Vehicle Maintenance Building Structural Evaluation

City of Ypsilanti Public Works Yard
14 West Forest Avenue
Ypsilanti, MI 4897

Prepared For:
City of Ypsilanti Department of Public Services
ATTN: Bonnie Wessler

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Client: City of Ypsilanti Department of Public Services
Project Location: 14 West Forest Avenue, Ypsilanti, MI 4897

1.0 Introduction and Scope of Evaluation

I conducted a structural assessment, on May 19th, 2023, of the Vehicle Maintenance Building located within the City of Ypsilanti Public Works Yard at 14 West Forest Avenue, Ypsilanti. This assessment was done at the request of Bonnie Wessler, Director of Public Services. The purpose of this structural assessment is to provide my opinion on the overall stability, current structural risks associated with the structure, and methods for mitigating the risks for continued use. The scope of this evaluation is limited to the Vehicle Maintenance Building structure only and is based on a visual inspection from ground level. It is also based on the condition of the structure at the time of my visit and assumes no further deterioration.

2.0 Existing Structure Description and History

The Vehicle Maintenance Building consists of a central vehicle bay, two adjacent sheds, and a concrete masonry unit (CMU) addition. The central vehicle bay was originally built in the late 19th century, and the adjacent sheds and masonry addition were added over time. The main area of concern is the central vehicle bay roof, which is noticeably sagging along the ridgeline and has been recently identified as structurally deficient. The adjacent sheds are primarily used for material and equipment storage, with some office space. The masonry additions are current used as vehicle maintenance bays and a vehicle wash bay.

3.0 Observations

3.1 Masonry Vehicle Bay Additions

The masonry vehicle bays are constructed with Concrete Masonry Units (CMU) walls with wood framed roof. At the time of inspection, no structural concerns were identified with the masonry additions. The masonry walls are in good condition and are performing adequately. No signs of distress such as cracking or settlement were visible in the CMU walls, and no evidence of past repairs was visible.

3.2 West Shed Addition

The majority of the interior and exterior of the west shed is finished, and therefore the structural members were not exposed for visual inspection. However, a central storage bay was unfinished and the existing framing appears to be in good condition. At the time of inspection, no structural concerns were identified with the West Shed.

3.3 East Shed Addition

The east shed roof and wall framing was exposed at the time of inspection. The existing roof framing appears to be in good condition. The east wall consists of three bay opening supported by steel columns. One steel column has entirely corroded to the point it is no longer making contact with the footing below, as shown in Figure 1.

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Figure 1: Corroded Column Bottom at East Wall of Eastern Shed

3.4 Central Vehicle Bay

The central vehicle bay is the oldest part of the structure, and, anecdotally, dates to the late nineteen century. It consists of pour concrete buttress walls that are approximately 11' tall. On top of the concrete walls are wood framed stud walls roughly 4' tall. The roof is framed with 2x6 rafters roughly 24" on center, and bear on the wood stud wall. The rafters are supported at mid span by either 4x4 or 4x6 purlin. The purlins are supported by a mix of framing that consists of larger timber trusses spaced every 10', smaller dimensional lumber, or nothing at all.

The roof substructure has seen significant modification and alternations over the years. The large timber trusses are likely original. However, many have been rebuilt to replicate the originals. Figure 2 shows a reconstructed roof truss. The trusses are missing along the southern end of the structure and on the north end. In these areas, the purlins are poorly supported, and the roof ridge is sagging as a result. Figure 3 shows the evident sag in the ridge on the southern end of the structure.

Additionally, in some areas the wood framed knee wall on top of the concrete wall has been forced out of plumb by the horizontal thrust forces from the roof. This is evident in the masonry vehicle bay area as shown in Figure 4. In areas where the wood trusses have been removed, the existing diagonal struts are over stressed and buckling. Figure 5 shows a typical strut that is buckling.

Figure 2: Typical Central Vehicle Bay Roof Substructure

Figure 3: Central Vehicle Bay Ridge Sag on Southern End of Building

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Figure 4: Knee Wall Lean from Roof Thrust

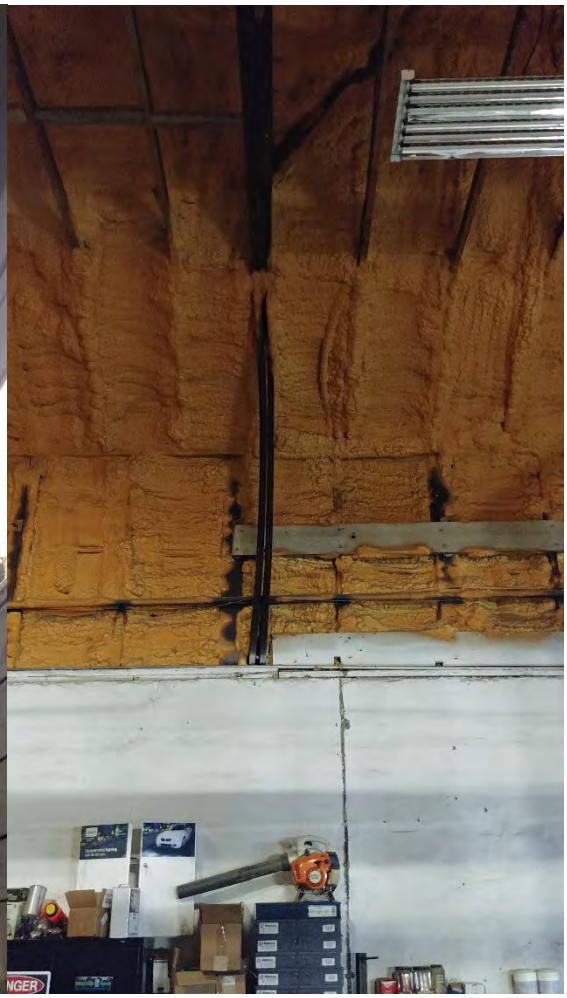

Figure 5: Buckling Strut

4.0 Analysis

This analysis focuses on the Central Vehicle Bay roof. The existing roof structure is undersized in some areas and poorly supported in others. The result is the dead weight of the roof and any additional loading from snow is causing the ridge to sag. The sag is occurring in areas of the roof where the purlins are no longer directly supported by the roof trusses below. The horizontal thrust from the sag is also causing the wood framed wall that is on top of the concrete to lean outward.

The open cell spray foam insulation that has been applied to the underside of the roof deck does act as a glue binding the structural members together. This does provide some stability to the structure. However, it prevents any meaningful inspection of the roof deck, rafters, and purlins.

5.0 Failure Modes and Structural Risks

Because of the issues noted above, the Central Vehicle Bay roof is not very resilient to external forces acting upon it. The primary cause of failure of the roof would be overloading from snow and/or wind. The two likely failure modes are: the roof splays out horizontally and/or the purlins fail and sections of the roof collapse into the vehicle bay. Although the roof has little ability to resist horizontal thrust generated by weight on the roof, the weight of the adjacent sheds and masonry structure act as buttresses. Therefore, the more likely failure is a collapse directly into the vehicle bay from the purlin failing.

Categorizing the likelihood of failure and accompanying risk is difficult. Nonetheless, for the structure to fail will require an external horizontal force acting either horizontally or vertically on the roof. The most likely cause of failure will be a heavy snow load on the roof. Additionally, a heavy wind could also overload the roof structure.

Since the existing framing is covered in insulation and not available for inspection, it is difficult to predict under what snow load or wind conditions the roof would fail.

6.0 Risk Mitigation Methods

Given the vehicle bay is generally occupied daily, the consequences of failure are high in terms of life safety. Therefore, I recommend the following risk mitigation strategies be employed if the structure is to remain in service:

Heating Central Vehicle Bay: Heating the vehicle bay during the winter months will help reduce the accumulated snow load on the roof. Even though the roof is insulated, heat loss through the roof assembly will either prevent snow accumulation or accelerate the melting of the snow.

Severe Weather Staffing Plan: Avoid staffing the central vehicle bay during predicted high wind and/or storm events. In addition, avoid staffing the central vehicle bay after a heavy snow fall until the snow has melted or slid off the roof.

Interior Load Limitations: Avoid hanging any additional interior loads on the existing framing to include lighting, door hardware, vents, or other building mechanical or electrical systems. Additionally, do not use the existing roof framing as anchor points for rigging or other lifting apparatus.

Roof Load Limitations: Limit any loading to the exterior roof surface to maintenance personnel access only. Any personnel should be limited to movements to the middle section of the central vehicle bay and avoid the northern and southern ends. Do no stage construction or building material on the roof.

Visual Inspection: Develop a program of visual inspection of the interior framing that can be conducted after a severe wind or snow event. The scope of this inspection will be limited since the framing is generally not accessible, and taking any precise measurements is not be feasible. The inspection will be a general common-sense survey of any changes. Items to note would be any water intrusion from the roof, any structural members that have noticeably failed, or any obviously movement in the framed

walls when viewed from the adjacent sheds. If the condition noticeable deteriorates, I would recommend the space no longer be occupied by facility staff until the structure has been evaluated by a design professional.

7.0 Structural Shoring

Given the varied and cobbled natured of the roof framing, attempting to shore the existing framing would be complex and would vary depending on the location of the roof being shored. Typical approaches would be: the addition of steel cable ties to prevent the roof from splaying out; additional interior framing to support the purlins; and reframing portions of the roof. Any shoring would need to be designed, which is beyond of the scope of this analysis. It is recommended any shoring be done as a design-build approach to best account for the varying site conditions and structural unknowns.

8.0 Conclusion

The primary concern of the Vehicle Maintenance building is the Central Vehicle Bay roof as identified above. Given that the building no longer meets the current needs of the department it likely is uneconomical to do any additional shoring to the structure unless extending the service life is the only option to maintain facility operations.

The structure can be safely occupied when no snow is on the roof and during calm weather provided the risk mitigation strategies have been employed. Predicting the remaining service life without any structural shoring is difficult. Given the structure has survived this long in its current state is an indicator that the roof structure has some resiliency and can withstand external loads to an extent. That said, when the failure occurs the structure likely will not be repairable nor recoverable.

If you have any questions, please feel free to contact me directly at 734-392-7034 or Adam@WagnerEngineer.com.