<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Emergence, development, and prevalence of brick nogging in American vernacular architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Authors(s)</strong></td>
<td>Laefer, Debra F.</td>
</tr>
<tr>
<td><strong>Publication date</strong></td>
<td>2004-11</td>
</tr>
<tr>
<td><strong>Conference details</strong></td>
<td>Presented at the Fourth International Seminar on Structural Analysis of Historical Constructions (SAHC) : Possibilities of Numerical and Experimental Techniques. November 10-13, 2004, Padova, Italy</td>
</tr>
<tr>
<td><strong>Publisher</strong></td>
<td>Taylor and Francis</td>
</tr>
<tr>
<td><strong>Item record/more information</strong></td>
<td><a href="http://hdl.handle.net/10197/2283">http://hdl.handle.net/10197/2283</a></td>
</tr>
</tbody>
</table>
INTRODUCTION

1.1 Background

A major challenge to the preservation of historic structures in the United States (US) is that the vast majority of resources and efforts have, to date, focused on the description and documentation of architectural elements, both interior and exterior. Such an approach may be a direct outgrowth of watershed architectural publications, such as Asher Benjamin’s 1796 Practice of Architecture – the Builder’s Guide, where the focus of this first American book related to building and architecture heavily concentrates on architectural details, ornamentation, and proportioning (Benjamin, 1796). Conversely, the situation may reflect the history of preservation in the US as a discipline developed from chemistry. Regardless of cause, the result is that critical information related to the affiliated underlying structural systems, the details of how these systems are assembled, and the dimensions and configurations of the foundations on which they sit are largely, if not entirely, absent in both the historical record and more recent publications. Without these key pieces of knowledge, effective protection, preservation, and restoration is not truly viable, especially when structures are subjected to changing geotechnical conditions and structural deterioration. As population levels heighten and previously rural areas experience the tendrils of urbanization, an ever-increasing number of historic structures are subjected to construction-induced ground moving, pile driving, and dewatering may all imperil the architectural finishes of a building, if not its actual structural integrity, if a good understanding of its weight, configuration, and load distribution is not available.

A key example of where this is problematic is with the presence of brick nogging, which significantly impacts weight, configuration, and load distribution, yet may be an entirely unknown phenomenon to the engineer charged with the protection or maintenance of the structure in which this material system is included. This paper will serve as documentation of the emergence, development, and prevalence of brick nogging in American vernacular architecture.

ABSTRACT: Despite being considered one of many seventeenth century American wall insulation systems, brick nogging emerges as a prevalent construction type throughout all of original colonies. Used in both framed and hewn-log structural systems, brick nogging is most typically found beneath clapboard siding. Because clapboard ultimately becomes a style in its own right, the presence of brick nogging beneath such clapboards becomes an unexpected complication for modern preservation and intervention efforts. The technique of placing fired and unfired bricks mortar, clayed, and dry laid, although poorly documented extends well into the nineteenth century increasing the anticipated weight of the structure by ten percent. Similarly, the presence of brick nogging substantially changes the structure’s wall stiffness. Identifying clapboard covered, brick nogging structures is not straightforward as their emergence was influenced by historical, fiscal and social factors in addition to engineering considerations.

1 INTRODUCTION

In American architecture, brick nogging is a wall filling or insulation technique traceable to the English, fifteenth century wattle-and-daub construction found with half-timber construction (Fig. 1). Also known as pugging, brick nogging is often absent from architectural dictionaries. What is poorly understood in the US, and even less appreciated, is the evolution of this widespread technique and its persistence into the mid-nineteenth century. Its unexpected presence beneath what are thought to be clapboard structures poses significant challenges to the structural engineer due to its additional weight and composite nature of vernacular structures

D.F. Laefer
Department of Civil, Construction, and Environmental Engineering, North Carolina State University, Raleigh, NC, USA
2.1 Half-timber construction

There is evidence that the earliest colonial structures were replicas of contemporary English construction (Fig. 2), but even as early as the late nineteenth century none of these examples of half-timber construction survived. Chandler (1916) attributes it to the probable use of clay instead of lime as the binding and parging material, which would have easily been washed away with heavy rains.

There are, however, church structures from over 100 years later with exposed half-timber. Built by the Moravians from 1743 to 1745 in Oley Township, Pennsylvania and later in the towns of Savannah and Augusta, Georgia and Winston Salem, North Carolina, these churches of half-timber are filled with clay and wood.

The framing of the exposed half-timber construction and the thousands of examples of cladded frame structures shared similar framing schemes. Typically, the studs of the frame were comprised of vertical timbers set on two-foot centers and framed into the sill below and the girt above (Chandler 1916).

Both in chimneys and building walls a wide variety of materials were employed for both basic construction and fill material. The spaces between the studs of the walls were filled with marsh grass, straw, clay, stone, and fired and unfired brick. Although traditionally considered as an exterior wall component, there are examples of its application to interior walls as well (Lane 1976). There is some evidence of a similar type of construction both with and without filling in Kent, England. According to Kimball (1927), “In England the most primitive form of filling, still common in many districts, was of wattle daubed on one side or both with clay, usually mixed with hay or straw, and finished with a thin coat of lime plaster for greater resistance to rain. In work of superior quality lathes were often used instead of wattle, still usually coated with clay, which was regarded in England as having its own advantage. Sometimes the clay was used alone as a filling. In “cat and daub”, the cats were pieces of “straw and clay worked together into pretty large rolls and laid between the wooden posts.” Closely allied to this was the use of sun-dried bricks, lumps of clay pressed in molds of a convenient size. The choice of materials was broad and influenced by local preferences even within a single English district (Kimball 1927).
but popular updraft kiln that was used extensively in vernacular structures in Portsmouth New Hampshire beneath the clapboards (Howells, 1937). There are a number of houses in Williamsburg with brick nogging, with no evidence that it was originally exposed. Kimball (1927) claims that no instance is definitively known of a framed building erected by the English colonists in which the filling of the frame was exposed on the exterior as “half timber.” (Kimball 1927), as will be further discussed in section 4.0.

Brick nogging was used with both frame structures and those of hewn logs. There are also examples of mixed construction where some of a structure’s walls were filled and others of solid brick.

3 BRICK USAGE

Brick making and usage in the US is well documented even in the earliest years of most of the colonies. Skilled labor, kilns, and fired brick appear to have all been readily available from the earliest years of the American colonies.

3.1 Brick availability

Bricklayers were among the first settlers at Jamestown in 1607 and brick making was begun no later than 1611. There are numerous reports throughout the colonies of clay and being in abundance. At the Massachusetts Bay Colony a kiln was set in 1629, at Plymouth brick production occurred no later than 1643, and in New Amsterdam a kiln was operating as early 1628 (Kimball 1927 and Chandler 1916). Similar records are found for Hartford and New Haven Connecticut by 1653, and there were brick houses in Boston no later than 1654. In Virginia several brick homes were begun by 1651 or 1652 (Kimball 1927).

3.2 Brick production

At the founding of the American colonies, the rudiments of brick making were fairly simple and easily configurable, even in the most rural locations thanks to the development of the scove kiln (Fig. 4). The scove kiln, also known as a field kiln, is a primitive hut nonular undraft kiln that was used extensively in and temporary kilns that have constructed out of clay bricks that were fired as part of the overall process. Thus, some of the bricks that were fired were stacked to form the outside structure of the kiln and became an inherent part of the firing apparatus (Rhodes 1968). The kiln incorporated several features including an enclosure in which to house the bricks, lower apertures to insert fuel, and a chimney mechanism up above. The bricks were placed in mounds creating the appearance of a long rectangle with slightly slanted sides and were strategically stacked to allow the flames and heat to access different sections of the mound via “passageways” (McKee 1973). The outer-bricks, prior to firing, were covered with a layer of clay and grass to allow venting of the vapors. In a single firing 40,000 – 50,000 bricks could be fired.

For scove kilns, initially brush, and then coal, was used as fuel (Rhodes 1968). The fires were fed and stoked for a week, and then the fire holes were covered with bricks and mortar to prevent the heat from escaping. During this period the fires burned out, but the greater portion of the heat remained. While the kiln remained closed the heat was allowed to dissipate for approximately one week.

Despite wide variability of the final product, the scove kiln was popular and commonly used, because it did not require the construction of a permanent facility (Rhodes 1968). The relative ease of constructability and mobility allowed the temporary placement of these kilns at the point of use, instead of miles away from the construction site, where transportation would have posed economic and logistical impediments. Scove kilns are known to have been used in the construction of the College of William and Mary, and remains of seven of these temporary kilns have been found in Williamsburg, Virginia (McKee 1973). Despite extensive production, brick was not the predominant building material. Analyzing the means of production and the resulting product provides a partial answer.
During the firing, bricks were exposed to varying temperatures up to 982˚ C resulting in very inconsistent strengths (Rhodes 1968). Bricks close to the fires were over-fired and sometimes vitrified, while bricks far from the flames were softer and often more porous, causing them to be less desirable because of their lower strengths.

Replication of historic material has also shown highly variable performance. Quarter-scale, extruded clay units were fired in a permanent, updraft kiln (Laefer 2001). The bricks were dried for a minimum of 24 hours at 66˚ C. The units were fired in a stationary (porcelain) kiln with electrical heating elements on five sides (Fig. 5). The bricks were placed in 2 masses, each 464 mm by 597 mm by 127 mm high, containing approximately 1,400 brick per firing. Approximately 25,000 brick were fired in 12 firings at 496˚ C (verified by a #09 Orton cone) for at least 12 hours, with an additional day for cooling.

The goal was to create high absorption, low strength brick, typical of low firing. Since the power source was electrical (as opposed to gas or coal), the oxidizing (as opposed to reducing) atmosphere facilitated a rough correlation between coloration and brick absorption and strength with the darker color being indicative of less absorptive and stronger brick; as the temperature increased the iron oxide within the clay reacts and exhibits color change (Tables 1 & 2). Using a Munsell Color Chart, the bricks were designated into categories and sorted according to color (Table 3). The classification numbers ranged from 1 to 5, 1 being lightly fired and 5 most fired.

![Figure 5. Electric kiln with miniature bricks.](image)

<table>
<thead>
<tr>
<th>Brick designation</th>
<th>Absorption (%)</th>
<th>Average strength (kN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16.4</td>
<td>3,103</td>
</tr>
<tr>
<td>2-3</td>
<td>16.2</td>
<td>3,916-5,978</td>
</tr>
<tr>
<td>4-5</td>
<td>15.8</td>
<td>7,350</td>
</tr>
</tbody>
</table>

Table 1. Brick Absorption by Coloration (Laefer, 2001)

<table>
<thead>
<tr>
<th>Clay brick type</th>
<th>Compressive strength (kN/m²)*</th>
<th>Water absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low absorption, solid</td>
<td>79,299</td>
<td>5.7</td>
</tr>
<tr>
<td>Medium absorption, solid</td>
<td>45,004</td>
<td>12.0</td>
</tr>
<tr>
<td>High absorption, frog</td>
<td>31,800</td>
<td>21.8</td>
</tr>
</tbody>
</table>

*Tested as full single brick capped with mortar top and bottom

Table 3. Color categorization.

<table>
<thead>
<tr>
<th>Laboratory designation</th>
<th>Munsell hue</th>
<th>Munsell classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5 yellow grey</td>
<td>8/2</td>
</tr>
<tr>
<td>1</td>
<td>7.5 yellow red</td>
<td>7/4</td>
</tr>
<tr>
<td>2</td>
<td>5 yellow red</td>
<td>6/8</td>
</tr>
<tr>
<td>3</td>
<td>5 yellow red</td>
<td>6/8</td>
</tr>
<tr>
<td>4</td>
<td>2.5 yellow red</td>
<td>6/8</td>
</tr>
<tr>
<td>5</td>
<td>2.5 yellow red</td>
<td>5/10</td>
</tr>
</tbody>
</table>

Figure 6. Compressive strength as an inverse of absorption.

The results of two firings demonstrated both the variability within a single firing and between firings that will occur, even under highly controlled procedures using Orton cones and timed firings (Fig. 6).
(Laefler, 2001). The variability from a single firing exhibited over a 100% strength difference between the strongest and the weakest brick. Although higher firing temperature or firings of longer periods of time would result in less variability, as well as a stronger product, the larger mass of brick needs to be considered since such comparative data is not fully available. The data presented herein may be considered qualitatively although not quantitatively indicative. These model bricks were also compared to a similar miniature product produced in a modern tunnel kiln (designated by the number 20), which resulted in a profoundly different product achieving strengths nearly 5 times greater than any of the lightly fired products (Fig. 7).

Although there is some evidence, including the limited presence of mid-eighteenth century glazed bricks, that more sophisticated kiln arrangements (Upton 1998), as was perhaps the case in the city of Medford, Massachusetts, where shortly after the American Revolution, the city was known to have an annual brick production of about four million units. Despite this, the vast majority of bricks produced in the first two hundred years in North America, especially those outside highly urban centers were generally soft and weak by modern standards. Table 4 compares two sets of pre-Civil War brick (one from a plantation in rural, eastern North Carolina – Somerset Place and one from a railroad town in central Illinois – Jakes’ House) to modern shale units. Even the more urban set show tremendous variability in absorption and strength. Comparing mid-nineteenth century brick to the expectations of Benjamin (1796), a late eighteenth century architect is instructive. The values that Benjamin provides of a first crack testing in Table 4) with an unknown testing orientation and a 7 per cent absorption are nearly equivalent to modern materials. The conclusion one must draw is that Benjamin was fortunate to live and work near modern brick making facilities or that familiarity with wood far outstripped his experience with masonry. Table 5 provides his material summary. Curiously, the unit weight of the proposed “typical” brick closely matches the historic material tested (Table 4).

<table>
<thead>
<tr>
<th>Material</th>
<th>Crushing strength (kN/m²)</th>
<th>Weight (kN/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>2,494,096</td>
<td>762</td>
</tr>
<tr>
<td>Brick</td>
<td>395,955</td>
<td>1,846</td>
</tr>
<tr>
<td>Granite</td>
<td>7,686,606</td>
<td>2,632</td>
</tr>
<tr>
<td>Marble</td>
<td>1,275,934</td>
<td>2,713</td>
</tr>
<tr>
<td>Oak</td>
<td>2,790,006</td>
<td>835</td>
</tr>
<tr>
<td>Pine</td>
<td>2,747,733</td>
<td>429</td>
</tr>
</tbody>
</table>

3.4 *Brick Importation*

As an alternative to local production, there was also a lesser tradition of bricks being imported as ship ballast. Only in New Netherlands do brick seem to have been imported to any appreciable degree and there is limited documentation of this circumscribed but long-standing practice. In New England in 1628 there was a shipment of 10,000 brick. In 1773, the bricks, nails, and lumber for the Kincaid Plantation in Fairfield County, South Carolina were all brought from England (Marsh 1962). Even as late as the early 1800’s bricks for ballast were carted from Charleston.
by, but American brick production was relatively expensive and widespread, with bricks from an early date being produced for export to Bermuda in exchange for limestone (Chandler 1916). The historical record is extremely strong that most of the brick found today was produced within a short distance of its final destination. The cost of transporting the material, particularly overland was simply prohibitive.

3.5 Transportation

For a small, two-storey house (100 m²) an entirely of brick would have required approximately 50,000 bricks in a double-wythe configuration and 75,000 in a triple-wythe one. The weight of the bricks at 1700 kN/m³ would have been over 120,000 kN for the thinner configuration. Given cart and horse limitations, the shear weight would have made most brick transportation simply impracticable.

In port cities such as Charleston, South Carolina and Wilmington, North Carolina, brick structures were much more readily apparent than those that were beyond easy transport of such materials. These may be dual examples of transportation ease and brick as ballast.

3.6 Brick aesthetics

In terms of aesthetics, both the method of molding and the method of firing may have discouraged the use of locally made brick for building exteriors. Large variations in size, shape, and color were expected from a hand-molded, scove-fired brick. A random sampling of bricks from Somerset Place showed a color variation from light orange to medium red and a typical volumetric deviation of nearly 17 percent from the average sampled brick. Materials from the Jakes House generated highly similar results in the color range but with more of a brown cast (less iron oxide in the clay) and typical volumetric deviation also of nearly 17 percent from the average sampled brick.

Although for both structures the consistency of brick shape was hard discern after installation and more than 150 years of exposure, the bricks were clearly hand-molded. To compensate for shape irregularities a variety of mortaring techniques were commonly in practice by the time of the American revolution to generate the appearance of straight, even, rows of brick.

There are certainly a wide variety of stately and important structures built entirely of brick, even hand molded brick as was the case of the “Old Brick Church” dating from 1788 in rural Fairfield County, South Carolina, where the congregation built the structure (Marsh 1962). Depending upon the local there are early seventeenth century examples of

3.7 Lime availability

A lack of lime has been cited by numerous authors as the reason for relatively few brick buildings in the early colonies. Despite one early reports of an abundance of lime, this was not the case, as extensively documented by Kimball (1927). Limestone was generally in scarce supply. Typically, lime had to be culled from oyster shells. Oyster shells were available from the Atlantic coast. Lime was eventually from the limestone ridges of the Hudson (Chandler 1916) and parts of Pennsylvania, which was preferable as it produced a more durable mortar.

The need for lime was so extreme that alternative, inferior products were tried, which in Connecticut lead to the explicit ban of mussel shells for use in lime production as late as 1724 (Felt 1845). When lime was not available, clay was used instead, leading to decreased durability and in the case of Governor Winthrop’s house in Mistick MA, the complete loss of two walls during a violent rainstorm. Given the desperate shortage of lime, clay was used as parging, plastering, wall filler, and mortar, all functions traditionally served by lime. Surviving physical evidence of the employment of clay as an alternative to lime dates to 1675 in the Corwin house in Salem and persists in German houses of Pennsylvania well into the middle of the nineteenth century (Kimball, 1927).

The argument that the lack of lime prevented a full use of brick for structural building materials fails to account for a wide variety of competing factors as will be seen in the rise of clapboard structures. Additionally, even where lime from oyster shells was readily available, the local building practices often favored alternatives to load-bearing brick systems. A prime example of this is the rise of tabby (also known as tappy), a mix of lime and oyster shells which were squeezed, while moist, into square wooden boxes to produce building blocks. The technique was used throughout much of the southern colonies due to ease of handling, rapid construction, and low cost (Lane 1996). An early example is
was described in 1743 as having a pretty strong Fort of tabby, barracks of tabby, and two, large, spacious buildings of brick and timber (Lane 1976).

3.8 Tradition of wood

The preference for wood seems to derive from a variety of economic, social, and historical factors.

3.8.1 Economic Factors

Given that the new continent was densely forested, in most lots timber had to be felled before the ground could be tilled. Wood was plentiful and easy to shape. These factors combined with the early introduction of sawmills and their widespread use long before they became established in England (Kimball 1927) to provide low cost, highly available products for framing in the early years of the colonies.

Bricks were also time consuming as they were usually mixed and molded and then left to dry for an entire season. Chandler contends that because of the additional cost of kiln-fired bricks, sun-dried ones were often used instead (Chandler, 1916), although time may have been an even more important factor during the earliest seasons in each community.

Despite regulations dating as early as the seventeenth century requiring brick structures (Chandler 1916) and repetitive devastating fires that destroyed hundreds of houses in single incidents, wood construction persisted as the preferred vernacular construction material through the late nineteenth century until the Chicago fire, although in urban areas residences such as the cities of Boston, Philadelphia, and New York, the prevalence of brick was more substantial than in more rural locations. In Boston in 1722, after 3 major fires in 32 years, there were 12,000 people and approximately 3000 houses with roughly 1000 of them being of brick (Chandler 1916).

Availability of material should not be mistaken with economy. These materials required substantial labor and were considered dear. Even in the late eighteenth century, building materials were deemed as major capital as exemplified by in the 1774 property accounting on the death of architect William Buckland of Anne Arundel County, Maryland where 3500 bricks, 60 bushels of lime, and 30 bushels of hair were listed as major assets.

3.8.2 Social Factors

Prejudice that houses of brick and stone were less healthy than those of wood was a wide standing belief and recorded by Thomas Jefferson in his Notes on Virginia in 1784. Stone or brick, unless laid in very thick walls or used in conjunction with other materials tended to be subject to damp penetration. Surviving examples include the Peter Tufts House at Peter Sergeant Squares in Boston built in the same period in 1667, with brick walls 0.61 m thick (most likely five-wythes thick). In contrast by the beginning of the end of the nineteenth century, with the exception of high-rise office buildings, more that three-wythes of brick is unusual to find.

Damp was not the only climate-related concern. Frame houses were generally considered cooler than brick ones so that despite a series of successive fires in Charleston prior to 1740, frame houses predominated (Chandler 1916).

3.8.3 Historical Factors

Historical precedent may have also been a controlling element. Kimball (1927) argues, “The use of wood by the colonists was...not the adoption of an inferior material due to local conditions, but the perpetuation of English custom where the need for abandoning it was lacking.” Certainly amongst the poor classes in England wood was the dominant house material.

4 CLAPBOARD USAGE

Clapboard structures have come to represent a highly American aesthetic but may be more rationally understand as an outgrowth of functional considerations.

4.1 Clapboard functionality

The traditional construction method of half-timber and wattle-and-daub was radically changed in the earliest colonies. Howells (1937) attributes the change in form and subsequent change in framing to the harsh nor-easter storms and general severe weather, which has also been attributed to changing roof styles from a double parallel to gambrel roofs. Certainly the climate played a large role. The wattle-and-daub was simply inadequate for the harsh winters. To retard the cold and damp the wattle-and-daub was covered

The resulting configuration was most popularly seen as clapboard over a frame and filled walls. A prominent example of this is 1705 House at 33-35 Deer Street in Portsmouth, New Hampshire. Howells (1937) contends that by 1701 a distinctive style had developed in the town of Portsmouth, New Hampshire and attributes the rapidity of which this style was adopted to the cultural homogeneity of the community of early settlers. Despite the town having been founded only a couple of decades before, an acutely uniform style had emerged.

Such uniformity was not typical throughout the colonies. Chandler (1916) documents many communities where a wide variety of construction materials
its founding three permanent building types emerged, including frame houses with hewn-timber frames covered by clapboards, brick houses and hewn-log construction. Kimball’s (1927) assessment is that material preference and amenities were a function of means and not opportunities or chronological sequence, which would support the physical record of brick construction dominating when funds prevailed or prestige required (mansions in the former case and churches in the latter).

Morrison (1952) notes that there was no physical evidence in extent structures that they were ever to have had wall fillings exposed, as the interior arrangements tended to appear completely haphazard. Conversely, there are written records that document the later addition of clapboards for both aesthetics and weatherproofing. A prime example is the John Roe House in Hancock County built between 1786 and 1803 with half-timber construction with clapboard added to the exterior walls after 1825 (Lane 1976). Whether done for warmth or prestige is unknown, although contemporary sources regarding Thomas Dudley’s house at Cambridge, Massachusetts claim warmth and not aesthetics for the requirement of clapboards nailed to the walls.

4.2 Clapboard manufacturing

Clapboards or weatherboards were first manufactured by hand typically from pine. Sawyers are recorded amongst the first settlers (Chandler 1916). Initially split from logs about four to six feet long was first split into quarters through its length, then further split radially with froe and club into wedges (fig. 8) (Lane 1996). The timbers were hewn square with a broadaxe, smoothed with an adze and notched joints cut with chisel, mallet, and auger. Clapboards appear to have been plentiful with some produced during the first winter at Jamestown for export.

The high cost of “pit-sawing in terms of both time and labor encouraged the adoption of the water-powered sawmills. Although common in Europe from the middle of the fifteenth century, they were not used in England until 1663, by which time hundreds were used in New England alone. The first “sash” sawmills were modified pit-saws driven by a crank on the shaft of a water wheel. This was later improved by incorporating several parallel saws (Chandler 1916). The first mention of a sawmill in Virginia was in 1625 (Chandler 1916). The Dutch and Swedish settlers both built sawmill based on wind and water power. By 1760 there were 40 sawmills in Philadelphia County alone.

4.3 Clapboard alternatives

A contemporary alternative to the clapboarding was shingles. There are at least a few known examples of brick nogging beneath shingles in New Haven Connecticut and were especially popular in New Jersey and Long Island New York. In 1679 Jasper Dankers wrote “Houses in Boston are made of thin small cedar shingles, nailed against frames and then filled with brick and other stuff (Chandler 1916). Sheathing may have first develop beneath shingled walls, where it was essential as a nailing base. The superior tightness of such a double layer led to the adoption of sheathing under clapboards beginning in 1700 and the gradual abandonment of clay or brick filling during the eighteenth century.

4.4 Clapboard usage

In New Amsterdam a 1642 contract specified 500 clapboards to be installed all around and overhead tight against the rain (Chandler 1916). In Massachusetts in 1638, the Symod’s house was built with “very good oak-hart inch board...(and) walls without to be all clapboarded beside the clay walls.” (Kimball 1927) Similarly, the first record of an artisan house frame was in 1639, where “the roofe and walles Clanboarde on the outsvde ” were to be used.
upon that to meet situation... to be otherwise "finished with daubings" (Kimball 1927).

Throughout the next century there is extensive physical and recorded documentation of clapboarding structures. By 1736 in the newly formed settlement of Savannah, Georgia the structures were covered with split boards. The presence of the Moravians may have also been a contributing factor in this community and the Winston-Salem area in North Carolina. Locally available brick may also have been highly inappropriate for the highly damp climate as confirmed by the decay of a 1740 brick church that was parged with plaster but in demise soon after (Lane 1976).

Early examples are well documented as, architectural historians are predominantly interested in the onset or introduction of a new element or style. The concept of the earliest date simply is revised backwards when new evidence emerges. What is more difficult and probably of more importance to the practicing engineer is to establish how late certain practices persist and how side spread they remained even when no long in fashion. An extremely late eighteenth century example is the Hinde house in Spring Hill Georgia (Lancaster 1991). Figures 10 and 11 show several mid-nineteenth century clapboard structures with brick nogging in rural North Carolina.

Knowledge of the presence of brick nogging is critical to the proper assessment of an existing structure, primarily in terms of its weight and stiffness.

5.1 Weight
Critical to the presence of the brick is the weight of the material. Where wood is only a quarter of brick weight and the assumption of an older clapboard structure has an empty cavity within the framing the presence of even a single wythe of brick could substantially impact the total dead load. Based on a late twentieth century load take down of Somerset Plantation’s large, main house, the total load was estimated at 803,770 kN (Fischetti, 1980). Base on the floor plan and assuming only noggin in exterior walls at a single thickness, the additional 1,200 square meters of material would increase the weight of the structure by 37,290 or nearly 5 percent. A double layer of the material would result in 10 percent increase. The critical point is in the understanding of the heightened load in specific piers, particularly if the house needs to be jacked or lifted.

5.2 Stiffness
The impact on stiffness is less straightforward. Tests of single-wythe low-strength brick showed elastic moduli around $3,000,000 \text{kN/m}^2$ with a high amount of variability (Laefer 2001). What is unclear is how much of a composite section the walls behave. A conservative assessment approach would be to assume that the brick controls the building stiffness

6 IDENTIFICATION
Identifying the existence of brick nogging is the most critical feature. The older and the more rural the structure is the more likely it is that brick nogging may be present. In frontier areas such as Kentucky architectural styles were influenced by the soldiers and settlers that entered the territory long after other parts of North America were well settled. The use of more traditional techniques decades, if not centuries, later than may have been expected from the architectural record in more urbanized areas should be considered as a direct outgrowth of the original factors that generated brick nogging beneath clapboards as a widespread construction style.

Determination of the presence of brick nogging may be achievable with only a minimal amount dismantling that may be done in a reversible and non-destructive manner. Figure 12 shows a gap between wall and floor, where the brick nogging was visible on a second story.
Another major clue may be the provenance of the original home builders. In the case of the Collins Mansion at Somerset Place, the family that built the structure had lived in a more urban area about 45 km away. The owner’s previous home there and several other surviving structures from that period are nearly identical in many of their critical features with the Collins Mansion built 30 years later.

7 CONCLUSION

The wall filling technique of brick nogging is poorly known in part because the historical architectural books do not emphasize the details of the wall construction and configuration either because usage was so extensively employed that the knowledge was considered obvious or later considered passe’. Subsequent documentation has also taken a highly superficial treatment of vernacular structures. The situation is further complicated by that fact that brick nogging was typically used beneath clapboards. The critical element to understand is that clapboard buildings may not be as they seem. The modern en-

8 REFERENCES

Fischetti, D. 1980. Subsurface exploration and analysis for the Collins Mansion, Somerset Place state historic site. For State of North Carolina, Department of Cultural Resources.
The younger generation of the Massachusetts Historical Society, 4th Ser., 7: 118-120, 1865.