PALMER PUBLIC LIBRARY ROOF COLLAPSE

Structural Observation Report

February 28, 2023

PND Project Number: 231025

PREPARED FOR:

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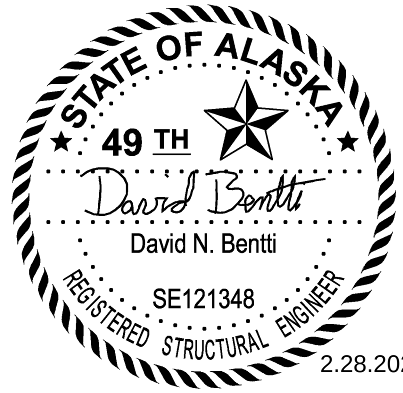

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1. INTRODUCTION

The roof of the Palmer Public Library suffered a partial collapse on February 15, 2023 at approximately 5:35 pm. The collapse occurred mainly over the children's section of the library. However, surrounding areas were also impacted by the roof collapse. The City of Palmer engaged PND Engineers, Inc. (PND) to complete a structural observation of the building to document the extents of the visible damage, determine the cause of the collapse, if possible, and assess if the building is safe to enter to allow contractors to begin selective demolition, clean up and collection of building contents.

2. BACKGROUND

The Palmer Public Library is a single-story building, designed in 1984, that is approximately 11,500 square feet. The building is founded on a traditional concrete shallow foundation. The building uses a combination of concrete masonry unit (CMU) walls, steel columns and dimensional wood walls to support the wood framed roofs. The roof framing consists of glu-lam beams supporting engineered wood I-joists. The City of Palmer provided PND a complete set of record drawings for PND's use and review. The record drawings indicate that the building was designed in accordance with the 1982 edition of the Uniform Building Code (UBC). The UBC was the building code used in many parts of the United States from 1927 to 1997. The UBC was replaced by the IBC after 1997.

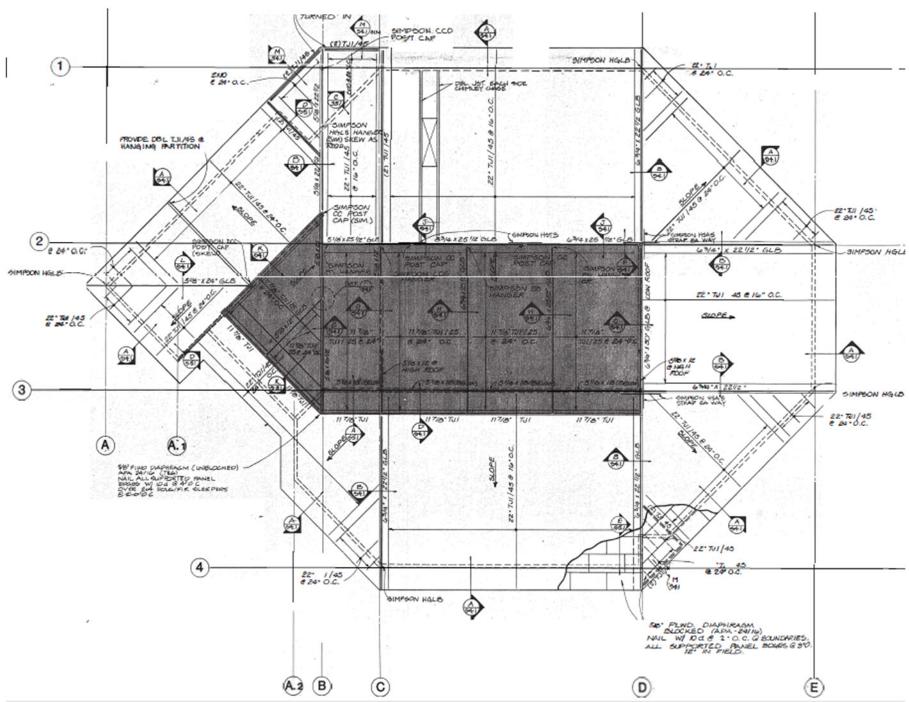

Figure 1: Roof Framing Plan

The record drawings specify that the roof was designed for a uniform roof snow load of 40 pounds per square foot (psf). It is possible that the original library designers may have considered additional snow loading to account for potential snow drifts. Snow drift loads are additional loads applied to the structure in addition to the uniform roof snow load in to account for the extra weight present on the roof in areas where snow drifts are likely to accumulate. There are no notes within the record drawings that indicate snow loads beyond the 40 psf uniform roof snow load were considered. Snow drifts were likely not included in the original analysis as the 1982 UBC did not include specific provisions for snow drift loading, as these requirements were not widely recognized as necessary for building safety until later. Under the currently adopted 2021 version of the International Building Code (IBC), the code required uniform roof snow load for Palmer is still 40 psf. However, modern codes also include provisions to account for snow drifts.

David Bentti and Elizabeth Swan from PND Engineers visited the Palmer Public Library on February 21, 2023 to observe structural components of the interior and exterior of the building. PND surveyor, Andrew Hamilton, also visited the site to fly a remote-controlled drone with a camera to provide a closer observation of the collapsed roof from the exterior of the building. This allowed for a more complete observation of the collapsed low roof while maintaining a safe distance.

Photo 1: Elevation of Roof Collapse

From the exterior of the building, PND observed that the lower roof over the children's section had separated from the glu-lam beam supports and collapsed inward **(Photo 1)**. PND also noted that the high roof line above the collapsed lower roof was visibly sagging. The source of this sag was not immediately clear from the ground level observation. Video footage obtained via the drone, showed that the glu-lam support beams that supported the low and high roof had been broken along their lengths **(Photo 2)**.

Photo 2: Annotated Elevation of Roof Collapse

The top half to two thirds of the glulam beams had collapsed with the low roof and only the lower portion of the glu-lam beams remained on the steel support columns. The loss of the top potion of the lower glu-lam beam left the high roof members without support and they settled until they came to rest on the remaining portion of the broken glu-lam beam. **Figure 2** shows a sketch of the structural section as observed from the record drawings which shows how the low and high roofs were supported by the glu-lam beam prior to the failure. **Figure 3** shows the approximate post-collapse position of the remaining framing.

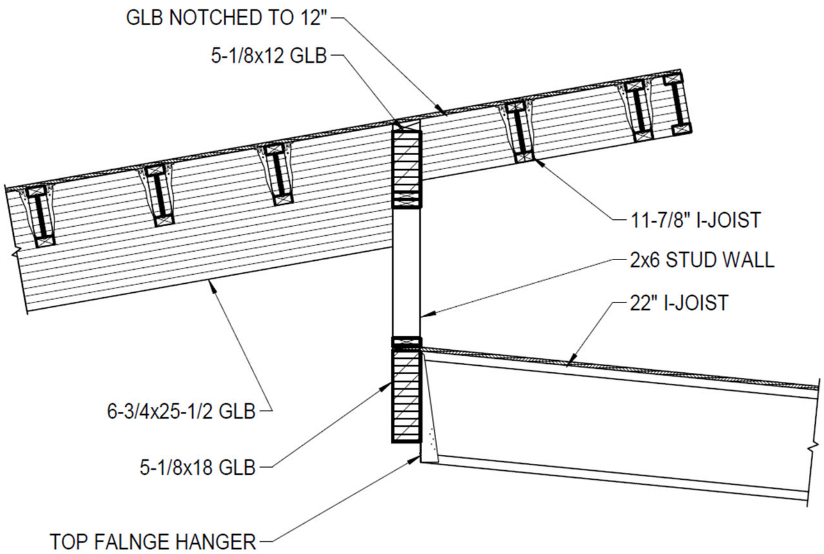

Figure 2: Roof Section before Collapse

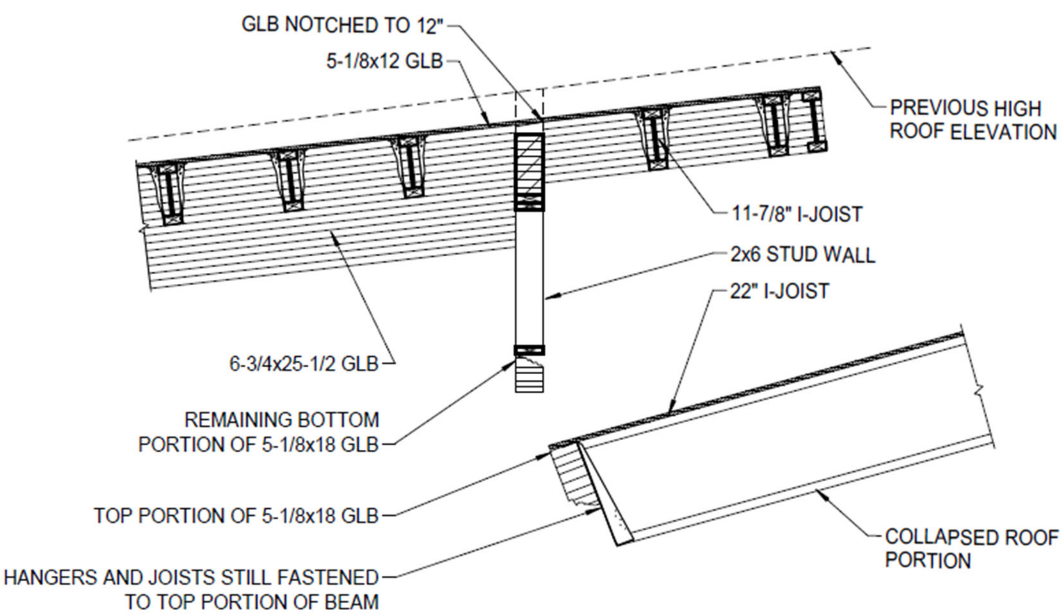

Figure 3: Roof Section After Collapse

Photo 3: Roof Snow Drift

PND was able to observe the snow drift on the intact portion of the low roof **(Photo 3)**. The snow extends from the low roof up to the underside of the high roof overhangs making the snow drift approximately 3 feet deep. The drift appeared to have a very dense lower layer that was topped by two or more layers of softer drifted snow. PND was unable to gain safe access to this drift to take a weight measurement.

PND also reviewed the condition of the exterior CMU support wall. The wall was observed to be plumb and intact. No signs of damage or displacement were witnessed. Once the low roof debris is removed, a complete survey of the CMU wall should be performed.

PND entered the building from the loading dock entrance on the North side of the building and focused the initial observations on determining if the structural integrity of the high roof was sufficient to allow for safe movement further into the building to observe the area of collapse. Much of the library has hard lid ceilings which did not allow access for observation. In the areas where drop ceilings were present PND was able to remove ceiling tiles to see the structure above. The wood members above the ceiling grid were wrapped in gypsum wall board so a full observation of the members and their connections was not possible. However, PND was able to see that the beams were still centered over the interior columns and there was no evidence of large displacements of the roof beams along gridline 2 between grids C & D **(Photo 4)**. PND recommends that the gypsum wall board in this area be removed to permit a full investigation of the area before other repairs are completed in the building. Based on the current limited review of this area, the beam and their connections appear to be intact.

Photo 4: Beam Centered Over Column

PND was able to observe damage to the backside of the soffit framing over the circulation desk area from above the ceiling grid **(Photo 5)**. This damage is the result of the high roof beams losing support along grid line 3 and dropping and crushing the soffits below. Since the soffit framing was firmly attached to the walls and columns below, they could not move downward without being crushed by the high roof **(Photo 6)**. Much of this soffit framing is not accessible for observation at this time. The soffit finishes should be removed in selected areas to allow for complete observation by an engineer before contractors begin clean up and repairs. This additional access will permit the engineer to determine the full extent of the damage and if the soffit needs to be removed to allow safe continued access to the area beneath it.

Photo 5: Damaged Soffit

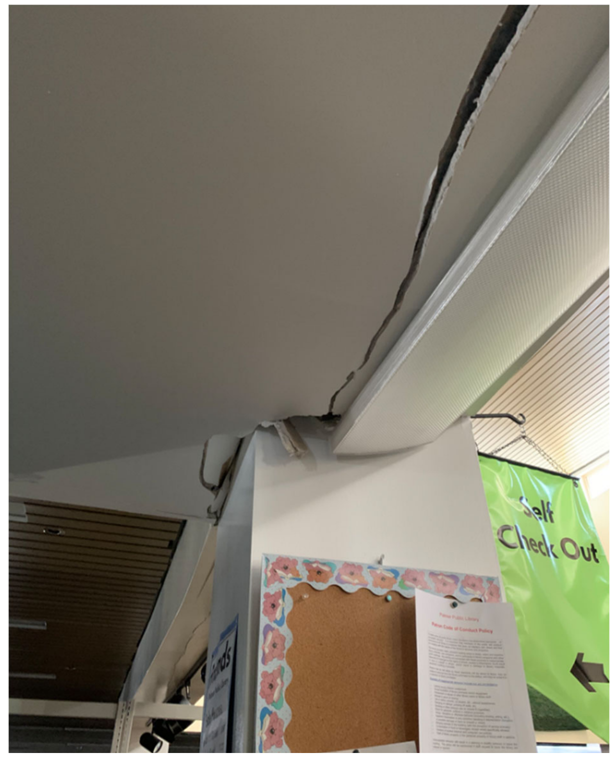

Photo 6: Crushed Soffit

Photo 7: Collapsed Framing and Remaining Soffit

After assessing the high roof, PND shifted the focus to reviewing the area of low roof collapse. The low roof framing came to rest on top of the bookcases. Because the structure is still partially suspended, the collapsed framing is obscured by the remaining soffit that was framed below the roof before the collapse **(Photo 7)**. PND was able to see that the top portions of the glu-lam beams, that broke away from the supports, were still attached to the low roof wood I-joists. The wood I joists were still sitting within the light gauge steel top flange hangers **(Photo 8)**. This observation meshes with the observations from the exterior of the building. PND was able to observe some water staining on the beams due to past water exposure but PND did not witness any areas of wood rot during the site visit. The complete condition of the round steel support columns and high roof beams could not be ascertained since the elements were still covered with finishes. At least one steel column appeared to be deformed as viewed from the from the drone footage **(Photo 9)**.

Photo 8: Joist in Top Flange Hangers

Photo 9: Damaged Steel Column

Figure 4 shows a roof plan from the building's record drawing with a summary of the damage observed during PND's site visit. This figure only identifies the areas of known damage. It is likely that additional damage will be discovered as building finishes are removed.

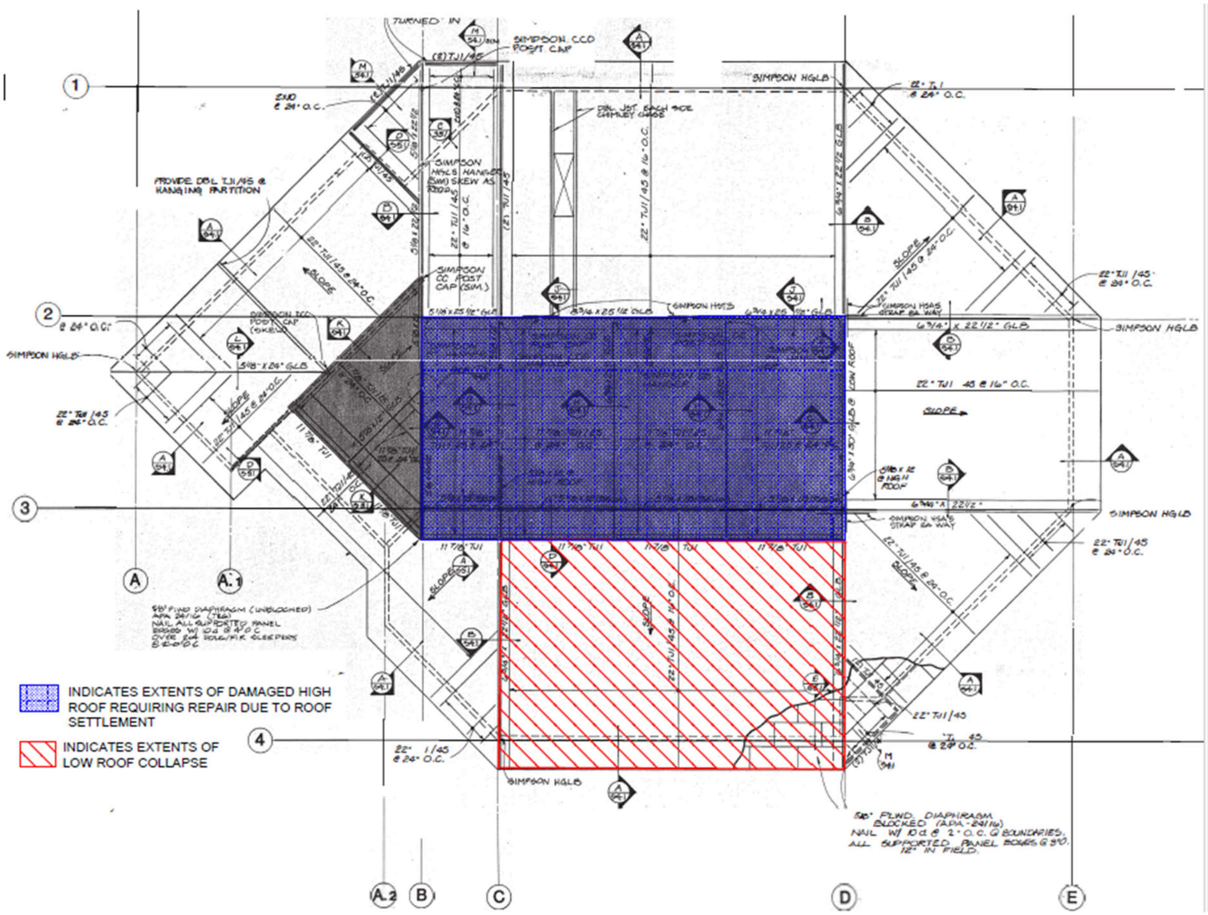

Figure 4: Summary of Observed Damage

3. RECCOMENDATIONS & CONCLUSIONS

After the site visit, PND performed calculations on the existing roof members to evaluate the expected capacity of the members when possible. The record drawings indicate that the low roof joists are Trus Joist TJI 45 series joists spaced at 16" on center. PND attempted to find legacy documents from the I-joist manufacturer to determine if these joists have the required capacity to support the uniform and snow drift loads. Unfortunately, PND was unable to find product data older than 1985 for the Trus Joist products. Therefore, PND could not verify the actual I-joist capacities per the original manufacturer. In the absence of this legacy data, PND chose to perform approximate calculations on joists by analyzing the modern-day joists that have the same flange dimensions as the joists observed in the field. The observed TJI 45 joists had 3-1/2" wide flanges which are similar to the modern I90 joists by Boise Cascade. Using this rough approximation, PND believes that the roof members were likely correctly sized for a uniform roof snow load of 40 psf. PND also reviewed the design of the of the low roof and high roof glu-lam beams and found that many of the members had very little reserve capacity left available after the application of the building self-weight and uniform snow load. PND then evaluated the low roof members with the additional snow drift loading that would be required by the current building code. Current building code requires the application of a tapered snow drift over the 16.5 feet of low roof starting at the step between the high and low roofs along gridline 3. The snow drift adds 59 psf of snow load in addition to the 40 psf uniform snow drift and the tappers to zero over the 16.5 feet. **Figure 5** shows the snow drift diagram required by the current building codes. This drift loading was not required in the 1980s when the structure was designed. PND could not accurately review the 22" I-joists with the additional snow drift due to the lack of the legacy product data with the manufacturer's member capacities.

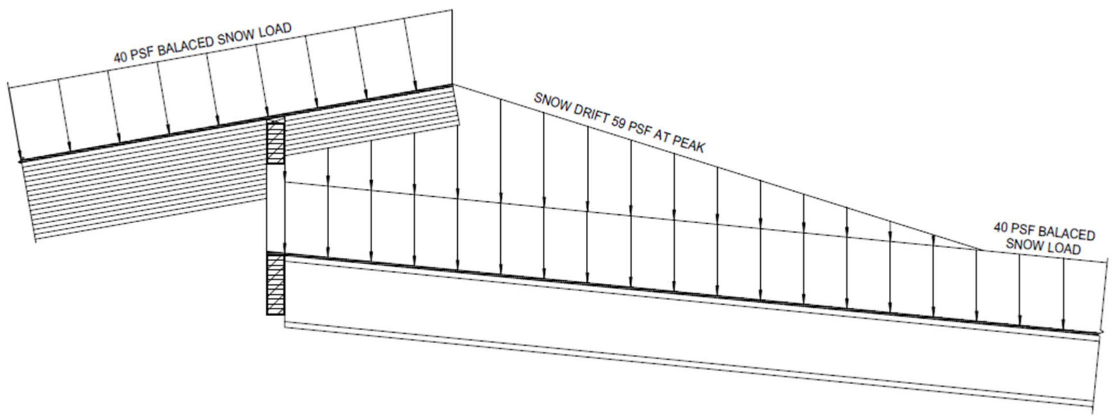

Figure 5: Code Required Snow Drift

With the additional snow drift loading, PND found that the 5-1/8" x 18" glu-lam beams supporting the low roof would be at 120% of their bending capacity. Even though the beams were found to be overstressed in bending, PND does not believe that this was the failure mechanism that led to the low roof collapse. The field observed damage to the beams does not appear to be from a bending failure. The beam failures appear to be the result of torsion on the glu-lam beams. The low roof joists were hung from one side of the glu-lam beam with top flange hangers. PND believes that the one-sided application of the high snow loads may have led to a rotational loading on the beams which exceeded their torsional capacity. Another possibility is that the low roof I-joists broke due to the high snow drift loading and the forces experienced during the collapse pulled the support beam apart. Both of these failure modes would have likely occurred before the glu-lam beams were overstressed in bending. Either of these failure modes would explain the observed longitudinal failures along the lengths of the support beams.

The failure of the lower roof glu-lam beams has left the high roof unsupported. PND strongly recommends that the high roof glu-lam beams by shored to provide support from the roof to the ground level before any recovery or repair efforts are conducted within the structure. Each high roof beam should be shored with either an 8x8 Douglas-Fir #1 timber post, a steel HSS4x4x5/16 column, or a steel shoring jack rated for 25,000 pounds. These posts shall be positively attached to the roof glu-lam beams and concrete slab to prevent movement during repairs. **Figure 6** shows the approximate locations of the recommended shoring posts. Once these shoring posts are in place, a contractor may begin to open up the damaged walls and soffits to allow a full observation of the structure. Once the full extent of the damage has been determined, the plans for cleanup and recovery of the structure may begin.

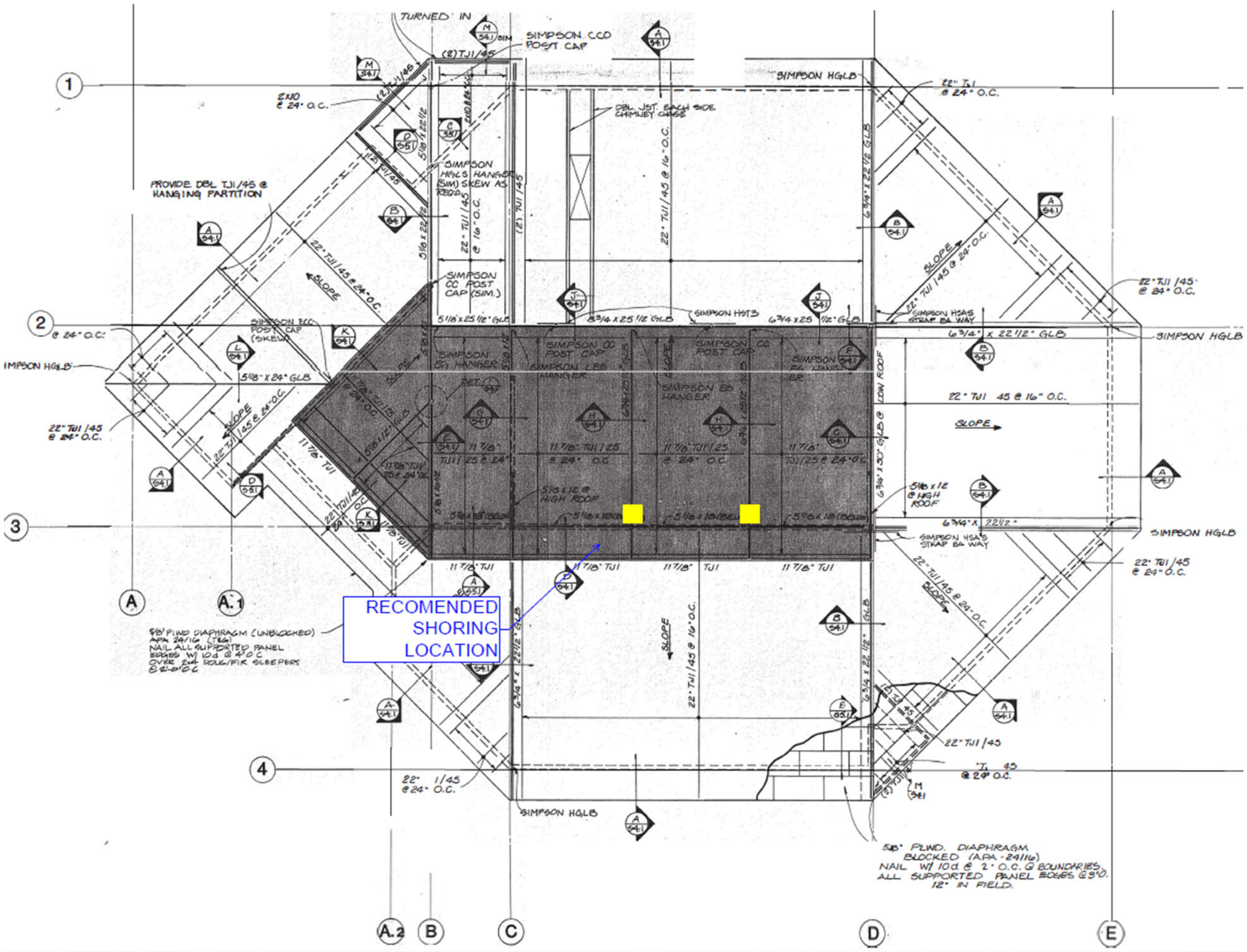

Figure 6: Approximate Shoring Locations

PND strongly recommends that the remaining snow drift on the low roof be removed by a qualified contractor prior to the commencement of other work. The removal of these drift will help migrate the potential for additional roof collapse. PND recommends the use of manlifts and/or roof rakes during the snow removal to minimize the personal on the roof as much as possible.

Finally, PND would like to emphasize that the extent of the structural roof damage exceeds thirty percent of the total roof area. Therefore, this classifies the roof damage as “*substantial structural damage”* per the International Existing Building Code (IEBC). Section 405.2.4 of the IEBC requires, “*Gravity load-carrying components that have sustained substantial structural damage shall be rehabilitated to comply with the applicable provisions for dead and live loads in the International Building Code. Snow loads shall be considered if the substantial structural damage was caused by or related to snow load effects. Undamaged gravity load-carrying components that receive dead, live or snow loads from rehabilitated components shall also be rehabilitated if required to comply with the design loads of the rehabilitation design.”* This code provision requires that any components requiring repair or elements that support components that require repair will need to be designed for the loading specified in the current edition of the IBC.