Existing Structural Conditions Report

INTRODUCTION

This report describes the existing condition of the structure of Fort River Elementary School as relevant to the potential school renovation project.

Discussions and findings in this report are based on:

- A walk-through site visit performed by staff of Lim Consultants, Inc. on September 24, 2018 to observe the condition of the existing building.
- Original architectural and structural drawings dated December 27, 1971 by Alderman and MacNeish Architects and Engineers.

EXISTING STRUCTURAL SYSTEM

The Fort River Elementary School was designed in 1971 by Alderman and MacNeish Architects and Engineers. The school is primarily a single story steel structure. The building is roughly rectangular in shape and covers a footprint of approximately 392' in the north south direction and 236' in the east west direction. The building is comprised of two structurally independent halves separated by a 1" expansion joint running in the north-south direction.

Roof Structure

The roof structure of the school is constructed non-composite steel roof deck on open web steel joists spanning between 30' to 41' in the north south direction. The joists are typically 18" deep in most areas, and 16"-22" deep in select spans. Most of the open web steel joists are installed pitched at one angle to conform with the roof profile. Sheet 1223-CD-S1 of the 1971 original drawings notes that the design total load for the roof deck is 45psf and the design total load for the open web steel joists is 55psf. The design roof live load is 30psf, which is in accordance with current codes. The open web joists rest on wide flange steel beams running in the east west direction. Typical beam spans are up to 35'. The beams rest on 4"x4" square or 4" diameter round tube steel columns in most areas and wide flange columns in select higher ceiling areas. The columns range from 8' to 25' in height. The general notes on sheet 1223-CD-S1 of the 1971 original drawings notes that all steel used has a yield strength of 36ksi.The steel roof structure of the building is founded on concrete spread footings resting on clay with a bearing pressure of 2500 psi. Footing sizes range from 3' square to 6' square and are located concentrically under the columns.

Mezzanine Structure

The only framed floor in the building is a small mezzanine floor for the mechanical room of the gymnasium. The mezzanine floor is constructed of concrete encased steel beams and columns. Sheet 1223-CD-S1 of the 1971 original drawings notes that the floor is designed for a live load of 100 psf.

Ground Floor Structure

The ground floor of the structure is a 4" concrete slab on grade in all areas. The slab is thickened to 12" with a haunch in locations below infill CMU masonry walls. Sheet 1223-CD-10 of the 1971 original drawings notes that the slab concrete strength is 3000 psi.

Lateral System

The lateral load resisting system is not explicitly stated in the 1971 drawings. The steel frame is not detailed as a lateral load resisting moment frame and no steel braces are provided. We suspect that the majority of the lateral loading is carried by the 8" thick CMU infill walls that are provided between beams and columns throughout the building. However, these walls do not appear to be detailed as shear walls. The CMU cells are not grouted or reinforced as shown in Figure 1. In many areas, the top of the CMU walls lack engagement to the beams and trusses above as shown in Figure 2. Thus, there is no engagement between the diaphragm and the CMU walls.

There is no reference to a building code or seismic loading on the drawings. Since the building's design in 1971 predates the first edition of the Massachusetts State Building Code, which became effective in 1975, earthquake loading was unlikely to be considered in the design.

Figure 1 – CMU Walls are ungrouted and unreinforced.

Figure 2 – Gap between top of CMU walls and steel structure

OBSERVED CONDITIONS AND REPAIRS NEEDED

The staff of Lim Consultants performed a general walk-through of the interior and exterior of the building and noted the existing condition of the structure. Observations were made from accessible, non-locked locations where the structure was exposed to view. Ceiling tiles were removed in select areas of the building to observe the construction of the roof structure, but no investigative demolition was performed. The structure appeared to be in overall good condition. The following are the noted observations pertaining the structure:

1) Expansion joint is provided in the steel roof structure, but not in the CMU infill wall. The CMU infill wall is cracking due to missing expansion joint. This is a cosmetic defect as the CMU wall is non-bearing.

Figure 3 – Crack in CMU wall is cosmetic and not a structural concern.

2) The steel deck, open web joists, girders, and columns appeared to be in very good condition. There are no signs of corrosion or deterioration from the locations above removed ceiling tiles.

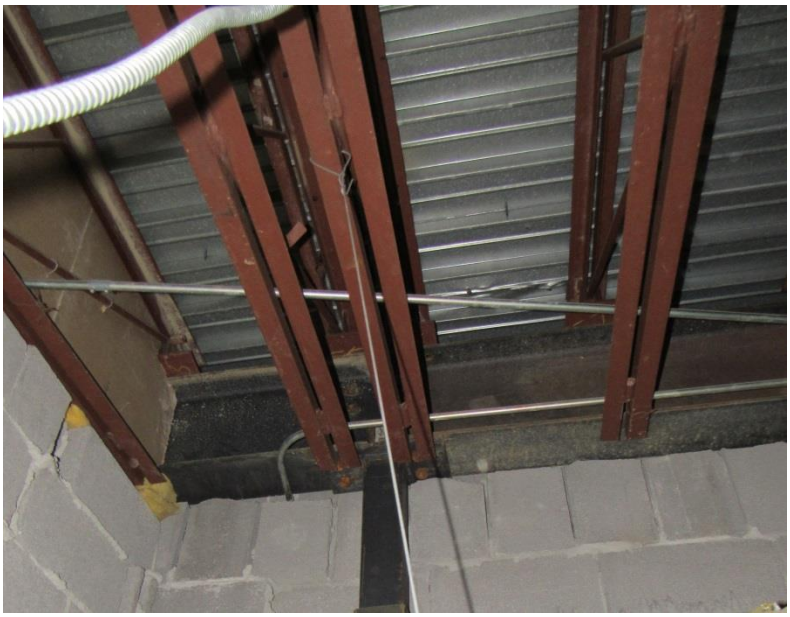

Figure 4 – Steel framing appears to be in excellent condition

3) The bolts are missing in this beam to column connection near gridline C-10. Bolts shall be replaced in all instances where a positive connection is missing.

Figure 5 – Bolts Missing in Beam Column connection

STRUCTURAL CONSIDERATIONS ON BUILDING CODE

Chapter 34 of Massachusetts State Building Code, which is a Massachusetts-amended version of the International Existing Building Code (IEBC), governs the proposed renovation. The requirements below are based on the 9th Edition MSBC, which amends IEBC 2015. The following discussion assumes the IEBC's work area method for alterations will apply to the renovation.

Alterations to Gravity Load Supporting System

According to IEBC, all existing structural members – deck slabs, beams and girders, bearing walls, and foundation in the load path of the new equipment, roofing, and other associated loads must be assessed for capacity under the proposed design gravity loads. Any stress increase in the existing members must be limited to 5 percent; all new structural members must comply with the requirements of the current International Building Code (IBC). When the 5 percent limit is exceeded, the existing structural members in the load path must be evaluated and reinforced if necessary to support the increased loading.

Alterations to Lateral Load Supporting System

The IEBC states that any existing lateral load-resisting structural element whose demand-capacity ratio with the alteration considered is more than 10% greater than its demand-capacity ratio with the alteration ignored shall comply with the reduced IBC level seismic forces.

If the demand-capacity ratio increases by more than 10% due to weakening/removal of lateral members, increased seismic mass, increased wind area, etc., the structure will require re-analysis and reinforcement where necessary. If the demand-capacity ratio increase do not exceed 10%, the proposed upgrades on lateral load carrying members will not be required.

In the Fort River Elementary School, we recommend minimal alterations to CMU walls along column lines and the exterior, as they are carrying the lateral loads. Other CMU is likely non-structural. If renovations do require the removal of more CMU, the structure will require re-analysis and will very likely require the addition of braced frames or shear walls. Horizontal in-plane bracing may be required pending analysis of roof diaphragm. Foundation work may also be necessary under braced frames and shear walls.

Diaphragm Anchorage

There are two triggers for diaphragm anchorage per the MSBC. If either of these triggers are met, the connection between the roof diaphragm and the masonry wall must be analyzed to take the IBC level reduced wind and seismic loads. If found inadequate, reinforcement of the diaphragm-wall connection with shear connectors, clip angles, or studs will be necessary on the entire building.

The first trigger is specified in IEBC section 907.4.5, which applies to buildings alterations which meet all of the following:

-Level 3 alteration (defined as reconfiguration of space in over 50% of building area)

-Building contains unreinforced masonry

-Are in seismic design categories B, C, D, E, or F

For the Fort River Elementary school, the CMU masonry is unreinforced and the building is very likely to be in seismic design category B, C, D, E, or F. If a Level 3 alteration is required, the diaphragm anchorage requirement will be triggered.

The second trigger is specified in IEBC section 707.3.2, which applies to building alterations which meet all of the following:

-Re-roofing work is planned for the entire area of the roof

-Building is located where the ultimate design wind speed is greater than 150 mph or the building is Risk Category IV per table 1604.5 of IBC 2015

For the Fort River Elementary School, this second clause will not be triggered because the ultimate design wind speed for Amherst for either Risk Category III or IV is 125 mph, which does not exceed the 150 mph threshold designated by Chapter 34 of MSBC.

Addition

In a horizontal addition, the IEBC requires re-analysis of the existing structure to comply with current IBC load requirements if the addition is structurally integrated. If expansion joints are provided to separate the existing and new building, only the new building is required to comply with the IBC load requirements for new buildings.

The IEBC also requires re-analysis of the existing building if the new building will impact the snow drift on the existing building. Therefore, analysis and possible retrofit will likely be required if an adjacent addition is taller than the existing structure.