6. ENGINEERING REPORTS

The Structures Studio, PLC
Structural Engineers

Jeudevine Library Expansion
Structural Evaluation of Existing Library Building - 93 North Main Street - Hardwick VT

Dear Tom,

At your request, I visited the existing Jeudevine Memorial Library building at 93 North Main Street in Hardwick, Vermont with you on June 7 of this year. The purpose of my site visit was to perform a walk-through structural evaluation of the existing building to determine the nature and condition of the existing structural systems, and the impact of the existing structure on the proposed library renovation and expansion. This letter documents my observations and recommendations.

The scope of this structural evaluation was limited to a walk-through visual evaluation of the existing structural systems, to the extent that they are readily visible and accessible, and preliminary load-rating calculations of a few typical framing conditions. It should be noted that in many places the existing structure could not be observed directly due to the presence of architectural finishes, so there may be hidden structural conditions that were not obvious during my visit. I have indicated below the extent to which I could see the framing in each area.

Description of Existing Structural Systems
The existing library was completed in 1896 and measures approximately 26' by 46' in plan. The front of the building faces southeast but for the purposes of this report this will be referred to as the east elevation, with uphill to the north and downhill to the south.

The first floor is primarily used for stacks and reading areas, with administrative offices tucked into the east end of the south reading room. A small mezzanine level over the administrative offices is also used as office space. There is a full basement level divided into three sections by interior brick walls; the south room is used for stacks and reading area, the north room for mechanical, and the space in between for storage.

The exterior walls are masonry load-bearing and shear walls. In the basement, the walls are granite to about four feet above the basement slab, at which point the interior face switches to brick. At the exterior, the granite continues to a few feet above grade before switching to a reddish sandstone for the remainder of the building height. The interior face of the wall continues in brick up to the underside of the roof. In the basement, there are two brick cross walls that divide the space into the three areas noted above, with two additional brick walls further subdividing the middle area. All four interior brick walls feature brick arches.

The first floor framing is fully-exposed within the basement and consists of wood joists spanning in the north-south direction between brick walls. Joists are of high-quality wood in excellent condition and typically measure 2-3/8"x11-1/2" at 16" spacing. The joists are pocketed into the brick at both ends, notched at top and bottom to about 10" to 10-1/2" deep to fit within the brick coursing.

PO Box 91, North Ferrisburgh VT 05473 tel 802.425.3300 / structures@gmavt.net

The nature of the mezzanine framing could not be determined as it is hidden behind finishes.

The roof framing is for the most part a simple gable structure with common rafters at a 12:12 pitch, tied at the base by attic joists that span east-west between the exterior walls. This framing is interrupted by a large gable dormer over the turret and building entry, also framed at a 12:12 pitch. The roof framing is fully-exposed at the south end of the attic. Interior paneling with knee walls was installed to finish a room at the north end of the attic, though the rafters are still visible outside the knee walls. The attic floor framing is entirely hidden by finishes, aside from an area of about 6'x9' over the building's entry that is used to access the attic. The "beams" running north-south at the ceiling over the first floor are non-structural decorative features.

The existing rafters are of high-quality timber and typically measure 1-7/8"x9-3/4" at 24" on center. The rafters bear against an unsupported 2x ridge board at the ridge. A horizontal collar tie (technically a collar strut, because it is in compression rather than tension) is heavily spiked to each rafters approximately 5'-6 above attic level, and typically measures 1-7/8"x9-3/4". The attic joists - to the limited extent they could be observed - are of high-quality timber and measure 2-3/8"x11-1/2", spaced at 24"on center to match the rafters. As the visible rafters are located beneath the gable dormer, they are simply pocketed into the exterior wall rather than spiked to the ends of the rafters as would be expected at the rest of the roof. It is assumed that the same size attic joists are used at the tied rafters, though none of these were visible on account of existing finishes.

The interior walls between the first floor reading rooms appear to be non-load bearing and could likely be removed or structurally altered. However, some additional probing would be needed at the attic level to confirm this.

The dormer ridge ends a few feet below the main roof ridge. Valley rafters measure 2"x11-1/2" and dormer rafters match the size of the typical roof rafters.

The roofing consists of slate, with snow free to slide off the ridge everywhere but where it gets trapped in the dormer valleys. While slate is one of the heavier roofing materials, it is structurally beneficial in that the slippery surface reduces the amount of snow load that can build up on the roof.

Condition Assessment

In general, the existing structural systems are in excellent condition. This is clearly a building that has been treated with loving care and has been well-maintained over its entire life. There are a few minor structural items that could use attention, but nothing to get in the way of the proposed library renovation and expansion.

From the exterior, the walls are plumb, the ridgeline is relatively straight, there is no appreciable sign of horizontal bowing at the eaves, and while some rafter deflection is visible it is nothing out of the ordinary. The only observed anomalies in the building lines were a slight dip in the ridge near the top of the valley rafters, and a more pronounced rafter deflection near the parapet at the northeast corner of the building that may indicate one or two deteriorated rafters in this area. Interior attic finishes would need to be removed to determine what is causing the increased deflection in this area. While I have not run any analysis at this early stage to check the valley rafters, I would anticipate that they are significantly undersized and not adequately supported by the surrounding framing at the ridge. They are working "well enough" now, but I would recommend some reinforcement of the roof framing in this limited area to make sure that the dip in the ridge does not get more pronounced over time.

The stonework at the exterior shows signs of minor differential settling of the building foundations at some point in the past, which resulted in cracks in the stone. All of the exterior cracks have been repaired and patched, with the repairs in good condition and no sign of new settlement cracking. The magnitude of differential settlement is estimated as no more than 1/2", and it appears from the lack of new cracks that no further settlement is taking place. Small settlements of this magnitude are not of structural concern, and the previous cracking (now repaired) had minimal impact on the structural integrity of the walls.

The remainder of the exterior stonework is in generally good condition, aside from some weathering of the stone which is most obvious below the parapets at the north and south facades. At some of these areas the surface of the stone has spalled off, possibly as the result of water that got into the far side of the parapet wall due to flashing failure at the roofing. It appears that these leaks have been repaired, aside from one new roof leak at the northeast corner that was noted by our hosts at the site visit. Repointing and other minor repair work has already been done, so that only continued maintenance repairs are expected for the renovation project. I would recommend checking all the weathered stone below the parapets during the renovation to see if any additional spalls are coming loose and should be removed.

All of the visible wood framing was in excellent condition, with no obvious signs of rot, water staining, insect infestation, or structural distress such as splits or crushing. Spot checks were made where the first floor joists pocket into exterior walls and there was no sign of deterioration where the wood enters the pockets.

The basement slab is in good condition, and there are no obvious signs of water infiltration. However, library staff report that the basement often feels damp, even though some prior drainage work was done on the west side of the building. The drainage work should ideally be continued around all sides of the building to the extent that the budget allows. Poor drainage can sometimes lead to the types of foundation settlements that have already been seen on this building, giving another reason to invest in improved drainage.

Where structural framing is hidden behind finishes, there is no sign of distress at the finishes such as cracking or bowing that might indicate problems with the framing behind the finishes.

Structural Capacity of Floor and Roof Framing

As part of this initial evaluation, typical joist and rafter sizes were checked against current code requirements to get a sense of any load rating limitations that might affect the proposed renovations and reuse of the building.

The wood grade has been judged equivalent to "select structural" based on straight grain and relatively small size of the knots. The wood species is unknown at this time, and has conservatively been taken as the equivalant of spruce-pine-fir (SPF) for purposes of this initial load rating. Given the date of construction, the very high quality of the wood, and the relatively large member sizes and lengths, it is unlikely that the wood was sourced locally. I suspect that the wood framing is west coast douglas fir, which is considerably stronger than SPF and our eastern species. If additional load rating capacity is needed, some wood samples could be removed and sent for formal identification to confirm whether the higher allowable stresses of douglas fir can be justified.

The following conclusions were made based on this preliminary load-rating effort:

- The typical common rafters are more than adequate for the weight of the slate roofing and code snow loads, assuming that nothing is added (such as snow guards) to prevent snow from sliding freely off the roof.
- The existing attic dead load (i.e., self-weight of structures and finishes) was estimated at about 15 psf. For this dead load, the live load capacity (i.e., allowance for occupants and furnishings) is about 30 psf. This exceeds the code minimum live load requirement of 20 psf for "uninhabitable attics" but is not sufficient to support mechanical equipment, office use, or storage. If the space is needed for any of these uses, the attic joists will need to be reinforced to support the new loads.
- At the first floor, the existing dead load is estimated at about 16 psf, though the exact build-up of finishes needs to be confirmed. The first floor joists are all the same size but vary in span: 18'-0" at the south room, 9'-5" at the middle bay, and 13'-2" at the north room. For this assumed dead load and conservatively assuming SPF as the species, the live load ratings are as follows:

South reading room	100 psf
Middle rooms	250 psf
North reading room	195 psf

The current code minimum live load is 150 psf for library stacks, 100 psf for general public assembly, 60 psf for library reading rooms, and 50 psf for office use. While the middle and north bays have sufficient live load capacity for all of these uses, the south room's 100 psf rating does not meet current code requirements for library stacks. Even if the joists in this area were confirmed to be douglas fir, the capacity would only increase to 120 psf - still not enough for stacks. (Note that the 150 psf stack live load applies to conventional stacks only. If especially dense stacks are used - such as movable shelving - a higher live load capacity would be needed.)

- Since the building is already being used as a library, there is no code requirement prior to expansion to upgrade the floor framing at the south reading room to meet the current code live load. I observed no signs of distress at the existing joists in that area, and do not consider the existing situation to be a hazardous situation in need of remediation. However, given the proposed scope of the library renovation and expansion, it is likely that the entire building will need to be brought up to code. In that case, the floor joists at the south reading room would need to be sistered or otherwise reinforced for that room to continue to serve as a stack room. The joists could be used as-is for occupancies with a live load requirement of 100 psf or less, such as public occupany, reading room, or office space.

- The first floor joists are interrupted by the hearth at the north reading room, reducing the available live load capacity of the joists that frame around the hearth. In addition, these flush-framed joists are simply spiked together, which is an unreliable connection for high floor loads, and one of the joist ends has split at as a result. At the very least I would recommend adding metal joist hangers at the flush-framed connections. If the north room is to be used for library stacks (150 psf) or public occupancy (100 psf) then the framing around the hearth will need to be reinforced, or posts added in the basement below to reduce the spans.

Seismic Considerations

The existing building is exempt from the seismic requirements of the current building code for its current use as a library. Most unreinforced masonry buildings are difficult and expensive to retrofit to meet the seismic code. This building is robust enough to be a better candidate for seismic upgrade than most historic masonry buildings, however the significant cost and complication of a seismic upgrade is best avoided. I recommend designing the renovations and new construction in a manner that does not require a code-mandated seismic upgrade of the historic building. This can be done relatively easily by:

- Supporting the new construction completely independently of the existing construction (i.e., expansion joint between new and existing buildings);
- Limiting new dead load in the existing building so that seismic loads do not increase more than 10% over existing conditions; and
- Doing nothing to reduce the seismic strength of the masonry walls and floor/roof diaphragms in the existing building.

Recommendations for Proposed Renovation/Expansion

Based on the above findings, I make the following recommendations with respect to the structural work needed for the proposed renovation and expansion:

- Reinforce the two valley rafters and the adjacent framing that supports them.
- Investigate the cause of increased rafter deflections at northeast parapet area.
- Reinforce attic joists wherever the attic floor needs to support mechanical equipment.

- Do not use the attic for storage or occupied space.
- Reinforce (sister) first floor joists at south reading room if this room is to be used for an occupancy requiring a live load of more than 100 psf.
- Reinforce the first floor framing around the hearth, or support it on new posts in the basement.
- Make maintenance-level masonry repairs, as needed. Check areas of weathered stone for any signs of new spalling.
- Complete the drainage system around the perimeter of the building.
- Design the renovations/new construction so as not to trigger a seismic upgrade of the existing building.

Thank you for this opportunity to evaluate such a treasured community building, and let me know if you have any questions.

Sincerely,

THE STRUCTURES STUDIO, PLC

Katherine E. Hill, PE
Principal