PETER MEIJER ARCHITECT, LLC

Limited Exterior Masonry Assessment
Roosevelt Elementary School

Volume 2 of 2

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Produced for:
Medford Public Schools
Medford, Oregon

In Consultation with:

ABHT STRUCTURAL ENGINEERS

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Introduction

Peter Meijer Architect, LLC (PMA) was retained by the Medford Public Schools to conduct a limited assessment of the masonry of the 1911 original school wing at Roosevelt Elementary School. Succinctly stated, Peter Meijer Architect, LLC was retained to focus on the condition of the existing rust colored brick. The appearance of the existing brick raised concern over the structural integrity and inherent strength of the brick to continue to function as an effective veneer skin. The intent of the assessment was to report on the physical properties and visible cracking associated with the existing brick. Furthermore, PMA was to ascertain the condition of the back-up wythes and to determine if the same quality of brick units were used throughout the construction of the 1911 wing.

The resulting report and assessment should not be construed as a second opinion engineering review of the proposed re-design of Roosevelt Elementary School nor as a second opinion engineering review of the June 10, 2007 Structural Seismic Report by DCI Engineers. The report is limited to the assessment of the physical properties of the face veneer brick.

General Building Information

The original circa 1911 wing of Roosevelt Elementary School consists of a concrete base and a two-story masonry façade with a masonry parapet, A decorative wood cornice consists of projecting wood "false" rafter tails and a wood architrave. The concrete base is a ½ story below grade and the first floor is a ½ story above grade. The major structural systems are a concrete foundation (The basement walls are cast-in-place concrete and extend approximately 8'-0" above the exterior finished grade. The basement floor is concrete slab-on-grade.), an un-reinforced masonry wall composed of three wythes of masonry. (The walls were observed to be (3) wythes thick at the second floor. (We were unable to determine the number of brick wythes from the second floor to roof level) The masonry wall has a face veneer of rust colored brick with blond brick accents, quoining, and blond brick decorative 2-story engaged columns. Both the roof trusses and the floor framing members are wood. At the attic level, the roof joists have been anchored to the exterior masonry wall with metal straps nailed to the roof joists and epoxy anchored into the existing masonry wall. Interior finishes include wood floors, plaster walls and ceilings, and wood trim work including a wood wainscot.

A significant visual difference is evident in comparing the material quality and labor workmanship between the rust colored brick and the blond brick. The blond brick has a very smooth surface void of imperfections and irregularities and was installed with ¼" or less masonry joints. The rust colored brick, however, exhibits numerous surface cracking, spalling of edges due to the cracking, and an irregular surface with many "imperfections." One such imperfection is a 2" long horizontal indentation likely made from a tool used to remove the masonry units during the firing process. Mortar joints are struck flush with the brick face and are 3/8" to ½" wide. Header courses occur every 8th course vertically and the field bricks were laid in a running bond. The irregularities, cracking, and workmanship were observed on all three facades of Roosevelt Elementary School with consistent and similar amounts.

Phase 1: Visual Observations

The brick veneer investigation consisted of two phases: Phase 1 consisted of PMA Visual Observation of the outer wythe, the middle wythe, and inner wythe of masonry; and Phase 2 encompassed the Laboratory Testing of individual units for both compression strength and the ability of the units to resist pull-out forces of an embedded helical anchor. Phase 1 was conducted on October 4, 2007 and included 1) the identification of two locations for further masonry assessments, 2) the removal of several brick from the outer wythe to observe the middle wythe, 3) the observation of the inner wythe of brick at the attic level; and 4) the removal of individual masonry units for further laboratory testing. Temperature and weather conditions during Phase 1 were partly cloudy and 62 degrees Fahrenheit.

After consultation on site with ABHT Structural Engineers and Rogue Valley Masonry, Peter Meijer Architect, LLC selected two locations at the level of the second floor framing on the east and west elevations as being representative of existing conditions. An area approximately 10ft x 10ft square was marked and each individual brick unit was observed for cracking. Approximately 100 brick units, not counting the header courses, were contained within the boundaries of the area. Of these 100 brick, only seven (7) units were noted to be either without cracks or very minor cracks.

After noting the condition of the face bricks, approximately 15 units were removed from the wall in an area roughly 3 running units wide by five courses high. The lower boundary of the opening was made just above the header course in order to verify the bonding and construction techniques. The initial removal process used a masonry saw to cut the horizontal joints followed by hand tools to scrape out the remaining mortar. After the initial brick units were removed, the removal process was slightly modified to eliminate the use of power tools and utilize only hand tools to remove the mortar.

The masonry courses are set in full bed joints, full back side joints, and head joints all of which meet industry standard construction practices. Although the mortar is "soft," the existing mortar joints are not exhibiting signs of failure. PMA conducted a limited observation of interior walls but did not observe signs of water intrusion. Mortar within the joints had not failed due to water intrusion or other sources. PMA did not conduct petrographic analysis on the existing mortar, but physical observation combined with knowledge of historic mortars suggests that the existing mortar is lime based. The bed and head mortar of the face veneer has been colored a dark grey. The mortar used for setting the back-up wythes and bonding the face wythe to the back up wythes is an off-white color.

When the mortar was removed, the brick units were dismantled using hand tools. Each unit was removed intact and no units crumbled or broke with hand pressure. It was observed that the cracks on the exterior face did not propagate the full depth of the unit but were present on all six faces. The bedding surfaces of the units contain several inclusions of large sand and rock fragments and has an overall rough texture. The prevalent cracking appears to result from the clay composition and shrinkage during drying as a result of the manufacturing process. When the cracking is clustered at the edges and corners, a portion of the unit is more likely to spall resulting in deformation of the face. The cracking and material composition was consistent from unit to unit and consistent at both elevations.

The back-up wythes (middle and interior) were observed from the exterior and attic levels respectively and found to be similar in color, composition, and texture. The number, type, and distribution of cracks in the back-up wythes was similar to the face veneer. At the attic level, previous seismic reinforcement of the roof joists consisted of connecting a steel strap to the inner masonry wythe with epoxy anchored bolts. No additional fracturing or cracking of the masonry wythes was observed at these locations.

Phase 2: Laboratory Testing

"The compressive strength of brick or structural clay tile is an important material property for structural applications. In general, increasing the compressive strength of the unit will increase the masonry assemblage compressive strength and elastic modulus. However, brick and structural clay tile are frequently specified by material standard rather than by a particular minimum unit compressive strength. ASTM material standards for brick and structural clay tile require minimum compressive strengths to ensure durability, which may be as little as one-fifth the actual unit compressive strength. A recent Brick Institute of America survey of United States brick manufacturers resulted in a data base of unit properties [6]. A subsequent survey of structural clay tile manufacturers was conducted. The compressive strengths of brick and structural clay tile evaluated in these surveys are presented in Table 1. As is apparent, all types of brick and structural clay tile typically exhibit compressive strengths considerably greater than the ASTM minimum requirements. Compressive strength of brick and structural clay tile is determined in accordance with ASTM C 67 Method of Sampling and Testing Brick and Structural Clay Tile.

TABLE 1
Brick and Structural Clay Tile Unit Compressive Strengths

Unit Type			Mean Unit Compressive Strength, psi (Mpa)	Standard Deviation of Compressive Strength, psi (MPa)
Solid brick	Forming Method	Extruded	11305 (77.9)	4464 (30.8)
		Molded	5293 (36.5)	1822 (12.6)
	Raw Material[1]	Fire clay	15346 (105.8)	5065 (34.9)
		Shale	11258 (77.6)	3487 (24.0)
		Other[2]	9169 (63.2)	3988 (27.5)
Hollow Brick[3]			6736 (46.4)	2447 (16.9)
Structural clay tile[3]		Vertical coring	10057 (69.3)	5578 (38.5)
		Horizontal coring	5119 (35.3)	2067 (14.3)

[1]Extruded only.
[2]Made from other materials or a combination of materials.
[3]Based on gross area."[1]

[1] The Brick Industry Association, Technical Notes on Brick Construction, No. 3A , "Brick Masonry Material Properties," December 1992.

Compressive Strength

Of the six brick units removed from Roosevelt Elementary School, three (3) were tested under compression, two (2) were used for helical pull tests, and one (1) was left as a control and for future testing.

ASTM provides durability classifications for building brick based on regional climatic conditions. Because Jackson Elementary School is located in the northwest, the masonry classification is C62 Building Brick, SW (Sever Weather). Based on this classification, the Brick Industry Association provides data on the physical properties of various brick based on the classification ratings.

The physical property requirements in most specifications are compressive strength, water absorption and saturation coefficient. These properties must be determined in accordance with ASTM C 67, Standard Methods of Sampling and Testing Brick and Structural Clay Tile or CSA A82. The minimum compressive strength, maximum water absorption and maximum saturation coefficient are used in combination to predict the durability of the bricks in use. The saturation coefficient, also referred to as the C/B ratio, is the ratio of 24-hour cold water absorption to the five-hour boiling absorption.

The compressive test results were as follows:

Location: Roosevelt Elementary		Compressive Strength (psi)
RW1 (West elevation; No. 1)		1850 *
RN 1		3820
RN2		3490

* The lower value for RW1 is a result of shear failure in the masonry unit following compressive failure of the mortar and subsequent horizontal forces placed on the unit from the test equipment.

The average for the remaining two units is 3655 psi. Based on Table 4, BIA Technical Note 9A, the minimum compressive strength for individual brick units is 2500 psi..[2]

[2] Brick Industry Association, Technical Notes 3A - Brick Masonry Material Properties, December 1992

Water Absorption

The Water Absorption test results for Jackson Elementary School were as follows:

24-hour cold water	5-hour boiling	Saturation Coefficient
11.5	14.7	0.78
11.6	14.7	0.79
13.8	16.3	0.85
14.3	16.5	0.87
16.9	20.7	0.82
16.6	20.6	0.81

The saturation coefficient average for all units is 0.82. Based on Table 4, BIA Technical Note 9A, the maximum saturation coefficient for individual brick units based on the durability classification is 0.80.

The 5-hour boiling absorption rate average for all units is 17.25%. Based on Table 4, BIA Technical Note 9A, the maximum 5-hr boiling rate for individual units based on durability classification is 20%.

Note: The initial rate of absorption (IRA) is a measure of how quickly the brick will remove water from mortar spread on it. IRA is not a qualifying property or condition of brick in the ASTM or CSA specifications. IRA values may be of interest when selecting mortar and in use of the brick on the jobsite.

Pull Tests

Note: Brick shear strength (pull-out test) is not a qualifying property or condition of brick in the ASTM or CSA specifications. This information is provided as a design tool only.

The brick pull out test results were as follows:

Location:		Resistance (psi)
RW3		780
RN3		286
E1		316

Freeze – Thaw Testing

Freeze-Thaw testing procedures followed ASTM C 67 “Test Methods for Sampling and Testing Brick and Structural Clay Tile,” Section 9 and results for Jackson Elementary School were as follows:

Unit No.	Weight Loss @ 50 cycles	Cracking @ 50 cycles
2a	0.24%	None
2b	0.06%	None
Rating	Pass	Pass

Each test cycle is a 48 hour span alternating freezing temperatures with high heat temperatures every 24 hours. At the end of 50 cycles measurements record two criteria of a masonry unit: 1) weight loss and 2) cracking.

ASTM provides a value of 0.50% or less as the criteria for weight loss as acceptable and "no crack exceeding the minimum dimension" as the crack standard.

Masonry units are rated as “pass” or “fail” depending on the above test criteria.

Conclusion

Although the construction methodologies used to build the masonry bearing wall at Roosevelt Elementary School are reflective of standards of the period, it is atypical for an exterior masonry veneer to be comprised of low aesthetic quality bricks. Most public buildings incorporated masonry with high quality clays and control of the manufacturing process that limited drying cracks resulting in higher aesthetic appearances. It is not unusual for back-up masonry to be composed of lower quality units.

The cracking in the units appear to be the result of manufacturing process and not accelerated aging or water penetration. Based on our review of the brick samples taken in the field, it appears that the cracking present in the bricks may have resulted from rapid cooling after the firing process was completed. Excessively rapid cooling can result in cracking and checking of the clay brick units. Although unsightly, the cracks are not expected to increase in size over time. When removed, none of the individual brick units failed.

Due to the amount of surface cracking, some edges and faces of the existing units are spalling and will continue to spall in the future. The water absorption test results are noted above. These results were within acceptable limits for water absorption based on durability classification but slightly out of acceptable range for saturation coefficient. The susceptibility of the brick units to freeze thaw is being evaluated through controlled laboratory tests. The results of the freeze thaw testing will add to the information regarding water absorption characteristics and be incorporated into this report when available.

The compressive tests results were almost identical for each school. The helical anchor pull out tests were performed on a limited number of samples and are provided for design purposes and not as an indication of the masonry properties.

Disclaimer

The recommendations stated in this report are based on limited site observation of the structure readily accessible to view and are consistent with our best engineering judgment. No calculations have been made to determine the adequacy of the structural system or its compliance with accepted building code requirements. We cannot guarantee that concealed problems do not exist.

End of Report