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TOBIN MONTESSORI AND VASSAL LANE UPPER SCHOOL
Cambridge, Massachusetts

EXISTING CONDITIONS STRUCTURAL REPORT

March 29, 2019

INTRODUCTION

Foley Buhl Roberts & Associates, Inc. (FBRA) is collaborating with *Perkins Eastman (PE)* in the review and evaluation of the Tobin Montessori and Vassal Lane Upper School in Cambridge, Massachusetts. The purpose of this *Existing Conditions Structural Report* is to identify and describe the structural systems of the facility and to comment on the structural issues/conditions observed. General comments relating to potential renovations, alterations and additions to the building (governed by the Existing Building Code of Massachusetts (MEBC - 9th Edition)) are presented as well.

The Tobin Montessori and Vassal Lane Upper School is located at 197 Vassal Lane in Cambridge. The building was constructed in 1971 on a generally flat site. The site is bordered by residential neighborhoods to the south and east, the Callahan Park/Playground to the northeast, the Cambridge Armory (former National Guard Organizational Maintenance Shop) to the northwest, and by commercial buildings including a gas station to the west. The site includes the school building, courtyards, playgrounds, and the school parking lots. The building footprint is a "bow-tie" shape and consists of Units A, B, and C. Units A and C are symmetrical two-story classroom wings with their lowest level at the 2nd floor, above a crawl space. Unit B is at the middle of the "bow-tie" and is partly a three-story wing and partly a one-story wing, with its lowest level at the 1st floor, partially below grade. A partial 4th level in Unit B is unoccupied. Unit B includes the Gymnasium, Auditorium, Cafeteria, and Library. An additional crawl space (used for outdoor storage) is located beneath the Gymnasium. There have been no significant additions or renovations made to the original building.

The Tobin Building currently houses both the Tobin Montessori School for pre-K to 5th grade students and the Vassal Lane Upper School for 6th to 8th grade students. The building was not originally designed for the two separate school facilities but the school district reorganized its structure in 2012 resulting in a sharing of the space. The layout of the existing building is not compatible for the separate areas needed for the two schools.

The total building (floor) area is 135,600+/- SF.

The current enrollment is approximately 270 students in the Vassal Lane Upper School and 300 students in the Tobin Montessori School.

The building is a reinforced concrete structure with non-load-bearing ground-face masonry block exterior walls. The gymnasium roof is framed with open web steel joists. Exposed concrete columns and beams are common at both the building interior and exterior. The interior partition walls are typically concrete block (CMU) construction (running bond). The roofs are flat with a built-up, ballasted EDPM membrane. The roof membrane is the original 1971 installation, with local repairs as needed throughout the years.

The location is the site of a former clay mining facility. After the mining activities ended, the clay pit was used as an uncontrolled waste pit (from the 1930's to the 1950's). As such, a sub-slab depressurization and venting system was installed in the 1990's to prevent migration of waste material and land-filled gas to the school building's indoor air. The school and neighboring Callahan Field are regulated under the Massachusetts Contingency Plan (MCP), and there is an Activity and Use Limitation (AUL) in place.

Structural conditions at the Tobin Montessori and Vassal Lane Upper School were reviewed at the site (where accessible and exposed) by FBRA on February 22, 2019.

The following documents were reviewed in the preparation of this Existing Conditions Structural Report:

> *John M. Tobin Elementary School - Cambridge, Massachusetts:* Architectural Drawings A1-A14, A21, prepared by Pietro Belluschi (Principal Architect) and Sasaki, Dawson, DeMay Associates, Inc. (Associate Architect) - Watertown, Massachusetts, dated October 25, 1968, Revised January 20, 1969.

> *John M. Tobin Elementary School - Cambridge, Massachusetts:* Structural Drawings S1-S17, prepared by LeMessurier Associates - Boston, Massachusetts, dated October 25, 1968, Revised January 20, 1969.

No exploratory demolition or structural materials testing was conducted in conjunction with this study**.** Soil borings were available from the original building (included in Attachment B of CDM Smith's Tobin School Phase 2 Comprehensive Data Report, dated July 17, 2018).

I. STRUCTURAL SYSTEMS DESCRIPTION

The existing building is a reinforced concrete structure with structural slabs and pile foundations. The structural slabs are supported by reinforced concrete columns and beams. The gymnasium roof is framed with open web steel joists.

Original Structural Drawings for this building were available for preparation of this report. The information presented below is based on the original Structural Drawings and conditions observed on site by FBRA.

Structural Materials: Structural concrete strengths are noted on the original Structural Drawings (S1) as the following:

Concrete:

Piles:	4,000 psi compressive strength
Columns, Beams, Slabs, and all Concrete Exposed to the Weather:	4000 psi compressive strength
Roof Fill:	2000 psi compressive strength
All Other Unless Noted Otherwise:	3000 psi compressive strength

Steel Reinforcing (deformed bars):

Column Vertical Bars, Beam Longitudinal Bars	60,000 psi yield strength
All Other Bars	40,000 psi yield strength

Welded Wire Fabric Reinforcing: ASTM A 185

Design Loads:

Design live load information was noted on the original Structural Drawings (S1), as listed below.

Roof (Snow):	30 psf (no provisions for snow drift)
Classrooms, Corridors (Including Partitions):	100 psf
Gymnasium, Auditorium, Kitchen:	100 psf
Mechanical Spaces:	150 psf
Transformer Room:	150 psf Min. (or Equipment Load)

Design wind load information was noted on the original Structural Drawings (S1), as listed below:

Wind:	
0 to 30'	20 psf
30' to 50'	25 psf

Representative structural calculations generally confirm these design live loads. Floor design loads are appropriate and meet or exceed present Building Code requirements. The current, minimum flat roof snow load required by the 9th Edition of the Massachusetts State Building Code for a school building in Cambridge is 30.8 psf; typical (non-drift) roof areas most likely meet this requirement. Snow drifting areas require further review.

The building appears to have performed satisfactorily over time under the current use. There are no apparent indications of structural overstress or failure. A comprehensive investigation and evaluation of the floor and roof structural capacity is beyond the scope of this report. However, it should be noted that reinforced concrete structures constructed in the 1960's and 1970's were designed under codes which were more conservative than current codes.

With respect to lateral (wind and seismic) loads, the building was presumably designed for the wind loads noted above. The current wind load required by the 9th Edition of the Massachusetts State Building Code for a school building with Exposure Category C is 43 psf ultimate or 25.8 psf service load. The existing structure may meet this requirement. As the design and construction of this facility preceded the introduction of the Massachusetts State Building Code, it was not designed for seismic loads and would not meet current Code requirements in that regard.

Story Heights: Story heights are as follows:

First Floor to Second Floor:	10'-8"
Second Floor to Third Floor:	10'-8"
Third Floor to Fourth Floor / Low Roof:	10'-8"
Fourth Floor / Low Roof to Main Roof:	10'-8"
Main Roof to Penthouse Roof:	10'-8"

Expansion Joints: There is reference to a ½" expansion joint along Gridline H at the Third Floor of Unit B, at the roof of the locker rooms (see Section 3-4 on S15). This expansion joint does not appear to track down to the Second Floor of Unit B. Elsewhere, in lieu of expansion/contraction joints, 3'-0" wide shrinkage strips/bays (infilled after main concrete placement has been allowed to shrink), were specified. These occur at the east and west ends of Unit B, at each level.

Structural Bays/Spans: The structural bay sizes vary throughout the building. The classrooms are situated in a pseudo-honeycomb arrangement and therefore are not rectangular. At Units A and C the classroom bays are roughly 25' to 30' x 34'. Typically there are columns at both sides of the central corridor.

Penthouse Roof Construction (Unit B): Penthouse roof construction at Unit B (Elevation 72'-0") consists of an 8" flat slab spanning to 16" wide x 32" deep concrete perimeter beams. The beams are supported by hexagonal concrete columns.

Roof Construction (Unit B): Roof construction at the Gymnasium (Elevation 61'-4") consists of 3" deep, 20 gage metal roof deck, spanning to 48LJ16 open web steel joists. The steel joists are spaced at 9'-9" and the top chord slopes to achieve the 1/8"/ft roof pitch. Steel joists are supported by concrete beams 16" wide x 32" deep, spanning to hexagonal concrete columns.

Roof construction at the Auditorium (Elevation 61'-4") consists of a one-way 6" slab supported by 16" wide x 32" deep concrete roof beams spaced at 9'-9" on center. The roof beams are supported by concrete roof girders spanning to hexagonal concrete columns.

Additional main roof areas at Unit B (Elevation 61'-4") consist of 8" flat slabs spanning to 16" wide x 32" deep concrete beams, which are supported by hexagonal concrete columns.

Roof Construction (Units A and C): Roof construction at Units A and C classroom wings (Elevation 50'-8") is a flat slab, typically 8" thick, supported by concrete beams spanning between hexagonal concrete columns. The beams are typically 16" wide x 32" deep. There are trapezoidal shaped balconies cantilevered along the perimeter. Concrete fill is added at the roof to achieve the required pitch for roof drainage.

Above the stairway at Units A and C is a 6" Penthouse Roof slab (Elevation 61'-4") supported by concrete beams and hexagonal concrete columns.

Fourth Floor Roof Construction (Unit B): Typical Fourth Floor roof construction at Unit B (Elevation 50'-8") consists of an 8" thick, flat slab supported by 16" wide x 32" deep concrete beams spanning to hexagonal concrete columns. Along the perimeter are trapezoidal shaped balconies, cantilevered from the main slab.

Low Roof Construction (Unit B): Low roof construction at the locker rooms adjacent to the Gymnasium (Elevation 40'-0") consists of 6" concrete joists spaced at 3'-0" on center, with a 4" minimum concrete topping. At the east side of the Gymnasium where the joist span is 19'-6", the joists are 8" deep. At the south side of the Gymnasium where the joist span is roughly 33'-9", the joists are 12" deep. The joists frame into concrete beams supported by hexagonal concrete columns. The concrete topping thickness varies in order to achieve the required pitch for roof drainage.

Third Floor Construction (Unit B): Typical Third Floor construction at Unit B (Elevation 40'-0") consists of a 9" thick, flat slab supported by 16" wide x 32" deep concrete beams and hexagonal concrete columns. At the corridor the slab is reduced to 8" thickness. At the Science Laboratory the slab is increased to 13" thickness. At the Auditorium the slab is sloped to accommodate the tiered seating. At select locations along the perimeter are trapezoidal shaped balconies, cantilevered from the main slab.

Third Floor Construction (Units A and C): Typical Third Floor construction at Units A and C (Elevation 40'-0") consists of a 9" thick, flat slab supported by 16" wide x 32" deep concrete beams and hexagonal concrete columns. At the corridor the slab is reduced to 8" thickness.

There are trapezoidal sections of slab cantilevered along the perimeter at balcony locations. Concrete fill is added at the low roof areas to achieve the required pitch for roof drainage.

Second Floor Construction (Unit B): Typical Second Floor construction at Unit B (Elevation 29'-4") consists of an 8" thick, flat slab supported by hexagonal concrete columns and 16" wide x 32" deep concrete beams. The base reinforcement in both the north-south and east-west direction is #5 bars at 9" on center bottom and #5 bars at 16" on center top. Additional reinforcement is added at certain locations. The main entrance to the school occurs at this level at the south side of the building at Elevation 23'-10 ¼". There are ramps up and down from the main entry area to access the Second Floor slab at 29'-4" and the First Floor slab at Elevation 18'-8". There is an opening in the slab to allow for a double-height space at the Cafeteria. At two locations along the perimeter are trapezoidal shaped balconies, cantilevered from the main slab.

Second Floor Construction (Units A and C): Typical Second Floor construction at Units A and C (Elevation 29'-4", the lowest occupied level at these units) consists of a flat slab, 8" or 12" in thickness, supported by hexagonal concrete columns and piles. The base reinforcement is #5 continuous bars at 12" on center bottom each way. Additional reinforcement is added at certain locations. There are 16" wide concrete grade beams at the perimeter. Below this structural slab is a crawl space (roughly 6'-0" high) with a 2½" concrete mud mat at the floor above 4" of gravel.

First Floor Construction (Unit B): Typical First Floor construction at Unit B (Elevation 18'-8", the lowest occupied level) consists of an 8" thick, flat slab supported by piles. The base reinforcement in both the north-south and east-west direction is #5 bars at 9" on center bottom and #5 bars at 16" on center top. Additional reinforcement is added at certain locations. There are 16" wide concrete grade beams at the perimeter. At the northern portion of the Unit B first floor (below the Gymnasium slab) is a crawl space (used for outdoor storage; 6'-8"+/- height), with a concrete mud mat at the floor pitched to drain. At the southern portion of the Unit B first floor are two 'sunken gardens' or courtyards, separated from the higher adjacent grade with retaining walls supported by wood piles.

Exterior Wall Construction: Typical exterior wall construction is non-load bearing ground-face CMU block in between the cast-in-place concrete superstructure (beams and columns).

Interior Wall Construction: Interior walls are typically non-load bearing ground-face CMU.

Stair Construction: Stairs are cast-in-place concrete construction.

Subsurface Soils/Foundations: No information is given on the Structural Drawings for the subsurface soil conditions or pile capacities. The building is supported on concrete end bearing piles typically, with some wood friction piles at Unit B. A 'Pile Location Plan' is included with the Structural Drawings on sheet S2, in addition to the pile cap details. Columns and perimeter grade beams are supported on pile caps, and there are also intermediate, single-pile pile caps providing additional support for the lowest level slab.

Drainage: The existing Structural Drawings do include a typical detail for foundation and underslab drainage, and the underslab drainage is shown on the First Floor plan for Unit B.

***Fire Resistance**:* The cast-in-place concrete structure has an inherent resistance to fire. The rating for the majority of the existing building would likely be over 1½ hours, given the structural slab thicknesses, concrete cover to reinforcing, etc. The unprotected steel joists at the Gymnasium roof have no fire resistance; however, the bottom of the steel roof joists is over 20 feet above the floor.

Lateral Load Resistance: As previously mentioned, the Structural Drawings note the design wind loads; presumably, the building was designed to resist these noted wind loads. While there is no explicit mention of shear walls or lateral frames on the Structural Drawings, it is implied that the overall concrete frame (beams and columns) was designed to resist the lateral wind load. The current Code design wind load is slightly higher than that noted on the Structural Drawings; hence, further analysis would be needed to determine whether the existing frame can meet current wind load requirements. As the design and construction of this facility preceded the introduction of the Massachusetts State Building Code, it was not designed for seismic loads and would not meet current Code requirements in that regard.

II. STRUCTURAL CONDITION/COMMENTS

Structural Conditions at the Tobin Montessori and Vassal Lane Upper School were reviewed (where accessible and exposed) on February 22, 2019. Generally speaking, floor and roof construction appear to be performing satisfactorily; there is no apparent evidence of structural distress that would indicate significantly overstressed, deteriorated or failed structural members.

Foundations appear to be performing adequately; there are no signs of significant total or differential settlements.

Where visible, floor and roof construction appear to have been constructed in accordance with the original Structural Drawings.

Structural/structurally related conditions observed during the February 22, 2019 site visit are noted below (Refer to photographs in the Appendix at the end of this report):

1. The condition of non-load bearing interior masonry corridor walls and partitions is generally satisfactory; minimal (shrinkage related) cracking was observed.

2. It appears that cementitious parging has been applied to structural concrete walls in some locations. Parging on the west wall of the Gymnasium in Unit B has debonded (See Photo 1). Cosmetic repair required.

3. Corroded reinforcing was observed in some locations on the building exterior, where bars were located too close to the exposed concrete surface. The expansion of the corroded reinforcing has resulted in local concrete spalling (see Photos 2, 3, 4 and 5). These conditions do not present an immediate structural concern; however, periodic monitoring is recommended to ensure that these areas remain stable. Any loose concrete should be removed.

4. Exterior, exposed concrete surfaces have deteriorated in a number of locations around the building (see Photos 6, 7 and 8). These conditions do not present an immediate structural concern; however, further review and monitoring is recommended.

5. Exterior (non-load bearing) masonry walls show signs of deterioration, efflorescence and discoloration at numerous areas around the building. Efflorescence is visible on interior wall surfaces at some locations as well. These conditions appear to be moisture related (absorption, wall/structure joint deficiencies, roof leaks, etc.). See Photos 9, 10, 11 and 12).

6. The outside face of exterior (non-load bearing) masonry walls has spalled in a number of locations at the upper levels of the building, and at base of the building, adjacent to

walkways. These conditions are due to the wetting of the masonry and freeze-thaw action. See Photos 13, 14, 15 and 16.

7. According to school maintenance personnel, wind-driven rains penetrate the exterior envelope in certain locations.

8. There is a significant roof leak in Unit B over the central (east-west) corridor (near the Library; Room 333). Water travels down through the entire building. There are also roof leaks in the Auditorium, the Gymnasium and elsewhere in the building. FBRA noted that the stone ballast on the roof was missing in a number of locations.

9. According to school maintenance personnel, there are no groundwater related issues at the lowest level floor slabs (note that the slabs in Units A and C are constructed over a crawl space). Underslab drainage was provided below the Unit B structural slab on grade. There are no moisture related issues with flooring.

10. The (minimal) expansion joint along Column Line H in Unit B does not appear to be functioning as intended at Column H-23 (See Photo 17). The details of this joint are not clear in the original documents; further review is recommended.

11. The entry stair on the south side of Unit C is showing signs of deterioration (See Photo 18).

12. Sidewalk construction has been damaged and displaced (likely due to frost heave) in some locations, resulting in a tripping hazard (See Photo 19).

13. Metal exterior doors have rusted at their base in a number of locations.

Note: Refer to the Architectural Report and those of the other consultants for additional information regarding the condition of the building envelope (exterior walls, roofing, windows, etc.), and recommendations for the repair, rehabilitation and/or replacement of these systems.

III. RENOVATIONS AND ADDITIONS - MEBC REQUIREMENTS

General comments relating to potential renovations, alterations, and additions to the Tobin Montessori and Vassal Lane Upper School are presented in this section. Renovations, alterations, repairs, and additions to existing buildings in Massachusetts are governed by the provisions of the Massachusetts State Building Code (MSBC; 780 CMR - 9th Edition) and the Existing Building Code of Massachusetts (EBCM; 780 CMR - 9th Edition, Chapter 34.00). These documents are based on amended versions of the *2015 International Building Code (IBC)* and the *2015 International Existing Building Code (IEBC)*, respectively.

Section 104.2.2.1 of the EBCM requires that the existing building be investigated and evaluated in sufficient detail as to ascertain the effects of the proposed work on the structural systems (both gravity load carrying elements and lateral force (wind and seismic) resisting elements).

The EBCM defines three (3) compliance methods for the repair, alteration, change of occupancy, addition, or relocation of an existing building. The method of compliance is chosen by the Design Team (based on the project scope and cost considerations) and cannot be combined with other methods.

The *Prescriptive Compliance Method* (IEBC Chapter 4) prescribes specific minimum requirements for construction related to additions, alterations, repairs, fire escapes, glass replacement, change of occupancy, historic buildings, moved buildings, and accessibility. If the impact of the proposed alterations and additions to structural elements carrying gravity loads and lateral (wind and seismic) loads is minimal (less than 5% and 10%, respectively), structural/seismic reinforcing of an existing building is not required. Provided that not more than 50% of the spaces in the building are reconfigured, seismic hazards such as bracing the tops of interior masonry walls and partitions, anchorage of floor and roof diaphragms to the exterior walls, bracing of parapets and chimneys, etc. would not be required by code, but could be addressed on a voluntary basis. If the area of reconfigured spaces exceeds 50% of the gross floor area, these seismic hazards must be addressed to meet the provisions of the EBCM.

The *Work Area Compliance Method* (IEBC Chapters 5 through 13) is based on a proportional approach to compliance, where upgrades to an existing building are triggered by the type and extent of work. The Work Area Compliance Method includes requirements for three levels of alterations, in addition to requirements for repairs, changes in occupancy, additions, historic buildings, or moved buildings. A complete seismic evaluation of the existing building is required under the following conditions: Level 2 alterations where the demand (mass/seismic force) to capacity (lateral force resistance) ratio of lateral load resisting elements has been increased by more than 10%, all Level 3 alterations, a change in occupancy to a higher category (not applicable here), and where structurally attached additions (vertical or horizontal) are planned. Provided that not more than 50% of the spaces in the building are reconfigured, renovations would be classified as *Level 2*. Assuming that modifications to the existing masonry walls and the existing concrete frame (each providing a degree of lateral force resistance) will not be significant (i.e. less than 10% reduction in capacity), seismic upgrades or seismic strengthening of the building would not be required by code. However, seismic hazards such as bracing the tops of interior masonry walls and partitions, anchorage of floor and roof diaphragms to the exterior masonry walls, bracing of chimneys, etc. could be addressed on a voluntary basis. In a *Level 3* alteration (more than 50% of the building reconfigured), these seismic hazards must be addressed by code.

The *Performance Compliance Method* (IEBC Chapter 14) provides for evaluating a building based on fire safety, means of egress and general safety (19 parameters total). This method allows for the evaluation of the existing building to demonstrate that the altered building, while not complying with the code requirements for new construction, will maintain or improve the level of compliance that existed prior to the alterations. A structural investigation and analysis of the existing building is required to determine the adequacy of the structural systems for the proposed alteration, addition or change of occupancy. A report of the investigation and evaluation, along with proposed compliance alternatives, must be submitted to the code official for approval.

Additions - General Comments - EBCM

The design and construction of any addition to the Tobin Montessori and Vassal Lane Upper School would be conducted in accordance with the Code for new construction. New additions should be structurally separated from the existing, adjacent construction by an expansion (movement) joint to avoid an increase in gravity loads or lateral loads to existing structural elements.

Renovations/Alterations - General Comments - EBCM

Where proposed alterations to existing structural elements carrying gravity loads result in a stress increase of over 5%, the affected element will need to be reinforced or replaced (if necessary) to comply with the Code for new construction.

Proposed alterations to existing structural elements that are resisting lateral loads (which are not explicitly identified in the Structural Drawings) that result in an increase in the lateral force demand to capacity ratio of over 10% (due to a capacity reduction) should be avoided, if possible. Essentially, this means that removal of masonry walls resisting lateral forces (or creating large openings in these walls) and/or removing sections of the existing slab, beam, and column framing that may be providing lateral force resistance should be avoided; otherwise, seismic strengthening of the building, as well as additional seismic upgrades, may be triggered.

End of Existing Conditions Structural Report

APPENDIX – PHOTOGRAPHS

Photo 1: Debonded Parging

Photo 2: Corroded Reinforcing/Spalled Concrete Cover

Photo 3: Corroded Reinforcing/Spalled Concrete Cover

Photo 4: Corroded Reinforcing/Spalled Concrete Cover and Surface Deterioration

Photo 5: Corroded Reinforcing/Spalled Concrete Cover

Photo 6: Crack in Concrete Spandrel Beam

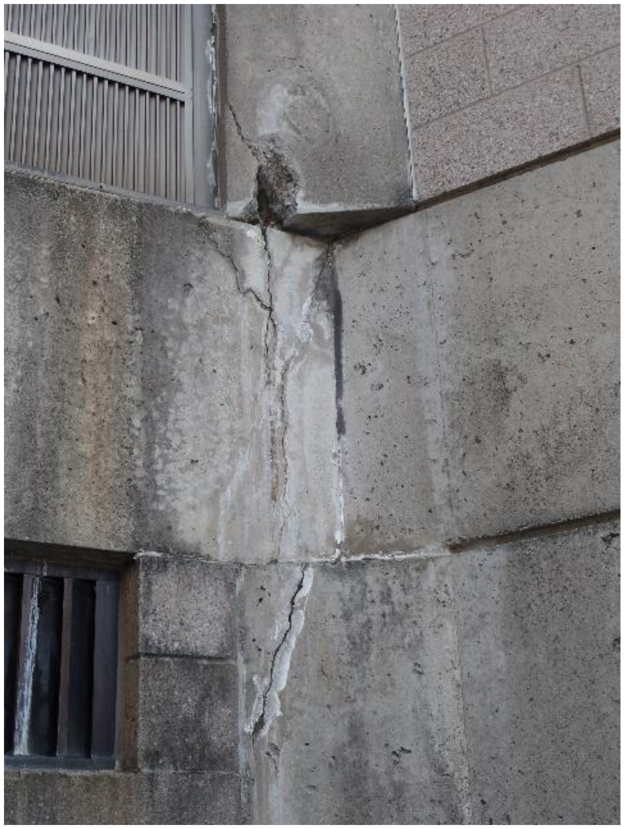

Photo 7: Corrosion/Spalled Concrete Cover and Cracking/Deterioration

Photo 8: Corrosion/Spalled Concrete Cover and Cracking/Deterioration

Photo 9: Exterior Masonry Wall - Moisture Damage

Photo10: Efflorescence on Interior Face of Exterior Wall

Photo 11: Exterior Masonry Wall - Moisture Damage

Photo 12: Exterior Masonry Wall -Moisture Damage

Photo 13: Exterior Masonry Wall - Surficial Damage at Walkway

Photo 14: Exterior Masonry Wall - Surficial Damage

Photo 15: Exterior Masonry Wall - Surficial Damage

Photo 16: Exterior Masonry Wall - Surficial Damage

Photo 17: Expansion Joint South of the Gymnasium

Photo 18: Unit C South Entry Stair

Photo 19: Cracked/Frost-Heaved Sidewalk