COUNTY OF MANITOWOC

COURTHOUSE DOME
CONDITION ASSESSMENT REPORT

January 30, 2008

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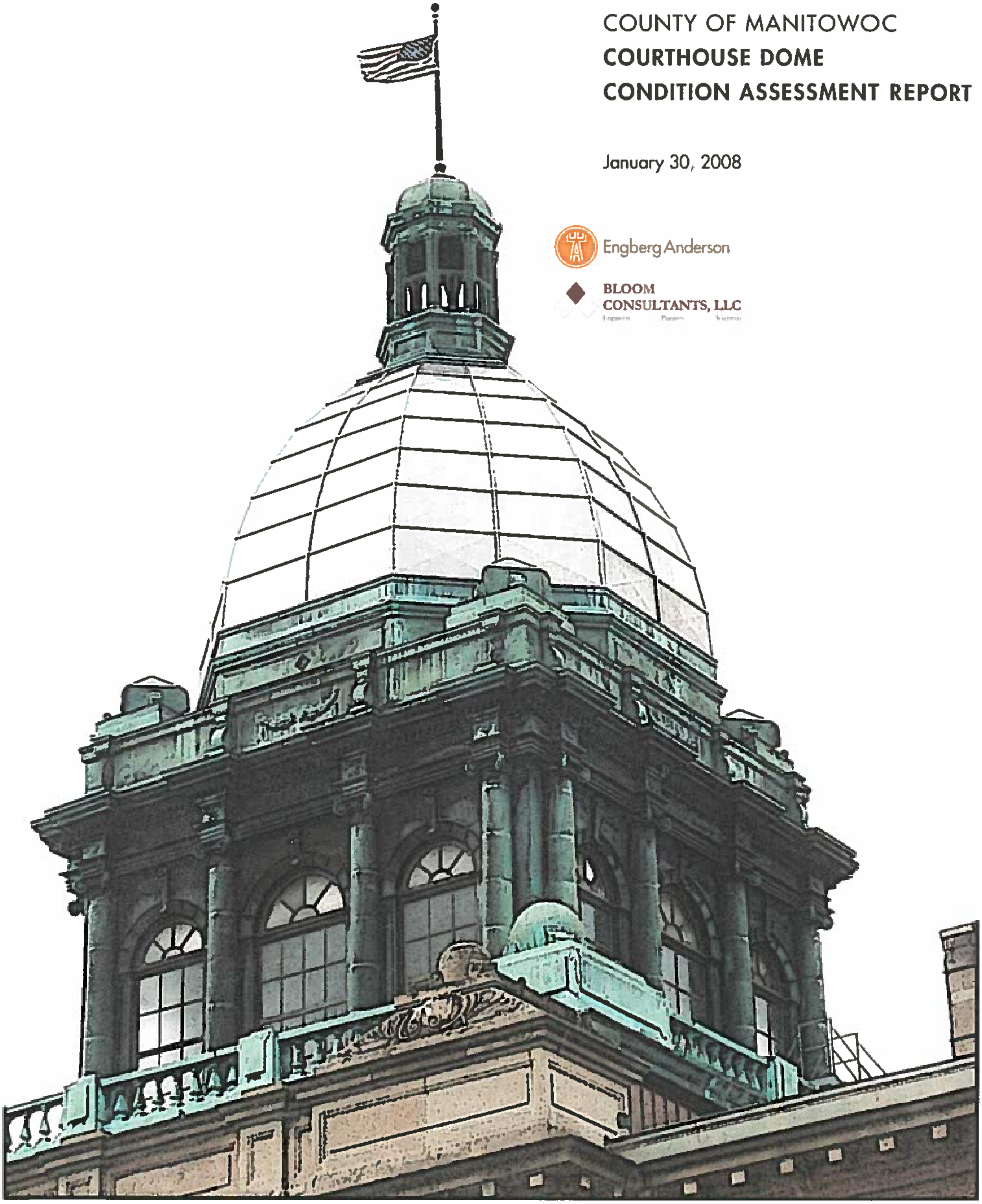
BLOOM
CONSULTANTS, LLC



1 • Introduction

1.1 Background

Completed in 1907, the Manitowoc County Courthouse features a prominent copper clad central tower with a stainless steel clad dome. *(figure 1)* Originally, the dome was clad in prismatic glass and copper trim. The glass dome, along with the large clerestory windows, introduced natural daylight into the building's central atrium via an interior glass dome at the base of the tower.

In the spring of 1950, the tower's copper cladding and its prismatic glass clad dome were extensively damaged in a storm.

Figure 1 Tower and dome as seen today.

The extent of the damage was documented in an historic photo. *(figure 2)* Close examination of this photo also provides evidence of previous attempted glass repairs. As the production of prismatic glass ceased in the 1930s, simple replacement was not an option.[1] In response to the damage, a full repair and remodeling of the central tower was undertaken. The existing copper balustrade and cupola were repaired while the rest of the tower was re-clad. As part of the project, the glass lites and copper weather caps of the dome were removed and replaced with stainless steel panels and weather caps. Additional work undertaken at this time included the introduction of an interior roof deck at the base of the dome drum, reworking of the cupola access ladder, and the covering over of the lower interior dome above the central atrium. Other alterations that may have been concurrent with or subsequent to this work include:

- The insulating of the closed off inner dome;
- The introduction of a large air return vent and ductwork at the peak of the inner dome.

Figure 2 The 1950 storm damage.

1.2 Purpose

The purpose of this investigation is to assess the current condition of the dome structure in preparation for the restoration of the dome glass.

Because the Manitowoc County Courthouse is listed in the National Register of Historic Places, a special level of care is required for all repair and remodeling work so as to not detract from the historic character of the building. The work will be reviewed for compliance with the Secretary of the Interior's Standards for the Treatment of Historic Properties, a series of guidelines overseen by the National Parks Service and each state's historic preserva-

1 Swanke Hayden Connell Architects, *Historic Preservation: Project Planning and Estimating*. Kingston, MA: RS Means, 2000: 309.

tion office. In addition, restoring an historic structure requires an understanding of existing and original conditions in order to successfully determine a course of action. Historic materials and construction will be documented and studied in preparation for designing and instituting repairs and replacement of missing elements. This report will describe the observed conditions in anticipation of implementing the appropriate repairs.

1.3 Project Team

The Courthouse Dome Condition Assessment Report is the first phase the proposed Dome Glass Restoration. Subsequent phases will include the design of the dome restoration, production of construction documents, and administration and observation of the dome restoration. The team assembled for this project is comprised of professionals with experience in historic restoration:

- Engberg Anderson, Inc. serving as team leader and Architect of Record.
- Bloom Companies, LLC providing structural engineering services and Engineer of Record.

During the investigation phase, access and selected removal/ construction services were provided by Hamann Construction Co. through a direct contract with the Manitowoc County Department of Public Works.

1.4 Methodology

The Courthouse Dome Condition Assessment was conducted through visual observation and limited disassembly of the stainless steel cladding system. Two stainless steel cladding panels and their associated weather caps were temporarily removed from the dome. The removal of these panels, located at the top and bottom of the south elevation, permitted the inspection of the structural system from the exterior face as well as documentation of the existing cladding systems. It also provided some insight into the original glass dome detailing.

In addition to site observations, dimensions of structural elements and cladding were taken. Construction documents from the 1950 renovation were consulted, as was the Manitowoc County Court House Historic Structures Report, dated August 2004.

2 • Project Area Description

2.1 General Description of Tower

From the exterior, the central tower of the courthouse begins with a large square plinth rising form the third floor roof. *(figure 5)* Originally clad in horizontal copper panels, it is currently clad with painted vertical steel panels. The top of the plinth is ringed with a copper cornice balustrade that is original to the building. Set atop the plinth and back from the balustrade is the copper clad clerestory with a trio of tall arch topped windows on each of its four elevations. The windows are glazed with prismatic glass. The clerestory is ornamented with an engaged Ionic order pedestal, column, and entablature. A copper clad parapet rises from the entablature to support an octagonal drum that forms the base for the octagonal dome. The clerestory, parapet, and drum were all extensively repaired or replaced in the 1950 renovation project. The dome was clad in stainless steel except for a copper skirt near the top. This skirt was also replaced in 1950. An octagonal cupola with flag pole rises from the skirt and is original to the building. The octagonal drum and dome are the focus of this report.

2.2 Description of Drum and Dome

The octagonal drum is approximately 5'-6" high and 31' wide. The octagonal dome is approximately 21'-6" high to the top of the copper skirt. The cladding is divided into seven rows of trapezoid panels. Structurally, the octagonal drum and dome are framed by eight metal trusses, one located in each of the corners of the octagonal plan. *(figure 3)* The trusses spring from steel columns at an area below the dome base interior roof and terminate in a compression ring at the top of the dome. *(figure 4)* The cupola structure is connected to the tops of the trusses. Lateral bracing in the form of horizontal trusses and beams stabilize the vertical trusses. A secondary structural system, the framing system for the sloped glazing, consists of copper wrapped horizontal and vertical members applied to the dome structure.

During the 1950 renovation project, an interior flat roof was installed to separate the interior space of the dome and drum from the clerestory and parapet interior spaces below. It is constructed of steel bar joists and corrugated metal decking, with a hot mopped roof over insulation. At the base of the drum, small through-wall scuppers protected with screening provide an outlet for drainage. The roof does not appear to be pitched for drainage.

Figure 3 Structure at drum and lower dome.

Figure 4 Compression ring at top of dome.

2 • Project Area Description

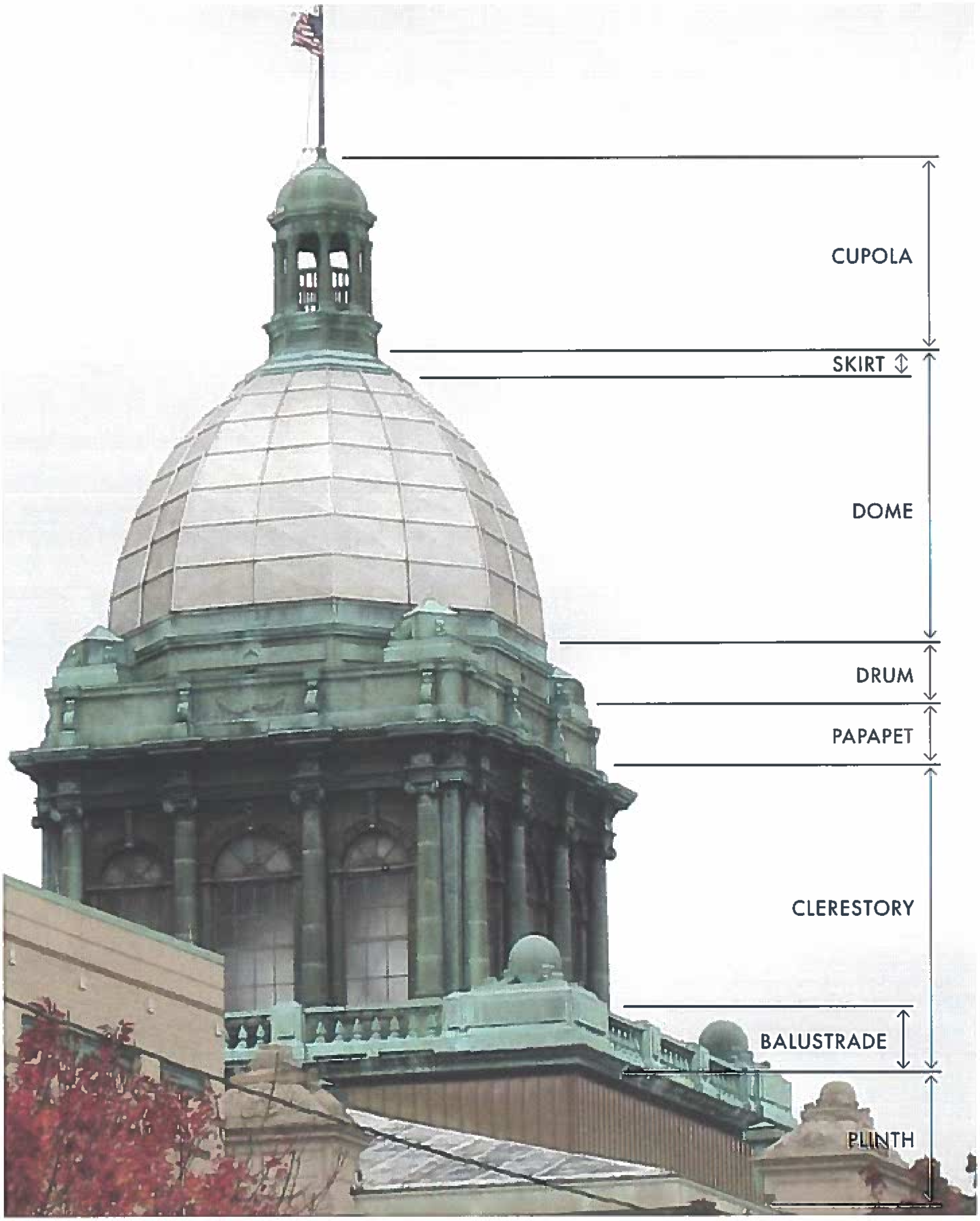


Figure 5 Central tower and its parts.

3 • Existing Condition Assessment

3.1 Materials

There are three main materials used in the construction of the dome. Understanding the properties and uses of these materials will help explain a number of the issues pertinent to the structural and architectural condition of the dome. These materials are the iron and steel of the primary and secondary structural systems, the copper flashing which wraps the secondary framing members, and the current stainless steel cladding system. The placement of copper in contact with iron or steel in this sometime humid and wet environment poses a potential problem in the form of galvanic action.

3.1.1 Galvanic Action

Galvanic action occurs at the molecular level when dissimilar metals are in direct contact and an electrolyte (moisture in any form) is present. Galvanic action can even occur when one metal is "downstream" of another in a water drainage condition. Each type of metal or alloy has an inherent positive or negative electrochemical potential. The more negatively charged materials will corrode the less negatively charged materials. Thus, the greater the electrochemical potential disparity between the two, the greater the potential for corrosion and the speed at which the corrosion will occur. Such is the case with copper and iron or steel. In a humid or wet environment, copper in contact with iron or steel will result in the corrosion of the iron or steel.

How metals corrode and the fact that different metals corrode differently must also be taken into consideration. When some metals corrode, such as copper, they develop a patina that forms a protective skin that slows down corrosion of the metal behind the skin. Other metals, such as iron and steel, slough off the corroded skin to expose fresh metal. Continued corrosion of these latter metals results in an expansion of the cross section of the material; for iron and steel, this can result in an expansion of up to ten times the original size. This expansion can cause the members to distort, and when in a confined situation, the expansion or "rust jacking" will force aside adjacent construction. In addition, corrosion does not have structural properties, and as a result, the loss of working cross section of a member reduces the member's original structural capabilities.

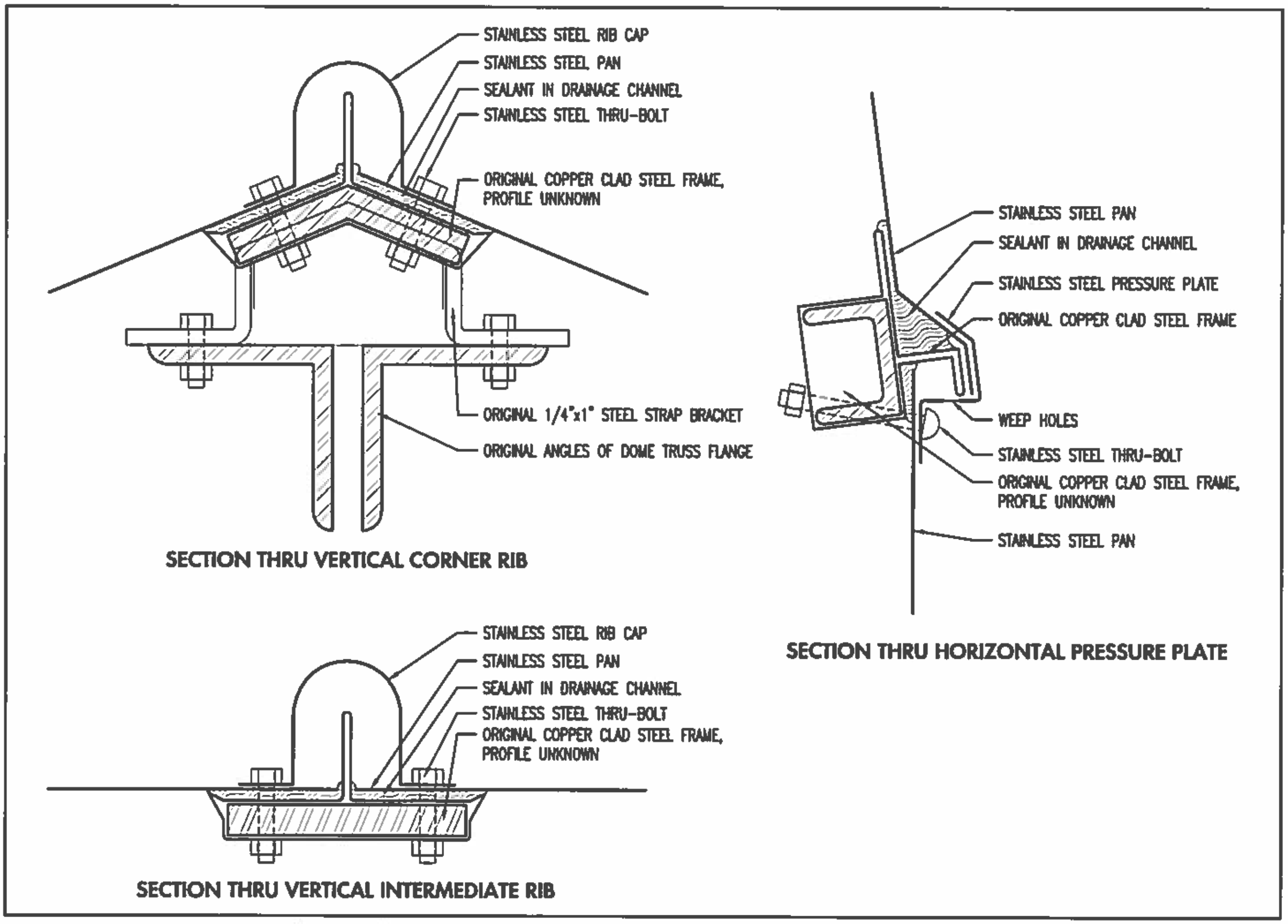


Figure 6 Detail of existing cladding conditions.

Stainless steel is an iron-carbon alloy that has the inherent property of being corrosion resistant in specific environments. In a few of its alloy forms, stainless steel can also act as a barrier between specific dissimilar metals. It is likely the 16 gauge, #302 stainless steel specified for the 1950 renovation was selected for these reasons.

3.2 Architectural Assessment

According to available construction documents, the existing stainless steel dome cladding consists of three elements. The first element is the original framing system that supported and defined the layout of the original glass cladding. The second element is the stainless steel panels set into the frame. The third element constitutes the weather cap, comprised of exterior surface applied stainless steel ribs and pressure plates that cover seams and secure the stainless steel panels.

3.2.1 Glazing Framing System

The original glazing framing system consists of a series of iron or steel members clad in copper flashing. The vertical framing members segment the curve of the dome along the rise, creating flat setting beds for the original glass. They are held off of the curved outer edge of the dome by a series of ¼" thick by 1" wide metal straps that are bolted back to the trusses. The copper flashing is wrapped around these members in a manner to create a central rib and a shallow drainage trough to either side of the rib. *(figure 6)* The horizontal members are directly bolted into the dome trusses. The copper flashing is formed in an 'h' profile, permitting the bottom of the panel above to rest on top without trapping water while the top edge of the panel below nests into a receiver pocket, shedding water from above over the glass and not behind it. *(figure 6)*

As the copper clad horizontal framing members are in direct contact with the steel dome trusses, most locations were found to have some limited galvanic action induced corrosion in form of scale. Significant corrosion was observed at the horizontal connection points at base of the top row of panels on the west, southwest, and south faces of the dome. *(figures 7 & 8)* These elevations face the prevailing southwest wind and will require repair of the structural members as noted in the structural assessment.

The condition and the exact profile of the horizontal and vertical framing members were not ascertainable without removing the copper flashing. The copper flashing was not removed at this time due to concerns of permanently damaging it. How-

Figure 7 Rust jacking at upper truss.

Figure 8 Close-up of rust jacking.

ever, visual inspection revealed several locations of copper with a protective lacquer coating. It is likely that these flashings were replaced as part of the 1950 dome renovation. It is not known if this was due to damage to the flashing or from required replacement of the actual framing member itself. It does, however, indicate a prior need to replace these elements.

3.2.2 Dome Cladding Panels

The stainless steel panels are flat panels cut to set into each framed opening. The bottom lip of the panel is formed to lap up and over the 'H' profile below. In order to create a watertight condition, the panels were set into sealant that generally completely filled the drainage troughs of the verticals and the beds of the horizontals. The sealant has become quite brittle, and numerous cracks and gaps were observed. Discoloration and corrosion patterns indicate that the sealant is no longer viable and is likely to continue to degrade through cyclical freeze thaw cycles. *(figure 9)*

3.2.3 Weather Cap

The stainless steel panels are held in place by a series of ornamental inverted 'U' shaped ribs at the corners and intermediate verticals, and 'Z' pressure plates at the horizontal edges. *(figure 10)* Both ribs and pressure plates are "through-bolted" to the framing with stainless steel bolts at 16" on center. Given the varying cross sectional location of these bolts, it is believed that these holes were field drilled at the time of the stainless steel installation and not part of the original installation. In addition, their general location would require the original glass to have been drilled to accommodate them.

3.2.4 Original Glazing Details

In examining the remnants of the original framing details, no definitive evidence was found as to how the original weather caps and glazing were held in place. It is typical for details of this era to through-bolt the weather caps through vertical or outward projecting flashing fin, however only one such possible hole was observed on one fin. There is some evidence of abandoned holes in the trough portion of the flashing. Through-bolting in this location would have resulted in compromising the flashing in the drainage pan by penetrating it. The 1950 photo does not show enough detail to see this condition. It does show in the lower left that the rounded rib was applied to the vertical fin and not an integral part of it. The exact profile and dimensions of the original weather caps remains unknown at this time.

Figure 9 Note brittle sealant around framed opening.

Figure 10 Horizontal and vertical weather caps.

3.2.5 Drum Cladding

During the dome condition assessment, small mounds of rust and pieces of sheet metal were observed on the interior flat roof behind each of the trusses. *(figure 11)* Further investigation revealed that the galvanized sheet metal armature for securing the drum's copper cladding back to the steel structure has corroded in many locations to the point that it either no longer securely connects the cladding to the structure. In some locations, it has completely corroded away providing no support. These armatures must be replaced with a more durable material not susceptible to electrolytic interaction with the copper.

It should be noted that the interior faces of the drum copper cladding panels are all painted with a protective lacquer coating. It is likely that these panels were also replaced during the 1950 renovation project. The galvanized sheet metal armature was likely introduced at that time.

Figure 11 Rust piling up behind bottom of truss.

3.3 Structural Assessment

Our assessment is based on a visual inspection the dome structure made in November 2007. The major structural framing elements, arch-trusses and compression ring, are generally in very good condition with limited deterioration. Observed deterioration was limited to the top chord of each of the arch trusses at the location one purlin line approximately 2/3 the height of the dome. There was significant rusting and subsequent rust jacking at the double angle top chord members of the arch truss at the purlin framing connection. The structural deterioration in this area should be readily repairable by welding or bolting plate new structural sections to reinforce the damaged area. The remainder of the areas showed no indication of structural deterioration.

The purlin row at the deteriorated connections will need to be replaced. The remainder of the purlins are in good condition and can remain. Secondary framing members supported by the purlins will be replaced with the new glazing system. The major structural framing system should be adequate for support of a new non-insulated laminated glazing system without reinforcement. If a heavier insulated glazing system were to be utilized, a detailed structural analysis and reinforcing will likely be required to determine the structural carrying capacity of the framing system.

The existing superstructure and purling system will require cleaning, media blasting and inspection prior to coating with a new high performance protective coating system.

4 • Recommendations

4.1 Repair, clean, prime and repaint all structural steel.

A complete restoration of the dome's structural system, from the truss bearing points through to the top of the compression ring is recommended. All existing drum, dome, and skirt cladding, armatures, and cladding/glazing framing should be documented and numbered, removed from the primary structural system, and salvaged as required. The existing coating on the structural steel should be tested prior to cleaning to identify the original coating system, any health hazards it may pose, and to recommend any special considerations for its safe removal. All structural steel should be blast cleaned to bare steel, inspected, and repaired as required. Upon the successful completion of cleaning and repairs, all structural steel should be primed and painted with a multi-coat, rust inhibiting, industrial coating system.

4.2 Reglaze dome.

It is recommended that a single glazed system be used. The use of a single glazed system addresses two practical issues, energy conservation and cost. Originally constructed without insulation, the third floor ceiling and inner dome perform as part of the building's thermal envelope. By maintaining the energy envelope at this existing location, the added costs of using insulated glazing units in the dome and clerestory, of retrofitting the structure to accommodate the additional weight, and of heating and cooling the entire central tower can be avoided.

In restoring the glass to the dome, two detailing options present themselves. Each option has its own benefits and limitations to be considered. Both will be required to use weather cap profiles modeled after the originals as much as possible given the limited available information (photographs).

4.2.1 Restoration option - restore the original glass framing and glazing system.

Existing copper clad steel framing would be documented for condition, detail, and location. All copper cladding would be removed. All steel framing for the cladding support would be removed and repaired or replaced, cleaned, primed, and painted with the same rust inhibiting industrial coating system used on the structural steel. Sloped glazing system details would be developed based on historical precedent and specific evidence available from the dome itself. Framing members would then be re-clad in copper and reinstalled on the dome structure. Glazing, sealant, and copper pressure plates would be installed. In light of this option, the following considerations should be noted:

- As all exterior portions of the original glazing system are missing, new details would need to be developed. Additional investigation of the copper clad framing will be required, and some modification of the remaining portion of the original details will occur.
- Re-cladding steel in copper to duplicate the original details may prove to be a costly option that also tests today's readily available level of craftsmanship. The steel should also be wrapped in a membrane to separate it from the copper cladding.
- The original system relied on glazing compound and shingled construction that provided a level of reasonable weathertightness for its day. Such a system may not be able to meet current acceptable and expected performance standards or current building practices with regard to wind and water infiltration.
- Proposed details should be mocked up in full scale on the ground and water tested to determine performance and viability.

4.2.2 Replacement option - provide a new sloped glazing system incorporating current standard practices and detailing, customized from standard parts as required.

All original cladding framing members would be documented for location and placement, and then removed. New framing members, likely extruded aluminum profiles, would be installed to duplicate the original glazing pattern framing. Depending on visibility, such members may be anodized brown or black to simulate the original bituminous painted steel or partially patinated copper cladding. Provide custom copper weather caps with profiles based on remaining documentation of originals. The following considerations should be noted:

- The aesthetic look of the system would need to be coordinated with the State Historical Society's Historic Preservation Division. As the original system no longer exists and its "test of time" performance is unknown, the state is open to discussing the possibility of a modern sloped glazing system. Their criteria would likely rest on being able to duplicate the original visual appearance without adversely impacting the remaining building fabric.
- A sloped glazing system based on current standard practices and detailing will perform to current performance standards. These standards will exceed those of the original system.
- The copper transition trim/flashing between the dome and

adjacent skirt and drum cladding will need to be modified or replaced with new trim/flashing that is coordinated with the new system. The existing trim/flashing pieces were part of the 1950 renovation.

- Care is required in the detailing and finishing of the new glazing system in order to adequately separate dissimilar materials and avoid conditions for galvanic action.

4.3 Glazing Material

The dome of the Manitowoc County Courthouse was originally glazed in prismatic glass. Prismatic glass was originally developed as a means of capturing light and refracting it into a space in an attempt to increase natural light distribution. The material has not been in production since the 1930s and its actual effectiveness can not be tested. In trying to replicate its visual appearance several options are available. In addition, each of these options will need to be weight for cost, strength, practicality, and appropriateness. The following are possible solutions:

- Custom cast glass – Profiles will be based on surviving remnants of the original glazing. In talking with custom cast glass manufacturer, a cost of $60- $80/sf is likely.

- Reeded glass – This textured glass has been cited by the National Parks Service as an acceptable substitute for historic prismatic glass. ¼" tempered or laminated (over all thickness) reeded glass typically ranges from $12-$21/sf

- Fritted glass – Standard float glass that has ceramic paint fused to its surface in a series of narrow stripes. These frits may provide a sense of obscuring the view similar to prismatic glass; however, as the frits are opaque, the amount of light entering the dome will be reduced.

- Laminated glass - Patterned or frosted plastic or polyvinyl laminates applied to the interior face or sandwiched between panes of glass may provide an acceptable look using alternate materials.

- Twin-walled, clear polycarbide panels – These panels are commonly used in greenhouses today and may also replicate the appearance of prismatic glass. The material is lightweight and strong. While it does not have the lifespan of glass, it is made with UV inhibitors to increase the materials lifespan. Polycarbonate does have a higher coefficient of expansion than glass and this material quality would need to be addressed in the detailing.

All materials cited are specialty or custom items. Given the importance of aesthetics, samples should be obtained with the intent of narrowing field choices to no more than two selections. Visual mockups made with purchased large scale samples may be warranted, and any selection should be discussed with the state historic preservation office.

In addition to aesthetics, current building codes must be taken into account. The Department of Commerce has confirmed that restoring glass to the dome will be considered new construction and thus subject to current code requirements. Current codes require that glazing above a walking surface and that is more than 15° from vertical be provided with additional safety features to protect areas below in case of failure. These features include non-corroding safety netting within 4" of the inner surface of the glazing, or the use of laminated glass. While the attic may be able to be classified as a non-walking surface, further code investigation and discussion with the State is warranted. This may also provide additional direction for the possible renovation of the inner glass dome, now or at a future date.

5 • Related Work

The restoration of glass in the Manitowoc County Courthouse dome will have an impact on the direction of future restoration and renovation work at the courthouse. Although outside of the current scope of work, these secondary recommendations are listed for the benefit of the Public Works Department and their consideration of broadened or future restoration efforts.

5.1 Repair/Restore of Copper Cladding and Ornament at Tower

Examination of early courthouse photographs, including that of the 1950 storm damage, indicate a significant loss of ornamentation and detailing to the clerestory, the parapet, and the cupola skirt as a result of the 1950 renovation. As the dome will need to be completely scaffolded, repair and restoration of the copper at this time would avoid having to replicate the cost and effort in the future.

5.2 Forced Ventilation of the Dome

As the dome will not be environmentally tempered, condensation is a concern. By installing a forced air ventilation system (outside air blown into the dome) connected to a building automation system, condensation could be limited or mitigated by minimizing the difference between interior and exterior conditions.

5.3 Restoration of Inner Dome

Restoration of the inner dome presents an opportunity to restore natural light to the courthouse atrium. Light levels and aesthetics would need to be evaluated to determine if this option were only suitable with the removal of the interior flat roof at the base of the drum. In addition, the atrium air return louver and duct currently located on top of the inner dome will have to be relocated and reworked. Possible solutions include providing a series of slot returns around the inner dome drum, or a series of return louvers in the ceiling of the top floor corridors surrounding the atrium.

Currently the inner dome is covered over with insulation. Since the attic above the dome is not part of the tempered space, consideration to providing insulated glazing in the dome should be given. The added weight of the glass will require a structural analysis of the inner dome framing and may require reinforcement of the frame.

5.4 Removal of Interior Flat Roof at Drum

With the restoration of the dome glazing, the interior flat roof at the base of the drum will become a visual anomaly, noticeable thru the clerestory windows from the exterior. Depending on the glazing system selected, the interior flat roof may continue to work as a valuable backup to leaks. In regard to the inner dome restoration, removal of this interior flat roof will likely increase light levels, and when seen from the atrium below, the removal of this dark cap would be noticeable through even a translucent inner dome.

The outright removal of the interior flat roof will present challenges of its own. The original cupola access ladder will need to be restored. Interior maintenance access to the dome would no longer be possible without extensive internal scaffolding. One possible solution to this is to remove the roof and decking while maintaining and laterally bracing the bar joists. A walkway around the perimeter of the drum could be maintained, and access to it from the existing stair and cupola ladder could be achieved with bar grating or perforated "diamond plank" metal decking. The perimeter walkway could be waterproofed to catch condensation from the drum's copper cladding.

5.5 Replace Roof at Balustrade Level

Currently the balustrade level roof consists of a mopped or rolled-on coating system over the original flat seamed copper roof. If the copper of the tower is being repaired, coordinated removal of the original roofing and installation of a more appropriate roofing system along with proper flashing to the copper cladding may be opportune and cost effective.