WINTHROP MIDDLE/HIGH SCHOOL
Winthrop, Massachusetts

Schematic Design Structural Narrative
July 17, 2013

INTRODUCTION

Foley Buhl Roberts & Associates, Inc. (FBRA) is collaborating with HMFH Architects, Inc. (HMFH) in the design of a new Middle/High School for the Town of Winthrop, to be constructed on a relatively flat site in the location of the present High School.

Structural systems and materials for the proposed, new school are described in this Schematic Design Structural Narrative. Estimated quantities of structural materials and Structural Outline Specifications are also included. This narrative is based on the preliminary Architectural Drawings prepared by HMFH, the September 6, 2011 Preliminary Foundation Engineering Report prepared by McPhail Associates, LLC and on discussions with the Project Team. It is intended to be used in conjunction with the Schematic Design Structural Drawings and the Schematic Design documents of the other disciplines, as the basis of the preliminary cost estimate.

I. GENERAL DESCRIPTION:

Program elements for the new, three-story school include classrooms, a Gymnasium an Auditorium, a Cafeteria/Kitchen and Administrative Offices. The new school will be approximately 185,000 square feet in area and will accommodate students in Grades 6 through 12.

The building will be steel framed, for reasons of economy, performance, flexibility and speed of construction. A composite structural steel floor system is proposed, as it exhibits superior stiffness, vibrational characteristics and less structural depth, compared to other steel floor framing systems. Floor framing will be wide flange steel beams and girders, acting compositely with cast-in-place concrete floor slabs on steel deck. Shear studs will be field welded to the beam/girder flanges to achieve composite action with the floor slab. The roof will be steel framed as well, with steel roof deck supported by wide flange steel beams and columns (no concrete slab). Longspan steel joists will be used at the Auditorium and Gymnasium roofs to economically achieve these larger, column free spaces. Typical columns will be rectangular hollow steel tube sections. Lateral stability for wind and seismic loads will be provided by steel bracing in each direction. Floor and roof steel framing will be surface prepped and be left unpainted, except at areas that will ultimately be exposed to view (Gymnasium).

Recent subsurface soil explorations (borings taken by McPhail Associates) indicate the presence of a varying depth fill layer on the site, overlying a discontinuous organic deposit. The fill and/or organic deposit is underlain by a marine deposit (clay underlain by sand). Subsurface information provided on the 1963 plans indicated similar soil profiles. Accordingly, there are premium foundation costs associated with this site. Foundations will be conventional shallow spread footing construction with a concrete slab on grade, bearing on natural soils that have been improved with Rammed Aggregate Piers (RAPs) or on compacted structural fill. The existing building and its foundations, along with existing utilities will be entirely removed prior to preparation of the site for the new building foundations. Groundwater was generally observed at depths ranging from about 6 to 8 feet below the existing ground surface; dewatering will be required during foundation construction.
Exterior walls will typically be masonry veneer at the base with architectural panels above, along with limited areas of glazed curtainwall. A galvanized, light gauge steel stud backup wall (16 gauge minimum thickness at brick veneer areas) will be provided in all veneer and panel areas.

II. BASIS OF DESIGN:

Codes and Design Standards


Steel Joists: SJI “Standard Specifications for Joists and Joist Girders”.

Concrete: ACI 318 and ACI 301; latest editions.

Design Loads/Parameters

Live Loads:

- Classrooms (with partition allowance): 70 PSF
- Corridors: 80 PSF
- Open plan areas: 100 PSF
- Stairs: 100 PSF
- Mechanical Areas: 150 PSF

Snow Loads:

- Basic Ground Snow Load (Winthrop): 45 PSF

Wind Loads:

- Wind Speed (Winthrop): 105 MPH

Seismic Parameters:

- Spectral Response – Short Periods: \( S_8 = 0.29g \)
- Spectral Response – 1-Second Periods: \( S_0 = 0.068g \)
- Seismic Use Group: III
- Seismic Design Category: C
- Site Class: D
- Structural System: Building Frame System
- Lateral Load Resisting System: Steel Braced Frames (*Not Specifically Detailed for Seismic Resistance*)

Response Modification Factor (R): 3.0
System Overstrength Factor (\( \Omega \)): 3.0
Deflection Amplification Factor (\( C_d \)): 3.0
Foundations:

The preliminary foundation design is based on an allowable bearing capacity of 4.0 kips per square foot (2.0 tons per square foot) on natural soils (improved with RAPs) or on compacted structural fill, based on the recommendations of McPhail Associates, LLC in their referenced report.

Construction Classification:

The new building will be Type IIB Construction (Noncombustible, Unprotected). Floor and roof construction do not require applied fireproofing, except when supporting rated enclosures. The new school will be fully sprinklered.

Sustainable Design Considerations:

Sustainable design considerations will be incorporated into the design; it is intended that the new building will follow the provisions of the Collaborative for High Performance Schools, Massachusetts High Performance Green School Guidelines: MA-CHPS Criteria.

III. STRUCTURAL SYSTEMS DESCRIPTION:

(Refer to the Schematic Design Structural Drawings for additional information)

Structural Bays/Spans: Structural bays/spans vary; however, the typical structural bay is 28 feet square. Roof spans over the Gymnasium and the Auditorium are approximately 112 feet and 70 feet, respectively.

Story Heights/Floor Elevations: The typical story height is 14'-0". The First Floor will be located approximately 4 feet above the present, exterior grade (similar to the existing High School).

Footings and Foundations: The preliminary foundation design is based on an allowable bearing capacity of 4.0 kips per square foot (2.0 tons per square foot) on natural soils (improved with RAPs) or on compacted structural fill, based on the recommendations of McPhail Associates, LLC. The typical, exterior perimeter foundation wall is designed as a cantilever retaining wall to facilitate the placement of compacted structural fill for the First Floor slab on grade (located approximately 4 feet above the average exterior finished grade).

As previously noted, subsurface soil explorations indicate the presence of a varying depth fill layer on the site, overlying a discontinuous organic deposit. The fill and/or organic deposit is underlain by a marine deposit (clay underlain by sand). Groundwater was generally observed at depths ranging from about 6 to 8 feet below the existing ground surface. Foundations will be conventional shallow spread footing construction with a concrete slab on grade, bearing on natural soils that have been improved with Rammed Aggregate Piers (RAPs) or on compacted structural fill. The existing building and its foundations, along with existing utilities will be entirely removed prior to preparation of the site for the new building foundations. Dewatering will be required during foundation construction.

Drainage: The need for foundation or underslab drainage systems is not anticipated, as there are no proposed basement areas. However, since groundwater was generally encountered at a depth of 6 to 8 feet below the present ground surface, dewatering will be required during foundation construction.
First Floor Construction will typically be a 6" thick concrete slab on grade, reinforced with No. 4 bars in each direction. The slab will be underlain by a heavy duty vapor barrier, 2" of rigid insulation and 6" of compacted gravel. Saw cut control joints (1½" deep) will be provided in each direction along each column line. Full depth isolation joints will be constructed around columns.

Second and Third Floor Construction: Composite structural steel framing: 3½” thick (minimum), normal weight concrete topping slab on a 2” deep, 18 gauge, composite type, galvanized steel floor deck (5½” minimum total slab thickness), reinforced with welded wire fabric, spanning 9'-4” to composite structural steel beams. All composite steel beams and girders will be unshored. Composite action will be achieved by field welding ¾” diameter x 4” long headed shear studs through the deck, to the top flanges of the beams and girders. To avoid compromising composite action, conduit or other, similar embedded items should not be placed in the concrete slab on steel deck construction. Slabs on composite steel floor deck will be placed at the required elevation, adding concrete to compensate for the deflection of the (unshored) steel framing (assume an approximate average of ¾” additional concrete required over the bay area).

Roof Construction: Typical roof construction consists of a 3” deep, 20 gauge, Type DR galvanized steel roof deck spanning approximately 9'-4” to wide flange steel beams. Steel beams are typically supported by wide flange steel girders, which span to HSS (Tube) steel columns.

Steel roof deck at the Gymnasium will be the cellular acoustic type, 3” deep; 20/20 gauge (Galvanized). Steel deck typically spans 5½ +/- feet to Deep Longspan steel joists. Steel joists (72” deep) clear span approximately 112 feet and are supported by wide flange steel girders, spanning to HSS steel columns.

Roof construction over the Auditorium consists of a 3” deep, 20 gauge, Type DR galvanized steel roof deck spanning approximately 5½ +/- feet to Longspan steel joists. Steel joists (48” deep) clear span approximately 70 feet and are supported by wide flange steel girders, which span to HSS steel columns.

Exposed steel framing in the Gymnasium will be classified as Exposed to View Structural Steel (E.V.S.S.). All E.V.S.S. will be surface prepped and shop painted with a primer that is compatible with the finished paint.

Exposed steel framing in the Gymnasium will be designed and detailed to resist net uplift wind forces.

Where practical, roof drainage will be achieved by sloping the steel to the internal drains. Some areas of tapered insulation should be anticipated, where it is not practical to slope the steel.

Concrete slabs on composite steel deck will be provided below rooftop mechanical units, for acoustical purposes.

Steel Framing Connections: Type 2 simple framing connections (shear only); double clip angles typically.

Columns: Typical columns will be rectangular steel tube (HSS).

Lateral Force Resisting System: Lateral (wind and seismic) forces will be resisted by steel bracing, for reasons of economy, stiffness, reduced structural depth and smaller column sizes. Bracing members will be square or rectangular HSS sections. Brace configurations may include chevrons, inverted chevrons (“V”), or single diagonals in short bays, as required by architectural
considerations. The bases of all braced frames will be tied together below the First Floor slab on grade with 2'-0" x 2'-0" reinforced concrete grade beams.

**Expansion (Seismic) Joints:** The southeast section of the building will be separated from the northwest section by an expansion joint, located along the southwest side of the Gymnasium. A fire wall will also be constructed at this location, allowing each section of the building to be classified as Type IIB construction.

**Exterior Walls:** Exterior walls will typically be masonry veneer at the base with architectural panels above, along with limited areas of glazed curtainwall. A galvanized, light gauge steel stud backup wall (16 gauge minimum thickness at brick veneer areas) will be provided in all veneer and panel areas. Vertical slip joints will be provided in the metal stud backup system at each level. A galvanized steel relieving angle will be required in limited areas, where the height of the veneer exceeds 30 feet, or in those locations where the veneer cannot be supported on the foundation. The outside face of masonry will be located 20" from the column centerline. Intermediate, HSS Steel girts will be provided at the perimeter of the Auditorium, to support exterior wall construction.

**Fire Protection:** The building will be classified as Type IIB Construction (Noncombustible, Unprotected), per the Eighth Edition of the Massachusetts State Building Code. Steel floor and roof deck and typical steel beams, girders, joists, columns and braces do not require applied fireproofing, except when supporting rated enclosures. The building will be fully sprinklered.

### IV. PRELIMINARY QUANTITY ESTIMATES:

Preliminary structural quantity estimates for the new school building are as follows:

- **Welded wire fabric for slabs on grade and slabs on steel deck:** \(6 \times 6 - W2.9 \times W2.9\).
- **Typical, exterior perimeter foundation wall:** 16" thick (including a continuous, 8" brick shelf), with and horizontal and vertical reinforcing each face (6.0+/- psf). The typical, exterior perimeter foundation wall is designed as a cantilever retaining wall to facilitate the placement of compacted structural fill for the First Floor slab on grade (located approximately 4 feet above the average exterior finished grade).
- **Typical, exterior perimeter foundation wall footing:** 4'-6" wide, by 16" deep, with continuous reinforcing bars, plus dowels to the foundation wall (25.0 +/- plf reinforcing). The bottom of the footing will be 4'-0" below the exterior finish grade for frost protection.
- **Typical interior column footings (28'-0" x 28'-0" interior structural bay):** 10'-0" x 10'-0" x 28" deep with 950 pounds of reinforcing. The bottom of the footing will be approximately 3'-4" below the First Floor slab on grade.
- **Typical, perimeter column footings (14'-0" x 28'-0" perimeter structural bay):** 7'-0" x 7'-0" x 22" deep, with 350 pounds of reinforcing. The bottom of the footing will be approximately 4'-6" below the exterior finish grade.
- **Piers/pilasters at interior/perimeter columns:** 2'-0" square, reinforced concrete with 40 plf reinforcing.
• Reinforced concrete grade beams between bases of braced frames: 2'-0" x 2'-0" with 45 plf reinforcing (assume 25 locations; 28 feet long).

• Estimated total weight of structural steel and steel joists (excluding entry canopies, equipment screens, etc.):

  Beams, columns, bracing, girts, plates, angles, connections, miscellaneous frames, etc.: 1,150 Tons

  Gym and Auditorium DLH/LH Joists, Including Accessories: 95 Tons

V. OUTLINE SPECIFICATION:

Concrete:

• All concrete shall be normal weight, 4,000 psi at 28 days, except foundation walls and footings, which shall be normal weight, 3,000 psi and exterior (exposed) concrete (paving) which shall be normal weight, 4,500 psi.

• Portland Cement: ASTM C150, Type I or II.

• Fly Ash: ASTM C618, Class F. Replacement of cement content with fly ash is limited to 20% (by weight). Fly ash is not permitted in exterior, exposed concrete, slabs on grade or slabs on steel deck/forms.

• All concrete shall be proportioned with 3/4" maximum aggregate, ASTM C 33, except 3/8" maximum aggregate shall be used at toppings less than 2" thick (e.g. metal pan stairs).

• All reinforcing shall be ASTM A 615 deformed bars, Grade 60.

• All welded wire fabric shall conform to ASTM A 185.

• Reinforcing bars, steel wire, welded wire fabric, and miscellaneous steel accessories shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with Submittal Requirements.

• Concrete products manufactured within 500 miles (by air) of the project site shall be documented in accordance with Submittal Requirements.

• Cure all concrete by moisture retention methods, approved by Architect; curing compounds shall not be used.

Reinforced Concrete Masonry (Elevator Shafts):


• Masonry strength, f'm shall not be less than 1350 psi.
• Requirements for load bearing block strength shall be as required for specified masonry strength (f’m) but shall not be less than 2000 psi on the net area of the block.

• Grout shall conform to ASTM C476, Type Fine, and shall be of strength required for specified masonry strength (F’m) but not less than 3000 psi.

• Mortar for reinforced masonry shall conform to ASTM C 270 Type S and shall be of strength required for specified masonry strength (f’m) but not less than 1800 psi.

• Reinforcing bars shall conform to ASTM A 615 Grade 60 deformed bars. Lap all continuous bars 48 diameters and provide bar positioners. Assume No. 5 bars at 2'-8" o.c. vertically and horizontal bond beams with 2 – No. 5 continuous at 4'-0" o.c.

• Joint reinforcing shall be 9 gauge ladder type conforming to ASTM A 82. Provide prefabricated corners and tees. Walls shall be reinforced horizontally with joint reinforcing at 16 inches on centers unless otherwise noted.

• Reinforcing bars, steel wire and miscellaneous accessories shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with Submittal Requirements.

• Elevator shaft walls shall be 100% solid grouted (all cores); low lift grouting.

• Masonry products manufactured within 500 miles (by air) of the project site shall be documented in accordance with Submittal Requirements.

**Structural Steel:**

• Structural steel shapes shall conform to ASTM A 992, Fy = 50 ksi.

• Steel tubes (HSS) shall conform to ASTM A 500, Grade B, Fy=46 ksi.

• Structural steel plates and bars shall conform to ASTM A 36, Fy = 36 ksi.

• Steel members shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with the Submittal Requirements.

• Steel manufactured within 500 miles (by air) of the project site shall be documented in accordance with the Submittal Requirements.

• Anchor Bolts: Anchor bolts at column base plates shall conform to ASTM F1554 – Grade 36 and shall be headed type. Provide a minimum of four (4), ¾” diameter anchor bolts at all columns; additional bolts and/or larger diameter will be required at bracing locations.

• Bolted connections shall be ASTM A 325, Type N (bearing) bolts, except slip-critical bolts shall be used at lateral brace beam connections.

• Shear connectors shall be ¾” diameter, 4” long, headed Nelson studs conforming to ASTM A 108.
• Shop and field welding shall be AWS D1.1 E70XX electrodes.

• Surface treatment for typical structural steel: SSPC Surface Preparation No. 3 (Power Tool Cleaning). Structural steel shall be left unprimed.

• Surface treatment for Exposed to View Structural Steel in the Gymnasium (E.V.S.S.) shall be SSPC Surface Preparation No. 6 (Commercial Blast Cleaning). Structural steel shall receive one coat of shop primer that is compatible with the finish paint.

• All exterior, exposed structural steel shall be hot-dipped galvanized.

**Steel Joists (Gymnasium and Auditorium Roofs):**

• All Longspan and Deep Longspan steel joists, open web steel joists, joist accessories and workmanship shall be in accordance with Steel Joist Institute (SJI) Standards.

• Steel joists shall be shop primed with one (1) coat of the manufacturer’s standard rust inhibitive primer. Primer for Deep Longspan steel joists exposed in the Gymnasium shall be compatible with the finish paint.

• Steel members shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with the Submittal Requirements.

• Steel manufactured within 500 miles (by air) of the project site shall be documented in accordance with the Submittal Requirements.

**Steel Deck:**

• Typical steel roof deck shall be 3” deep, 20 gauge, Type DR, conforming to ASTM A653, Grade 33 (minimum), galvanized in accordance with ASTM A 653, coating class G-60.

• Acoustical steel roof deck (Gymnasium) shall be 3” deep, 20/20 gauge cellular type, conforming to ASTM A653, Grade 33 (minimum), galvanized in accordance with ASTM A 653, coating class G-60. Acoustic steel deck shall be shop treated and painted with a primer that is compatible with the finish paint.

• Steel floor deck shall be 2” deep, 18 Gauge, composite type, conforming to ASTM A 653, Grade 33, galvanized in accordance with ASTM A 653, coating class G-60.

• All steel floor deck and roof deck accessories (pour stops, finish strips, closures, etc.) shall be the same finish as the deck; 18 gauge minimum.

• Steel deck shall contain a minimum of 25% (combined) post-industrial/post-consumer recycled content (the percentage of recycled content is based on the weight of the component materials). Certification of recycled content shall be in accordance with the Submittal Requirements.
• Steel deck manufactured within 500 miles (by air) of the project site shall be documented in accordance with the Submittal Requirements.

• Provide 14 gauge sump pans at roof drains.

END OF SCHEMATIC DESIGN STRUCTURAL NARRATIVE