

THE PROPERTIES OF BEEHIVE KILN FIRED BRICKS USED IN A NINETEETH CENTURY BUILDING

J. M. Nichols

Assistant Professor,
Texas A&M University

D. M. Dietz PE
Principal

Laura A. Brown E.I.T.
Senior Engineer

Kassaw and Dietz, Inc.,
Consulting Engineers
5620 Old Bullard Road Suite 130
Tyler Texas 75703

SUMMARY

The McNeill Drugstore is located in Tenaha Texas and was constructed around about 1870. The building has a lime mortar with a salmon-reddish brick. This paper presents a summary of the investigation this Texas drugstore, which is typical of the period and presents the experimental results on testing of a sample of bricks from the building. The bricks were manufactured in a beehive kiln.

INTRODUCTION

Dresden's Frauenkirche represents the atypical revival of a building from the ashes of war. There are many masonry buildings scattered throughout the world that have fallen into a state of disrepair similar to the Frauenkirche. Some of these buildings will be saved, but most will not. This paper documents an investigation into an old drug store in located in a small town, Tenaha, Shelby County in North Eastern Texas (Figure 1 (Benbennick, 2007)).



Figure 1. Shelby County, Texas

Tenaha is situated in the central northern region of Shelby County (Figure 2)

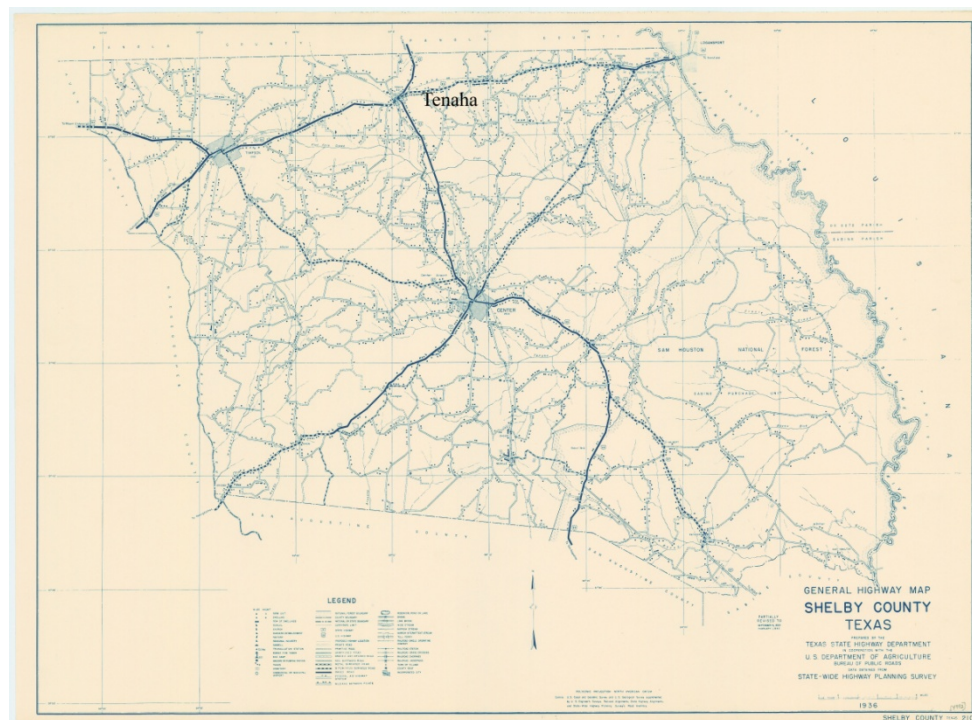


Figure 2. Location of Tenaha, Shelby County, Texas
(Courtesy Texas State Highway Department -1940)

The McNeill Drugstore represents the quintessential American Drugstore of the late 19th and early 20th centuries, and like most such drugstores, chain stores have displaced these familiar sites from the old town squares of America. The McNeill Drugstore has not been occupied from some years and has fallen into a state of disrepair (Figure 3)



Figure 3. McNeill Drugstore – Street Elevation.

This paper presents a summary of the structural investigation for this Texas drugstore, which is typical of the period and presents the experimental results for a sample of bricks taken from the building.

LITERATURE REVIEW

An investigation has been completed by the Structural Engineering firm of Kassaw and Dietz, Inc (Brown and Dietz, 2007; Nichols, 2007) into the structural condition and the work required to update the building to modern standards of practice. The style of the building, including the use of cast iron columns, indicates that construction of the building occurred somewhere between 1870 and the 1900. Restoration of this type of masonry structure occurs elsewhere in the USA. The bricks used in the construction of the McNeill Drugstore were manufactured in a beehive kiln. Robert Compton photographed the old Lorton Bee Hive kiln in 1994 (Figure 4). Prison convicts used this kiln for firing bricks to construct the Lorton Prison. Lorton Prison is located in Lorton, VA on the Occoquan River.



Figure 4. – Beehive Kiln (Photo courtesy of Robert Compton of *Robert Compton Pottery*.)

One of the critical aspects in engineering the restoration of older masonry structures is gaining an experimental understanding of the physical properties of the bricks used in the construction of the building. A significant body of experimental data exists on nineteenth century bricks from tests completed at the Watertown Arsenal in the USA (Baker, 1914). This data has been summarized and presented in SI units (Nichols, 2005). Baker presented the results for a series of tests on bricks displayed at the Louisiana Purchase Exposition (Table 1).

Figure 5 shows the plotted results from the data presented in Table 1. Brick results typically have a coefficient of variation of 25% (Page, 1973) and the data shown in Figure 5 would be considered typical for the later part of the nineteenth century. The difficulty in manufacturing bricks in a beehive kiln is quality control, and minimizing the variations in quality of the bricks. Baker provides a summary of the different grades of bricks produced in a single firing in a beehive kiln. Although Baker does not explicitly state that results 4 to 8 for bricks from Massachusetts brick kilns, but this appears a reasonable assumption based on the town names.

Table 1. – Louisiana Purchase Exposition – Brick Compressive Stress Results

Ref Num.	Kind of Brick	Compressive Stress (MPa)		
		Min	Max	Mean
Face Brick:				
1	Stiff-mud	61.6	105	88
2	Dry-pressed	61.6	124	77
3	Re-pressed soft mud	39.8	52.1	47
Common Brick				
4	Hard-burned, soft mud, Cambridge	63.1	102	78
5	Hard-burned, soft mud, Brookfield	29.9	31.6	31
6	Hard-burned, soft mud, Mechanicsville	35.2	46.4	40
7	Medium burned, soft mud, Cambridge	31.8	59.2	45
8	Medium burned, soft mud, Brookfield	28.9	47.2	36

The distinct difference in the results for Sample 4 and 7 highlight the issue of temperature control in the firing of bricks in beehive kilns.

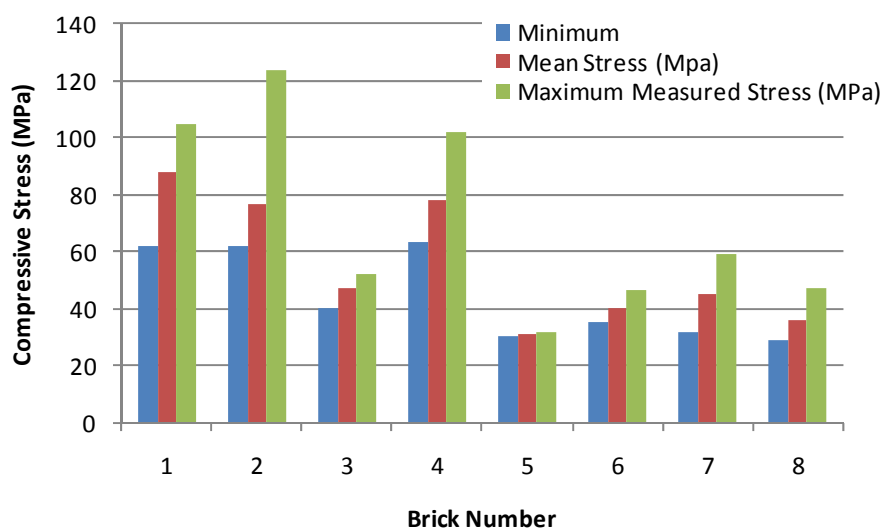


Figure 5. Louisiana Purchase Exposition – Brick Compressive Stress Results

The position in the kiln also affected the strength properties of the bricks. The clinker bricks were over-burnt, which resulted in a brittle weak brick. The hard bricks are used for construction. Salmon bricks are under-burnt and soft. The salmon refers to the colour of the brick and this was used as a marketing ploy to allow the bricks to be sold, even though they were classed as substandard at the time.

BUILDING CONDITION

The drugstore is not currently in use, nor is the building habitable without a significant reconstruction effort to bring the building up to acceptable occupation standards. A picture of the northern wall is shown in Figure 6. This picture clearly shows evidence of the building located in the grassy space visible in front of the wall. There is an area of heavily damaged bricks in the lower left hand quadrant of the wall.



Figure 6. McNeill Drugstore – Northern Elevation.

Figure 7 shows the eastern elevation looking westward.



Figure 7. McNeill Drugstore – Western Elevation.

The western wall provides access onto the rear laneway. The initial concern for the building was centered on the gap between the two external walls for the Old Bank Building on the left-hand side of Figure 7 and the McNeill Drugstore on the right-hand side of the picture. This arrangement was for the safety of the bank building to prevent unauthorized access through the drugstore walls, reminiscent of “The Red-Headed League”(Doyle, 1892). This wall needs

to be re-pointed and checked for plumb, but there would appear to be no viable method to eliminate the space that did not place further significant strains on the two buildings. A close up view of the gap between the buildings is shown in Figure 8. Building orientation is maintained in this photograph.



Figure 8. McNeill Drugstore – Southern Elevation, showing the gap to the Old Bank Building.

A picture showing the typical brick detail is shown in Figure 9.



Figure 9. McNeill Drugstore – Southern Elevation - Close up of joints

Figure 10 shows the interior of the building.



Figure 10. McNeill Drugstore – Interior

The building requires a significant effort to return the structure to a habitable standard. The key findings were to improve the drainage beneath the floor area, rebuild the street frontage using the available original bricks and columns, re-point the mortar, and rebuild the damaged areas of external bricks. The southern or rear wall requires significant work to repair cracked lintels and to remove the ivy on the walls. The design of the overall structure will require careful consideration to achieve an acceptable level of safety for a wind or earthquake load. Shelby County is located away from the Texas coastal strip, which reduces the design wind velocity and is far enough away from the major fault located north of Dallas, Texas so that a normal intraplate design standard for earthquake would be appropriate (American Society of Civil Engineers and Structural Engineering Institute, 2003). The interior design will be dependent on the proposed use of the structure.

Why would anyone want to save the McNeill Drugstore? This is the main question between the pure economic rationalism of a large section of the modern development community and the historic community with a desire to save at least a representative fraction of the historical buildings. McNeill's Drugstore is located far enough away from the coast that global warming and sea level change will not be an issue; the same statement cannot be made for some of the historic structures elsewhere in the United States, with New Orleans potentially becoming more isolated from the mainland (Bourne, 2007). There is little doubt that the McNeill building has the potential to provide a reasonable economic return given the correct circumstances, which is one of the criteria for saving a building and the second is an interest in saving the building in the local community. The time and effort taken to prepare the engineering assessment reports indicates a reasonable level of local interest.

Four bricks were obtained from the structure's interior. Figure 11 shows three of the four bricks tested in the experiments. The bricks were tested for compression strength (AS 3700-2001/Amdt 2-2003, 2001) using an Instron 600DX (Instron Corporation, 2005). The testing protocol used endwise tests, with plywood capping, as for all other tests by the first author.



Figure 11. McNeill Drugstore – Brick Samples

The brick failure patterns showed a brittle failure mode, with significant color variation indicating the normal problems of firing in a beehive kiln. The kiln fuel source is unknown at this stage in the research. Figure 12 shows four of the sample specimens after testing.

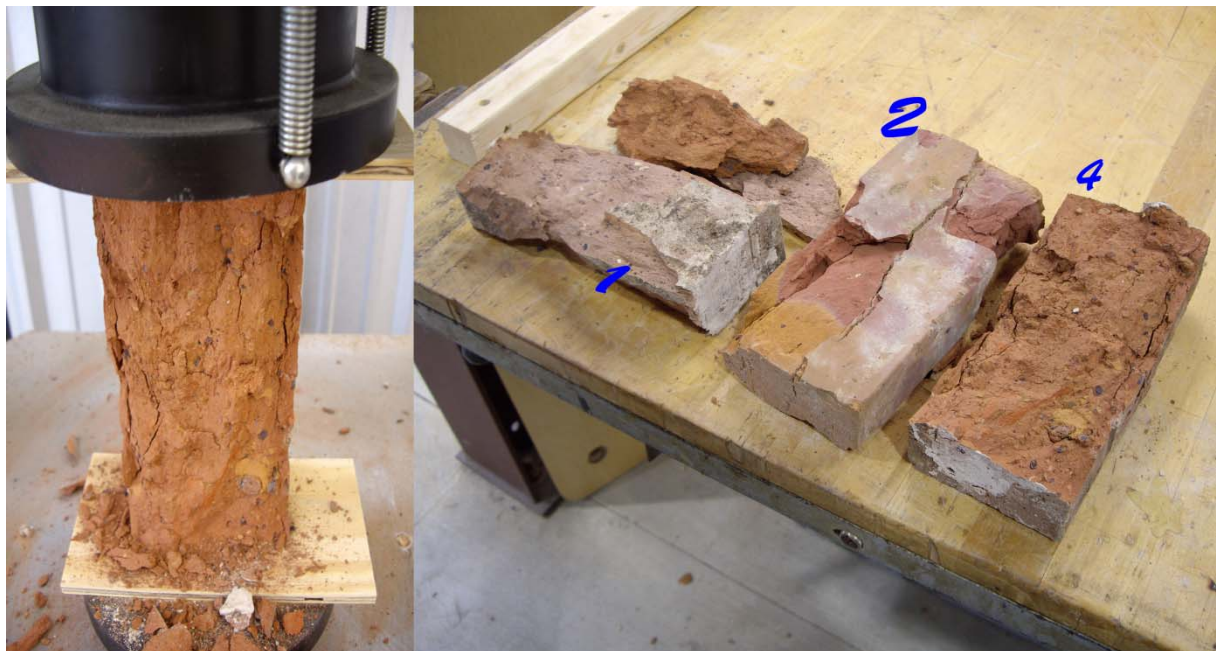


Figure 12. Specimens after testing, Specimen 4 in the Test Rig.

Dimension detail, peak load and stress values for the four bricks are presented in Table 2. Mortar samples have not been tested at this stage in the research for the building restoration.

Table 2 Brick Dimensions (millimeters)

Brick number	Length	Depth	Breadth	Peak Load (kN)	Peak Stress (MPa)
1	203 ± 2	60 ± 2	98 ± 2	87.9	15.4
2	203	62 mm	98	93.2	15.6
3	206		92	120.4	21.1
4	203		92	48.8	8.56
Mean Value mm	204		95		15.1 ± 5.3

Figure 13 shows the plot of stress against displacement for the four bricks. The Young's modulus cannot be determined from the tests because of the use of plywood capping. Further testing using Linear Velocity Displacement Transducers would be required to determine Young's modulus and Poisson's ratio (Totoev and Nichols, 1998).

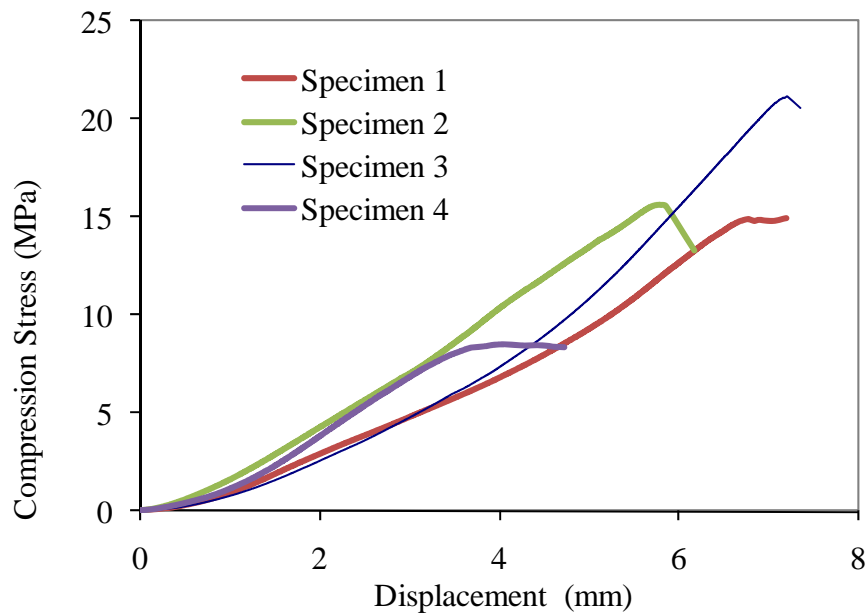


Figure 13. Brick Experimental Compression Test Results

CONCLUSIONS

It is of no great surprise that Texas has limited historical structures of any age because of the relatively short period since the recent European invasions by the Spanish, French, British, and United States. The architectural influences in Texas in the later part of the nineteenth century lean heavily towards the US influence, as the period prior to the nineteenth century lean heavily towards the Spanish influence. One of the interesting features in the historical record of the American country town is the drug store. The drugstore formed an integral part of the economic history of most towns in the central part of the United States. The McNeill Drugstore appears from the anecdotal stories to have been typical of these establishments. The drug store fits within the category of historical building that is worth preserving. The second issue is the economic viability of preserving the structure. It has been beyond the scope of this paper to discuss economic viability, but these drugstores are being used for modern uses

elsewhere in the USA whilst maintaining the key elements of the historic fabric of the building. The building needs work, but this is not unexpected for a building of this age and condition. As with most masonry buildings of this age and type the front façade requires the greatest level of work to provide a safe front to the building in terms of wind and earthquake safety. Four bricks were obtained from the interior of the building and tested for peak compressive stress. The mean stress results were 15.1 ± 5.3 MPa. This is a limited set of tests for determining design values and the single soft brick, which exhibited the “soft” interior use only brick characteristics defined by Baker, clearly reduces the design characteristic strength. Additional testing of bricks would provide a better guide as to a reasonable characteristic strength. The tensile flexural stress capacity would need to be assumed as zero due to the use of lime mortar. The bricks were manufactured in a beehive kiln and show a typical results range.

REFERENCES

- American Society of Civil Engineers and Structural Engineering Institute. *Minimum design loads for buildings and other structures / American Society of Civil Engineers*. Reston, VA, American Society of Civil Engineers, Structural Engineering Institute, 2003.
- AS 3700-2001/Amdt 2-2003. *Masonry Structures*. Sydney, Standards Australia, 2001.
- Baker, I. O. *Treatise on Masonry Construction*. New York, Wiley, 1914.
- Benbennick, D. *Map of Texas highlighting Shelby County*, Wikipedia 2007.
- Bourne, J. K. "New Orleans A Perilous Future." *National Geographic* Vol. No., August 2007, 2007 pp.
- Brown, L. E. and D. M. Dietz. *Structural Due Diligence*. Tyler, Kassaw and Dietz, Inc 2007.
- Doyle, A. C. *The Adventures of Sherlock Holmes*. London, George Newnes, 1892.
- Instron Corporation. *Instron Model DX Series Static Hydraulic Universal Testing Machine*. Norwood, MA, Instron, 2005.
- Nichols, J. M. "A Treatise on Masonry Construction" Application to the Modern Practices for Historic Building Restoration. , *10th Canadian Masonry Symposium*. Banff, Alberta. 1, 2005, pp. 116-116.
- Nichols, J. M. *Structural Condition of McNeill Drug Store located in Tenaha, Texas*. College Station, TAMU 2007, pp. 11.
- Page, A. W. *Structural Brickwork - A Literature Review*. Newcastle, Department of Civil Engineering, University of Newcastle, 1973.
- Totoev, Y. Z. and J. M. Nichols, Further Dynamic Testing of Masonry by the Longitudinal Vibration and Ultrasonic Pulse Velocity Method. *Proceedings of the 8th Canadian Masonry Conference*, Jasper, 1998.