: interior

Temple of Bacchus
The early Greek theatre consisted of an auditorium (simply a hill slope with stone seats), a semi-circular orchestra where the chorus sang and danced, and a wooden stage from which a single actor would hold a dialogue with the chorus. The number of actors was raised to two or three by Aeschylus (525-456 B.C.) and Sophocles (495-406 B.C.), who also introduced painted scenery and a dressing hut or skene. In the 4th century B.C. a wooden skene A was erected with a proscenium B having a row of columns, usually Doric, 8-12 ft from the skene wall supporting a stage of planks called the logeion or speaking-place C. Three doors in the skene wall were for entrances and exits of actors. At the two ends of the proscenium were the parodoi or open passage-ways D.
The Theatre, Orange (restored), c.a.d. 50. Designed to seat 7000. Stage 5 ft high, 23 ft deep. Built up on stone and concrete piers.
A Semi-circular cavea or auditorium
B Proscenium replaced by a frons scena
C Covered passages — vomitoria

Introduction

Plan of a Roman theatre based on 4 equilateral triangles in a circle (Vitruvius v, 6)

A Renaissance adaptation of a Roman theatre.
The Teatro Olympico, Vicenza, Italy, designed by Palladio and completed by Scamozzi, A.D. 1584
Triumphal Arches with one opening

Arch of Augustus, Susa, Piedmont, c. A.D. 8

Arch of Titus, Rome, A.D. 70
Earliest use of the Composite order.

Town gateway with four archways
The Porte S. André, Augustodonum (Autun).
An arcade gallery with Ionic pilasters creates an antiphonal response with the rise and fall of the large and small arches below

Tomb of the Julii, Provence, S. Remy, c. 30 B.C.-A.D. 14

Trajan's Column, Rome, A.D. 114.
The Library, Ephesus (restored), C.A.D. 115. Lower storey Composite and upper storey Corinthian order, both having smooth shafts.

EARLY CHRISTIAN

Basilian church of S Peter, Rome (restored), A.D. 330. Pulled down in the 15th century

S. Costanza, Rome, A.D. 330

S. Apollinare in Classe, Ravenna, A.D. 534-539

Visigothic before the Moslem invasion, with horse-shoe arch: S. Juan de Baños, Cerrato, Spain, c. A.D. 500-713

Church, Roueiha (restored), c. 6th century A.D.

Syria, 5th-6th centuries: churches built of large stone blocks and timber roofs

Baptistery of Constantine, Rome, A.D. 430-440
COMPARATIVE PLANS
plans and sections in black to the same scale

S. Prassede, Rome, 822

S. Clemente, Rome, rebuilt 1084-1108 over a 4th-century church

S. Riquier, nr Abbeville, France (restored as in 800)

S. Maria de Naranco Asturias, Spain, A.D. 824-840

S. Clemente, Rome, rebuilt 1084-1108 over a 4th-century church

Oratory, Germigny-des-Prés, France, A.D. 806

Early Christian-Romanesque: S. Miniato, Florence, A.D. 1013

Mozarabic, 'Arabized Spanish': S. Miguel de Escalada, León, A.D. 913

Spanish-Romanesque: S. Vicente de Cardona, Catalonia, c. 1024-1040
Basilica of Ulpia, Rome, c. A.D. 98-112; a part of Trajan's Forum built by the Hellenistic architect, Apollodorus of Damascus

TIMBER ROOFS

Rafters tend to push walls outwards

A beam supports rafters at AA and a post at B

Scientific tie-beam construction: king-post or suspensory tie B holds up the tie-beam AA

A tie-beam
B king-post
C queen-posts
D straining-piece

Tie-beams lengthened by scarf-joints and iron bolts

S. Paolo fuori le Mura, Rome
CHRISTIAN CHURCHES

Basilican church of S. Paolo fuori le Mura, Rome, A.D. 320; burnt down in 1832 and rebuilt to the original design

Columns supporting a flat entablature:
S. Maria Maggiore, Rome, A.D. 432

Columns supporting semi-circular arches:
S. Apollinare in Classe, Ravenna, A.D. 534-539

Aisles in two storeys:
S. Agnese fuori le Mura, Rome, A.D. 625-638
BYZANTINE

ROMAN

The Minerva Medica, Rome, c.A.D. 260

The Pantheon, Rome, A.D. 120-124

S. George, Salonika, c.A.D. 400

S. Vitale, Ravenna, A.D. 526-547

SS. Sergius and Bacchus, Constantinople, A.D. 527-553

S. Sophia, Constantinople, A.D. 532-537

PERSIA:

detail of Palace, Feruz-abad, A.D. 450

SYRIA:

S. George, Ezra, c.A.D. 510
COMPARATIVE PLANS

plans and sections in black to the same scale

Carolingerian cathedral, Aix-la-Chapelle, A.D. 796-804

Holy Apostles, Salonika, A.D. 1200

S. Mark, Venice, A.D. 1042-1085

S. Basil, Moscow, A.D. 1554-1560

S. Irene, Constantinople, A.D. 740

Church, Daphni, nr Athens, c. 11th century A.D.

S. Saviour Pantepoptes, Constantinople, early 12th century

S. Sophia, Salonika, c. 6th century A.D.

S. Front, Perigueux, France, A.D. 1120
To build an arch centering is necessary,

but a dome can be built in successive rings of horizontal arches without centering

Domes on pendentives built with bricks not radiating from centre

S. Sophia, Salonika, c. A.D. 495

Little Cathedral, Athens, A.D. 1250

Dome with drum: cross-in-square plan
S. Sophia (Hagia Sophia = divine wisdom), Constantinople, A.D. 532-537 (plan p.74)

Built for Justinian by two Greek architects, Anthemius of Tralles and Isodorus of Miletus. Built of brick; the dome probably erected without centering, with bricks about 24-27 inches square and 2 inches thick laid in deep mortar and covered with 1/4 inch lead; the dome supported on 4 piers, the thrust being taken by 2 semidomes and 4 massive buttresses; the interior lined throughout in coloured marbles and mosaics.
ROMANESQUE

plans and elevations to the same scale

ITALY

S. Miniato, Florence, 1062

FRANCE

Pisa Cathedral, 1063-1272

S. Riquier, nr Abbeville (restored), c. 799

S. Philibert, Tournus, c. 950-1120 & later

Abbaye-aux-Hommes (S. Etienne), Caen, 1066-1077

GERMANY

S. Cyriakus, Gernrode, 961 and later

Speyer Cathedral 1031-61 & 12th century

SPAIN

Ripoll Abbey, Catalonia, 1020-1032

Santiago de Compostela, c. 1075-1121: pilgrimage church similar in plan to Tours, Limoges, Conques and Toulouse
PLANS & ELEVATIONS

S. Ambrogio, Milan, c.1140

Campanile, Pisa, 1174; belfry 1350

Baptistery, Pisa, 1153-1278, Gothic additions 14th century

Cluny Abbey III (restored), 1088-1131 (elevation reversed to show the apse)

GERMANY

Angoulême Cathedral, 1105-1128 and later

Worms Cathedral, 1105-1128 and later

Maria Laach Abbey, 1093-1156

ENGLAND (Norman)

tower 1145

Durham Cathedral, 1093-1133

Peterborough Cathedral, 1177-1190

Façade 1233

1170-1175

1240-1290
ROMANESQUE

scale for sections

BARREL VAULTS

GROINED VAULT

S. Savin-sur-Gartempe,
a. 1060-1115

S. Sernin, Toulouse,
1080-1096

S. Madelaine, Vézelay,
c. 1104-1132

centering of mounded earth
timber centering

groin stones
1,2 joint moulds
1a, 2b plans

wedges
STONE VAULTING

RIBBED VAULT

Durham Cathedral:
nave 1093-1133

insert blocks
to remove
centering

domical vault,
semi-circular
diagonal and
transverse ribs

oblong bay:
the lines of the
groins 'wave'
on plan, and
need specially
shaped groin
stones

vault with
level crowns
transverse ribs
stilted as at A

Gothic
ribbed vault
with pointed
arches which
can be made
any height
for any span
**English Architectural Periods**

- **Norman**: late 11th & 12th centuries
- **Early English**: 13th century
- **Decorated**: 14th century
- **Perpendicular**: 15th century

**French Architectural Periods**

- **Gothique à Lancettes**: 12th century
- **Rayonnant**: 13th century
- **Flamboyant**: 14th, 15th & early 16th centuries

**Brick Gothic**

- Lübeck
- Chorin

**‘Hall’ Churches**

- Bremen
- Münster

**Single-nave Churches**

- Albi
- Avignon
- Arles

**The retreat of the Moors**

- c.1212
- c.1230
- c.1475
The enlargement of S. Denis, 1144 (p.89) inaugurated a lyrical form of construction in which pointed arches, high stone vaults and flying buttresses were fused into an organic whole, and which reached a crescendo in the cathedrals built in the Ile de France (pp.100-101). Gothic, or the 'style Ogivale' (Fr.: pointed) was known as 'Opus Modernum' or 'Opus Francigenum' (French work); the term 'Gothic', i.e. barbarian, was first used by the Humanists of the Renaissance. Few plans survive by the lay master-masons, who designed their buildings with 'a good wit of geometry' and who directed the quarry-men, stone-cutters, smiths, carpenters & workmen. In England (pp.102-105), France (pp.106-107), Italy (pp.108-109) and Germany (pp.110-111) castles, parish churches, guild-halls and houses followed the same pattern of pointed arches, pinnacles, spires & high-pitched roofs. South of the Alps in Italy Gothic was neutralised by the Roman tradition and ceased with the advent of the Renaissance in the 15th century.
GOTHIC

Plans and elevations to the same scale

Amiens Cathedral, 1220-1288

FRANCE

Notre Dame, Paris, 1163-1235

Marienkirche, Lübeck, 1251-1310

GERMANY

Salisbury Cathedral, 1220-1258

York Cathedral, 1261-1324

ENGLAND
PLANS & ELEVATIONS

ITALY

Florence Cathedral, 1296-1462

Siena Cathedral, 1245-1380

dome added by Brunelleschi 1420-37

three apses completed 1421

SPAIN

Burgos Cathedral, 1220-1500

St Peter's, Rome, begun 1506
Lincoln Cathedral, 1220-1280

Rheims Cathedral, 1212-1300

A Nave for laity
B Crossing
C Transept
D Choir aisle
E Sacristy
F Chancel
G Choir for dean & chapter
H Presbytery
I Cathedra or bishop's throne
K High altar
L Reredos
M Retro-choir
N Principal shrine
O Ambulatory
P Lady chapel
THE PARTS OF A CATHEDRAL

Laon Cathedral, c. 1235

Notre Dame, Paris, c. 1200-1250

Rheims Cathedral, c. 1255-1290

Wells Cathedral, c. 1220-1242

Peterborough Cathedral, c. 1235

THE WEST FRONT
ENGLAND, STONE VAULTING

Introduction of liernes or small ribs with shorter web courses
Winchester Cathedral nave, 1371-1460
Norwich Cathedral nave, 1463-1472

Fan vaults: all ribs of equal span and the web carved from the same stone
King’s College Chapel, Cambridge, 1446-1515
Henry VII’s Chapel, Westminster Abbey, 1502-1512

Courses parallel and not parallel with the ridge
Plan and projection of ribs
Method of laying the web
S. Elizabeth, Marburg, c.1233-1283:
one of the many 'Hall' churches in North Germany,
having the nave and aisles of equal height

Chorin Abbey, c.1273-1334:
west front

Freiburg Cathedral, c.1268-1288:
west front
The Turks take Constantinople 

& block trade with the Orient: this leads to maritime discoveries

Spain united 1497 1519—Charles V—1556—Philip II of Spain—1598

Italy Florence: the Renaissance Rome: temporal power of the Popes Venice: trade lost

France Franco-Spanish rivalry in Italy 1515—Francis I—1547 Italian influence

Holland

War of the Roses Italian influence

England 1485—Henry VII—1509—Henry VIII—1547—1558—Elizabeth I—1603

Germany head of some 300 states 1483—Martin Luther—1546

Protests (hence Protestants) against the Roman Church leads to the Reformation

1499-S. Ignatius Loyola—1556 founded the Society of Jesus

The Medieval universe, haunted by the law and order of the Roman Empire

The Renaissance (Florence) High Renaissance (Rome) Mannerism

Renaissance churches were centralized and designed on the drawing-board.

They were inspired by classical architecture, as interpreted by Vitruvius (above all, by Roman temples, arches, domes & the Five Orders (pp.116-117)), & obeyed the canon of the Divine Proportions (pp.118-119).

The increasingly dramatic movements of High Renaissance and Mannerist buildings became, especially in the 'theatrical' churches of the Counter-Reformation, an interplay of forces. (This required the drawing of
three-dimensional elevations and curved details by means of projective geometry, which had been developed by the new science of dynamics.)

This Baroque style was finally resolved into the lighter curves of the Rococo.

The architecture of each European country was a reaction to that of Italy, modified by its own native characteristics. France (pp. 130-133), Germany & Austria (pp. 134-135), Spain (pp. 136-137), England (pp. 138-159).
Pope Julius II (1503-13) had the old basilican church pulled down (p. 70), and successive plans were made for the new church:

1. Bramante (1444-1514) 1506
2. Raphael (1483-1520) 1515-20
3. Sangallo the Younger (1485-1546) 1539
4. Michelangelo (1474-1564) 1546-64

also designed the dome, completed 1585-90 by Giacomo della Porta (1541-1604)
and Domenico Fontana (1543-1607);

5. side cupolas added 1564, by Vignola (1507-73)
6. Carlo Maderna (1556-1629) lengthened nave to form a Latin cross & added the façade 1606-12

St Peter’s, Rome, 1506-1612 (pp. 93, 124)
The Dome of the Invalides, Paris, 1693-1706
J. H. Mansart
(1646-1708)

J. B. Fischer von Erlach
(1656-1725)

Sir Christopher Wren (1632-1723)

The Gesù, Rome, 1568-75
Vignola (1507-73)

The Escorial, near Madrid, 1559-84

S. Maria della Salute, Venice, 1632
Longhena (1640-75)

Piazza, St Peter’s, Rome, 1655-67
Bernini (1589-1680)

Vierzehnheiligen, S. Germany, 1744-72 Neumann (1687-1753)

Juan de Herrera (c. 1530-97)

(1656-1725)

St Paul’s Cathedral, London,
1675-1710

(125, 131)

(144-145)
Sources of Italian architectural theory:
1. The study of Roman buildings.
2. The Platonic-Aristotelian description of God and the Universe as a perfect circle.
3. The Pythagorean, and Medieval, idea of Man as the microcosm of the Universe (the macrocosm).
4. The linking of Geometry and Music, two of the Seven Liberal Arts: ‘Geometry makes visible the musical consonances’ (Boethius, De Musica, c.500).

In Florence Cosimo de Medici (1389-1462) founded the Platonic Academy.

Plato gives an account of the creation and geometrical form of the universe. He represents the four basic elements and the cosmos as:

these ‘Platonic’ bodies are the 5 regular solids. The elements of the cosmos, as well as its soul-substance & its motion, were created proportionate to musical ratios based on Pythagoras (582-c.507 B.C.) He ‘regarded numbers as the elements of all things and the whole heaven as a numerical scale’ (Aristotle), & found that tones could be measured by striking cords proportionate in length.

Plato gives the ‘Harmonic’ scale as:

which contain the musical consonances 1:2, 2:3, 3:4.

For Renaissance architect-theorists, churches based upon these axioms, would be microcosms of the universe of God:

‘... the little temples we make ought to resemble this very great one’ (Palladio).
In Baroque churches musical ratios were resolved into an orchestration of visual forces comparable to the fugue, & measured by the eye and the mind of the beholder.
Baptistery, S. Miniato, S. Maria Novella, Florence, c.1456

Alberti (1404-72)

The Gesù, Rome, 1568-75
Vignola (1507-73) (p.122)

Arrangement & permutations of columns & pilasters to compose a visual ‘overture’

Roman arches and temples

S. Andrea, Mantua, 1470 S. Francesco della Vigna, Venice, 1562 Il Redentore, Venice, 1576-92
Alberti (p.122) Andrea Palladio (1508-1580)
ITALY, CHURCH FAÇADES

SS. Martina e Luca, Rome, 1635-50  
Pietro da Cortona (1596-1669)

S. Agnese in Piazza Navona,  
Rome, 1653-55  
Francesco Borromini (1599-1667)

S. Maria della Pace,  
Rome, 1656-57  
Pietro da Cortona (1596-1669)

S. Susanna, Rome, 1597-1603  
Carlo Maderna (1556-1629)

S. Carlo, Rome, 1665-7  
Borromini (p.123)

S. Gregorio, Messina, 1660  
Guarini (1624-1683)
ITALY, CHURCHES

S. Carlo alle Quattro Fontane,
Rome, 1638-41
(Facade 1662-67, p.121)
Borromini (1599-1667)

S. Lorenzo, Turin, 1668-87 Guarini (1624-83)
RENAISSANCE - BAROQUE

- The Pantheon, Rome, A.D. 120-124
- Florence Cathedral: Rome, 1420-34
  - Brunelleschi (1377-1446)
  - (pp. 91, 109, 116)
- St Peter's, Rome, 1506-1625
  - (pp. 91, 116)
- Circular temples, Vitruvius (iv, 9)
- Tempietto, S. Pietro in Montorio, Rome, 1502-10
  - Bramante (1444-1514)
- Dome 1564-90
  - Michelangelo (1475-1564)

- Cover: St. Peter's, Rome, 1506-1625
- Page 91: St. Peter's, Rome, 1506-1625
- Page 109: St. Peter's, Rome, 1506-1625
- Page 116: St. Peter's, Rome, 1506-1625

- Diagrams of architectural elements:
  - Circular temple structures
  - Domed ceilings with decorative elements
  - Architectural plans and elevations

- Text references:
  - Vitruvius, IV, 9
  - Bramante
  - Michelangelo
ITALY, DOMES

S. Ivo della Sapienza, Rome, 1642-50, 
Borromini (1599-1667)

St Paul's Cathedral, London, 1675-1710
Wren (1632-1723)
(pp. 146-7)

The Dome of the Invalides, Paris, 1693-1706
Jules Hardouin-Mansart (1646-1708)
(p. 131)

Sanctuary, Vallinotto, near Turin, 1738-9
Bernard Vittone (1704/5-70)
Palazzo Medici-Riccardi, Florence, 1430
Michelozzo (1397-1473)

Palazzo del Te, Mantua, 1526-35
Guido Romano (1492-1549)

Palazzo Rucellai, Cancelleria, Rome, 1450-1460
Alberti (1404-172)

The Capitol, Rome, 1549-1644
Michelangelo (1475-1564)

The "Colossal" Order

Bramante (1444-1514)

The "Colossal" Order
ITALY, PALACES

Collegio Propaganda Fide, Rome 1646-66
Borromini (1599-1667)

Palazzo Carignano, Turin, c.1678-80
Guarini (1624-1683)

Palazzo Farnese, Caprarola, 1559-1564
Giacomo Barozzi da Vignola (1507-1573)

cycloidal curves
Pascal (1623-1662)
The Italian campaigns of the French Kings, Charles VIII (1483-98), Louis XII (1498-1515) and Francis I (1515-47), failed in their aims; instead France was invaded by the ideas and the arts of the Italian Renaissance.
FRANCE, CHURCHES

Church of the Invalides, Paris, 1680-91
Jules Hardouin Mansart (1646-1708)

Panthéon (St Généviève), Paris, 1764-90
Jacques-Germain Soufflot (1713-80)

(pp. 56, 117)
(p. 124)
A. Central pavilion, 1570-1592
Philibert de l'Orme (c.1515-1570)

B. 1600-09
Jacques du Cerceau
(c.1550-1614)
(Remodelled 1860-65)

C. Course du Vieux Louvre, begun 1546
Pierre Lescot (c.1510-78)

Château de Chambord, 1519-1547
Philibert de l'Orme

Château de Maisons, 1642-46
François Mansart (1598-1666)

Palais du Louvre, Paris, 1546-1878
FRANCE, CHATEAU TO PALACE

Palais de Versailles
A. Small château, 1624-26
De Brosse (1562-1626)
B. Enlarged 1669-83
for Louis XIV (1643-1715)
Louis le Vau (1612-70)
decoration, Le Brun
(1619-90); gardens
Le Nôtre (1613-1708)

C. Galerie des Glaces, & Façade
1679-82 J. H. Mansart
(1646-1708)

D. East front, 1667-70
Claude Perrault (1613-88),
Louis Le Vau (1612-88) &
Charles Le Brun (1619-90)

Baroque: detail of masterpiece Jean le Pautre, engraver (1613-88)

Rococo: detail of room 6, 1700-50 Jules Andrieu Monstret (1668-1735)

First project and

final project made by Bernini (1598-1680)
in Paris, 1665 for the East Front of the Louvre
Italian Baroque churches

Vaults, domes and apses were frequently 'opened out' to heaven by means of *sotto in su* (Italian: 'from below upwards'), illusionist paintings, and often reinforced by three-dimensional figures.

In Southern Germany and Austria, many Jesuit Baroque churches were built in the style of the Gesù (p.122). The Thirty Years' War (1618-48) was followed by a resurgence of church-building in which all the arts—architecture, sculpture, painting and music—were fused into Rococo.
Vierzehnheiligen, Southern Germany, 1744-72
Balthasar Neumann (1687-1753), architect, mathematician, military engineer, town-planner, designer of fountains, bell-caster; possessed Guarini's dell'Architettura Civile, 1737 (p. 123)

jets of water describe parabolic curves
parabolic, forward tilted, three-dimensional arches
It is the 'Plateresque' (platero = silversmith), from the use of extravagant decoration 1492-1556.

II. Herraran style or 'Estilo desornamentado' (plain style), 1556-1650: adaptation of the design of the Italian High Renaissance by Juan de Herrera (c.1530-97)

The Escorial 1574-82 (p.115), Doric Church, first designed by Juan Bautista de Toledo (d.1567), philosopher and mathematician, who worked under Michelangelo; redesigned by Juan de Herrera (c.1530-97) built in yellow-grey granite, in 2:3 ratios.
III ‘Churrigueresque’, named after José de Churriguera (1665-1723)

Cathedral, Santiago de Compostella:
west façade,
known as ‘El Obradoiro’, c.1738
Fernando de Casas y Novoa (fl. 1711-94)

Charterhouse sacristy, Granada, 1713-47.
Designed by Francisco Hurtado (1669-1725), begun 1730 by Luis de Arevalo (1727-64), stonemason; plasterwork by Luis Cabello
Pre-Fire Design for a domed crossing, 'in a Latine style', 1666

Old St Paul's, destroyed in the Great Fire, 1666

Centralized designs 'after a Roman manner', remote from 'the Gothick rudeness of ye old Design'. The chapter 'thought the model not enough of a cathedral fashion', and a longitudinal plan, based on the Latin Cross, was adopted.

Greek Cross Design, c.1672

Basilica of Constantine, c.1668-69

The Pantheon Design

The Great Model, 1673

The Warrant Design, before 1675

Projects for St Paul’s Cathedral, London, by Sir Christopher Wren
outer dome of timber covered with sheet lead, on a brick cone 18'' thick, also with an inner brick dome 18'' thick.

St Peter's, Rome: dome Bramante (1444-1514) (from Serlio)

The mathematician Robert Hooke wrote that Wren used the 'catenary line'.

St Paul's Cathedral, London, c.1675-1711
Sir Christopher Wren (1632-1723)
Vaulting of brick, walls of ashlar stone with rubble filling, façades of Portland stone
Sir Christopher Wren (1632-1723).
Early scientific pursuits: optics, hyperbolic lenses & a treatise on cycloids.
Newton in the *Principia* described Wren as ‘one of the greatest geometers of our times’.
Professor of Astronomy, London 1657 and Oxford 1661.
First architectural works 1662.
Studied buildings in and around Paris 1665; met F. Mansart, Le Vau, Bernini and probably Guarini.

St Bride, Fleet Street, 1670-84; spire, 1701-3
St Mary-le-Bow, Cheapside, 1670-83
The fire of London lasted from 2-5 September 1666. On 11 September Wren submitted a plan for rebuilding the City of London.

Though this plan was later abandoned, of the 87 churches destroyed 52 were redesigned by Wren as preaching halls for Protestant services.
Kedleston Hall, Derbyshire, 1756-70
designed by James Paine (1725-89);
south front & interior by
Robert Adam (1728-92).
Studied in Italy 1754-58

Pitzhanger Place, Middlesex,
1800-1803

26, Grosvenor Square, London,
1773-74 Adam (demolished 1862)

Bank Stock Office, Bank of England,
1792-93 (demolished 1927)

Sir John Soane (1753-1837) Visited Italy 1778-1780
ENGLAND, STONE, BRICK & IRON

London’s ‘Metropolitan Improvements’ 1812-1835
John Nash (1752-1835)

A The Quadrant, Regent Street 1818
Cast-iron columns

B Carlton House Terrace, 1827 Cast-iron Doric columns

Cotton mill, Manchester, 1801. Cast-iron columns & beams
James Watt (1736-1819) & Matthew Boulton (1728-1809)

First iron bridge: Coalbrookdale, Shropshire, 1775-79
Thomas Farnoth Pritchard (d.1777)

Cast-iron Bridge, Sunderland, 1793-96

Cast-iron rib-and-truss Bridge, Craigellachie, 1815
Telford

Suspension Bridge, Menai Straits, 1819-26
William Telford (1751-1834)

Mill, 1801:
Section of cast-iron column Watt & Boulton

Oxford Circus
Piccadilly Circus
Buckingham Palace
St James’s Park
Regent’s Park
1 mile

St Katherines Dock, London, 1828: Telford
22 churches and chapels built by Augustus Welby Northmore Pugin (1812-52) from frontispiece to An Apology for the Revival of Christian Architecture, 1843.


Gothic

Regency Villas, Cheltenham, c. 1825

Classic

Clifton Suspension Bridge, Bristol, designed 1829-31; begun 1836

Isambard Kingdom Brunel (1806-59)

The Houses of Parliament, London, 1840-63 Sir Charles Barry (1795-1860), assisted by Pugin

iron roof

cast-iron dome Sidney Smirke (1799-1877)

The Red House, Kent, 1859 Philip Webb (1831-1915) for William Morris (1834-96)

The Crystal Palace, Sydenham, London, 1851-54 Paxton; water towers, Brunel (Moved from Hyde Park, p. 163)


Hotel, 1865-75 Sir George Gilbert Scott (1810-77)
ENGLAND

Projected Roman Cathedral, Liverpool, 1929-41 succeeded 1962
by the design of Frederick Gibberd (1908-)

School of Art, Glasgow, 1896 Art Nouveau
Charles Rennie Mackintosh (1868-1928)

Village College, Impington, Cambridgeshire, 1936
Walter Gropius (1883- ) (pp.174-5)
& Edwin Lutyens (1869-1944)

House, Rutland, 1901
Charles Annesley Voysey (1857-1941)

Heal & Son Store, London, 1910-14
Smith & Brewer
Peter Jones Store, London, 1936-39
William Crabtree

Royal Festival Hall, London, 1951
Robert Hogg Matthew (1906-)

St Paul's Cathedral, London
The Forth Bridge, 1882-1890
Sir Benjamin Baker & Sir John Fowler

Auditorium insulated by foyers

F. R. S. Yorke (1906-62)
& Marcel Breuer (1902-); born Hungary, U.S.A. 1937

Steel frame
CAST IRON is the direct result of smelting iron ore in a blast furnace with coke. The liquid ore solidifies on cooling & can be given the desired shape by being poured into moulds. The process was first carried out c.1710 by Benjamin Darby (1677-1717). Cast iron is brittle & reacts to bending stress. Used primarily for vertical columns.

WROUGHT IRON is obtained by oxidizing white-hot cast iron. It is puddled (purified) from an excess of carbon & impurities in a ‘reverberatory’ furnace, introduced by Henry Cort c.1760s. Ductile and malleable, wrought-iron can be pulled out into wire or rolled into beams.

STEEL is made from cast-iron, the carbon being burnt out by a blast of air through the molten metal in a ‘Converter’, invented by Sir Henry Bessemer in 1856. Steel has equal strength in compression and tension.

THE BEAM

& TRUSS

compression boom
tension boom

S. compression or strut
T. tension or tie

CAST IRON, WROUGHT IRON, STEEL

The Crystal Palace, Hyde Park, London, 1851
Sir Joseph Paxton (1803-1865)

Constructed in 17 weeks in cast-iron with pre-fabricated standardized parts and based on multiples of 24 feet standard glass size 49" by 10"

The Fair Building, Chicago, U.S.A., 1893
William Le Baron Jenny (1832-1907)


Casa Battló (‘House of the bones’), Barcelona, 1903-07 Gaudi

Parc Güell, Barcelona, 1900-14 Gaudí
tilted helicoid columns

Model of plan with weights hung proportional to the loads to be carried

Project for Güell Colony chapel, nr Barcelona 1898-1914 Gaudi

Antoni Gaudí (1852-1926): born Reus, near Tarragona; worked & died in Barcelona. ‘Gaudi
SPAIN, MODERNISMO, GAUDÍ

Casa Milá
('The Quarry'),
Barcelona,
1905-10
Gaudí

Sagrada Familia,
Barcelona, 1883.
Unfinished at Gaudí's death,
1926;
work continues

is the constructor of 1900, the professional builder in stone, iron and brick' Le Corbusier
Colonial or Georgian period: The Revolution, 1775-1783

The Governor's House, Virginia, 1705 (rebuilt 1932)

Federal Period

The Bank of Philadelphia, 1798-99
Benjamin Latrobe (1764-1820): born England; U.S.A. 1796

Greek & Gothic

Washington Memorial, Baltimore, 1829
Robert Mills (1781-1855)

St Michael, Charleston, South Carolina, 1761

The Bank of Philadelphia, 1798-99

St Michael, Charleston, South Carolina, 1761

State House, Boston, 1793-98
Charles Bulfinch (1763-1844)

Westover, Virginia, c.1730 1761

State House, Richmond, Virginia, 1785-96 Jefferson

Redwood Library, Newport, Rhode Island, 1750 Peter Harrison (1716-75): born England; U.S.A. 1740

Temple, Nimes

First design

Maurice, Charlottesville 1770-1809

the Pantheon, Rome

Thomas Jefferson (1743-1826); studied Roman buildings in Europe 1784-89

University of Virginia, Charlottesville, 1822-26

Jefferson

Trinity Church, New York, 1846
Richard Upjohn (1802-1878)
revivals

Civil War 1861-1865

The Chicago School 1883- (pp.168-9)

Crane Library, Quincy, Massachusetts, 1883

Exchange, Philadelphia 1832-4 William Strickland (1788-1845), pupil of Latrobe

Trinity Church, Boston, 1872-77

Henry Hobson Richardson (1838-1886): studied in Paris

The Capitol, Washington: central block, 1792-1828,

William Thornton (1750-1828) & others.

Wings & dome (cast-iron), 1851-65

Thomas Ustick Walter (1804-1887)

James Bogardus (1809-1874)

Cast Iron Buildings, their Construction and Advantage New York, 1858

300 coliseum in cast-iron: suspended roof

Project, New York World’s Fair, 1853

Brooklyn Bridge, 1869-1883 John Roebling (1806-69) & W. A. Roebling (1837-1926)
Frank Lloyd Wright (1867-1959), born Wisconsin, worked with Louis Sullivan 1888-93.
U. S. A., FRANK LLOYD WRIGHT

Johnson Wax Factory, Racine, Wisconsin, 1938-39

Guggenheim Museum, New York,
designed 1943-46, built 1956-59. Reinforced concrete

Falling Water, Bear Run, Pennsylvania, 1936.
Reinforced concrete

He innovated designs for an 'organic' architecture, kaleidoscopic in its variety
Development of the curtain wall

Fagus Factory, Alfeld-an-der-Leine, 1911

Walter Gropius (1883-): assistant to Behrens, 1907-11 (p. 173); director of the Bauhaus,

Chrome-plated steel columns, slabs of travertine and glass

German Pavilion, International Exhibition, Barcelona, 1929

Ludwig Mies van der Rohe (1886-): born Aachen, Germany; worked with Behrens 1908-11;
Bauhaus Buildings, Dessau, 1926.

Project: the 'Total Theatre', 1927

Weimar 1919-25, at Dessau 1925-8; worked in England 1934-37 (p.161), U.S.A. 1937

Project: Convention Hall, Chicago, 1953

Two 26-Storey blocks of flats:
No. 860, Lake Shore Drive, Chicago, 1951

director of the Bauhaus, Dessau, 1930-33; to U.S.A., 1937. His dictum: 'less is more'
Peri Luigi Nervi (1891-), born Lombardy, engineer in reinforced concrete, follows both...
Corrugated roof composed of prefabricated units 13'0" long 1"1/2" thick joined at A by concrete poured in situ

Exhibition Hall, Turin, 1948-50

Nervi developed prefabricated units of ferro-cemento (iron-concrete), speedily assembled on a light scaffolding

Palazzetto dello Sport, Rome, 1956-57

Arch. Annibale Vitellozzi, eng. Nervi
Eero Saarinen (1910-61), born Finland, went to U.S.A. in 1923.


Richard Buckminster Fuller (1895-), 'comprehensive designer'.

Geodesic Domes from 1948.
Dulles
International
Jet Air Port,
Washington,
1960-63
Saurinew
suspended roof,
concrete slabs
laid on cables

‘Key project’ for Ellis Island,
New York Harbour, 1959-61,
one of the last projects made by
Frank Lloyd Wright (1867-1959)