Mortar (masonry)

Mortar is a workable paste used to bind construction blocks together and fill the gaps between them. The blocks may be stone, brick, cinder blocks, etc. Mortar becomes hard when it sets, resulting in a rigid aggregate structure. Modern mortars are typically made from a mixture of sand, a binder such as cement or lime, and water. Mortar can also be used to fix, or *point*, masonry when the original mortar has washed away.[1]

Mortar holding weathered bricks

Ancient mortar

The first mortars were made of mud and clay. Because of a lack of stone and an abundance of clay, Babylonian constructions were of baked brick, using lime or pitch for mortar. According to Roman Ghirshman, the first evidence of humans using a form of mortar was at the ziggurat of Sialk in Iran, built of sun-dried bricks in 2900 BC.[2] The Chogha Zanbil Temple in Iran was built in about 1250 BC with kiln-fired bricks and a strong mortar of bitumen.

In early Egyptian pyramids constructed about 2600–2500 BC, the limestone blocks were bound by mortar of mud and clay, or clay and sand.[3] In later Egyptian pyramids, the mortar was made of either gypsum or lime.[4] Gypsum mortar was essentially a mixture of plaster and sand and was quite soft.

In the Indian subcontinent, multiple cement types have been observed in the sites of the Indus Valley Civilization, such as the Mohenjo-daro city-settlement that dates to earlier than 2600 BCE. Gypsum cement that was "*light grey and contained sand, clay, traces of calcium carbonate, and a high percentage of lime*" was used in the construction of wells, drains and on the exteriors of "*important looking buildings*." Bitumen mortar was also used at a lower-frequency, including in the Great Bath at Mohenjo-daro.[5] [6]

Historically, building with concrete and mortar next appeared in Greece. The excavation of the underground aqueduct of Megara revealed that a reservoir was coated with a pozzolanic mortar 12 mm thick. This aqueduct dates back to c. 500 BC.[7] Pozzolanic mortar is a lime based mortar, but is made with an additive of volcanic ash that allows it to be hardened underwater; thus it is known as hydraulic cement. The Greeks obtained the volcanic ash from the Greek islands Thira and Nisiros, or from the then Greek colony of Dicaearchia (Pozzuoli) near Naples, Italy. The Romans later improved the use and methods of making what became known as pozzolanic mortar and cement.[4] Even later, the Romans used a mortar without pozzolana using crushed terra cotta, introducing aluminum oxide and silicon dioxide into the mix. This mortar was not as strong as pozzolanic mortar, but, because it was denser, it better resisted penetration by water.[8]

Hydraulic mortar was not available in ancient China, possibly due to a lack of volcanic ash. Around CE 500, sticky rice soup was mixed with slaked lime to make an inorganic–organic composite mortar that had more strength and water resistance than lime mortar. [9] [10]

It is not understood why the art of making hydraulic mortar and cement, which was perfected and in such widespread use by both the Greeks and Romans, was then lost for almost two millennia. During the Middle Ages when the Gothic cathedrals were being built, the only active ingredient in the mortar was lime. Since cured lime mortar can be degraded by contact with water, many structures suffered from wind blown rain over the centuries.

Portland cement mortar

Laying bricks with portland cement mortar

Portland cement mortar (often known simply as cement mortar) is created by mixing Ordinary Portland cement (OPC) with sand and water.

It was invented in 1794 by Joseph Aspdin and patented on 18 December 1824, largely as a result of various scientific efforts to develop stronger mortars than existed at the time. It was popularized during the late nineteenth century, and owing to the First World War, by 1930 it had superseded lime mortar for new construction. The main reasons for this were that Portland cement sets hard and quickly, allowing a faster pace of construction, and requires less skilled workers. However, as a general rule, Portland cement should not be used for the repair of older buildings constructed in lime mortar, which require the flexibility, softness and breathability of lime if they are to function correctly.

Polymer cement mortar

Polymer cement mortars (PCM) are the materials which are made by partially replacing the cement hydrate binders of conventional cement mortar with polymers. The polymeric admixtures include latexes or emulsions, redispersible polymer powders, water-soluble polymers, liquid resins and monomers. It has low permeability, and it reduces the incidence of drying shrinkage cracking, mainly designed for repairing concrete structures. For an example see MagneLine.

Lime mortar

The speed of set can be increased by using impure limestones in the kiln, to form a hydraulic lime that will set on contact with water. Such a lime must be stored as a dry powder. Alternatively, a pozzolanic material such as calcined clay or brick dust may be added to the mortar mix. This will have a similar effect of making the mortar set reasonably quickly by reaction with the water in the mortar.

Using Portland cement mortars in repairs to older buildings originally constructed using lime mortar can be problematic. This is because lime mortar is softer than cement mortar, allowing brickwork a certain degree of flexibility to move to adapt to shifting ground or other changing conditions. Cement mortar is harder and allows less flexibility. The contrast can cause brickwork to crack where the two mortars are present in a single wall.

Lime mortar is considered breathable in that it will allow moisture to freely move through it and evaporate from its surface. In old buildings with walls that shift over time, there are often cracks which allow rain water into the structure. The lime mortar allows this moisture to escape through evaporation and keeps the wall dry. Repointing or rendering an old wall with cement mortar stops this evaporation and can cause problems associated with moisture behind the cement.

Pozzolana mortar

Pozzolana is a fine, sandy volcanic ash, originally discovered and dug in Italy at Pozzuoli in the region around Mount Vesuvius, but later at a number of other sites. The ancient Roman architect Vitruvius speaks of four types of pozzolana. It is found in all the volcanic areas of Italy in various colours: black, white, grey and red.

Finely ground and mixed with lime it acts like Portland cement and makes a strong mortar that will also set under water.

Radiocarbon dating

An international team headed by Åbo Akademi University has developed a method of determining the age of mortar using radiocarbon dating. As the mortar hardens, the current atmosphere is encased in the mortar and thus provides a sample for analysis. One major challenge is various factors that affect the sample and raise the margin of error for the analysis.[11]

References

[1] tuckpointing masonry (http://www.maconline.org/tech/maintenance/point1/point1.html)

[2] http://www.presstv.ir/detail.aspx?id=37364&sectionid=3510304

[3] (http://www.touregypt.net/featurestories/smallstep.htm)

[4] (http://www.hcia.gr/3a.html)

[5] O. P. Jaggi, *History of science and technology in India, Volume 1* (http://books.google.com/books?id=Qm3NAAAAMAAJ), Atma Ram, 1969, , "*... In some of the important-looking buildings, gypsum cement of a light gray colour was used on the outside to prevent the mud mortar from crumbling down. In a very well constructed drain of the Intermediate period, the mortar which was used contains a high percentage of lime instead of gypsum. Bitumen was found to have been used only at one place in Mohenjo-daro. This was in the construction of the great bath ...*"

[6] Abdur Rahman, *History of Indian science, technology, and culture* (http://books.google.com/books?id=4bnaAAAAMAAJ), Oxford University Press, 1999, ISBN 9780195646528, , "*... Gypsum cement was found to have been used in the construction of a well in Mohenjo-daro. The cement was light grey and contained sand, clay, traces of calcium carbonate, and a high percentage of lime ...*"

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