Condition Assessment Report

Denny Sanford Premier Center
Sioux Falls, South Dakota
5 January 2018

SGH Project 171728

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

PREPARED FOR:

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5 January 2018

Mr. Scott Rust
City of Sioux Falls
224 West Ninth Street
Sioux Falls, SD 57117

Project 171728 – IMETCO CF-12 Flush Metal Panel Assessment, Denny Sanford Premier Center, Sioux Falls, SD

Dear Mr. Rust:

Enclosed please find our report documenting our independent review of the IMETCO CF-12 Flush Metal Panel system on the Denny Sanford Premier Center in Sioux Falls, South Dakota for functionality and structural soundness. Our visual assessment also included a review of the performance of the air and moisture barrier system behind these metal panels.

Sincerely yours,

Peter M. Babaian
Principal

Emily W. O'Keefe
Senior Staff II – Building Technology

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1. INTRODUCTION

This report summarizes the findings and recommendations from our condition assessment of the IMETCO CF-12 metal panels on the Denny Sanford Premier Center in Sioux Falls, South Dakota. The project team includes the following:

- Owner: City of Sioux Falls (City)
- Architect of Record: Sink Combs Dethlefs (SCD)
- Associate Architect: Koch Hazard Architects (KHA)
- Construction Manager at Risk: M.A. Mortenson Company (Mortenson)
- Metal Panel Installer: MJ Dalsin Roofing and Sheet Metal, Inc. (Dalsin)
- Building Manager/Operator: SMG Worldwide Entertainment & Convention Venue Management (SMG)

The following individuals from Simpson Gumpertz & Heger Inc. (SGH) comprised the evaluation team:

- Peter M. Babaian, Principal-in-Charge
- Emily W. O'Keefe, Project Manager
- David M. Lutz, Project Engineer

1.1 Background

The Denny Sanford Premier Center (Center) is a multipurpose facility in Sioux Falls, South Dakota, that hosts events year-round, including sports, concerts, and conventions (Photos 1 – 3). The City of Sioux Falls (City) commissioned the design and construction of the Center adjacent to the Sioux Falls Convention Center on 8 November 2011. During and after construction, the Center experienced issues with the IMETCO CF-12 exterior metal panels buckling. We understand that the City reached a settlement with the design and construction teams.

Following the settlement, the City sent out a request for proposal (RFP) in October 2017 for an independent enclosure consultant to perform a condition assessment of the IMETCO CF-12 metal panel system to determine whether there were concerns with the IMETCO CF-12 metal panel system's function or structural soundness. SGH submitted a proposal for the assessment on 6 November 2017 and signed a contract with the City on 22 November 2017.

1.2 Objective

Our objective is to evaluate the functionality and structural soundness of the IMETCO CF-12 metal panels on the north, west, and south elevations of the Center. Secondary objectives include determining the potential causes of the visible panel buckling and evaluating the backup waterproofing and air barrier system. Metal panels other than the IMETCO CF-12 panels are not included in the scope of our assessment or in this report. References to metal panels or flush metal panels in this report are solely to the IMETCO CF-12 unless otherwise noted.

1.3 Scope of Work

SGH performed an assessment, which included the following:

- Review of available design and construction documents and relevant reports.
- Two-day on-site visual assessment of the metal panel system from an aerial lift.

Our deliverable to the City is this report summarizing our findings.

2. DOCUMENT REVIEW

We performed a limited review of the following documents provided by the City:

- Volume 2: Architectural, “For Construction,” Drawing Set by Sink Combs Dethlefs and Koch Hazard Architects, dated 8 March 2013.
- Volume 2: Architectural, “Record Drawing Set,” by Sink Combs Dethlefs and Koch Hazard Architects, dated 19 February 2016.
- Volume 1 of 2 Project Manual, “For Construction,” by Sink Combs Dethlefs, dated 8 March 2013.
- Metal Panel Product Data Submittals, marked “Reviewed, Exceptions Noted,” by Koch Hazard Architects, dated 23 April 2013.
- Metal Panel Shop Drawings, marked “Reviewed, Exceptions Noted,” by Koch Hazard Architects, dated 22 April 2013 (sill detail revised 15 August 2013).
- Metal-panel-related Requests for Information (RFIs).
- Metal panel Change Orders (COs).
- Limited construction photographs.

We obtained the information presented in this section from the above-listed documents and verified it only to the extent explicitly identified in the Field Investigation section of this report. We summarize the relevant information, in part, below.

In Section 2.5, we identify applicable industry standards, including:

- American Iron and Steel Institute (AISI) S100-2007 – the North American Specification for the Design of Cold-Formed Steel Structural Members.
- American Institute of Steel Construction (AISC) Structural Steel Manual, Fourteenth Edition.

2.1 “For Construction” Drawing Set

The Premier Center consists of five levels referred to, from bottom to top, as Event Level, Concourse Level, Suite Level, Upper Concourse Level, and Mechanical Level. The oval building has four quadrants, numbered clockwise starting at the Northwest Quadrant, as indicated in the drawings. The majority of the elevations are clad with flush and corrugated metal panels and aluminum-framed glazing systems, with insulated precast concrete panels at the stair towers, one at each approximate corner of the oval. The west end of the building has a curved radius of approximately 128 ft. The flush metal panel cladding system extends up to the mechanical level (approximate height of 63 ft), with corrugated metal panels extending to the roof line. Four-inch-wide horizontal reveals occur every 2 to 5 ft vertically between panels. We note the following:

- Sheet A0.10 indicates that governing building code is the 2009 International Building Code (IBC) with amendments.

- Details 1, 9, and 10 on A8.20 show the typical wall construction at the flush metal panel system. It includes, from interior to exterior, 5/8 in. gypsum wallboard, 8 in. steel studs with 1-1/2 in. horizontal hat channels at 16 in. o.c. vertically on the exterior, 3 in. min. spray insulation (between studs and encapsulating the hat channels), 1/2 in. exterior gypsum sheathing, sheet membrane, and 1-1/2 in. metal panel system. The flush metal panel fastening is not shown, but the metal panels are oriented horizontally and nested vertically, with a male top edge and female bottom edge.

- Detail 12 on A8.21 shows the metal panel expansion joint at the typical floor line. Detail 2 on A3.12 shows an elevation, indicating movement joints at each of the floor lines. The detail includes hex head fasteners with washers, though no information or spacing is provided.

- The drawings do not contain vertical panel-to-panel end joint details.

2.2 "Record Drawing Set"

Changes to the information above in the Record Drawing Set include the following:

- Detail 1 on A3.12 shows an enlarged west elevation. The elevation includes vertical furring at 3 ft o.c. and at panel end joints in the flush metal panel areas.

- Detail 2 on A3.12 shows an enlarged south elevation. The elevation includes vertical furring at 3 ft o.c. and at panel end joints in the flush metal panel areas. Slip joints are indicated at the floor lines (reference is Detail 12 on A8.21).

- Sheet A3.13 (not included in the Construction Drawings) indicates two locations for metal panel mockups and provides details.

    - Detail 3/A3.13 is a vertical section through the metal panel mockup detail. In addition to the typical wall assembly, described in Detail 1/A8.20 above, it includes vertical furring at 8 in. o.c. outboard of the sheet membrane and 1-5/8 in. horizontal furring at the midheight of the panel. Fastening instructions read "West wall: predrilled holes 1/8 in. larger than fasteners with washers as required for connection strength. Fasten through both panels to vertical furring at all joints." The section shows a fastener through the bottom leg of the upper metal panel reveal (female end) into the vertical furring.
    - Detail 4/A3.13 is a horizontal section through the metal panel J-trim joint. The vertical furring is shown at 8 in. o.c. maximum for the west wall and at 36 in. o.c. maximum for the north and south walls. At select panel-to-panel end joints each panel terminates with a J-channel covered with a 4 in. to 6 in. snap-on trim. Two lines of vertical furring exist on either side of J-channel joints, spaced 6 in. apart.

- Detail 1 on A8.20 is modified. The detail includes vertical furring at 8 in. o.c. maximum for the west wall and at 36 in. o.c. maximum for north and south walls, along with the

1-5/8 in. horizontal furring at the midheight of the panel. Fastening instructions are the same as those given in Detail 3/A3.13.

- Detail 15 on A8.20 (not included in the Construction Drawings) shows an alternate vertical panel-to-panel joint. It is identical to Detail 4/A3.13.

2.3 Project Manual "For Construction"

We reviewed Section 07 42 13 – Metal Wall Panels in the "For Construction" project manual and noted the following:

- Para. 1.1.A.1 states that the specification section includes flush profile wall panels.

- Para. 1.2.A (Performance Requirements) states that the metal panel system must be capable of withstanding wind and other design loads as indicated on the drawings, and allows for a maximum deflection "for wind loads, no greater than 1/180 of the span."

- Para 1.2.B (Performance Requirements) "Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss." The temperature range is 120°F, ambient, and 180°F, material surfaces.

- Para. 1.2.D (Performance Requirements) "Accommodate tolerances of building structural framing."

- Para. 1.3.D (Submittals) "Submit panel profile characteristics and dimensions, and structural properties. Submit design calculations."

- Para. 2.1 (Manufacturer) Imetco products are included in the list of comparable products acceptable as an alternative to the basis-of-design product (Centria IW-10A).

- Para. 2.3.A (Concealed-Fastener, Interlocking Metal Wall Panels) "Provide factory-formed metal panels designed to be field assembled by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps. Include accessories required for weathertight installation."

- Para. 2.3.B (Flush-Profile, Concealed-Fastener Metal Wall Panels) specifies the following requirements for these panels:

    - Material: 20 ga G-90 Galvanized Steel.
    - Surface Finish: Smooth.
    - Panel Depth: 1-1/2 in.
    - Panel Width: 12 in.
    - Panel Orientation: Horizontal.

- Para. 2.4.A (Cold Formed Metal Attachments/Support Framing) "Cold rolled steel framing to ASTM A792, 55 percent AL-ZN, nominal coating weight of 0.5 oz per square foot (total both sides) of gauge and spacing required to comply with metal wall panel system's structural requirements as recommended by the panel manufacturer and engineer of record and in accordance with approved shop drawings." Additional listed requirements include the following:

- 18 ga, vertical box girt, 2.0 in. wide by 0.75 in. deep.
- Attached through predrilled holes, 8 in. o.c., to receive fasteners and thermally isolated washer assembly for attachment to substructure.
- Regularly spaced, threaded holes in vertical box girt indented to double thickness of metal at opening to facilitate M8 screw attachment of horizontal J-track.
- CI-Girt by Knight Wall Systems.

- Para. 2.4.C (Flashing and Trim) "Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Finish flashing and trim with same finish system as adjacent metal panels."

- Para. 2.4.D (Panel Fasteners) "Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners."

- Para. 3.2.B.1 (Weathertight Installation) "Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommended by manufacturer on side laps of nesting-type panels; and elsewhere as needed to make panels watertight."

- Para. 3.2.B.3 (Weathertight Installation) "At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates."

2.4 Construction Phase Documents

2.4.1 Metal Panel Submittals

We reviewed the product data sheets by IMETCO, the manufacturer of the metal panel system used on the building, which were returned on 23 April 2013. We noted the following:

- The profile is CF-12 flush wall panel without beads, with factory-applied joint sealant.

- The panel is 1-1/2 in. deep by 12 in. wide installed coverage.

- The metal panels are 20 ga smooth G-90 galvanized with a two-coat 70% Kynar 500 Mica Finish.

- The product has a 20 yr finish warranty and a 20 yr material warranty.

- For galvanized steel sheets, the metal is Grade 40 (40 ksi yield strength) structural steel with a G90 coating, both conforming to ASTM A653.

- The positive wind load table for steel panels identifies that for 20 ga material, with three spans up to 4 ft long, the positive window load is 189 psf. Notes on this load table include the following:

- The allowable loads are based on 1986 AISI and 1986 Aluminum Association Specifications.
- The allowable loads are based on stress only.
- The allowable loads have been increased by one-third for wind loading.
- CF-12 panels are to be used for siding only.
- CF-12 panels should be used vertically only.

2.4.2 Metal Panel Shop Drawings

We reviewed the shop drawings by IMETCO, manufacturer of the metal panel system used on the building, which were returned on 22 April 2013. These included typical details for both the flush metal panel system (CF-12) and their corrugated metal panel system (Latitude). We noted the following:

- CF-12 panels are 13-3/8 in. wide with 12 in. of exposed surface and 1-7/16 in. deep. The top edge of the panel is folded, forming a flange, the male portion of a nested connection. The bottom edge of the panel is bent with a radius, forming the female portion of a nested connection. The fastener penetrates through the exposed portion of the bottom edge of the panel (p. 1 of 14).

- Notes on p. 1 of 14:

  - "When installing CF-12 panel horizontally, orient female leg (mounting flange) to the bottom to allow for water to drain from seams. Field swage panel ends 3 in. to lap, install sealant as required. No other information on vertical panel-to-panel joints is included in the shop drawings.
  - "Some oil canning of panels is common in the industry and is not considered cause for product rejection".
  - "Use a continuous bead of non-hardening, high quality sealant compatible with Kynar and polyester finishes. For formed coping, extenders, fascia and wall caps, apply sealant bead to the concealed portion of the splice plate. (Sealant by erector)."
  - "All panels, battens and seams to have field bent transitions. (Example: change of plane)."
  - "All continuous lengths of panel trim to be notched, lapped and sealed 3 in. minimum at lap splices. (Typical)."
  - "Panel trim's thermal movement occurs at lap splices <u>Do Not Anchor Trim at Lap Splices</u>. (Typical)"

- The details and notes do not describe either longitudinal or transverse joint spacing.

- A note added by Koch Hazard reads "Installation of flush panels will be from top elevation to bottom elevation" (p. 6 of 14).

- Detail S/11 shows a vertical section through the horizontal reveal for the CF-12 metal panel system. The metal panels fasten to 20 ga 7/8 in. hat channels, installed vertically at 36 in. o.c. fastened through a vapor barrier (by others) and glass-mat sheathing (by others) to horizontal hat channels spanning between steel studs. The CF-12 panels and reveal orientation are horizontal with the female portion of the joint on the bottom, fastened at 36 in. o.c.

- Detail Q/11 shows the CF-12 metal panel system termination at a window jamb. The basic wall assembly is similar to that shown in Detail S/11. The jamb trim extends from the window jamb perpendicular to the face of the metal panel system. It turns 2 in. onto the face of the metal panel system and terminates with a hem. The trim is sealed and fastened to the face of the metal panels with butyl sealant and #44 1/8 in. prepainted S.S. rivets at 12 in. o.c.

- Detail P/11 shows the CF-12 metal panel system termination at the window sill and head. At the sill, an unidentified Z-shaped furring is fastened to the backup structure and the metal panel at 12 in. o.c. A hold-down cleat is sealed (with butyl sealant) and fastened to the outside face of the metal panel in line with Z-shaped furring. The metal sill flashing (identified as fascia trim) extends from under the window sill over the top of the metal panel and down around the hold-down cleat. A note instructs the erector to remove the top metal panel flange in the field. At the window head, sill closure trim extends out from the window head and turns up the exterior face of the sheathing. A piece of sill trim extends out from the exterior face of the sheathing to form a drip edge. The trim extends back up the exterior face of the wall 3 in. and is fastened at 12 in. o.c. This flashing is counterflashed by the vapor barrier. A continuous Z-backer is fastened at 12 in. o.c. to the backup wall. The CF-12 panel is fastened to the Z-backer with #44 1/8 in. prepainted S.S. rivets at 12 in. o.c.

    - Detail P/11 was revised in a later submission to include a rivet at 48 in. o.c. through the fascia trim, hold-down cleat, and metal panel, and into the Z-shaped furring.

- Detail HH/13 shows the CF-12 metal panel system jamb termination at the precast concrete. The metal panel system is terminated with a J-shaped jamb trim extending onto the face of the metal panel system 2 in. and terminating with a hemmed edge. The trim is sealed to the metal panel with butyl sealant. The 20 ga 7/8 in. hat channels are located at 36 in. o.c. The jamb trim is fastened to the hat channel (fasteners and fastening pattern unidentified). The metal panel is fastened to the same hat channel.

- Details FF/13 and GG/13 show the inside and outside CF-12 metal panel system corners, respectively. At each detail, the metal panels stop short of the corner, and a piece of corner trim covers the joint, extending 3 in. or 4 in. onto the face of each metal panel, respectively. It is sealed with butyl sealant to the metal panels and fastened with #44 1/8 in. prepainted S.S. rivets at 12 in. o.c.

2.4.3 Metal Panel RFIs

We reviewed the RFIs related to the metal panel system and noted the following:

- RFI 00485 Metal Wall Panel Install – Vertical Hat: “IMETCO, the metal wall panel manufacturer requires a support that runs perpendicular to their panels. The current details show the metal wall panels fastening to the hat channel that runs parallel to the panels behind the exterior sheathing. Contractor proposes to install a vertical hat channel over the air barrier for support of the metal wall panels as described in the attached letters. The hat channel will be installed at 2’ spacing on radiused walls at the west elevation of the building and at 3’ spacing at all other locations. The proposed installation will be at no additional cost to the owner. Please confirm this is acceptable.”

- Answer: “Proposed revision is acceptable. Hat channel outside of sheathing to be galvanized. Detail revisions due to added system depth to be coordinated with shop drawings.”
- Per KHA on 25 March 2013.
- The letters attached to this RFI both reference the IMETCO Latitude metal panel system.

2.4.4 Metal Panel Change Orders (COs)

We reviewed the COs related to the metal panel system and noted the following:

- Proposed Change Order 008, Incorporating Bulletin 58, signed 6 August 2013.

    - Bulletin 58 identifies comments from the WJE enclosure review, both addressed and unaddressed. As they pertain to the CF-12 wall assembly, WJE recommends using a breathable fluid-applied or adhered sheet product WRB on the outboard face of the sheathing. This comment was not addressed by a revision. Additionally, they recommend that horizontal surfaces, including the reveals and sill flashing, be sloped to shed water. This comment was not addressed by the revision.

- Proposed Change Order 210.2, Incorporating Bulletin 122, signed 21 January 2014.

    - Bulletin 122 incorporates the following changes to the Metal Wall Panel Furring: cost to provide Centria mockups on the south side of the building, added hat channel on the south and west sides of the building, and added temporary enclosure costs due to these changes.
    - These changes are illustrated on drawing Sheets A3.12 and A8.20, as noted in the changes from Construction Drawings to Record Drawings.

2.4.5 Construction Phase Photos

We reviewed construction phase photos from Mortenson showing various phases of construction.

We noted the following:

- The sheet membrane on the exterior sheathing behind the metal panels is Tyvek Commercial Wrap. It turns into window openings at sills, jambs, and heads. The Tyvek is wrinkled, but does not appear to have major gaps or fishmouths. Flashing details, cuts, damage, and penetrations through the Tyvek are treated with Tyvek StraightFlash.

- Vertical hat channels are installed over the Tyvek, fastened with hex head screw fasteners to the backup wall construction.

    - On the north and south elevations, there are approximately six vertical hat channels per 16 ft panel.
    - On the west elevation, there are approximately eight to ten vertical hat channels per 16 ft panel.   The spacing appears to vary.
    - In some photos of the north and south elevations, small sections of vertical hat channel, approximately one panel high, appear to be installed between the full-height hat channels.

- In photos dated June 2014, of the west elevation, we observe a distinct pattern in the panels. All the metal panels appear to be installed. A single photo includes a portion of the south elevation, and we cannot discern a similar pattern.

2.5 Industry Standards

We consulted the following standards as part of our assessment.

2.5.1 AISI S100

The 2009 International Building Code Section 2209 (Cold-Formed Steel) refers to the American Iron and Steel Institute (AISI) S100, the North American Specification for the Design of Cold-Formed Steel Structural Members. This manual includes design guidelines for fastener pullout and pull-over capacities in steel-to-steel connections and the associated industry-accepted safety factors.

2.5.2 Structural Steel Manual

The 2009 International Building Code refers to American Institute of Steel Construction (AISC) Steel Construction Manual (14th Edition). Table 17-11 contains the average coefficient of linear expansion for steel and the equations for the resulting stress and strain in members under thermal expansion.

3. INFORMATION FROM OTHERS

We spoke with Scott Rust, Mark Cotter, and Shannon VerHey, representatives of the City of Sioux Falls. Mr. Rust provided the above-listed reference documents. Additionally, they noted the following regarding the metal panel construction:

- The metal panels were delivered to the site and installed on the building flat, without a radius or bend.

We spoke with Jeff Gortmaker, the Director of Operations, and Troy Mulroy, Facilities Maintenance Manager, for SMG, during our investigation. They noted the following regarding the building operation and metal panel construction:

- Currently, no water leakage occurs at the building.
- They observed moisture on the floor adjacent to an exterior wall in a mechanical room at the Mechanical Level when the building first opened. They investigated the source by cutting through the interior wall board. They could not identify the source of the moisture and it has not returned in the years since.

We spoke with Keith Thompson of Koch Hazard Architects following our condition assessment, who reviewed construction phase documents and was present during the construction of the building. He noted the following regarding the metal panel construction:

- The metal panels were delivered flat and were not pre-bent in the factory or on site.
- The project team discussed a proposed change order to install small sections of vertical furring at every vertical end joint location that was not already immediately adjacent to vertical furring on the west curved elevation based on the spacing given in the shop drawings. He stated that the additional furring were never installed.

An email discussion among Keith Thompson of Koch Hazard Architects, Shannon VerHey of the City of Sioux Falls, and George Jones of IMETCO addresses the issue of staining or residue on the panel surfaces.

- IMETCO notes that this is likely residue from the butyl sealant in the panel joints. It can be scraped off and then cleaned using mineral spirits and should not reappear.

4. FIELD OBSERVATIONS

Emily W. O'Keefe and David M. Lutz of Simpson Gumpertz & Heger Inc. visited the building on 12 and 13 December 2017 to perform a condition assessment of the flush metal panel system. Peter M. Babaian of Simpson Gumpertz & Heger Inc. visited the building on 13 December 2017. We made observations of the building envelope from the interior, the low roof, the ground, and an aerial lift. Our observations are summarized below.

4.1 Interior Observations

On 13 December 2017, SGH performed an interior inspection of the building, accompanied by staff from SMG. During our inspection, we noted the following:

- We did not observe any signs of water leakage into the building through the opaque wall system supporting the flush metal panels. We note that there was no precipitation during or surrounding the time of our site visit.
- The aluminum-framed glazing system is made up of thin vertical mullions 1-3/4 in. wide and horizontal mullions 3-1/2 in. wide, with a depth of 4-1/2 in. (Photo 4).
- We observed water streaks on the vertical mullions (Photo 5).
- At the reported leak location in the mechanical room, the exterior wall remained open from the moisture investigation. From the opened wall we observed 6 in. deep steel studs, spaced approximately 18 in. on center, with batt insulation filling the cavity. We also observed rigid board insulation 1-1/2 in. outboard of the studs (air space in between). We did not observe any moisture in the cavity at the time of inspection (Photo 6).

4.2 Exterior Observations

We made observations from the ground and an aerial lift at eight locations on the north, west, and south elevations. Our observations are summarized below:

- The CF-12 metal panels appear buckled just shy of the panel-to-panel end joints, creating a regular pattern (Photo 7). When viewed from an oblique angle these joints appear to protrude from the smooth curved surface of the adjacent metal panels (above and below) (Photo 8).
- The locations of fasteners attaching the metal panel to the furring are not readily observable. On the south elevation, we observed a location where the window head flashing is missing, exposing the metal panel fasteners (Photo 9). The measured spacing was approximately 3 ft on center.
- We made the following observations of the panel-to-panel end joints (vertical joints):
    - The panel-to-panel end joints between adjacent metal panels are constructed by lapping one panel over the other by approximately 2 in. (Photo 10).
    - The panel beneath (inner panel) is swaged at the end (pressed and reduced in size) in order to fit behind the lapping panel (Photos 11 and 12). The lapping

panel (outer panel) is often cut back approximately 3 in. to help accommodate the panel behind (Photo 13). This is most noticeable below the reveals, where sealant is applied across the top to cover the gap (Photo 14). In one location, this cut back is approximately 6 in., with a rivet installed to secure this panel to the one behind (Photo 15).
    - The swage-and-lap method was not performed consistently, with different resulting dimensions of overlap, swage, cut back, bulge, and other portions of the details (Photo 16 and 17).
    - The metal panel finish (paint coating) of the panels is scraped at some locations adjacent to the end joints. The most consistent scrapes are on the surface of the inner panel, perpendicular to the end joint (Photo 18).
    - The outer panel appears to be cut at the joint with no finish on the cut edge. Two perpendicular nicks are cut into the outer panel at third points across the 12 in. portion of the panel (Photo 19).

- We took measurements of thirty-four panel-to-panel end joints throughout the building (south, west, and north elevations), recording the in-plane dimension between the cut end of the outer panel and the swage of the inner panel (Photo 20), and the dimension that the lapped panel is bulged out (Photo 21). These end joints are generally tight, with an average gap of less than 1/16 in. The average bulge at the end joints perpendicular to the adjacent panel surface is 1/16 in. (with some as large as 3/16 in.).

- We made the following observations of the longitudinal metal panel joints (horizontal joints):

    - The panels appear to be ship-lapped, with the lower panel nested into the panel above, as shown in the shop drawings. We were unable to observe this directly, but the lower panel does appear to turn up where we could observe it at the larger gaps.
    - We observed water collecting within the longitudinal joint opening at one location (Photo 22)

- We took measurements of twenty longitudinal metal panel joints throughout the building, recording the in-plane dimension between adjacent panels (Photo 23). The joint gap is difficult to measure because of the radiused bends in the panel, but we observed that the gap typically varied from 1/32 in. to 1/16 in., but many locations are butted up against each other such that a credit card cannot be slid into the gap.

    - We observed that these tight gaps often correspond to locations where there is buckling in the adjacent panels (Photo 24).

- We performed qualitative pull tests on twenty-six metal panels throughout the building with a suction cup. Our testing found that the panels appear to be securely attached to the substructure with fasteners and properly interlocked with the surrounding panels (Photo 25).

- The metal panel trim at sills, jambs, and building corners is typically riveted to the metal panels (Photo 26).

    - We observed one rivet pulled through the steel trim at the window head on the third floor on the curved west elevation (Photo 27), leaving this portion of the panel loose.

    - The corner trim piece at the southeast corner of the corrugated metal panel cladding system is attached with rivets. A number of the rivets are pulled through either the front or back piece of metal, or appear to have never engaged both pieces (Photo 28).

- We observed two different methods of treating metal panel reveals where they terminate at window jambs. The most common is a fillet joint of sealant from the metal panel to the window jamb trim (Photo 29). At isolated locations, on the lower two levels of windows, a bent piece of trim is slid into the gap. The trim is typically loose and does not appear to be attached to the adjacent cladding in any way (Photo 30).

- At isolated areas of the reveals, we observed a dark stain emanating from the top of the reveal along an area several inches to several feet long (Photo 31).

5. CALCULATIONS

5.1 Wind Load Calculations

We performed wind load calculations on the panels to determine whether the fasteners have appropriate pull-out strength for the required wind conditions.

We performed our calculations in accordance with ASCE 7-05 – Components and Cladding, Calculation Method 2, as referenced in IBC 2009.

- The building is high occupancy and is classified as Risk Category III.
- The code-mandated wind speed is 90 mph.
- The building is located in an area equivalent to Exposure Category B with a 1.0 topography factor and a 0.85 directionality factor.
- The building height is 63.60 ft to the top of the parapets in CF-12 metal panel areas.

Following the procedure outlined in ASCE 7-05, Section 6.5, we determined that the maximum negative wind pressure is 34.85 psf in Zone 5 (outside corner areas) and 19.01 psf in Zone 4 (all other wall areas). Using the information provided in the shop drawings and in the construction photographs, we calculated the following fastener loads:

- On the north and south elevations, fasteners are spaced a maximum of 3 ft o.c. horizontally, with a panel height of 1 ft. Therefore, assuming Zone 4 wind loading, the load on the fastener is 57 lbs.
- On the curved west elevation, fasteners are spaced a maximum of 2 ft o.c. horizontally, with a panel height of 1 ft. Therefore, assuming Zone 5 wind loading, the load on the fastener is 69.7 lbs.

We do not have the fastener information specific to the building construction from either specification or submittals. Dalsin recently provided fasteners to the City of Sioux Falls for attic stock and stated that they were used on the building. We used the properties of these fasteners and the design information provided in AISI S100 to calculate the following fastener strengths:

- The pullout strength of the fasteners through a 20 ga 40 ksi steel hat channel is 242.25 lbs.
- The pull-over strength of the fasteners through a 20 ga 40 ksi steel panel is 891 lbs.
- On the north and south elevations, the safety factor for pullout and pull-over failure of the fasteners (strength divided by load) is 4.2 and 15.6, respectively.
- On the west elevation, the safety factor for pullout and pull-over failure of the fasteners (strength divided by load) is 3.5 and 12.8 respectively.

5.2 Thermal Expansion Calculations

Materials expand and contract with temperature change based on their thermal expansion coefficient. The total material movement is a function of the thermal expansion coefficient, the temperature change, and the original material dimensions. Using the following information for the IMETCO CF-12 metal panels, we calculated the following movements and stresses:

- We used a coefficient of thermal expansion equal to 6.5×10^{-6} in./in.°F and the specified temperature change of 180°F for our calculations, per the AISC steel manual and specifications.
- For a 16 ft panel, the total expansion is approximately 0.23 in., or approximately 0.042 in. per section of panel between vertical supports.
- For the 1 ft panel height, the total expansion is approximately 0.014 in. of expansion.
- The corresponding internal stress caused by the temperature differential if expansion is constricted is 34.5 ksi.

We performed calculations to see if the temperature induced stress exceeds the critical buckling stress of the panel, following the methods in AISI S100 Section C4.1.

- Along the length of the panel, we calculate that a 20 ga steel plate with a 3 ft unbraced length and the given cross-section (radius of gyration 0.332 in.) has a critical buckling stress of 30.0 ksi.

6. DISCUSSION

6.1 Visual Appearance

The appearance of warping/buckling/bulging of the IMETCO CF-12 flush metal panel system resulted in this assessment for the Denny Sanford Premier Center.

While on site, we made similar observations of the IMETCO CF-12 flush metal panel cladding appearance, noting distortion throughout the assemblies that appeared worse on the west wall and had a recognizable pattern to it. Based upon our hands-on evaluation of the panels and visual observations, we observed that the appearance of warping, buckling, and bulging is concentrated at the panel-to-panel end joints. This issue is most likely due to the method of construction. Based on reports by persons on site during the installation (KHA and Sioux Falls) and by references in the documents provided, IMETCO supplied flat panels that were not pre-bent to fit the west elevation radius. Dalsin created the curve in the panels for the radius by fastening the panels to the vertical furring along the west elevation. The field installation puts an internal stress in the steel, which can cause buckling at seemingly random locations along the panel.

At the panel-to-panel end joints the problem is more apparent. Unless the vertical joint is located directly at a vertical furring location, the two lapping panels extend tangentially from their last fixed points in a relatively straight line. What appears as buckling is most likely the obtuse corner of the panel-to-panel end joint in comparison to the curved plane created by the other panels. We modeled this effect on the west elevation and found that a panel would protrude approximately 0.1 in. away from the curved plane when it is fastened 2 ft on center due to this geometry alone (SK-01). We also modeled this geometry in three dimensions to convey the visual effect of this offset on a curved surface (SK-2 to SK-4). We note that the appearance of out-of-planeness is made worse by the lapped nature of these joints, forcing the outer panel out even further. We observed this condition to be most pronounced on the west elevation, where the radius of curvature is the smallest, despite the more frequent spacing of vertical furring on this elevation (12 to 24 in. instead of 36 in.). These joint issues would have likely been visible in a mockup.

6.2 Thermal Expansion

The appearance of warping and buckling likely becomes more pronounced during hotter periods as the metal panels try to expand and are restrained by the adjacent construction. Our calculations are based on a surface temperature swing of 180°F (per the specifications). The required expansion allowance in the joints should be approximately 0.04 in. in the end joints and 0.014 in. in the transverse joints. Though the required expansion is small, we observed tight joints throughout the metal panel cladding with virtually no expansion allowance, confirmed with 1/32 in. (0.031 in.) and 1/64 in. (0.018 in.) thick cards during our visit. We observed these tight joints under relatively cold temperatures (between 20°F and 35°F) during our investigation, and these joints will only get tighter as the ambient temperature increases. This results in internal stresses that are higher than those required to cause buckling of the metal panels, resulting in further buckling of the panels.

We performed buckling strength checks for the panels and found that buckling is possible under this temperature variation because the stresses due to thermal expansion exceed the buckling strength by 13%. However, because the expansion length is so small, we expect the visual effect of this buckling due to thermal expansion alone to be minimal, though it could contribute to the other visual distortions in the panel. This loading will be cyclic in nature, varying with the temperature, potentially causing the panels to fatigue, creating more pronounced buckling in the long term. If the more pronounced buckling is unacceptable, those panels can be replaced with attic stock. We recommend inspecting the metal panels at 10 yr intervals for this issue.

The specifications require that the joints and fastening accommodate thermal effects. No information provided in the shop drawings indicate that thermal effects are accommodated. We did not find structural calculations for the metal panel system as part of the submittal. The specification requires design calculations, and the design team should have specifically requested them if they were not provided by the contractor. While these issues appear to contribute to the appearance of buckling and warping, they do not cause failure.

6.3 Structural Integrity

The construction photos and the observations that could be made without removing panels indicate that the IMETCO CF-12 metal panels are fastened 3 ft on center on the north and south elevations and 12 to 24 in. on center around the west curved elevation. This does not comply with the 8 in. spacing indicated in the as-built drawings, but does comply with the approved shop drawings and manufacturer recommendations. Our calculations show that the metal panel fasteners have a safety factor over 3 for the west elevation and over 4 for the north and south elevations. AISI 100 recommends a minimum safety factor of 3 for fasteners. For our calculations, we used ASCE 7-05 defined wind zones of Zone 5 wind loads for the curved west elevation panels and Zone 4 wind loads for the north and south elevation panels. ASCE 7-05 assumes a rectangular building in developing these zone wind loads. A curved surface will create a slightly different wind profile, which requires wind tunnel testing or computational fluid dynamics modeling to determine, both of which are beyond the scope of this report. However, the corner zone effects captured by Zone 5 of the standard method approximate the wind loading sufficiently for this analysis.

Additionally, these calculations do not account for the nested or stacked nature of the panels. The female-to-male joints at the top and bottom of panels not only integrate the panels with one another, forming a less-permeable surface, they also enhance the ability of the system to share load between fasteners. This type of systems distributes local occurrences of high loading (the maximum load used in our calculations) to larger areas of the panel, involving more fasteners.

During our limited qualitative pull tests on site, we did not observe any panels that felt loose or unattached; the panels appear to be interlocked, as shown in the shop drawings, and appropriately fastened.

We noted isolated cases of metal trim rivets which are pulled through the metal trim or metal panel cladding behind (Photo 27 and 28). Additionally, we observed isolated locations of loose bent metal trim at window jambs. We recommend that these pieces be attached or reattached and that the building be monitored annually for any trim that appears loose or poorly attached.

6.4 Water Infiltration

SMG informed us that this building does not experience any water intrusion through the exterior wall system. During our interior condition assessment, we did not observe evidence of water intrusion through the opaque wall system. We identified water streaking on interior mullions, but this could be related to water from construction, condensation, or interior window washing. Further investigation is necessary to determine the cause of this staining, if so desired. We recommend monitoring these locations during the next rain event to confirm that water is not entering the building from the exterior at the windows.

We note that the primary water barrier of the exterior wall system is the Tyvek CommercialWrap behind the IMETCO CF-12 metal panel system. The metal panels are a rainscreen system, deflecting bulk water away from the building and creating space for ventilation, drainage, and evaporation of water that gets behind the metal panels. We expect some water to infiltrate at metal panel gaps or areas of missing sealant, collect in the cavity, and be drained to the exterior at window flashings or the base of the wall. Without removal of the metal panel system, we could not assess the current condition of the Tyvek CommercialWrap. We do not believe this is necessary given the lack of water infiltration to the building.

6.5 Maintenance Items

During the condition assessment, we noted several additional items for maintenance:

- The bent trim pieces between the window jamb and the reveal panels do not appear to be secured to the wall in any way, and at least three are visibly loose. We recommend that these pieces be removed and reattached by riveting them to the window jamb trim or by setting them in silicone to prevent future falling hazards.

- We observed dark staining on the face of the reveal panels, typically originating at the top. As discussed in the documents provided, the staining is likely due to residue from the butyl sealant used in panel joints, which has not washed off the panels. We recommend scraping and washing this off the panels, as described in the IMETCO email, and monitoring for reoccurrence.

- One window head trim piece is missing on the south elevation. We recommend replacing this component to complete the assembly, cover the exposed fasteners, and standardize the visual appearance of this area.

7. CONCLUSIONS

Based on our visual condition assessment of the Denny Sanford Premier Center, we conclude the following:

- The metal panel cladding is generally installed according to construction documents and shop drawings. The installation does not meet the specification requirements allowing for thermal movement.

- The metal panels generally appear to be fastened to the building per the approved shop drawings. The fastening pattern indicated on the shop drawings, assuming the fasteners recently provided by Dalsin are the same as those used on the project, is sufficient to resist the applied wind loads.

- There are no reports of leakage into the building. Water and air leakage do not appear to be occurring through the building enclosure, including at the IMETCO metal panel locations and opaque wall systems. Window systems need to be monitored to confirm that observed stains are not active water leaks.

- The visual appearance of warping, buckling, or bulging at joints is most likely due to the lapped construction of flat metal panels around a curved building. Tight transverse and longitudinal joints between metal panels contribute to the appearance of buckling due to thermal expansion. To avoid this appearance, the panels needed to be precurved. Long term, the appearance of buckling may worsen due to cyclic loading, and regular inspections could identify panels for replacement based on excessive buckling.

- Loose trim components need to be secured to the building. Inspect the building trim to identify issues with the attachment, set in sealant and mechanically attach with rivets or screws, if necessary.

8. RECOMMENDATIONS

We recommend the following:

- Inspect the IMETCO CF-12 metal panels every 10 yrs to confirm that the thermal cycling has not resulted in excessive buckling in the panels or bends forming in the panels at the buckled locations.

- Monitor the windows during rain events to determine whether the observed stains are related to ongoing water leakage.

- Clean the butyl residue from the surface of the metal panels, as described in the IMETCO email, and monitor for reoccurrence.

- Identify loose trim components. Set trim in sealant and mechanically attach with rivets or screws if necessary.

We performed our services and prepared this report in accordance with applicable generally accepted architecture engineering consulting practice. We make no other warranties, either expressed or implied, as to the character and nature of such services and product.

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Photo 1

Overall view of north elevation.

Photo 2

Overall view of west curved elevation.

Photo 3

Overall view of south elevation.

Photo 4

View of the aluminum-framed glazing system from the interior.

Photo 5

Streaking on the vertical mullions.

Photo 6

Sample opening in mechanical room wall at location where moisture was observed.

Photo 7

Pattern of visible change at panel-to-panel end joints.

Photo 8

Panel end joints protrude from the plane of adjacent panels.

Photo 9

Exposed fasteners at window head.

Photo 10

Panel-to-panel end joint overlap.

Photo 11

View of swaged panel (left) inserted behind the lapping panel.

Photo 12

Inner panel swaged to fit within outer panel. Outer panel protrudes slightly to accommodate inner panel.

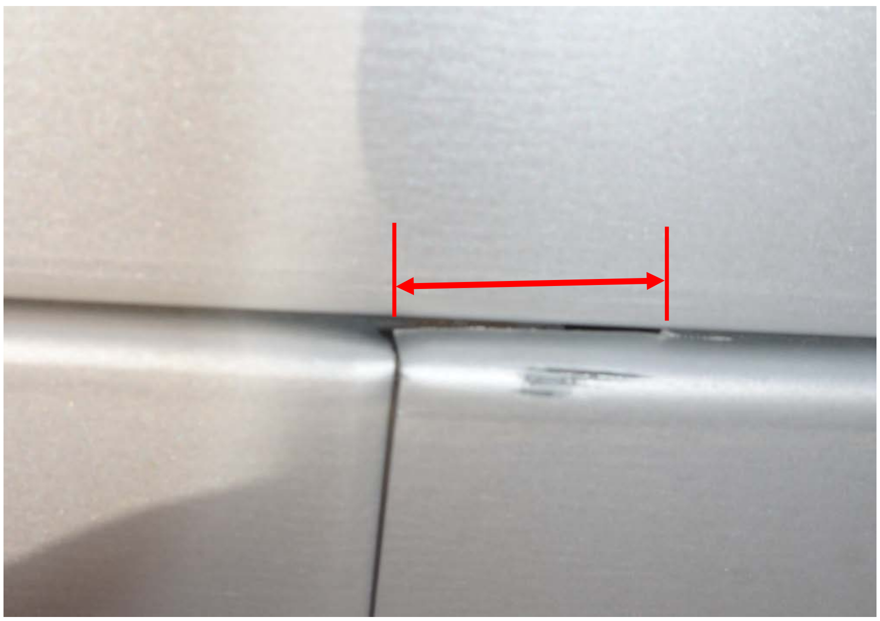

Photo 13

Lapping panel has been cut back to accommodate the swaged panel behind.

Photo 14

Sealant applied over notched gap in panels.

Photo 15

One lapped panel flange we observed is cut back more than 6 in. There is a rivet installed at the joint.

Photo 16

Observable variations in gaps and bulges at panel-to-panel end joints.

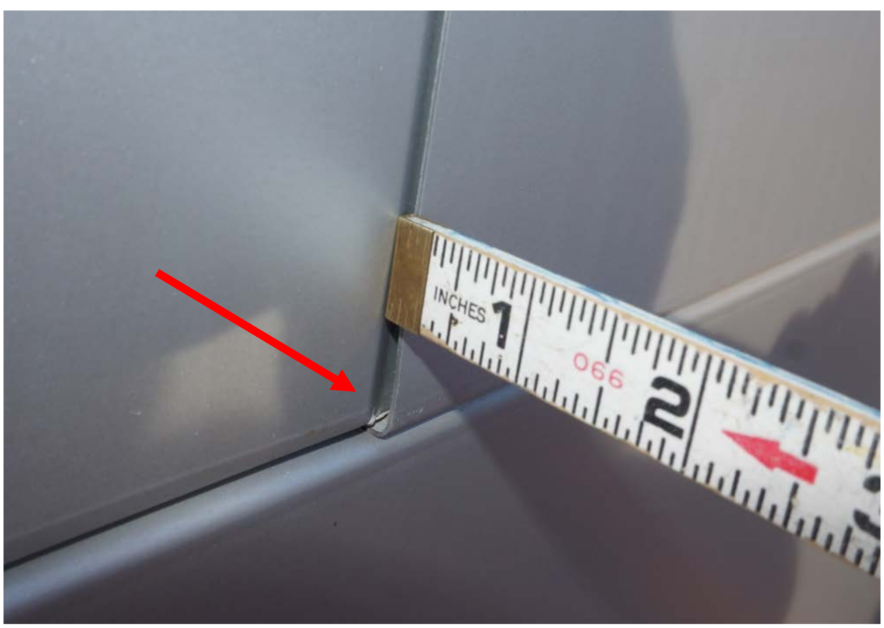

Photo 17

Bulging at bottom of outer panel due to end lap treatment.

Photo 18

Paint scraped off metal panel at end joint.

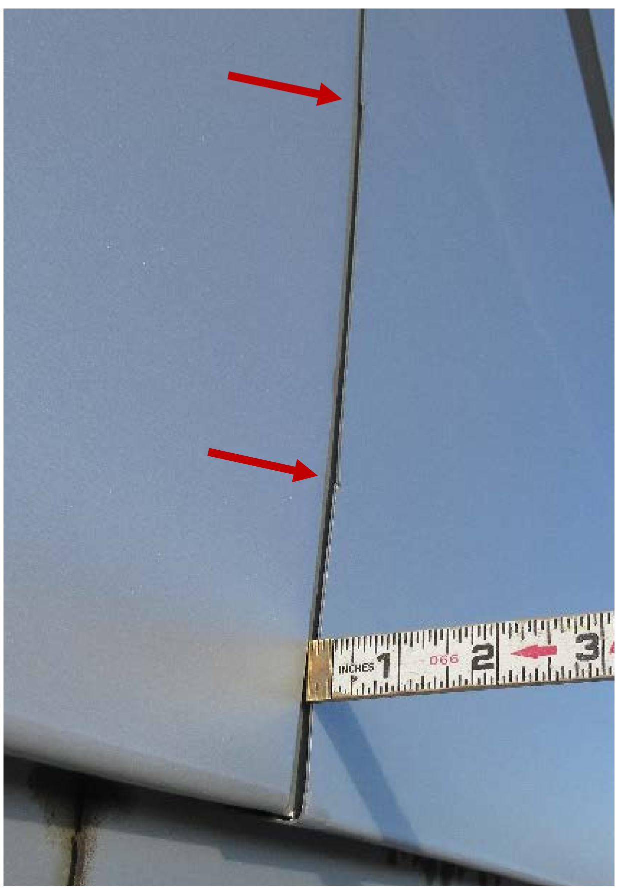

Photo 19

Outer panel appears to be cut at the joint with no finish at the cut edge, with two perpendicular nicks.

Photo 20

Measurements of end joint widths.

Photo 21

Measurements of end joint widths.

Photo 22

Water collecting within the longitudinal joint opening.

Photo 23

Measurement of horizontal joint.

Photo 24

Example of tight horizontal joint where a card (< 1/32 in.) could not fit in the gap.

Photo 25

Pull test of metal panel.

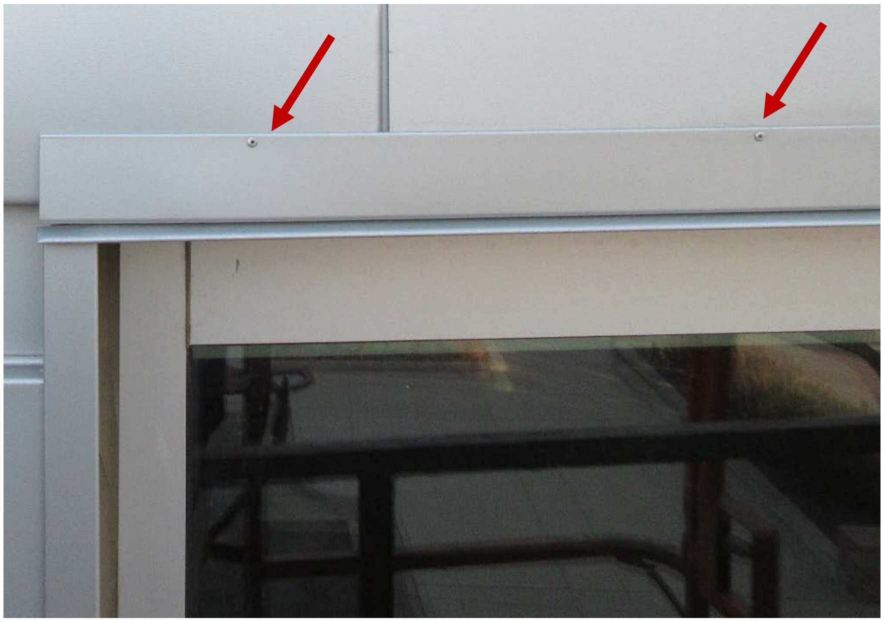

Photo 26

Metal panel trim at head is riveted into the metal panels behind.

Photo 27

Rivet that has pulled through the steel trim at the window head on the third floor on the west curved elevation.

Photo 28

Corner trim piece on the southeast corner pulled through the rivets that attached in to the corrugated panels on the east side.

Photo 29

Gap between window jamb trim and reveal panel filled with sealant.

Photo 30

Trim cover piece between the window jamb and reveal panel is loose.

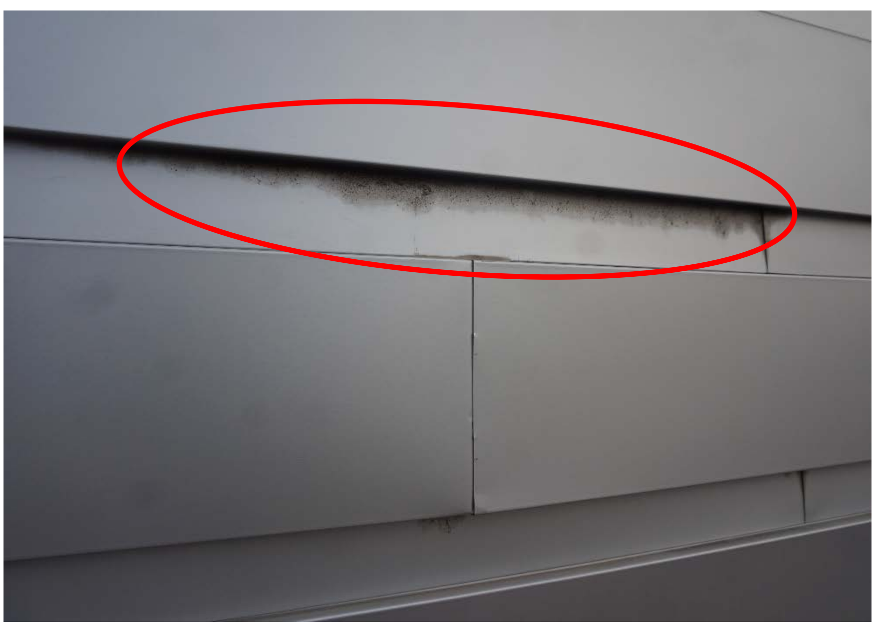

Photo 31

Staining on metal reveal panels throughout the building.

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Engineering of Structures and Building Enclosures

CLIENT	City of Sioux Falls
SUBJECT	Denny Sanford Premier Center
SHEET NO.	1 of 2
PROJECT NO.	171728
DATE	05 JANUARY 2017
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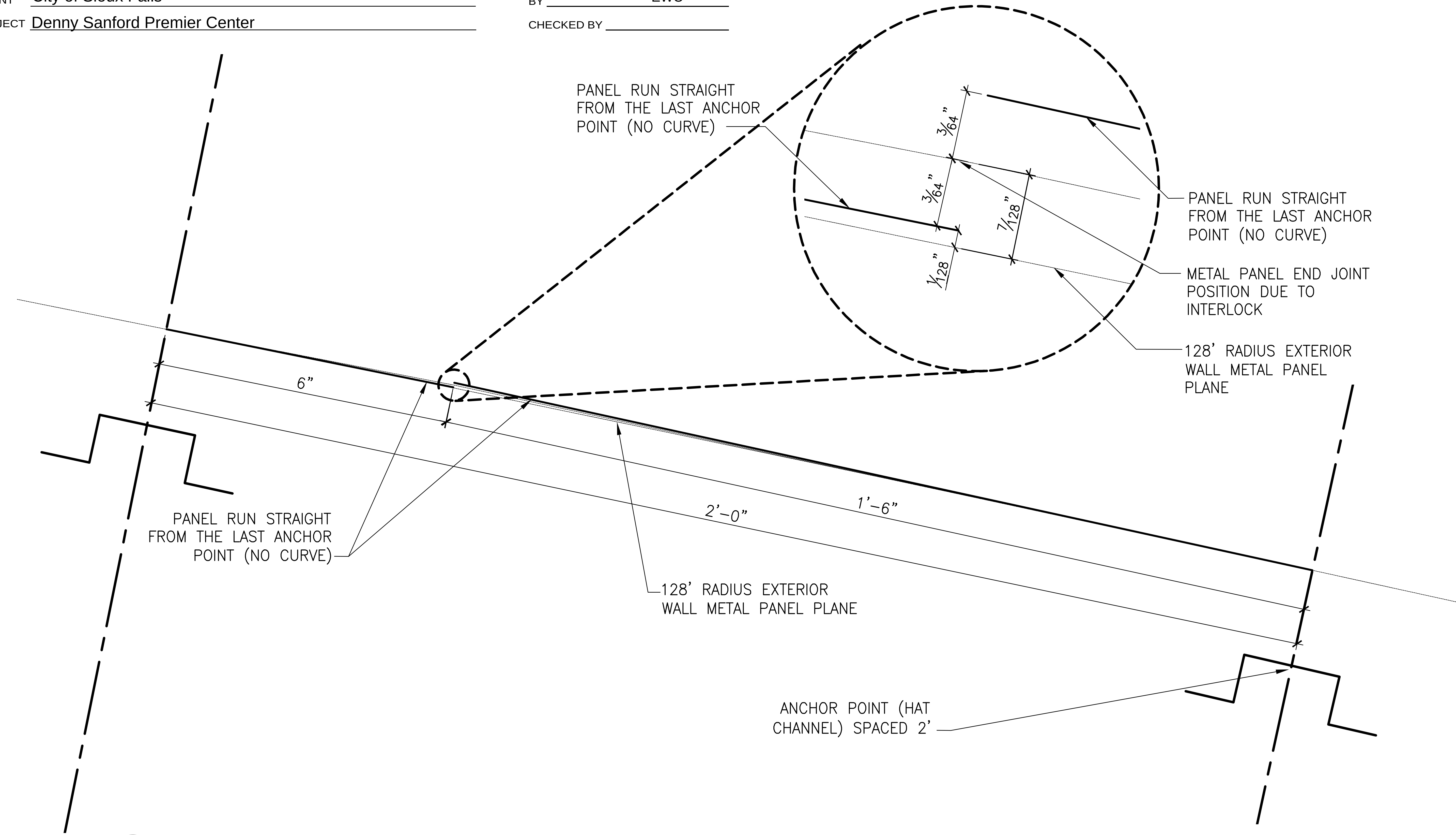

SK 1

End Joint Geometry

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CLIENT City of Sioux Falls

SUBJECT Denny Sanford Premier Center

SHEET NO. 2 2

PROJECT NO. 171728

DATE 05 JANUARY 2017

BY DML

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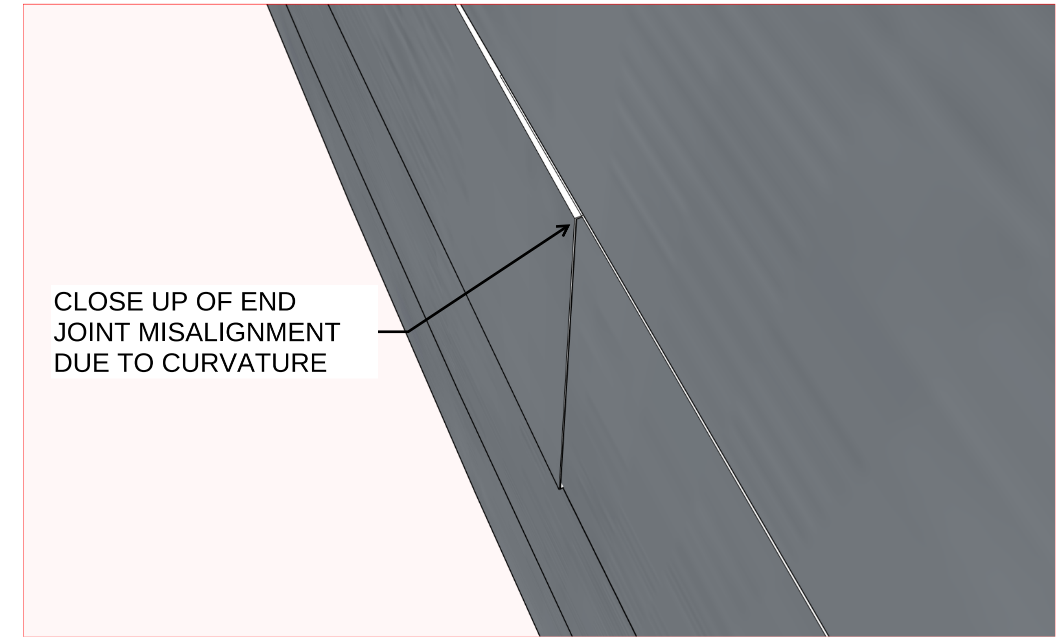
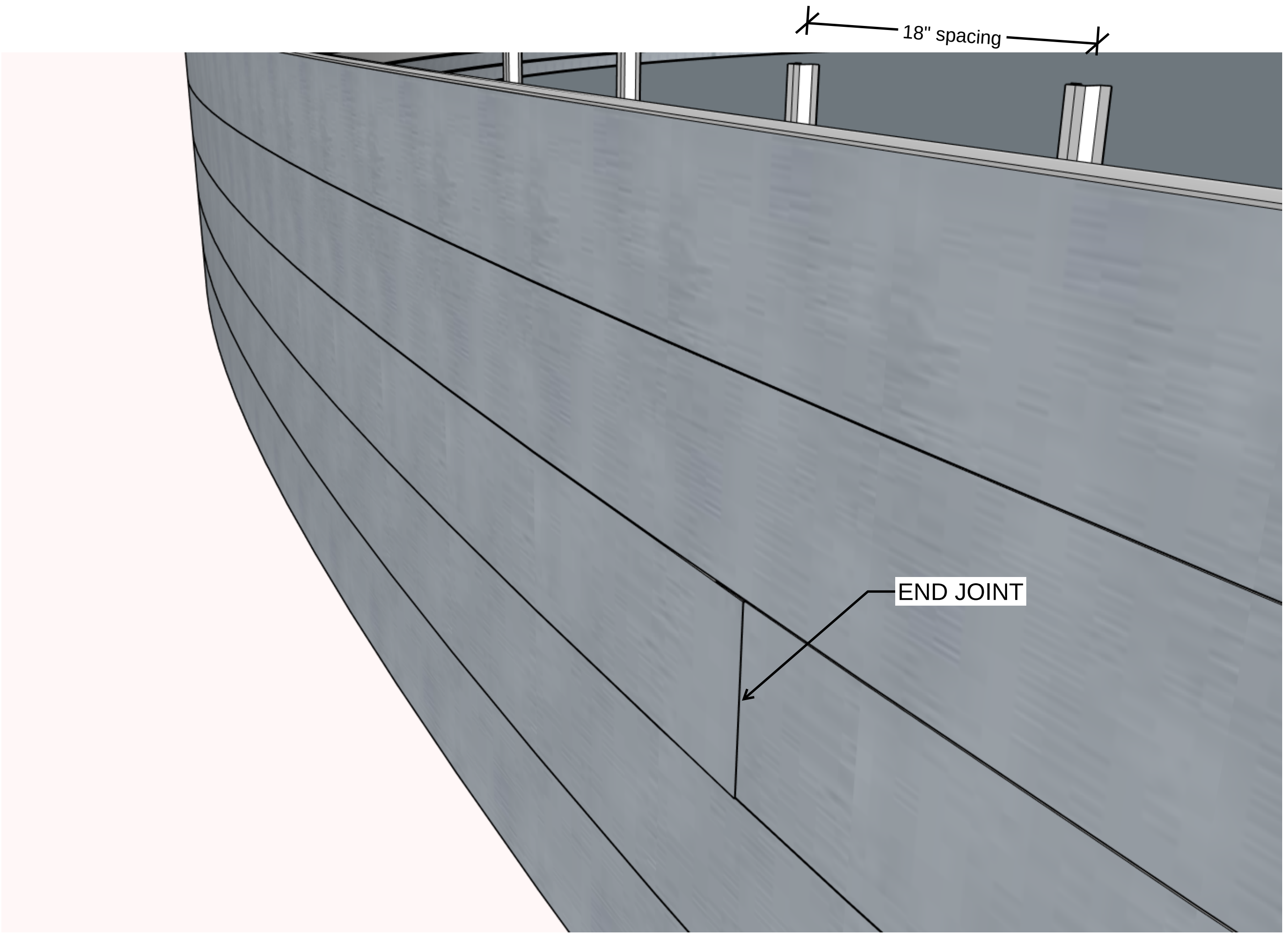
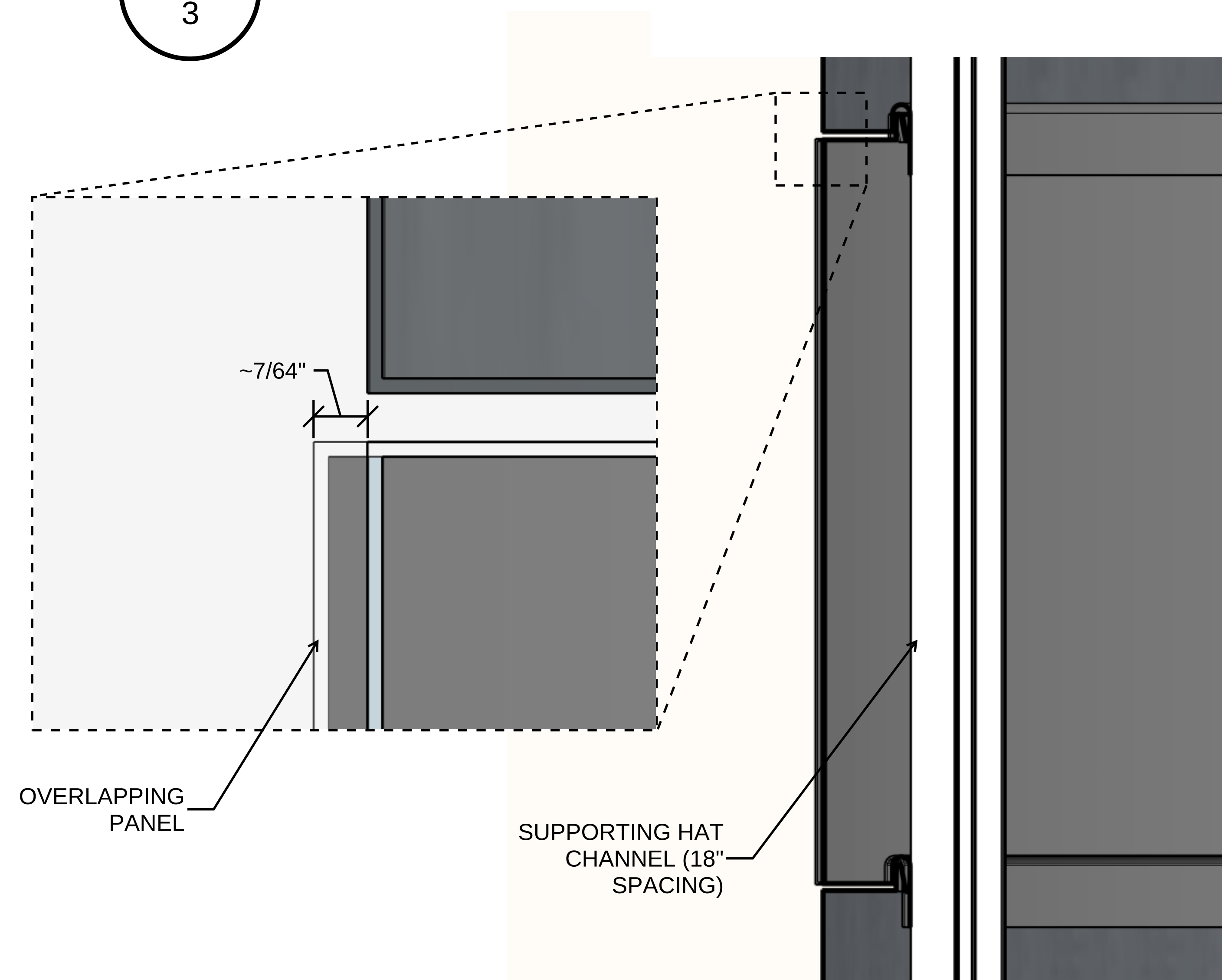


SK 3 SketchUp Model of End Joint



SK 2 SketchUp Model of End Joint



SK 4 Section View At End Joint