

1.0 Structural Systems

1.1 Code and Loading Requirements

While all new construction will be in compliance with the 2006 International Building Code, existing portions of the building that are to remain in service will need to be designed per the 2006 International Existing Building Code (IEBC). As part of this scope of work, JVA has performed a cursory review of the existing building in terms of code compliance.

Chapter 10 of the IEBC, Historic Buildings, contains provisions for the repair of historic buildings and thus applies to this structure. Per Section 1006, a component or portion of a building or structure defined as dangerous shall be repaired, strengthened or replaced. Specific definitions for what comprises a dangerous element are listed in the appendix to this report. The definitions and loadings listed below will be used for all evaluations of the existing structure covered in this report and for the proposed new construction.

Current Building Code

International Building Code; IBC 2006 Edition

Design Loads

Occupancy Category, Table 1604.5, III Substantial Hazard

Roofs:

Ground Snow,	Pg	43 psf (drifting calculations)	
Flat Roof Snow,	Pf	30 psf	
Snow Exposure Factor	Ce	Table 1608.3.1	0.9
Snow importance Factor,	Is	Table 1604.5	1.1
Snow Thermal Factor,	Ct	Table 1608.3.2	1.0

Floors:

Classrooms	40 psf
Corridors & Public Spaces	100 psf
Corridors above First Floor	80 psf
Storage Areas	125 psf

Lateral:

Wind IBC 1603.1.4, ASCE 7-02		Analytic Method
3 Second Gust Velocity		110 mph
Importance Factor		1.15
Building Category and Internal Pressure Coefficient		
IBC 1609.2, ASCE Figure 6-5	Enclosed	GCpi=0.18
Exposure	C	
Seismic Use Group	2	
Importance Factor	1.25	

1.2 Existing Structural Systems

1.2.1 1924 Original Building

Building Code: Not indicated.

Live Loads: Not indicated; Drift not likely considered.

Wind Design: Not indicated.

Seismic Design: Not indicated.

Foundation System: Concrete stemwalls on continuous spread footings.
Allowable Bearing Pressure not specified.
Lower level slab-on-grade construction.

Principal Building Superstructure: Perimeter load-bearing multi-wythe brick or concrete walls with a cast-in-place reinforced concrete flat slab at the First and Second Floors. The roof and ceiling joists are wood framed and supported on interior bearing walls. Long span steel trusses supporting wood framing support the auditorium floor over the original gym and gable roof over the auditorium. Lateral restraint is provided by concrete and masonry shear walls.

Roof Structure:

Gym Roof	2x10 @ 16" spanning 13'-6; 2x10 @ 12" spanning 16'-0
Front Corridor:	2x8 @ 16" spanning 12'-6 Double 2x8's specified each side of 8'-9 wide Skylight
Front Classrooms:	2x12 @ 16" spanning 22'-9
Science Roof:	2x12 @ 16" spanning 22'-0

1.2.2 1955 Folded Plate North Gym/Classroom Addition

Building Code: Not indicated.

Live Loads: Roof - 25 psf on folded plates, 30 psf on flat portions; Drift not likely considered.
Classrooms - 60 psf
Cafeteria & Kitchen - 75 psf
Stairs, Corridors & Mechanical Equipment -100 psf

Wind Design: Not indicated.

Seismic Design: Not indicated.

Foundation System: Reinforced concrete grade beams spanning to isolated spread footings bearing directly on claystone bedrock.

Allowable Bearing Pressure:

Dead Load Pressure - 20,000 psf

Total Load Pressure - 35,000 psf

Equivalent Lateral Fluid Pressures for retaining site walls not indicated.

4" slab-on-grade on 12" gravel layer.

Principal Building Superstructure: Cast-in-place reinforced concrete frame supported on 12" square columns with a tapered concrete Second Floor Slab and a prominent 3-1/2" concrete folded plate roof. Exterior walls are double wythe brick construction. Lateral resistance is provided by the concrete frame and brick infill walls. A significant 8" concrete retaining wall provides for a 14' driveway where grade drops off sharply to the north.

1.2.3 1970 Library Addition

Building Code: 1967 Uniform Building Code

Live Loads: Roof - 30 psf; Drift not likely considered.

Library Reading Room - 60 psf

Other Rooms - 40 psf + 20 psf partition allowance.

Corridors and Stairs - unspecified.

Wind Design: Not indicated (Arch'l Drawings note 30 psf on exterior Tennis Volley Walls)

Seismic Design: Not indicated

Foundation Design: Drilled 18" diameter reinforced caissons with 4' penetration into bedrock. Estimated average pier length is 10'-0.

Allowable Bearing Pressure:

Total Load Pressure - 40,000 psf

Principal Building Superstructure: Structural Steel frame (ASTM A36) at Second Floor and Roof supported on wide flange steel columns that bear on isolated drilled piers below. A central beam line in the floor allows for two 20' joist spans at the library floor (J Series) and the roof joists (LJ Series) clear span 40' from east to west. Floor joists are spaced at 2'-0 and support a 3" concrete slab on form deck. Lateral restraint in the east-west direction is provided by bolted beam/column moment connections, but it's not clear how the north-south restraint is achieved.

1.2.4 1990 Science Floor Remodel / Addition

Building Code: 1988 Uniform Building Code

Live Loads: Roof - 30 psf; Drift not likely considered.
Classrooms - 40 psf
Corridors - 100 psf

Wind Design: $V(30) = 90$ mph (fastest mile), Exposure C.

Seismic Design: Not indicated and likely not considered.

Foundation Design: Drilled 18" & 24" reinforced concrete caissons with a 6' to 10' penetration into bedrock. Minimum pier length is 10'.
Allowable Bearing Pressure:
Total Load Pressure - 40,000 psf
Maximum Design Side Shear - 2,000 psf

Principal Building Superstructure: This steel frame (ASTM A36) superstructure frames between the original 1924 building and the 1955 north gym addition. A rigid connection is made along the south interface with the main building at the Second Floor and Roof with an expansion joint along the north interface. Steel wide flange girders running north-south bear on wide flange columns and support steel bar joists (H Series) running east-west at the Second Floor with a 3-1/2 concrete slab on form deck. The floor girders support light tube columns that extend to the roof and carry the north-south roof beams above. H Series roof joists spaced at 6' support 1-1/2" steel roof deck. Exterior walls are framed with 4"x18 GA studs spaced at 16" behind brick veneer. It's not clear how lateral restraint is provided, although the addition is a narrow infill with little wind exposure.

1.3 Known Areas of Distress and Prior Repairs

Prior to visiting the site under this contract, JVA was aware of building movement and areas of distress at Casey Middle School based on our review of existing documents, involvement in prior repairs and anecdotal information supplied to JVA by the BVSD facilities staff during earlier investigations. These areas include but are not limited to:

- Settlement of the 1955 Classroom Addition at the northeast corner of the original building. The 1983 Renovation included significant remedial work involving the installation of five new steel tube columns for permanent support and jacking of the Second and Third Floors.
- The 1983 Renovation drawings also reflect repair work to the south wall of the principal east-west corridor that interfaces with the Open Court. JVA is aware of additional repair work in this corridor wall due to continued movement in the late 1990's. The source of

the movement in the building was not identified, although it was probably differential heave from swelling soils.

- Significant cracks developed in interior east-west concrete walls near the west wall at the Ground Floor in the central portion of the original building. The 1986 Renovation Drawings acknowledged the problem, but it's not clear if repairs were made. JVA examined similar distress in the lower level in the late 1990's and the cracks did not pose safety hazards so no repairs were made.
- The 1986 Renovation drawings also identified removal and replacement of the ground floor slab in the entire Science Classroom at the northern edge of the original building. It's likely this replacement was due to excessive heave of the slab due to swelling soils. In the late 1990's, JVA examined areas of significant Ground Floor slab heave throughout the northwest corner of the original facility relatively close to the Science Classroom. We believe this condition exists today.
- JVA's 1997 Stabilization drawings addressed rotation of the original west façade at the north entrance and in the 24 foot section of wall that extends to the northwest corner of the building. The west brick wall rolled outward to the west and the concrete diaphragms at the upper two floors completely cracked and separated from the wall. Significant distress was observable in the outside face of the brick in this 36 foot section of wall. It was determined that the wall and foundation were rotating, most likely due to differential swell, so JVA stabilized the footing by installing a total of nine helical piers on the outside face of the foundation that directly attached to the concrete stem walls. These piers extended to the south corner of the entrance. In addition, a series of three full height 5" steel tube strongback columns were installed on the inside face of the wall to brace the wall and reestablish the connection to the diaphragm. Bearing plates are visible today on the outside of the building where the columns connect to the wall.
- JVA has been involved in an investigation of water infiltration in the ceiling slab over the original coal rooms that project outside the building footprint to the west. These rooms sit below the exterior concrete patio along the west façade. Infill slabs and support steel have corroded at the coal chutes. In 2005, JVA recommended a slab overlay to correct the condition and prevent water infiltration, but this repair was never completed.

1.4 Structural Observations

The exterior survey was performed from the ground around the perimeter of the building. In general, with the exception of the northern 36' of the west façade, only minor cracking in the exterior wall was observable. The remainder of the west façade, and south and east walls of the original building are performing well. Significant distress in the façade in the region of the 1997 repair is still visible because Phase II joint repair was never completed. It appears the extent of cracking has not progressed since the stabilization, although minor movement would be difficult to detect.

Exterior distress in the veneer and concrete at the Second Floor and Roof was observable in several locations in the south face of the 1990 Classroom Addition above the roof of the single story classrooms to the south. This distress is above the corridors below that were repaired in 1983 and then again in the late 1990's.

1/16" wide diagonal cracking was seen at the northeast corner of the 1955 Gym Addition near the door to the lower level. Minor horizontal displacement was also detected. The foundations in this area are minimal isolated footings that were to bear directly on bedrock. Movement could be due to heave, or perhaps the corner footing isn't bearing on bedrock and the large bearing pressures used in the design could not be achieved, thereby resulting in settlement. The bottom of the grade beam is exposed at this corner. The exposed concrete structure along the north façade of the 1955 Addition typically exhibits some cracking and spalling of the concrete in the horizontal beams. The west façade of the 1955 Addition is performing well, although the Second Floor line seems to be reflected in a horizontal crack in the exterior brick along the entire length of the addition.

No significant distress was observed in the 1970 Library Addition. The site walls and exterior flatwork to the west of the building are in reasonable condition, but need general maintenance to address tuck pointing and slab joints in disrepair.

Our interior examination of the facility did not uncover any new areas of concern other than those already identified above. The slab heave in the northwest corner of the original building is significant. The concrete wall cracks at the Ground Floor do not seem to have progressed further, although they too are significant. Repairs were made to the hallway finishes in the east-west corridor that has experienced movement and there were no signs of new movement.

1.5 Discussion/Recommendations

Overall the original building and additions are performing adequately, although the structure has a history of repairs due to building movement as a result of swelling soils. At some time during JVA's earlier involvement in an investigation in the 1990's, anecdotal information was passed on to us that said this site, prior to construction of the original building, had been a source of clay for a brickyard. We have not been able to verify this information elsewhere. Based on our review of the drawings for the additions to the original building, it appears bedrock is relatively close to the surface and the material is firm given the high bearing values used in design. Only the original building is founded on continuous strip footings, and the subsequent additions are on either isolated pads or drilled piers that are relatively short.

JVA has a significant concern that re-use of the existing facility in conjunction with proposed new additions will create a compatibility problem since it's probable that the new construction will be founded on drilled piers. All of the new construction will need to be isolated from the existing facility. More importantly, the existing facility will always be susceptible to differential movement from swelling soils. The building has performed well to date because the walls and

foundations are massive, and for the most part have been able to resist the swelling pressures from the clay or claystone bedrock. The lower slabs in the northwest corner have little dead weight and have heaved dramatically. More lightly loaded concrete walls near the west side of the building have heaved and cracked at the Ground Level. Differential heave likely caused the foundation to roll in the west façade where helical piers have been installed to prevent further movement. Ultimately, there is not a failsafe method of preventing future movement in the original building. Maintenance dollars will need to be set aside annually for future slab and finish repairs, and replacement of the entire existing slab with a structural floor to isolate the floor from the soil similar to the work done years ago at Broomfield Middle School would be cost prohibitive.

Isolating the existing foundations from the swelling soils will allow the building to perform well for years to come, although to do so for the complex matrix of interior existing foundation walls would be a multi-million dollar effort. However, in conjunction with discussions with RB+B, JVA has given thought to re-supporting the perimeter foundation walls of the original building in an effort to re-use portions of the building.

A structural solution that would isolate the existing foundations from swelling soils pressures would involve the following:

- New support for the existing walls could be provided by paired drilled piers with a deep concrete beam that extends under the existing footing and perpendicular to the wall. Support would need to be provided at approximately 15' centers to allow the existing concrete stem wall to span between new supports beams. This "pump handle" solution allows for excavation from one side and would require two piers to be spaced 12' to 20' apart, with the pier closest to the wall approximately 4' off of the face to allow for drill access. The piers will be approximately 24" diameter and relatively short.
- A similar solution would involve paired piers, one on each side of the wall, with a transverse beam supporting the existing foundation. This requires excavation both inside and outside the building and makes temporary shoring of the wall more difficult.
- Once the new grade beams are installed, a void can be excavated below the existing footing to isolate the building wall from the soil. This will require hand excavation.
- Drilling of the piers will require removal of the interior floors for rig access unless all of the work is done on the outside of the building. RB+B is examining an option that involves removing the interior floors completely in conjunction with incorporating the west and south walls of the original building into the new design. Floor removal will require extensive temporary shoring on the outside of the building, but it will facilitate construction of the "pump handle" foundations on the interior. The new paired piers will support a steel structural frame that braces the original façade and also supports gravity loads, thereby taking some of the load off of the outside wall.

- Helical piers or heavy screw piles may be an acceptable alternative to the use of drilled piers, although the concrete piers will be more compatible with the other new construction.
- Incorporation of these existing masonry walls will require strengthening of the existing masonry to better tie the multiple brick wythes together. Installation of epoxied stainless steel or nylon pins from the back face of the wall is commonly done in preservation work to maintain or reestablish wall integrity.
- Special attention will need to be paid to the area along the west wall that was stabilized in 1997. Incorporation into a new facility will require additional reinforcement that can add another fifty years to the life of this wall.

JVA has performed a cursory analysis of representative structural elements on the original building and subsequent additions to assess structural adequacy for current building code design loads. Roof drift is definitely a problem in some areas, hence reinforcement of the roof will likely be required where the deficiencies fall outside the acceptable limits established by the IEBC.

Appendix to Structural Assessment

1.0 Referenced Documents

Background information was obtained from the following documents provided by the Boulder Valley School District:

- 1924 Original North Side Intermediate School Building; Robert K. Fuller, Architect
- 1955 North Gymnasium and Classroom Addition to Casey Junior High School; Hobart D. Wagener, Architect
- 1970 Library Addition and Alterations to Casey Junior High School; Atchison Kloverstrom & Atchison Architects
- 1983 Casey Junior High Remodeling Improvements; EZTH Architects
- 1986 Restoration and Repairs at Casey Junior High School, C.R. Hazelwood Consulting Architect
- 1990 Casey Junior High School Science Floor Renovation and Addition; James D. Copeland Architects
- 1999 Toilet Room Renovation to Casey Middle School; RB+B Architects
- 1997 Casey Middle School West Wall Stabilization, Phase One Foundation Stabilization, JVA Consulting Structural Engineers
- 1969-2000 Miscellaneous Topo, MEP, Fire Alarm, Architectural Finish, Irrigation and Window Replacement Drawings

2.0 IEBC 2006 Structural Design Load Requirements

Per IEBC Section 1106.2, only components or portions of a historic building determined to be dangerous as defined in Section 202 require repair, strengthening or replacing. Per Section 202, dangerous is defined as:

- 1) The stress in a member due to factored dead and live loads is more than 1.33 times the nominal strength allowed in the IBC.
- 2) Any member likely to fail or collapse and thereby injure persons
- 3) Any portion of a building that is not capable of resisting a wind pressure of two thirds of that specified by the IBC for new buildings without exceeding the nominal strength permitted in the IBC.
- 4) The building or any portion thereof is likely to collapse because of dilapidation, deterioration, decay, damage or instability.
- 5) Vertical structural members list, lean or buckle to such an extent that a plumb line passing through the center of gravity does not fall inside the middle one third of the base.

The IBC demand loads used in analysis of the existing structure for compliance with these provisions are as stated in Section 1.1. Note that reductions in applied loading allowed by the IEBC are not reflected in the stated loads.