Clay Products.

Structural clay products, ceramic products intended for use in building construction. Typical structural clay products are building brick, paving brick, terra-cotta facing tile, roofing tile, and drainage pipe. These objects are made from commonly occurring natural materials, which are mixed with water, formed into the desired shape, and fired in a kiln in order to give the clay mixture a permanent bond. Finished structural clay products display such essential properties as load-bearing strength, resistance to wear, resistance to chemical attack, attractive appearance, and an ability to take a decorative finish.

Manufacture

Structural clay products are made from 35 to 55 percent clays or argillaceous (clayey) shales, 25 to 45 percent quartz, and 25 to 55 percent feldspar. As with all traditional ceramic products, the clay portion acts as a former, providing shaping ability; the quartz (silica) serves as filler, providing strength to the formed object; and the feldspar serves as a fluxing agent, lowering the melting temperatures of the clay and quartz during firing. The proportions cited above are often found directly in shale deposits, so that blending is often not necessary. In addition, little or no beneficiation, or crushing and grinding of the mined material, is employed. Local clays or shales of highly variable composition are used in order to keep transportation costs as low as possible. The colour of the finished product derives from impurities, most notably iron oxides, present in the raw materials. Colours can range from buff and other light shades of brown through red to black, depending upon whether an oxidizing or reducing atmosphere exists in the kiln.

In the processing of structural clay products, stiff-mud plastic-forming operations predominate—for example, pressing operations for brick and extrusion for brick or pipe. Formed objects are usually fired in continuous conveyor belt or railcar operations, with the ware, as it traverses the tunnel kiln, proceeding from room temperature into a hot zone and finally to a cooler zone at the other end.

Properties

The properties exhibited by structural clay products are determined by particle size, firing temperature, and ultimate microstructure. Compared with finer ceramic products such as whitewares, much coarser filler particles are used, and lower firing temperatures are employed—typically in the range of 1,050° to 1,100° C (approximately 1,925° to 2,000° F). At such low temperatures the filler particles (usually crushed quartz) are normally not affected. Instead, the clay or shale ingredients contain sufficient impurities to melt and form a glass, thus bonding the particles together. As is the case with whitewares, crystalline mullite needles grow into this glassy phase. The resulting microstructure consists of large secondary particles embedded in a matrix of fine-grained mullite and glass—all containing a substantial volume of large pores.

Because of the presence of large and small particles in their microstructures, fired clay products have relatively high compressive strengths. This ability to bear relatively heavy loads without fracture is the prime property qualifying these products for structural applications. The size and number of pores is also important. If underfired, structural clay products have low strength and poor resistance to frost and freezing, owing to the presence of many small pores in the clay regions. Overfired ware, on the other hand, has too much glass. It is strong but brittle and is susceptible to failure under mechanical and thermal stress. Furthermore, it is impossible to obtain a good bond when glassy products are used with mortars. Small pores and high glass content are desirable, however, when chemical resistance and imperviousness to water penetration are required.

Products

By some estimates structural clay products make up as much as 50 percent of the entire ceramics market. The industry is highly conservative, with development aimed primarily at automation and labour minimization rather than the introduction of new products.

There is a wide variety of structural clay products, broadly classified as facing materials, load-bearing materials, paving materials, roofing tile, and chemically resistant materials. Examples of facing materials are face brick, terra-cotta, brick veneer, sculptured brick, glazed brick and tile, and decorative brick. Building brick, hollow brick, and structural tile for floors and walls are examples of load-bearing materials. Paving materials include light traffic pavers, quarry tile, and paving brick—this last product once in more common use than at present. Roofing tiles are quite common in many parts of the world, red and black colours being of particular note. Chemically resistant materials include sewer pipe, industrial floor brick, drain tile, flue liners, chimney brick, and chemical stoneware.

Laminar composites

A laminar composite is a composite material that consists of two or more layers of different materials that are bonded together. They are also called laminated composites or laminates. A laminate usually consists of two or more layers of planar composites in which each layer (also called lamina or ply) may be of the same or different materials. Similarly, a sandwich laminate is a composite construction in which a metallic or composite core layer is sandwiched between two metallic or composite face layers. The composite face layers may also be in the form of laminates. Laminated and sandwich composite structures are very strong and stiff, and are commonly recommended for lightweight structural applications. In materials science, Composite laminates are assemblies of layers of fibrous composite materials which can be joined to provide required engineering properties, including in-plane stiffness, bending stiffness, strength, and coefficient of thermal expansion.

The individual layers consist of high-modulus, high-strength fibers in a polymeric, metallic, or ceramic matrix material. Typical fibers used include graphite, glass, boron, and silicon carbide, and some matrix materials are epoxies, polyimides, aluminium, titanium, and alumina.

Layers of different materials may be used, resulting in a hybrid laminate. The individual layers generally are orthotropic (that is, with principal properties in orthogonal directions) or transversely isotropic (with isotropic properties in the transverse plane) with the laminate then exhibiting anisotropic (with variable direction of principal properties), orthotropic, or quasi-isotropic properties. Quasi-isotropic laminates exhibit isotropic (that is, independent of direction) inplane response but are not restricted to isotropic out-of-plane (bending) response. Depending upon the stacking sequence of the individual layers, the laminate may exhibit coupling between inplane and out-of-plane response. An example of bending-stretching coupling is the presence of curvature developing as a result of in-plane loading.