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HISTORY AND DEVELOPMENT OF MASONRY TECHNOLOGY

The unwritten record of history is preserved in buildings—in temples, fortresses, sanctuaries, and cities constructed of brick and stone. Early efforts to build permanent shelter were limited to the materials at hand. The trees of a primeval forest, the clay and mud of a river valley, the rocks, caves, and cliffs of a mountain range afforded only primitive opportunity for protection, security, and defense and few examples survive. But the stone and brick of skeletal architectural remains date as far back as the temples of Ur built in 3000 B.C., the early walls of Jericho of 8000 B.C., and the vaulted tombs at Mycenae of the fourteenth century B.C. It was the permanence and durability of the masonry which safeguarded this prehistoric record of achievements, and preserved through centuries of war and natural disaster the traces of human development from cave dweller to city builder. Indeed, the history of civilization is the history of its architecture, and the history of architecture is the history of masonry.

1.1 DEVELOPMENT

Stone is the oldest, most abundant, and perhaps the most important *raw building material* of prehistoric and civilized peoples. Stone formed their defense in walls, towers, and embattlements. They lived in buildings of stone, worshiped in stone temples, and built roads and bridges of stone. Builders began to form and shape stone when tools had been invented that were hard enough to trim and smooth the irregular lumps and broken surfaces. Stone building was then freed from the limitations of monolithic slab structures like those at Stonehenge and progressed through the shaped and fitted blocks of the Egyptians to the intricately carved columns and entablatures of the Greeks and Romans.

Brick is the oldest *manufactured* building material, invented almost 10,000 years ago. Its simplicity, strength, and durability led to extensive use, and gave it a dominant place in history alongside stone.

Rubble stone and mud bricks, as small, easily handled materials, could be stacked and shaped to form enclosures of simple or complex design. Hand-shaped, sun-dried bricks, reinforced with such diverse materials as straw and dung, were so effective that kiln-fired bricks did not appear until the third millennium B.C., long after the art of pottery had demonstrated the effects of high temperatures on clay. Some of the oldest bricks in the world, taken from archaeological digs at the site of ancient Jericho, resemble long loaves of bread with a bold pattern of Neolithic thumbprint impressions on their rounded tops (*see Fig. 1-1*). The use of wooden molds did not replace such hand-forming techniques until the early Bronze Age, around 3000 B.C.

Perhaps the most important innovations in the evolution of architecture were the development of masonry arches and domes. Throughout history, the arch was the primary means of overcoming the span limitations of single blocks of stone or lengths of timber, making it possible to bridge spaces once thought too great. Early forms only approximated true "arching" action and were generally false, corbeled arches. True arches carry their loads in simple compression to each abutment, and as long as the joints are roughly aligned at right angles to the compressive stress, the precise curve of the arch is not critical.

The excavation of ruins in Babylonia exposed a masonry arch believed to have been built around 1400 B.C. Arch construction reached a high level of refinement under the Romans, and later developments were limited primarily to the adaptation of different shapes. Islamic and Gothic arches led to the design of groined vaults, and eventually to the high point of cathedral architecture and masonry construction in the thirteenth century.

Simple dome forms may actually have preceded the true arch because, like the corbeled arch, they could be built with successive horizontal rings of masonry, and required no centering. These domes were seen as circular walls gradually closing in on themselves rather than as rings of vertical arches. Barrel vaults were built as early as the thirteenth century B.C., and could also be constructed without centering if one end of the vault was closed off.

Initial exploitation of the true dome form took place from the mid–first century A.D. to the early second century, under the reigns of Nero and Hadrian. The brick dome of the Pantheon in Rome exerts tremendous outward thrusts counteracted only by the massive brick walls encircling its perimeter. Later refinements included the masonry squinch and pendentive, which were instrumental in the construction of the dome of the Florence Cathedral, and buttressing by means of half domes at the sides, as in the Church of Hagia Sophia in Constantinople.

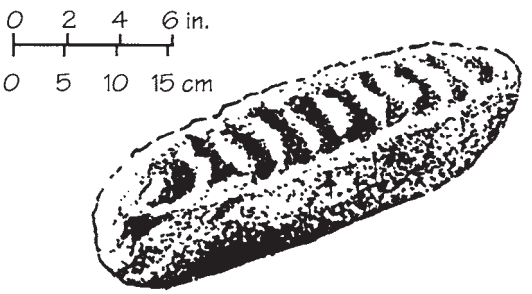

Figure 1-1 Sun-dried brick, circa 8000 B.C.