Identification of Historic Bricks

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1. Isn’t one brick the same as another?
2. Why the fascination with bricks?
3. Chemistry, Physics, Geology?
4. Why should preservationist be concerned with this?
Let’s look at a special building

St. Mary Catholic Church in Wilmington, North Carolina

Built between 1908 and 1911

Style: Spanish Baroque

Architects: Rafael Gustavino and Joseph Taft


Construction: all brick and stone, no iron or steel
St Mary Catholic Church
An Encyclopedia of Masonry

All Brick Construction

Located on corner of Fifth and Ann Streets in Wilmington, NC (the extreme SE edge of the Colonial Boundary).

Site of the 19th century St. Thomas School

Site of the Colonial Meeting place – “The Town Oaks”
Good and Bad Masonry
Different Bricks – Many Sources
Special Shapes & Sizes

Unique masonry that contains many different shapes of bricks in many bond patterns
“Brand” Paving Bricks

These paving bricks can be seen on the Ann Street side of St. Mary Church.
Handmade Bricks

This wall dates from the time of the old 19th century St. Thomas School.
Salmon Bricks are under-fired bricks used in interior walls. Because they are porous, they insulate. They deteriorate when exposed to moisture.
Physical attributes

*Handmade bricks* - lighter than machine made bricks, a strike mark (a stick used to clean away excess clay with molding) is visible on one side, the opposite side is smooth, or has mold impression (such as a kick, or lettering, mold imperfections).

*Machine made bricks* – Extruded, not molded; has cut marks (usual semicircular) on both face and obverse.

*Pressed Bricks* – Dense; the clay in compressed into the mold rather than hand molder.
Handmade Brick

This brick show horizontal strike marks, internal signs of folding, and layers of irregularly mixed clay. It is much lighter than a machine made brick of the same size.
Bricks with distinguishing markings-
Mold marks and brands
Extrusion Brick Machine (1890)

FREY-SHECKLER CO., Bucyrus, Ohio.
MANUFACTURERS.

Fig. B. No.10.
Wire cut on an extruded brick
Layers in an extruded brick
Clays in North Carolina

*Residual Clays* – Found in the piedmont and mountains; has particles of parent material; course grained

*Alluvial Clays* – Found near rivers, and in the Coastal Areas; very fine grained

Brick Clays range in color from black to red to light gray-green. Iron compounds in the clay are responsible for the brick’s red color after burning.

Feldspar is the parent material of *Kaolinite* (Hydrous Aluminum Silicate).
Alluvial Clay

Layers of topsoil, white sand, and clay can be seen in the Lower Cape Fear River Basin in Bladen County. Clays form deposits called “lenses.”
Brick made from alluvial clay
Residual Clay excavated at UNCG
Parent material in Residual Clay
Bricks made from Residual Clay – Stone Building, UNCG
Read the Brief to find out MORE! Ask for a copy.

Fluxing & Non-fluxing compounds, specific gravity, tensile strength, “bats,” and “clinkers.”
A BRIEF ON BRICKS

Introduction

Replacement of bricks, in whole or part, in restoration projects should be approached with the intention of achieving as close a match as possible. To achieve this, the preservationist must be able to provide makers of replacement brick with accurate information about the original brick. By inspection one must be able to identify period brick making techniques used in the historic structure, and identification of sources of clays used in the production of replacements. This brief will describe the interdisciplinary science of brick identification and demonstrate how these techniques can be applied to bricks manufactured in southeastern North Carolina before 1900.

The preservation expert attempting to match a clay source – even when the clay source is well documented – must be aware that fluxing materials can vary throughout some clay deposits. In this case, a higher or lower firing temperature might well alter the appearance and strength of a replacement brick made from a matched clay. The goal of the manufacturer of modern brick, if employed to produce a batch of historic replacement brick, might deviate from the goal of the preservation expert on this point. Even when provided with an exact match of clay sources, the preservation expert is looking for a replacement that looks and acts like the original even if it is under fired or over fired. A perfectly fired brick placed in a wall of imperfectly fired brick will not have the same porosity, coefficient of expansion, and electro-chemical properties as the original.

The Physical and Chemical Properties of Clays

Clay is sediment formed through the erosion of felsic minerals (persilicic rocks). Felsic minerals contain high amounts of silica (65 percent or greater of SiO₂), and are common to igneous, plutonic, and some metamorphic rock. The parent material of many types of clay is feldspar. Feldspar, a silicate of aluminum with traces of potassium, sodium, calcium, and barium, is found in intrusive igneous rocks such as granite. The crystal forms of clay minerals may be hexagonal (kaolinite), tubular (halloysite), and can more hydrous (montmorillonite) or less hydrous (illites). The mineral kaolinite is the principal component of clays used in the making of bricks and ceramics. Ceramics contain more kaolinite, and brick earths contain less kaolinite or illite with quartz, mica, calcium carbonate, organic material, and salts in varying proportions. Pure kaolinite is chemically described as Hydrous Aluminum Silicate [Al₂Si₂O₅(OH)₄ or (Al₂O₃•2SiO₂•2H₂O)]. Water (2H₂O) acts as a lubricant among aluminum silicate molecules, giving raw clay its plasticity. The principle is much like placing water droplets between panes of glass: the water both holds the surface of the panes together, and also allows the panes to slip across the surface where they make contact. Drying and burning removes the water from clays, thus making a non-plastic solid. At higher temperatures, aluminum silicates fuse to make a glassy solid. The process is called Vitrification (the vitrified surface of a brick serves as a protective
moisture barrier). The size of grains of clay is usually determined to be less than 0.004 mm (0.00015 inches). These grains are considerably smaller than grains of sand (0.063 – 2.000 mm), and can remain suspended in water when sand and silt have been deposited out of solution. In places where water trapped in depressions evaporates, clay, because of its size, tends to be deposited in formations called lenses. Further compaction and cementation of these deposits can cause the lithification of these sediments into rock.

Clays can be divided into two distinct categories: 1) Primary clay is formed by the breaking down of the parent rock through hydrothermal action; 2) and Secondary clay is formed by fluviatile, lacustrine, glacial, marine, or eoline processes. Primary clays tend to contain fragments of the parent material, and are found close to its sources. They can also be termed residual clay. Secondary clay, the material of choice for brick making, is often termed alluvial clay. Bricks are made from both types of clay.

Impurities in Clay

Clays used in brick making may contain quartz and feldspar (common sand), along with a range of mineral and organic impurities. These impurities are classified into fluxing and non-fluxing categories. Fluxing materials are necessary in order to achieve a vitrified brick; however the proportion and kind of fluxing materials can determine the temperature at which the clay vitrifies. The fluxing materials commonly found in clays are alkalis, calcium oxide (lime), magnesium oxide, and silica.

Alkalis in clay include ammonia (found in damp clays with an abundance of decayed organic material). Ammonia is quickly lost in the firing process. Potash and soda, however, require considerably higher temperatures to vaporize, and may affect all stages of burning. Alkaline salts such as potassium carbonate, unless chemically altered in the burning, will remain water-soluble. Salts of this type may form a white coating on the finished brick (called efflorescence) when they are rendered soluble as the brick absorbs moisture. However, the presence of soluble alkaline salts on the surfaces of bricks can provide clues to the origin of the clay from which it was made. Alluvial clays and clays from regions that experience adequate rainfall and moderate yearly climates tend to have less of an accumulation of salts. Salts percolate out of the clay and are taken away by runoff into the drainage basin and are carried with the flow. Alkaline sulphates, such as iron sulphate, can release sulphuric acid during burning that will react with the clay base and other alkaline compounds in the clay resulting in blistering of the surface and internal weaknesses. Mica, an insoluble alkaline compound, may remain as a solid in fired brick because of its extremely high melting point. The presence of large particles of mica in brick made from residual clays – such as is found near intrusions of some granite – is not indicative of bricks made from alluvial clays. Iron present in clay is not only a flux, but also a coloring agent. Iron is present in clay in the form of silicates (such as mica), oxides, sulphates, sulphides, and carbonates. Ferrous carbonate and ferrous hydrate, unlike ferrous silicates, are not usually present in the parent material and enter the clay with ground water. When fired, ferrous hydrate turns to ferrous oxide. If the temperature of the firing is not properly controlled – a situation that was common prior to the use of gas kilns – the presences of ferrous salts would produce red bricks with a black interior. Raw clay may contain various
ferrous and ferric compounds in varying proportions that produce a range of colors from yellow to black, and these proportions determine the color of the brick when it is fired. Calcium carbonate, common to clays found near marl deposits and limestone deposits, produces carbon dioxide when the clay is fired. This arrests the coloring action of iron oxides, and also deforms the brick. The action of carbon dioxide in a brick is akin to the action of yeast in bread. As the brick cools, it will also absorb moisture from the air, will swell further, and be more porous. Higher temperatures stabilize the calcium carbonate in clay by forcing its interaction with silicates. However, the brick will have the appearance of stoneware because the calcium carbonate will interfere with the coloring actions of iron compounds present.

Hydrofluoric acid will produce effervescence if calcium carbonate is present in clay. Gypsum (hydrated calcium sulphate) when present in clay can release sulphuric acid under heat and will cause blistering just as iron sulfate does. Generally, the presence of calcium is a strong indicator that the brick was made from clay found in coastal plain formation where cretaceous sediments are found, but it also can be found in areas where calcium rich feldspars exist.

Non-fluxing impurities in clays include silica, organic matter, various metallic oxides, and water. Silica, in the form of quartz and sand, can decrease tensile strength in bricks. Large grains of silica can cause a brick to expand when fired, and smaller grains will inhibit shrinkage. Metallic oxides such as titanium oxide are found in slates, and determining their presence in bricks can be useful in finding a clay source. Organic matter in clay is burnt off when a brick is fired. Water evaporates during firing.

Brick Clays and Bricks in late 19th Century North Carolina

In 1897, the North Carolina Geological Survey published a preliminary report by Heinrich Ries on the North Carolina clays and clay industry (NCGS Bulletin No. 13). This report included information that the preservation specialist should find valuable. Through careful analysis of many clay sources throughout the State, Ries found that North Carolina clays were composed of 52-70% silica, 13-28% alumina, 1.5-11.5% ferric oxide, 0.10-2.5% lime, 0.10-1.5% magnesia, 0.20-4.5% alkalis, and 4-12% water (total fluxes ranging 3.5-17.5%). Clay sources in Bladen, Buncombe, Burke, Catawba, Cleveland, Cumberland, Forsyth, Gaston, Guilford, Halifax, Harnett, Jackson, Lincoln, Macon, Mecklenburg, Montgomery, Rowan, Richmond, Robeson, Surry, Union, Wake, Wayne, Wilkes, and Wilson counties are identified, and are subjected to rigorous chemical analysis. Companies manufacturing bricks at the time are named in this study, and substantial detail is provided about the processes and techniques that are used by these companies.

For example, an analysis of the brick clay at Dean’s Brickyard in Greensboro is composed of 59.27% silica, 22.31% alumina, 6.69% ferric oxide, 0.25% lime, 0.13% magnesia, 0.90% alkalis, 1.90% moisture, and 9.00% water lost on ignition (67.20% clay substances, 33.25 free sand, and 7.97 fluxes). The specific gravity (ratio of mass of the substance to the mass of an equal volume of water at 4º C) is 2.46 for this clay. The average tensile strength of briquettes made from this clay is 66 pound per square inch. The clay is residual and described as coarse. By comparison, the composition of the clay from the pit at
Poe & Brothers’ Brickyard at Fayetteville is 64.93% silica, 17.08% alumina, 5.57% ferric oxide, 0.43% lime, 0.59% magnesia, 3.85% alkalis, 2.48% moisture, and 6.58% water lost on ignition (53.13% clay substances, 45.90% free sand, and 10.44% fluxes). The specific gravity for this clay is 2.55. The average tensile strength of briquettes made from this clay is 144 pound per square inch. The clay is alluvial and described as medium. The bricks made from both clay sources burn to a red color. While the chemical composition of bricks made from these sources might appear similar, the tensile strength of bricks differs significantly. It clearly disproves the notion that a brick is a brick.

In this study, the briquettes were fired in a regenerative gas furnace in a laboratory. The manufacturing of commercial brick in North Carolina at the end of the 19th century did not employ such high tolerances. Ries reports that no continuous kilns were in use in North Carolina at the time of his study. The soft mud method of making brick was the usual method employed by the State’s brick makers because it “requires the least amount of capital.” Handmade soft-mud brick tend to be more porous and weigh less than pressed brick. Unfired bricks were stacked in rectangle of 35-40 courses with “open spaces, or arches, left at the bottom of the pile.” R. B. Morrison’s Brickmakers’ Manual, published in 1890, provides detailed illustrations of the arrangement. Wood was the fuel of choice for burning bricks. Ash residue from wood can infiltrate the surface of bricks close to the fire. The more remote bricks in this arrangement tend to be under-fired. These bricks are called salmon bricks for their pinkish color. These bricks were used for interior walls because they insulate; however, they are susceptible to moisture. When exposed to the weather, they wear much more quickly than those with a vitrified surface and have an earthy appearance and feel. Clinkers are over-burnt bricks found near the fire (Some have melted surfaces and some are fused together). Bats are bricks that break into parts during the firing.

Ries also mentions that the addition of coal dust (one bushel per 1000 bricks) to the clay aided the burning. The use of coal dust is a practice that started in England in the mid-17th century. The coal dust burns inside the brick when it is fired in the kiln. The result is an evenly fired brick. Some late 19th century North Carolina brick makers used this technique. However, most commercial brick makers of North Carolina of the time ran simple operations, which tended to be less controlled, and the builder would use clay for the closest source. Uniformly burnt bricks were a rarity, and are more likely to be found where large permanent downdraft kilns were constructed.

Physical Characteristics of Bricks

The common methods of molding in the late 19th century included hand molding, extrusion, and pressing. These methods imparted to the brick a number of distinguishing physical characteristics that can be interpreted by the preservation experts. The interpretation of bricks (as artifacts) emerged from research in the field of historical archaeology.

The most obvious clue to the origin of a brick is the brand. These are identifying marks in raised or sunken relief on the face of the brick. Karl Gurke, in Bricks and
Brickmaking, A Handbook for Historical Archaeology, provides an appendix that lists many of the common brands. The International Brick Collectors Association has an index containing over 11,000 brands. Firebricks and paving bricks usual bear a brand mark. Another distinguished mark on a brick is the frog or depression on one or both faces of a brick. This depression facilitated handling, and allowed more space for mortar. It was made by placing a piece of wood called a kick in the bottom of a mold. Some manufacturers tacked a covering of leather in these kicks, and the impression on the brick would carry the tack marks. Another characteristic to look for is the strike of the brick. On a handmade brick, the strike mark appears on the face. After the clot of clay was pressed into the mold, the molder would cut the excess clay from the top of the brick with a strike. This tool could be a stick, a drag board, a wire bow, or metal shim. The impression left on the face of the brick by this tool can be distinguishing as a fingerprint. The obverse face of handmade bricks appears smoother than the side that is struck. Brick machines that extrude brick material continuously used blades or a rotating wheel set with piano wire. An extruded brick will have strikes on both sides of the brick. These might appear as horizontal striations or curving striations. Extruded bricks bear marks from the die of the extruder. Striations on the sides of some extruded bricks are intentional decorative features.

As stated earlier, weight varies according to the manufacturing method used. Pressed bricks are the densest and most evenly fired of all the historic bricks. The pressing of brick was developed in the early 19th century, but remained for a considerable time a specialty of large-scale manufacturers. It was a time consuming process that produced an expensive product usually reserved for use in public building and large commercial offices. Because of the durable nature of pressed brick, it was also used as a paving material. Surviving streets that were paved with pressed brick attest to its value as a durable material – surviving the burden of traffic, in some cases, for more than a hundred years. The lightest brick is the handmade brick. When a handmade brick is broken it breaks unevenly. Pressed brick will cleave in layers parallel to the brick’s faces. Extruded brick, the middle weight of the brick types, tends to cleave in layers that are at right angles to the faces. The edges of some imperfect extruded brick break off. Cracks in extruded bricks appear as concentric oblong lines on the faces of the brick. Depressions and deformities in extruded bricks also appear on the faces and not the edges. The die of the extruder creates more compression of the clay at the edges than in the center.

Size is another consideration in determining the origin and age of bricks. The National Brick Manufactures Association established a standard size of 20.96 x 10.16 x 6.03 cm in 1886. The present standard for common brick is 20.32 x 9.53 x 5.72 cm. The size of English brick was regulated by Parliament from an early time. An English brick manufactured between 1769 and 1784 would measure 21.0 x 10.2 x 6.3 cm. Before 1803, the size was increased to 23.5 x 11.0 x 11.0 cm. A volume standard of 150 cubic inches (2, 458 cubic centimeters) was established after 1803.