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MINUTEMAN HIGH SCHOOL
STRUCTURAL EVALUATION – 2012 UPDATE

758 MARRETT ROAD
LEXINGTON, MASSACHUSETTS 02421

Prepared for:

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July 30, 2012

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INTRODUCTION

This updated structural evaluation of the Minuteman High School, located at 758 Marrett Road in Lexington, MA, was undertaken at the request of Mr. Michael McKeon, AIA, of Kaestle Boos Associates, Foxborough, Massachusetts.

The purpose of this structural evaluation was to reassess the structural condition of the Minuteman High School buildings, using the findings in Odeh Engineers' previously issued 2008 Minuteman Career & Technical High Preliminary Structural Examination Report as a starting basis for this report. This structural re-assessment of the Minuteman High School building was to determine whether structurally deficient conditions that were identified in the 2008 report had worsened. In addition, this updated structural evaluation report will be integrated with the Seismic Evaluation report that is concurrently being performed by Odeh Engineers.

STANDARD OF CARE AND USE OF REPORT

Please note that the results of this investigation are limited to visual observations of the accessible areas only. While we have made our best efforts to thoroughly review the areas of concern, many conditions were concealed by architectural finishes or were otherwise inaccessible, and therefore additional damage or other unforeseen conditions may be present. The findings of this report therefore represent our best professional opinion based on the information available to us at this time.

We understand that this report is intended for use only by Kaestle Boos Associates and their client to evaluate the existing structural condition of the Minuteman High School building. In any budgeting, the owner must carry adequate contingency for hidden or unforeseen conditions that are not identified or are worse than described herein.

Please note that all dimensions of the existing structure given herein are approximate and based on measurements of representative members. Dimensions can and will vary, and must be considered as "+/-" in all cases (whether or not the "+/-" symbol is indicated).

DOCUMENTS AVAILABLE

Kaestle Boos Associates provided Odeh Engineers with a virtually complete set of the original Architectural and Structural Design Drawings to assist in the creation of this report.

KEY PLAN

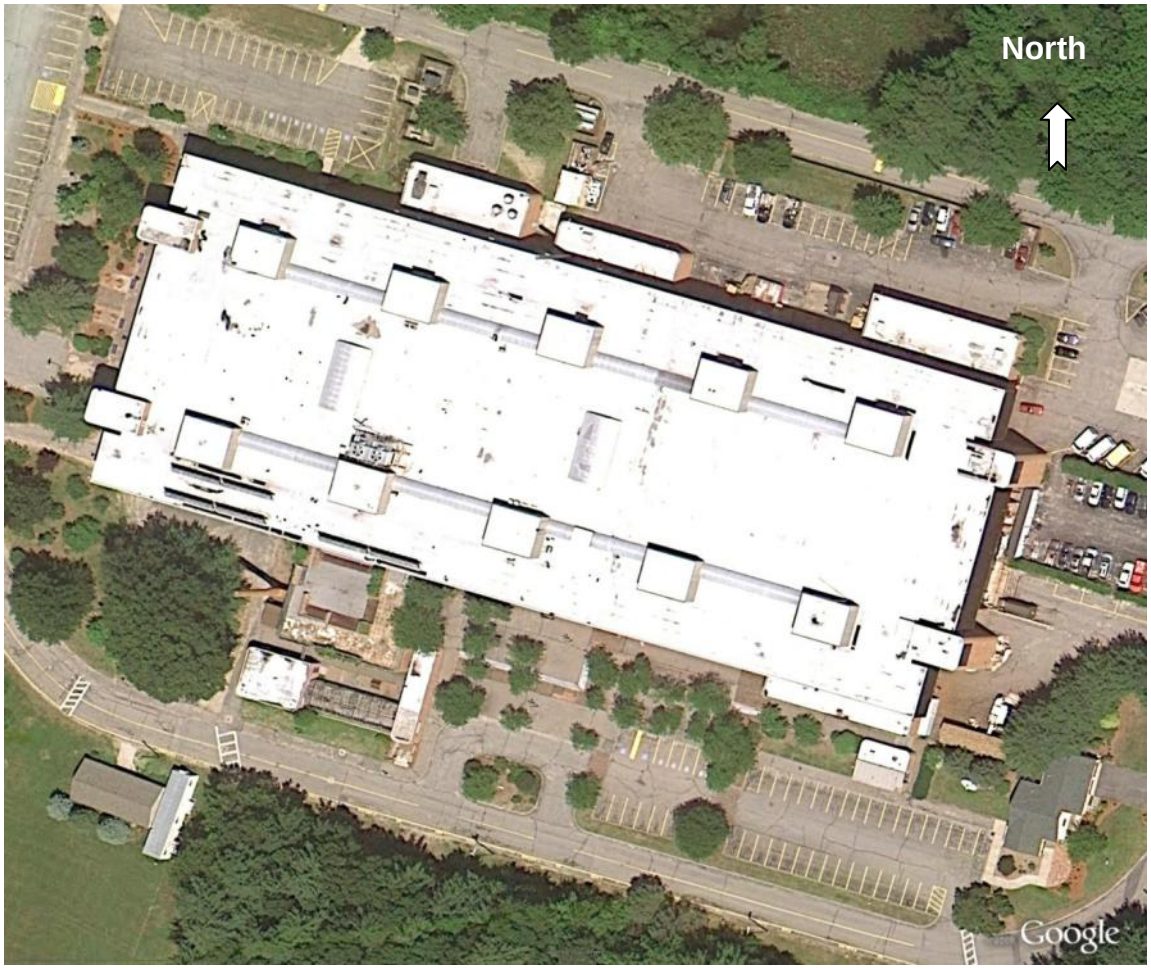

FIGURE 1

Aerial photograph of the Minuteman High School located at 758 Marrett Road in Lexington, Massachusetts. This Key Plan is oriented such that north is vertically up in this image.

ACTIONS TAKEN

Odeh Engineers, Inc. undertook the following actions to complete this structural evaluation:

- On Tuesday, June 19, 2012, Odeh Engineers Project Engineer Dan Batt, P.E. and Field Engineer Paul Wilkinson visited the Minuteman High School. Upon arrival, the Engineers made their presence known to Mr. Matthew MacLean, Facilities Coordinator for the Minuteman High School. Mr. MacLean assigned a member of the Minuteman High School maintenance staff to accompany and assist the Engineers in accessing the building spaces. The Project Engineer and the Field Engineer subsequently conducted a visual examination and assessment of the Minuteman High School building looking for evidence of corrosion, deterioration, displacement, cracks and other indications of structural decay and/or distress.
- On Wednesday, July 11, 2012, Odeh Engineers Field Engineer Paul Wilkinson returned to the Minuteman High School building to perform further investigation of the multi-story building expansion joints.
- Prepared this written summary of findings and recommendations.

DESCRIPTION OF EXISTING STRUCTURE

The Minuteman High School main building is a large, multi-story, steel-framed building constructed on cast-in-place concrete foundations. The ground floor of the building is a concrete slab on grade. A large, below-ground cast-in-place concrete swimming pool is located at the western end of the building.

The exterior walls are typically constructed with brick veneer cavity walls, or with either corrugated or standing-seam Cor-Ten metal siding panels.

The one-story kitchen cafeteria and shop buildings located on the north side of the building are constructed with steel columns supporting steel roof girders and steel roof beams. The steel roof framing supports concrete slabs on composite metal deck.

The one-story Boiler Room on the south side of the building is a steel-framed building with a formed, cast-in-place concrete roof slab bearing on the steel roof beams. The roof of the Boiler Room building was formerly used as an outdoor patio area. The roofing system on this building is unknown.

The elevated floors and the roof of the multi-story main school building are typically constructed with steel columns supporting steel girders and steel beams. The steel framing of the elevated floors and the roof support concrete slabs on composite metal decking.

There are two expansion joints, running north/south through the multi-story building at approximately the one-third points in the school building. The building is laterally braced in the north/south direction with braced frames. Moment frames are used to brace the

building in the east/west direction.

The two pairs of stair towers at the east and west ends of the building are constructed with concrete block masonry back-up walls with a brick veneer. The masonry block back-up walls support the steel framing for the metal pan stairs and the metal deck roof at the top of the stair towers.

The roofing system on the school building is a non-ballasted rubber roofing membrane.

OBSERVED STRUCTURAL DEFICIENCIES, POTENTIAL PROBLEM AREAS, AND COMMENTS

The following structural deficiencies and potential problem areas were observed by Odeh Engineers, Inc. during our investigation of the existing building. Each observation is accompanied by comments on the cause and impact of the deficiency. Please refer to the photographs in Appendix A for additional information.

- **Cracks in the concrete floor slab-on-grade throughout the school building:** Numerous cracks were observed in the ground floor concrete slab on grade. **(Photo #1)**
  - **COMMENT:** The cracks in the Ground Floor concrete slab on grade appear to be shrinkage cracks caused by improper construction or improper curing of the concrete floor slab. These cracks degrade the usefulness and serviceability of the concrete floor slab, but are not structurally detrimental.

- **Cracks and spalls in the concrete floor slab in the natatorium and abutting pool filter room:** Several cracks and spalls were observed in the concrete apron around the swimming pool and in the floor of the adjacent filter room. **(Photo #2.)**
  - **COMMENT:** The cracks and spalls in the apron around the swimming pool and in the pool filter room are likely exacerbated by the corrosive action of the chlorine that is contained both in the water and in the air in these rooms. Preventative actions should be taken to repair these cracks and spalls to arrest further degradation of the floor slabs in these rooms.

- **Deteriorated metal form deck under concrete between pool and surge tank in pool filter room:** It was reported to Odeh Engineers that the metal deck under the concrete in the tunnel area between the pool and the pool surge tank in the filter room was deteriorated. This area can only be accessed when the pool is drained. **(No photos available.)**
  - **COMMENT:** Odeh Engineers review of the original structural drawings for this area shows metal form deck at this location. It appears that the metal form deck is used only to act as a temporary form for the cast-in-place concrete slab until the concrete hardened. Provided the structural concrete remains in good condition, the deteriorated metal form deck could be

removed with no adverse effects. Alternatively, the metal form deck can be left in place, cleaned, and painted with an epoxy coating system.

- **Cracks and spalls in the natatorium concrete bleachers at guardrail inserts:** Large cracks and spalls have occurred at several locations in the natatorium where the guardrails for the bleacher seating around the swimming pool are pocketed into the concrete. **(Photos #3 and #4.)**
    - **COMMENT:** The cracks and spalls in the concrete where guardrails are pocketed into the concrete bleachers appear to be caused by the expansive corrosion of the steel inserts that secure the ends of stainless steel guardrail posts. Under the current conditions, the guardrails may not be able to resist the thrust for which they were designed. Odeh Engineers recommends that the guardrail steel inserts be replaced with stainless steel inserts and the cracked and spalled concrete be repaired with modern, high-performance concrete repair products.

- **Numerous cracks in interior masonry block partition walls:** Throughout the school building, many cracks were observed in the non-bearing concrete masonry block partition walls. The cracks are typically found where the building steel columns are contained within these walls. **(Photos #5 and #6.)**
    - **COMMENT:** The cracks in the interior masonry block partition walls appear to have occurred due to two main reasons. Apparently during construction of these walls, there was not sufficient room provided within the wall cavities to accommodate the movement of the building structural frame. Compounding this problem is the fact that weaknesses in the blocks are created by having to notch the masonry block webs and face shells to accommodate the structural members. The movement of the structural frame due to lateral loads and thermal dimensional changes may impinge upon the notched blocks, causing the walls to move and crack. Secondly, there are virtually no control joints in the masonry walls to allow for dimensional changes in the masonry due to temperature and moisture variations. A third possible factor causing the cracks and displacements in the masonry may involve the expansion joints in the multi-story building. This factor will be addressed later in this section of the report. Although the walls are structurally stable in their current condition, the cracks in the masonry block partition walls substantially reduce the strength of these walls to resist lateral movements during severe wind or seismic events. In addition, fragments of masonry block may fall out of these cracks over time and could cause personal injury.

- **Water infiltration and the growth of vegetation has damaged the exterior brick walls of the Boiler Room building and the terrace walls and pavers above the Boiler Room building:** Long term water infiltration and the subsequent growth of vegetation has damaged the exterior brick walls of the Boiler Room building and the brick walls and the patio pavers of the terrace above the roof of the Boiler Room building. **(Photos #7 to #11.)**

- **COMMENT:** In addition to damaging the exterior walls of the Boiler Room building, and the terrace walls and pavers above, the water infiltration may be jeopardizing the structural concrete roof slab of the Boiler Room building. It was reported to Odeh Engineers that some minor repairs to the exterior brick veneer walls of the Boiler Room building had been performed since Odeh Engineers previous investigation in 2008. However, no long-term, systematic repairs to these exterior brick walls have been undertaken.

- **The load-bearing masonry block walls at the two pairs of stair towers located at the east and west ends of the school building are cracked and displaced:** The masonry block walls at the two pairs of stair towers are cracked and displaced. The most significant cracks occur in the masonry pillars on each side of the window openings just below the high roof framing elevation. **(Photos #12 to #16.)**
  - **COMMENT:** Based on our recent examination of these structures, it appears that the cracking and displacements of the load-bearing masonry block walls of these stair towers may be due to the movement of the steel frame of the building from thermal expansion and contraction (see discussion of improperly constructed roof expansion joints below), and/or from lateral wind loads.

    Additionally, the tall slender nature of the masonry pillars (which appear to be unreinforced), make them particularly susceptible to flexural cracking due to lateral movement of the stair tower. At the high roof level, the stair structure is not tied back to the main superstructure and therefore these pillars may be moving excessively under wind loads.

    In order to mitigate additional cracking and deterioration of the masonry stairway walls, Odeh Engineers recommends that the slender "pillars" at the top of each stairwell be removed and reconstructed using solid grouted and reinforced masonry piers.

- **The roofing system on the school building has reached the end of its useful life:** The rubber roofing membrane on the roof of the building has reportedly been patched many times. The failed roofing system has led to roof leaks into the building. The roof leaks have caused some corrosion and deterioration of the composite metal roof decking. Many of these roof leaks have occurred at, or near the roof drains, and along the two expansion joints in the building. **(Photos #17 to #20.)**
  - **COMMENT:** The roofing system needs to be replaced as soon as possible. Continuing roof leaks may cause significant deterioration of the composite metal roof decking and the concrete slab. Long-term roof leaks can create serious structural issues if left unattended.

- **Minor cracking of the exterior brick walls:** Minor cracking of the exterior brick walls was noted at several locations. **(Photos #21 and #22.)**
  - **COMMENT:** In general, the cracking of the brick veneer appears to be the result of an insufficient number of control joints to allow for the expansion and contraction of the brick. A maintenance program of repairing the bricks

and raking and repointing the mortar joints should be established to prevent water from entering the building envelope through these cracks. The creation of additional control joints should be considered.

- **Failed or missing joint sealants in the exterior brick walls:** Odeh Engineers noted several locations where the sealants in the existing control joints in the exterior brick walls has failed or is missing. **(Photos #23 to #25.)**
    - **COMMENT:** A maintenance program should be established to restore the sealants and the functionality of the control joints to prevent water infiltration and to assure the long-term performance of the brick veneer.

- **Deteriorated closure plates on base of Cor-Ten siding:** The closure plates at the base of the exterior wall vertical metal siding panels have deteriorated at many locations around the building. It was reported to Odeh Engineers that the deterioration of some of the bottom closure plates was so severe that the closure plates were removed. Birds and bees are nesting in the voids of the metal siding panels that are exposed by the deteriorated or missing closure plates. **(Photos #26 and #27.)**
    - **COMMENT:** The deteriorated bottom closure plates for the exterior wall metal siding panels are not structural. This is an architectural issue.

- **No sliding movements of structural frame members was observed at either of the multi-story building roof framing expansion joints:** At all roof framing expansion joint connections observed by Odeh Engineers, there was no evidence of the sliding movements of the roof framing members that is expected at the expansion joints. Furthermore, the roof level expansion joints were not constructed in conformance with the structural details. **(Photos #28 to #31.)**
    - **COMMENT:** The steel members at the roof level expansion joints typically have the greatest amount of movement due to the changes in temperature from the heat of the sun and the winter cold. The roof framing members at the expansion joints are typically covered with a thick, stiff coating of spray-applied fire resistance material (SFRM). Assuming that the expansion joints were functioning properly, cracks should have developed in the SFRM where the opposing sides of the roof framing structural members at the expansion joints would move relative to each other. No cracks in the SFRM or any other indications of movement of the opposing members on each side of the expansion joints were in evidence.

      In addition, the original structural details of the roof level expansion joints show a bent plate supporting the concrete slab from the adjacent girder to the joint. In the existing construction, no bent plate was installed and the metal decking extending from the roof girder to the joint supports the concrete roof slab. This means that the concrete roof slab effectively ties together both sides of the expansion joint, likely restraining the movement of the joint.

      The apparent lack of functioning expansion joints may cause excessive movements of the steel framing over the length of the building and may be

exacerbating the cracking and displacements of the masonry walls found throughout the building.
As part of any renovation, Odeh Engineers recommends that the expansion joints be reviewed and perhaps repaired to allow for improved movement in the steel frame. Odeh Engineers will also address concerns related to seismic loading through these joints in a separate report on seismic deficiencies in the building.

CONCLUSION

The building is in generally good condition with the exception of the localized deficiencies identified above. Odeh Engineers has performed additional investigation into specific areas of cracking and structural distress observed in our previous report from several years ago, and provided additional guidance on the potential causes and repairs of these items.

We trust that this report meets your needs at this time. Should you have any questions, or require any additional information, please do not hesitate to contact this office.

Sincerely,

Paul Wilkinson
Field Engineer

David J. Odeh, PE, SECB
Principal in Charge

APPENDIX A: PHOTOGRAPHS

Photo #1

Photo of one of the many cracks in the ground floor concrete slab on grade found throughout the school building.

Photo #2

This photo shows some of the cracks and spalls in the natatorium and pool filter room concrete floor slab.

Photo #3

This photo shows one of the several locations where cracks and spalls have occurred where the natatorium bleacher seating guardrails are pocketed in the concrete.

Photo #4

This photo shows another location where cracking and spalling of the natatorium bleacher seating has occurred where the guardrails are pocketed in the concrete.

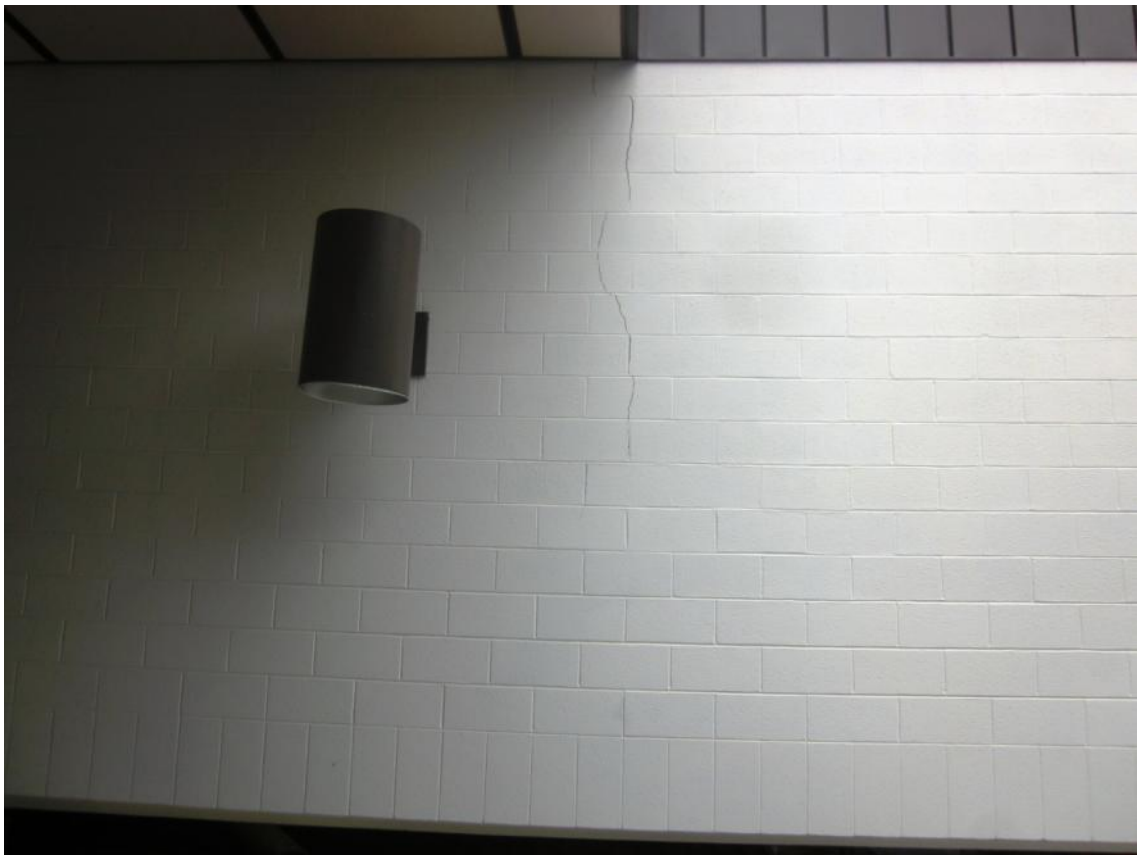

Photo #5

This photo shows one of the many cracks found in the non-bearing interior masonry block partition walls.

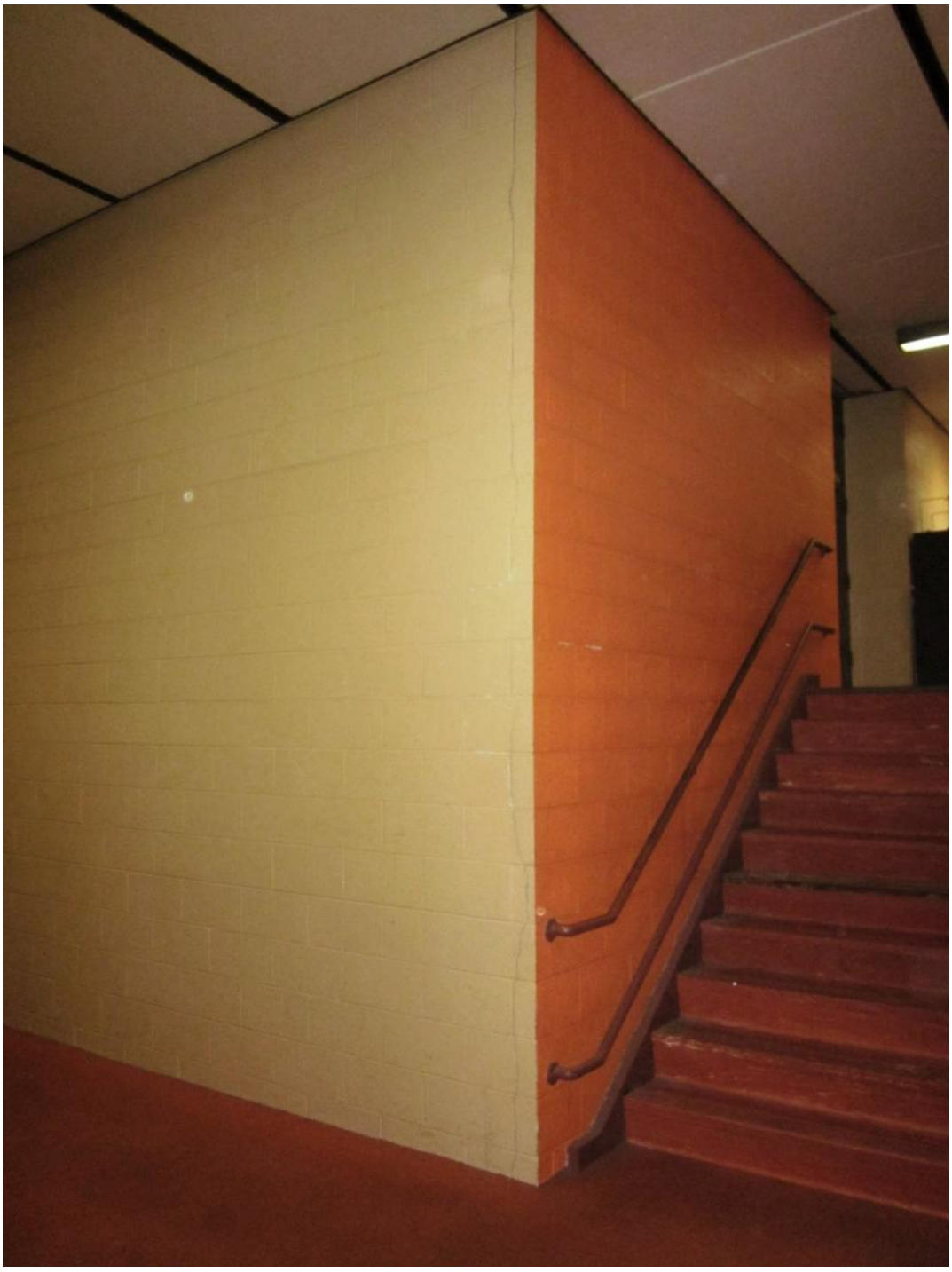

Photo #6

This photo shows another of the many locations throughout the school building where the interior masonry block partition walls are cracked.

Photo #7

This photo shows the damage to the brick walls and the patio pavers at the terrace above the roof of the Boiler Room building due to long-term water infiltration and vegetative growth.

Photo #8

This photo shows another view of the damage done to the terrace above the Boiler Room roof from long-term moisture infiltration and vegetative growth.

Photo #9

This photo shows the efflorescence leaching from the exterior brick walls along the east side of the Boiler Room building resulting from water infiltrating these walls from the terrace above.

Photo #10

This photo shows another view where water infiltration from the terrace above is damaging the south brick wall of the Boiler Room building.

Photo #11

This photo shows the efflorescence leaching from the west exterior wall of the Boiler Room building due to water infiltration from the terrace above.

Photo #12

This photo shows the typical cracking of the masonry block walls found at each of the multi-story stair towers located at the east and west ends of the school building.

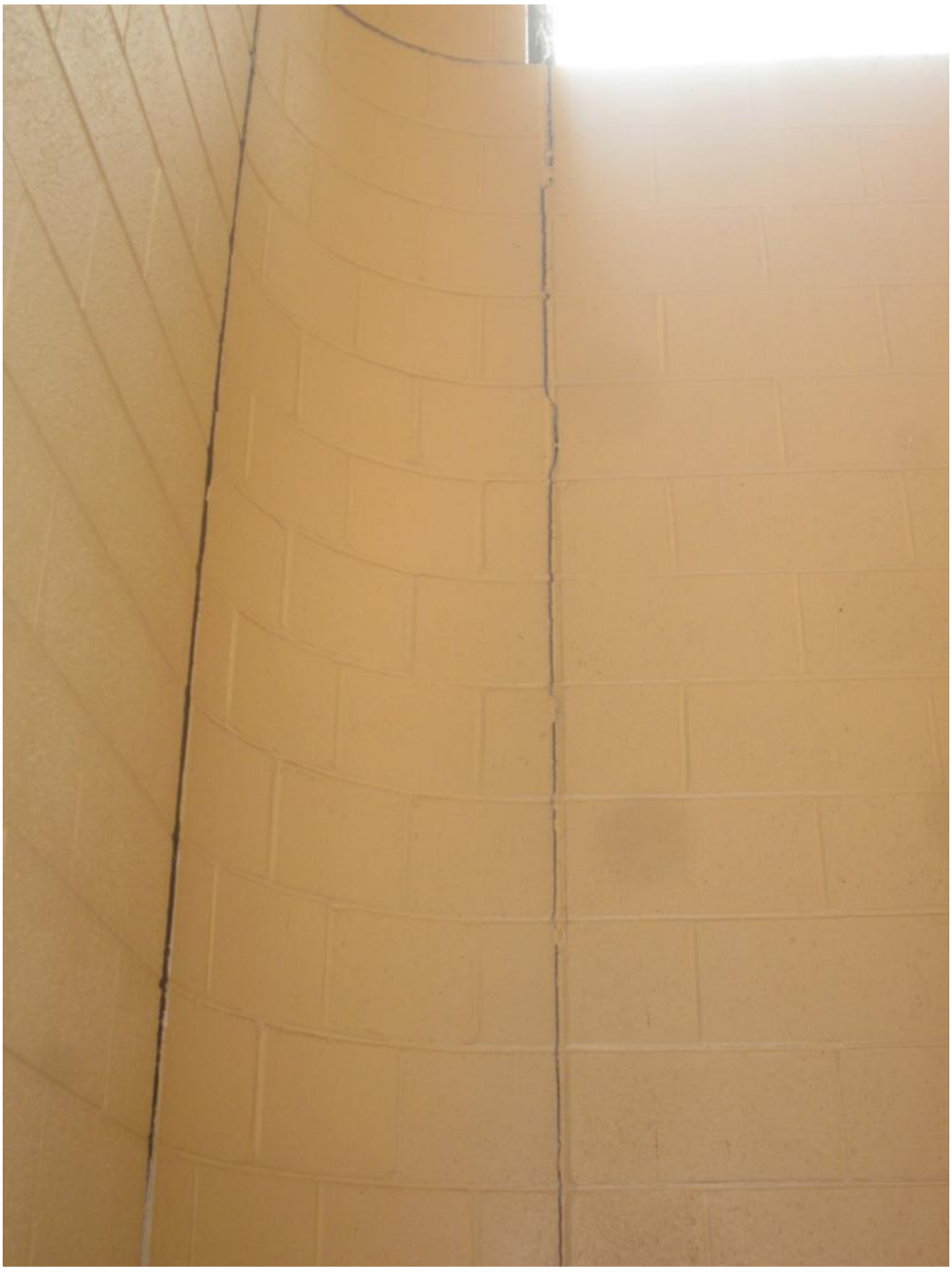

Photo #13

This photo shows the vertical crack in the load-bearing masonry block walls of one of the multi-story stair towers at the east and west ends of the building.

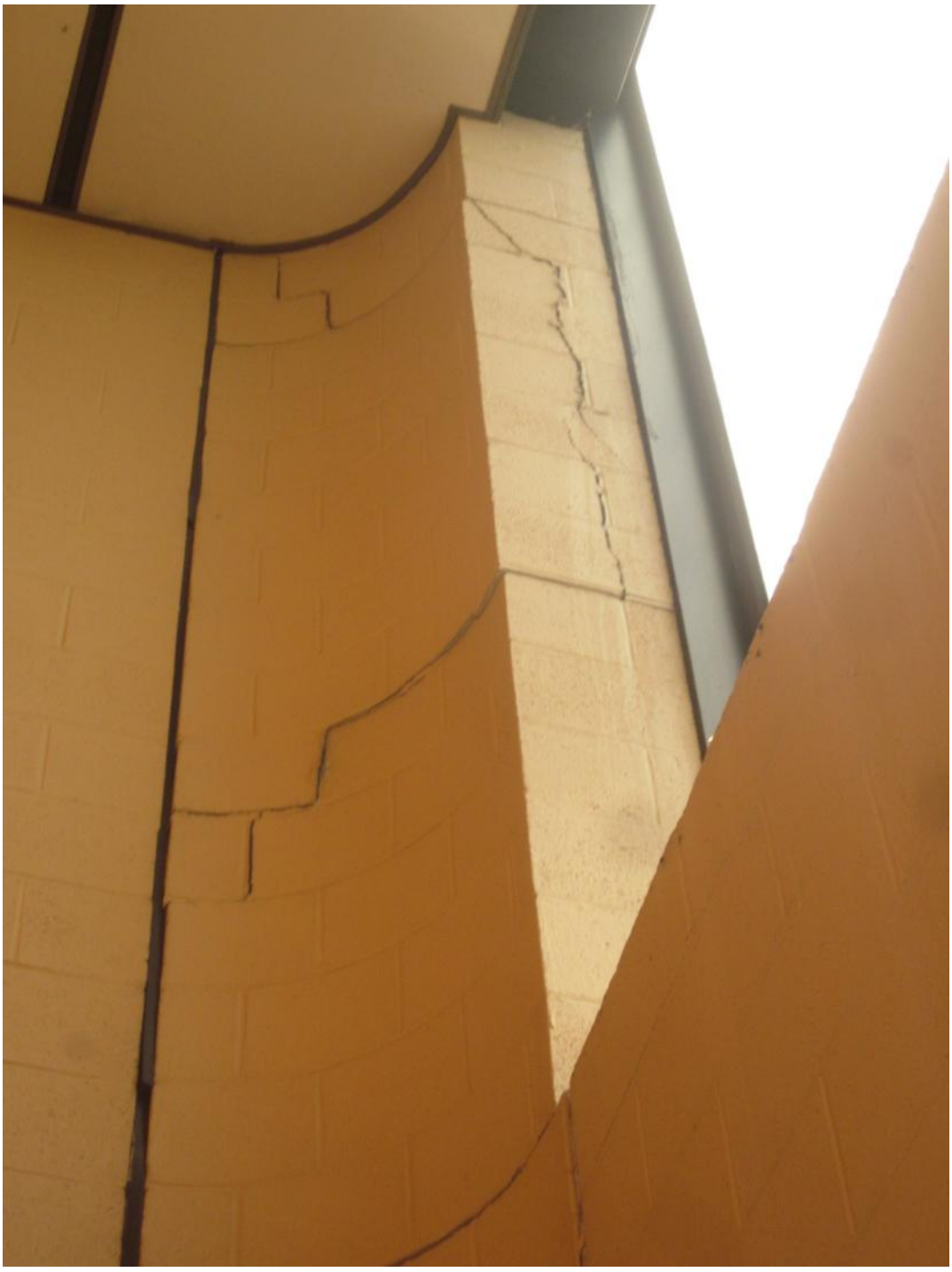

Photo #14

This photo shows the cracking and displacements of the masonry pier along the window of the multi-story stair towers at the east and west ends of the school building.

Photo #15

This photo shows the cracking and displacement of another of the concrete block walls in the stair towers at the east and west ends of the school building.

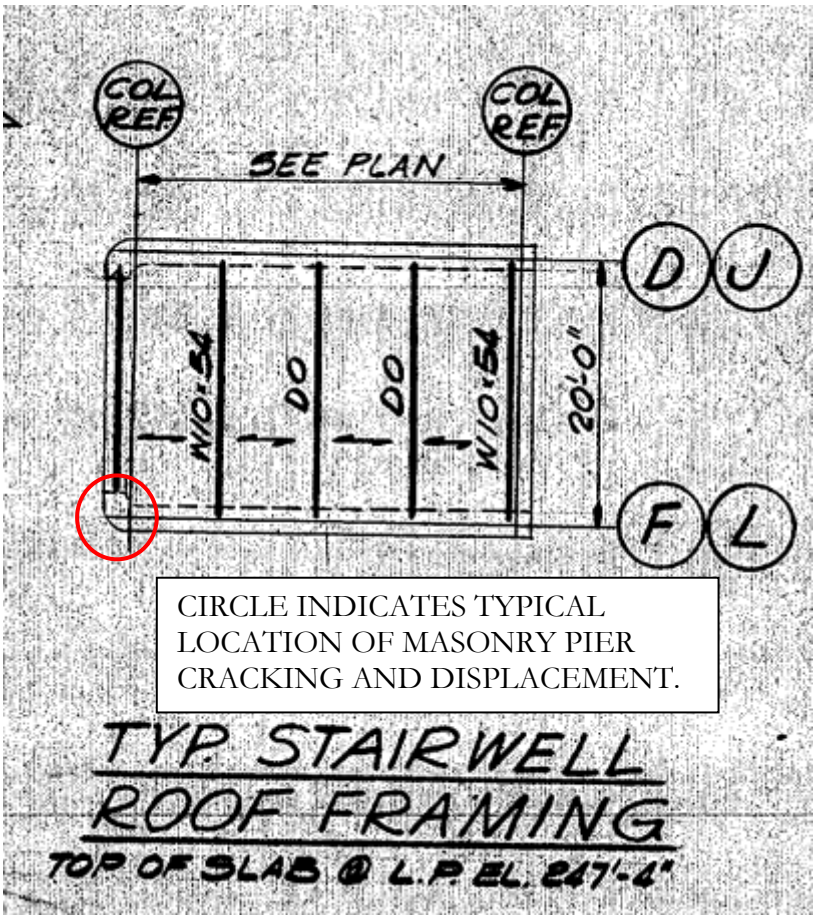

Photo #16

This photo shows a copy of the typical stairwell roof framing of the stair towers at the east and west ends of the school building.

Photo #17

This photo shows some of the many patches in the aged roofing system on the school building roof.

Photo #18

This photo shows one of the locations where minor corrosion of the composite metal roof deck has occurred apparently from leaks in the roofing membrane.

Photo #19

This photo shows the corrosion of the composite metal roof decking along one of the expansion joints in the roof of the school building.

Photo #20

This photo shows another of the roof leaks that has occurred along the expansion joint adjacent to the Instructional Media Center.

Photo #21

This photo shows one of the locations where minor cracking of the exterior brick veneer has occurred.

Photo #22

This photo shows another location where cracking of the brick veneer has occurred.

Photo #23

This photo shows one of the many locations where the joint sealant in the exterior brick wall control joint is partially missing.

Photo #24

This photo shows another location where the sealant in the exterior brick wall control joint is missing.

Photo #25

This photo shows another location where the sealant is missing from the top of the control joint, and the sealant is being squeezed out from the lower portion of the exterior brick veneer control joint.

Photo #26

This photo shows the deterioration of the bottom closure plate at the base of the Cor-Ten metal siding on the west side of the school building.

Photo #27

This photo shows a location where the bottom closure plate for the exterior wall metal siding panels was reportedly removed due to significant deterioration of the closure plate.

Photo #28

This photo shows one of the steel roof beams framing into a steel roof girder along the west expansion joint of the multi-story building. The gray material on the roof beam and girder is the spray-applied fire resistance material (SFRM). The roof beam is seated on a slide-bearing assembly mounted on the roof girder. No visible evidence of cracking of the SFRM or other indications of movement of the steel framing on opposite sides of the expansion joint can be seen.

Photo #29

This photo shows another of the sliding-bearing assemblies located along the west expansion joint of the multi-story building. Again no evidence of the expected movement of the framing members on opposing sides of the joint can be seen.

Photo #30

This photo shows the sliding-bearing assembly located along the east expansion joint of the multi-story building. Note the lack of the bent plate and the installation of the metal roof decking between the roof girder and the joint.

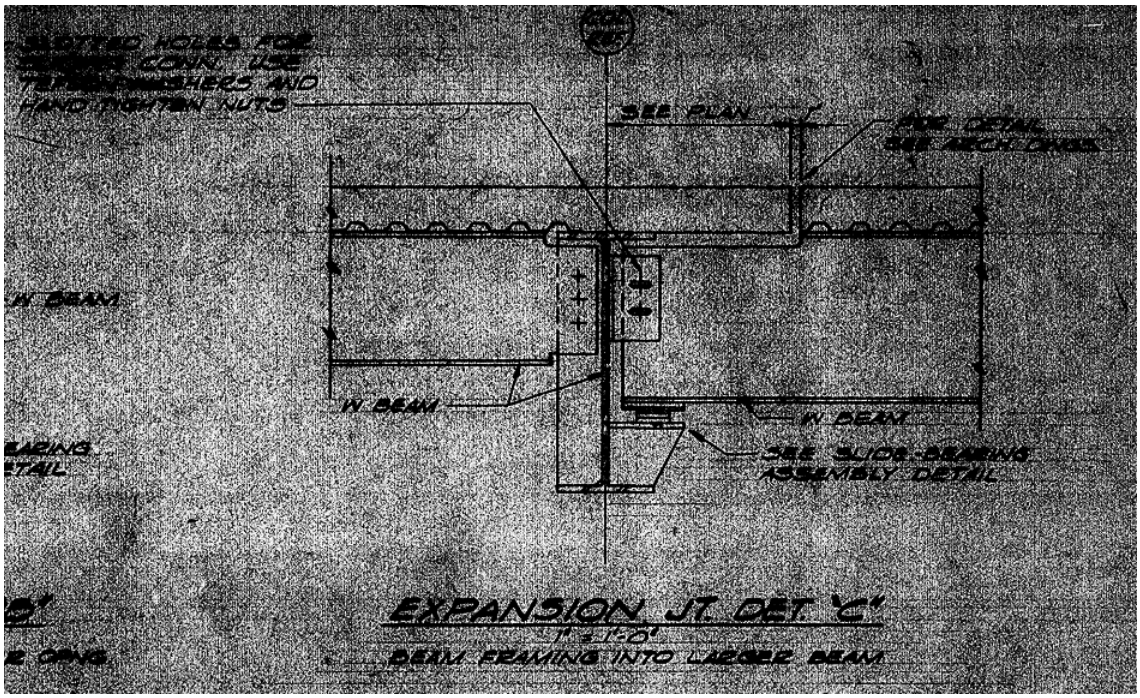

Photo #31

This photo shows a copy of the typical roof framing level expansion joint detail in the multi-story building. Notice the steel bent plate that was to extend from the roof girder to the slab expansion joint.