BEAUDETTE CONSULTING ENGINEERS, INC.
bce STRUCTURAL

www.bceweb.com

131 WEST MAIN ST.
MISSOULA, MT 59802
TEL: 406.721.7315
FAX: 406.542.8955

450 CORP. DR., #112
KALISPELL, MT 59901
TEL: 406.752.5675
FAX: 406.752.5677

1289 STONERIDGE DR,
SUITE #1A
BOZEMAN, MT 59718
TEL: 406.556.8600
FAX: 406.556.8608

201 MAIN ST., #103
RAPID CITY, SD 57701
TEL: 605.791.3090
FAX: 605.791.3092

March 11, 2013

John Carter
Helena Public Schools – Maintenance Department
1200 Sanders Street
Helena, MT 59601

Re: Seismic and General Structural Condition Report
Central School
Helena, MT

Mr. Carter,

As requested, we have completed a general structural conditions assessment for the Central School building in Helena, MT. Jami Lorenz, PE and Samantha Lidstrom, EIT completed the assessment and this report. The site was visited on Friday, February 22, 2013. As per the scope of our initial assessment, no destructive investigations or material tests were performed at this time. The findings and recommendations in this report are based solely on our visual assessments during the site visit and the original building drawings obtained from the Helena School District**.**

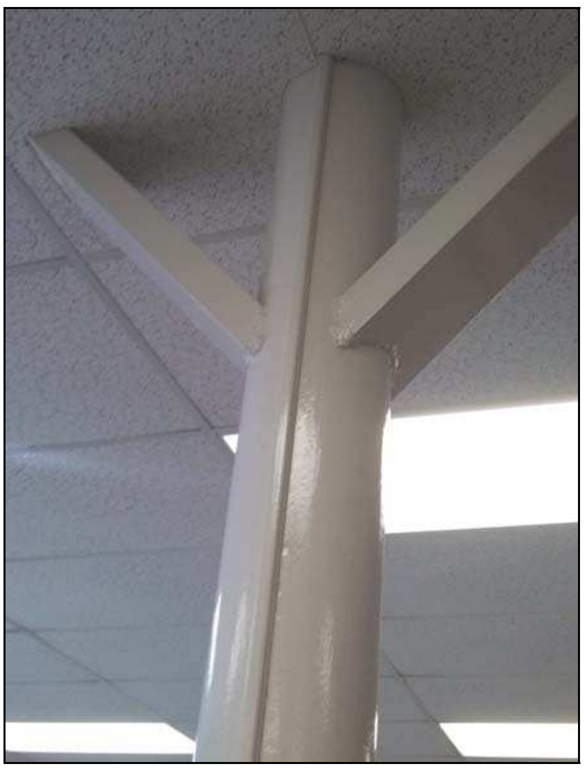
The intent of the investigation and this report is to determine the general structural status of the building considering basic life-safety occupancy, and to assess the level of conformance of the existing structure to the International Building Code (IBC) and International Existing Building Code (IEBC) where it may apply. The IEBC allows the design for historic buildings to be established for life safety parameters and general construction standards. Existing structures need not meet every specific code requirement for new construction as outlined in the IBC.

Figure 1: Central School from North Warren St.
(Photo Credit: www.helenahistory.org)

Observed Structural System

Central School was built in two phases. The original building was constructed in 1915 and an addition was completed in 1921. Both portions are similar in construction. Some retrofits were observed that were presumably added after the earthquakes of 1935 in select areas of the building.

The foundation consists of cast-in-place reinforced concrete strip footings and rubble stone foundation walls. Floor and roof framing consists of cast-in-place reinforced concrete slabs that bear on the exterior brick walls, and are supported by interior reinforced concrete beams and columns. The exterior walls of the building are unreinforced brick masonry that support the concrete slabs; no concrete beams or columns exist at the exterior walls. Some steel columns and knee braces (Figure 2) were found in the classrooms located in the original portion of the building. These columns were presumed to have been added during the construction of the addition or as part of the earthquake retrofit around 1935. Steel channels have been bolted to the exterior of the unreinforced brick on the east and west elevations, as can be seen in Figure 2, below. The channels were assumed to have been added sometime after the earthquake. Where exposed, non-structural partition walls were observed to be clay tile masonry.



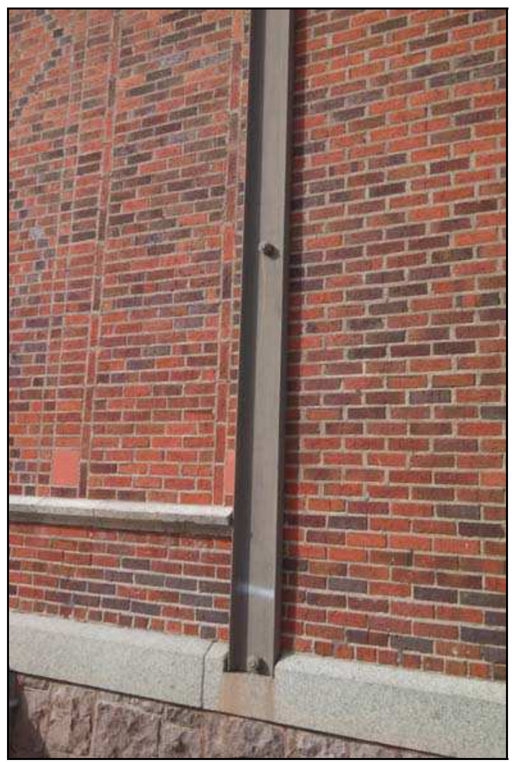


Figure 2: Post-construction retrofits. Steel columns and knee braces found in the classrooms in the original building portion are shown left and steel channels added to the exterior unreinforced masonry walls are shown right.

Inspection

The inspection of Central School was based solely on visual observations made while on-site.

Exterior Observations

The underside of the elevated slab at the main entrance at the West elevation showed signs of damage. The concrete was deteriorated and spalling in several locations, leaving rebar exposed; see Figure 3, right. The rubble stone foundation walls appeared to be in good condition from the exterior of the building where exposed. They have been regularly maintained and the mortar shows little sign of deterioration. Some visible deflection of the long window headers could be observed on the North elevation; see Figure 3A. The exterior brick masonry walls also appeared to be in generally good condition, however the mortar in the soldier courses at some windows showed sign of deterioration; see Figure 3B. At the North and South elevations, some diagonal cracking was observed underneath the windows which could be indicative of damage due to a seismic event; see Figure 3C.

Figure 3: Spalling and exposed reinforcement on underside of slab at the main entry.

Figure 3A: Long Window Headers with Deflected Steel Angle Lintel

Figure 3B: Deteriorated Brick Sill

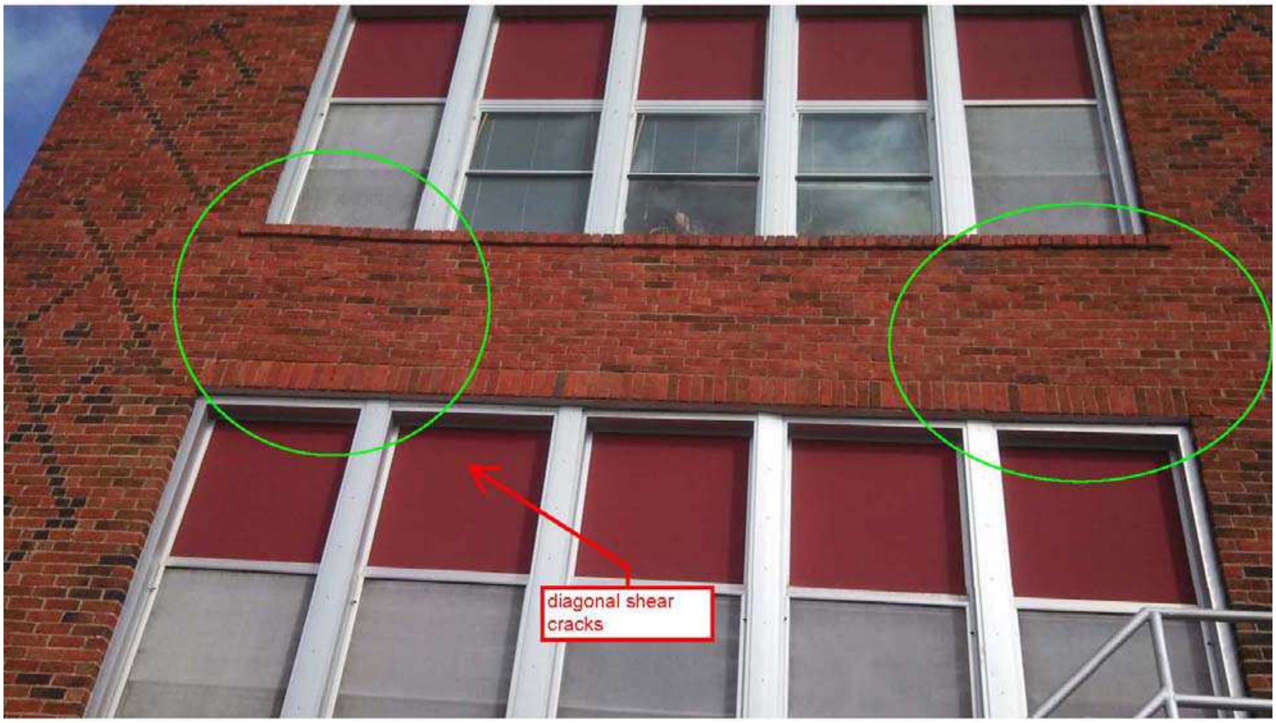


Figure 3C: Diagonal Shear Cracks Under Windows

Interior Observations

Due to the non-destructive scope of this investigation, very few of the interior structural elements could be visually observed. However, there were a few visible areas where signs of deterioration of the structural elements were found. In the boiler room on the roof, some cracking of the roof slab was found as shown in Figure 4. In the sub-basement, the rubble stone foundation walls and concrete columns in the 1921 addition portion could be observed. There were some openings in the rubble stone foundation walls with no visible beams or headers to support the masonry walls above. In the mechanical chase in this area, we observed some very poor-quality rubble-stone foundation walls. The mortar was heavily deteriorated and, in the worst instances, the stones could easily be pulled from the wall.

Figure 4: Cracking in the concrete roof slab.

We also observed concrete columns in this area that showed signs of deterioration in the steel reinforcement at the base due to exposure and lack of concrete cover. The rebar was rusted and completely exposed in some areas, and the concrete had been completely broken away from the reinforcing steel inside the column. The lack of concrete cover could have been a result of damage from the earthquake in 1935. See Figure 5, below, for images of the deteriorated and damaged column bases.

Figure 5: The concrete is deteriorated at the column bases in the sub-basement. In several locations, the concrete is spalling away and the reinforcement is exposed, leaving it susceptible to further corrosion and damage.

Analysis

A limited structural analysis was conducted to determine the adequacy of both the gravity framing system as well as the lateral force resisting system for general life-safety parameters. Where applicable, the IEBC was referenced in our review of the existing structure – otherwise the current IBC governed our analysis. As previously mentioned, we were unable to verify the structural framing at the time of our inspection and were utilizing the original structural drawings and site observations in our analysis.

Gravity Loads

A very limited gravity load analysis was performed to verify that the member sizes were sufficient for current life safety loading. The structure was found to be adequate for the state minimum roof snow load of 30 psf and code mandated floor live loads per the IBC.

In-Plane Lateral Loads

In regards to the lateral force resisting system, we first referenced the IEBC in our initial review. In many cases, the IEBC allows for the consideration of existing unreinforced masonry to be used as part of the building lateral force resisting system. However, Central School falls under Occupancy Category III: “a substantial hazard to human life in the event of a failure”.

The current IEBC does not allow the provisions for existing unreinforced masonry to be used for Occupancy Category III buildings in areas of high seismic activity. Because Central School is assigned to a high seismic region (Seismic Design Category D), the existing unreinforced masonry cannot be considered as part of the lateral force resisting system. In addition, the absence of a regular reinforced concrete beam and column system at the exterior of the building does not provide for a possible secondary justifiable lateral system.

However, a preliminary analysis was run on the existing structure assuming that the IEBC provisions did apply in order to assess the urgency of the required structural upgrades. For example, if the building was being used as an apartment complex, the existing unreinforced masonry walls could be considered to resist a reduced value of lateral forces if deemed adequate for these shear loads.

Our analysis revealed that the existing unreinforced brick masonry would *not* be sufficient to resist the required seismic forces in the event of an earthquake, even if allowed by the IEBC. Furthermore, if the existing exterior brick has not been replaced or repaired since the 1935 earthquake (which it does not appear to have been), it is likely that its allowable shear capacity of the brick wall assembly was compromised during that seismic event.

The absence of any brick bearing walls at the interface of the 1915 and 1921 buildings causes a severe torsional irregularity when subjected to seismic loads. With stiff wall elements at the exterior and less stiff columns/beams at the center of the building, the columns would have taken a significant amount of load and movement before re-distributing their loads to the stiff outer walls. Because of this irregularity, it is likely that the earthquake could have been the cause of the damage to the base of the concrete columns that was observed in the sub-basement.

Out-of-Plane Lateral Loads

In addition to the inadequacies of the building to resist in-plane lateral shear forces, the building has virtually no means of resisting out-of-plane lateral seismic forces due to the brick wall self-weight. There is no evidence in the existing drawings or in our on-site observations of a positive connection between the concrete slabs and the brick bearing walls. The original detail connection of the slab as shown in Figure 6 would have provided some strength due to friction between the slab and brick wall that inherently exists when it was poured in place. Since there are no signs that this connection was upgraded following the earthquake, this interaction would likely have been compromised due to movement of the structure.

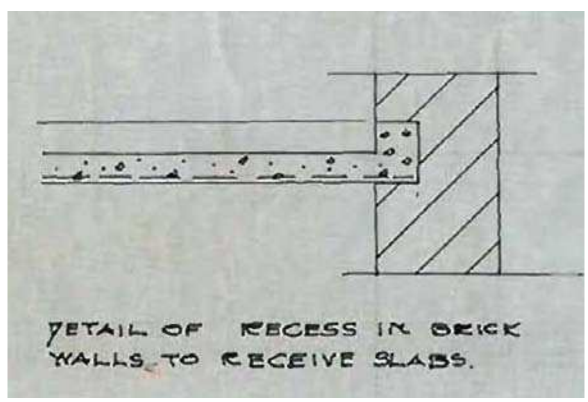


Figure 6: Detail of slab-to-wall connection from 1921 drawings.

In the event of an earthquake, there would be nothing but that same friction described above to prevent the slabs from separating from the wall completely due to out-of-plane lateral forces, causing partial or complete collapse of the structure. Finally, the steel channels on the exterior of the building do not appear to be attached to the floor structure since the bolts do not line up with floor levels, and therefore are not able to provide for supplemental connection to the interior floor and roof slab diaphragms.

Recommendations

Because of the extreme lateral instability of the structure and observed damage to the structure without any observable retrofit measures in the past, we recommend that the school be vacated as soon as possible to allow for the installation of the required lateral system upgrades outlined below and in the attached floor plans. There may be some emergency measures that could be put in place to aid in avoiding the failure of the exterior walls in an earthquake, such as providing a positive attachment between the floors and walls. But, these repairs are very disruptive to install while the building is occupied and would not guarantee that the building would withstand a design seismic event. We have analyzed the lateral system in depth and cannot justify the school for basic life-safety parameters; therefore we believe that the students should not occupy the building until the interior retrofit measures are completed. The retrofit measures are described below and are shown in the drawings attached.

Interior Upgrades – To Be Installed Immediately

RECOMMENDATION #1: REINFORCED CONCRETE/CMU SHEAR WALLS
The upgrade of the seismic lateral force resisting system should be executed immediately and will require the addition of interior reinforced concrete or CMU shear walls at three levels. It will also require the addition of new grade beams and helical piers at the foundation level underneath the new shear walls to transfer lateral loads to the ground. The projected locations of the new shear walls are shown in the retrofit plans attached, but would be further refined with an in-depth structural design effort.

RECOMMENDATION #2: NEW ATTACHMENT OF BRICK WALLS TO CONCRETE SLABS
A positive connection between current concrete slabs to the existing brick walls must be established. This would be achieved with steel angles attached to the concrete floor structure and brick walls with epoxy anchor rods around the perimeter of the building.

RECOMMENDATION #4: CONCRETE COLUMN REPAIR IN SUB-BASEMENT
In the sub-basement, all exposed concrete showing signs of deterioration should be repaired. All exposed rebar should be cleaned, severely deteriorated rebar removed and replaced, and all concrete should be patched and sealed.

RECOMMENDATION #5: EXPOSE AND INSPECT REMAINDER OF INTERIOR CONCRETE COLUMNS
During the retrofit process, the remainder of the architecturally finished columns should be exposed to verify that they do not show similar signs of deterioration.

RECOMMENDATION #7: REPAIR/REINFORCE STONE RUBBLE FOUNDATION WALLS
At full-height stone rubble foundation walls, the mortar should be repaired wherever a new adjacent concrete shear wall is not being installed as part of the lateral force resisting system

upgrades. This repair could also be achieved by installing a 4 inch layer of reinforced shotcrete over the stone rubble walls to provide a more permanent repair to the foundation walls. We also recommend that steel angle headers be added above the doorways at the rubble-stone walls in the sub-basement to support the walls above.

RECOMMENDATION #8: BRACING OF INTERIOR PARTITION WALLS
Finally, all interior partition walls should be further investigated with architectural finishes removed in select locations to assess the existing condition. It is very likely that bracing will be required to prevent collapse of these walls in case of a seismic event.

Exterior Upgrades – To be Performed According to the Retrofit Plan schedule

RECOMMENDATION #3: MONITOR EXTERIOR BRICK CONDITION
Monitor the cracking of the exterior brick walls on an annual basis.

RECOMMENDATION #6: DETERIORATED CONCRETE REPAIR AT FRONT ENTRY
At all locations of concrete deterioration, exposed rebar should be cleaned and all concrete should be patched and sealed to prevent any further deterioration.

RECOMMENDATION #9: REPLACE LONG-SPAN WINDOW LINTEL HEADERS
The deflecting, undersized lintel headers at the north side of the building should be replaced with adequate steel angle members. Any deteriorating brick mortar should be re-pointed to prevent further deterioration.

Summary
We understand that this report is general in nature and our findings are not favorable in light of the timing in the school year. We are at your disposal to discuss these findings and brainstorm the best approach to solve this problem and provide life-safety for the school occupants. A more in-depth structural analysis and design effort by a design team will be required to provide for the necessary construction documents for this structural stabilization effort.

Please contact us at your earliest convenience to discuss our findings and how we can work together to move forward on this stabilization plan.

Sincerely,

Beaudette Consulting Engineers, Inc.

Jami Lorenz

Jami Lorenz, PE

Samantha Lidstrom, EIT

RETROFIT PLAN SCHEDULE				
Item	Description	Objective	Time Frame	Estimated Cost (2013)
1	ADD REINFORCED CONCRETE OR CMU SHEAR WALLS AT THREE LEVELS WITH CONCRETE GRADE BEAMS AND HELICAL PIERS AT FOUNDATION LEVEL	*To provide an adequate lateral force resisting system.This will include adding walls, upgrading connections, and installing new foundations in these locations.*	Immediately.	$875,000
2	UPGRADE CONNECTION OF SLAB TO (E) BRICK WALLS	*To ensure the stability of the floor and roof slabs in the event of an earthquake.*	Immediately.	$20,000
3	MONITOR CONDITION OF EXTERIOR BRICK	*To ensure that cracking resulted from 1935 earthquake and is not the result of an on-going condition.*	At regular intervals once/year.	N/A
4	REPAIR DETERIORATED CONCRETE COLUMNS IN SUB-BASEMENT	*To preserve the structural integrity of the columns.*	Immediately.	Assume 4 column bases in sub-basement: Total Cost = $20,000
5	EXPOSE REMAINDER OF FINISHED CONCRETE COLUMNS TO ENSURE SIMILAIR DETERIORATION HAS NOT OCCURRED	*To preserve the structural integrity of the columns.*	Immediately.	N/A
6	CLEAN AND PATCH ALL EXPOSED REBAR AT BUILDING EXTERIOR	*To preserve the structural integrity of the slab and to prevent further deterioration of the concrete and rebar.*	Within the next 2 years.	$4,000
7	REPAIR/SHOTCRETE DETERIORATED RUBBLE-STONE FOUNDATION WALLS IN SUB-BASEMENT	*To preserve the structural integrity of the foundation walls.*	Immediately (with seismic upgrade)	$26,000
8	INVESTIGATE AND BRACE INTERIOR PARTITION WALLS AS NECESSARY	*To prevent the collapse of interior partition walls in case of a seismic event.*	Immediately (with seismic upgrade)	$90,000
9	UPGRADE UNDERSIZED EXTERIOR LINTEL HEADERS	*Replace undersized, deflecting window headers.*	At next major renovation.	$5,000

N/A - INDICATES RECOMMENDATION TO WHICH AN ESTIMATED COST CANNOT BE ASSIGNED WITHOUT FURTHER INVESTIGATION

TOTAL PROJECTED COST:	***$1,040,000***