

## **Report of Findings**

Knott Laboratory Project Number: 20939

Northern Colorado Regional Airport  
"C" Hangars  
4930/4960 Grumman Street  
Loveland, Colorado 80538

### **Prepared for:**

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VIA EMAIL (Michelle.martin@civilinnovations.com)

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**Re: Report of Findings**

Property: Northern Colorado Regional Airport  
"C" Hangars  
Address: 4930/4960 Grumman Street  
Loveland, Colorado 80538

Ms. Martin:

Knott Laboratory, LLC (Knott) inspected the buildings at the above-referenced property. This report provides the findings and conclusions reached as a result of that investigation.

**1. Background**

The subject property consisted of two single-story steel-framed hangar structures. Online records with the Larimer County Assessor's Office were not available for the property, but the age of the buildings have been described to Knott as approximately 45 years. As such, the buildings were constructed prior to the first publishing of the International Building Code (IBC), in 2000. The Loveland Building Department, under whose jurisdiction the hangars are located, has currently adopted the 2018 editions of the I-Codes with Loveland Building Code Amendments. This is set to change to the 2021 editions on June 1<sup>st</sup>, 2023. Reportedly, in April 2020, the Northern Colorado Regional Airport and the cities of Loveland and Fort Collins gained total ownership of the "C" Hangars. An aerial photograph of the property is provided in **Appendix A** as **Figure 1**.

The property was the subject of a limited previous inspection and corresponding report by ditiesco Project & Construction Engineering Services (ditiesco), with a reported inspection date of August 18, 2022, and report publishing date of September 20, 2022. The "C" Hangars, as well as the adjoining "A" and "B" Hangars, were evaluated by ditiesco to provide general conditions of the hanger buildings and inform the owner(s) of the buildings of the current conditions of each hangar, and a summary of conclusions reached. At the time of publishing, that report concluded *"all four of the structures were observed to have significant issues with the subgrade, foundation, anchorage, and structural members...due to the cumulative effects of the issues observed, there is not an opportunity to implement an isolated repair without addressing the structure[s] in its entirety...there are no recommendations for remediation to safely extend the lifespan of the hangars."* ("Northern Colorado Regional Airport T-Hangar Structural Analysis, ditiesco, September 20, 2022).

## **2. Purpose**

Knott was retained by Civil Innovations to provide a facility condition assessment of the property. Knott's Facility Condition Assessment (FCA) process is intended to evaluate the condition of the structure as well as look for signs of any underlying issues or deferred maintenance items, and to provide guidance and prioritization of repairs as a result of that evaluation.

In the case of the "C" hangars, this included a more detailed onsite investigation of the main structural elements visible from the interiors and exteriors of the hangars than was previously completed, and an evaluation of the existing conditions of those structural elements for a full documentation of the building. As the "C" hangar buildings were constructed before the first edition of the IBC, it is unlikely that the structure, with a complete analysis using modern building codes, would be sufficient. In contrast, a facility condition assessment allows Knott to consider the historical performance of the building, and tailor repair recommendations based off the types of failures observed, the geographic risk factors associated with the building, and an evaluation of the existing failures recorded. Correspondingly, Knott has approached this project using the provisions of Chapter 4 "*Repairs*" of the 2018 International Existing Building Code's (IEBC) repair provisions regarding "*less than substantial structural damage*," (Section 405.2.1) which allows for the restoration of elements to their pre-damaged state if restoration of the structure would cost less than 50 percent of the market value of the structure before the damage occurred.

This inspection was to be followed by a report identifying the repairability of the "C" hangars and discussing areas that require repairs for the purpose of extending the life of the buildings another 3-5 years, at the request of the client.

As such, the contents of this report and repair recommendations are *not* intended to restore the building to a state of full compliance – instead, they are intended to restore life-safety components of the building's gravity, lateral and foundation systems to their pre-damaged condition. Knott should be contacted if this limited additional service life window is to be changed.

## **3. Procedure**

Knott's Scott B. Hargrove, M.S., P.E.; Austin D. Friday, M.S., P.E. and Jesse Niethammer, E.I.T. conducted an inspection of the "C" Hangars on April 7, 2023. This inspection included a review of all observable structural elements within each hangar building. On a limited basis, a ladder was used to assist in observations of rooftop structural elements. Francis Robbins of the Northern Colorado Regional Airport and Ken Pavlick of Civil Innovations were present during the inspection. Knott documented and photographed the available information during the inspection. Due to the nondestructive nature of

Knott's investigation, any interior finishes and/or obstructions installed by the tenants of the hangar units (e.g. insulation, gypsum wallboard, furniture) were not removed. As such, these items did occasionally impede Knott's visual inspection (see Section 5.2.5 "Items Not Reviewed"). The photographs depicted in **Appendix A** are a sample of the photographs taken by Knott, and the remaining may be presented upon request.

#### **4. Documents Reviewed**

The following documents and materials were reviewed and/or referenced as part of Knott's investigation, and/or contain information pertinent to the discussion and conclusions presented herein:

1. Larimer County Assessor's Office online property records, URL:  
<https://www.larimer.gov/assessor/search#/property/>.
2. Applied Technology Council Hazards by Location tool, URL:  
<https://hazards.atcouncil.org/#/>.
3. ditiesco Project & Construction Engineering Services "*Northern Colorado Regional Airport T-Hangar Structural Analysis*," Dated September 20, 2022

#### **5. Findings and Discussion**

Knott Laboratory has divided this section of the report into the following subsections for clarity: "*C" Hangar On-Site Investigation Summary* and *Repair Recommendations*. Photographs referenced in the discussion are provided in **Appendix A**.

##### **5.1. "C" Hangar On-Site Investigation Summary**

The "C" Hangars were arranged to contain 20 individual hangar units per building, nested alongside one another in a rough "T" shape. An overview of the hangar layout in each building is provided as **Figure 2**. An exemplar plan of a "T" shaped individual hangar unit is provided as **Figure 3**. Each also contained 2 storage units each, similarly nested at opposite ends of the building. An exemplar plan of the storage unit is provided as **Figure 4**.

Knott was able to access all 20 units and 2 storage units within each "C" Hangar building. An exemplar overview of a typical "T" shaped individual hangar unit is provided as **Figure 5-7**, and an exemplar overview of a typical storage unit is presented as **Figure 8 and 9**. During the inspection, visible gravity and lateral load-carrying members were examined and their condition noted, with the exception of elements that were obscured (Section 5.2.4 "*Items Not Reviewed*").

The gravity load-bearing system was observed to be a metal roof deck atop roughly equally spaced light-gauge beam members, which spanned approximately 20'-0" to built-

up, tapered wide-flange girder members (referred to as “I-beams” within the ditiesco report). These girder members were arranged perpendicular to the exterior of the hangars and were located approximately 20’-0” on-center. The girder members spanned from two columns, located approximately 30’-0” from one another, and were cantilevered an additional 15’-0” beyond those columns to the exterior of the building. The exterior wall, including the operable hangar doors, were supported by wide-flange beams spanning between load-bearing column members, spaced at the corners of the “T”-shaped units at approximately 40’-0”. The load-bearing column members were observed to be comprised of (2) light-gauge channel elements, placed with webs facing one another and intermittently welded together. All load-bearing column members were positioned upon pier foundations.

The gravity load-bearing system was generally observed to be intact and functional. The metal deck was largely free of deterioration and observable penetrations from the limited ground-based inspection Knott performed. Knott does not recommend any repairs or ongoing maintenance to the rooftop metal deck. Light-gauge rooftop beam members were similarly observed to be largely free of deterioration, with isolated elements exhibiting deviations from the vertical (visually “rolling”). While no specific repair recommendations are prescribed for the rooftop beam members, these elements should be monitored for excessive deflection in the upcoming 3-5 years of service life. Isolated cases of deterioration were observed in the supporting wide-flange girder members. In addition to monitoring these elements for excessive deflection, Knott recommends (1) girder element be cleaned and inspected to ensure the connecting welds and section remain undamaged. Additionally, isolated cases of detached and missing bracing elements were observed along the wide-flange girder members that require restoration. See “*Repair Recommendations*” for more information. Load-bearing column members were observed to be generally intact and functional, with isolated cases of deformation (presumed to be due to impacts) and/or section loss. Knott recommends monitoring these elements for indications of further damage. The connection from load-bearing column members to the foundation elements below were observed to be generally deteriorated and in need of repair, particularly at the exterior wall of the hangar buildings. See “*Repair Recommendations*” for the locations and extents of these repairs.

The lateral system was integrated into the same elements used as the gravity load-bearing system. Braced frames were formed by connecting vertical tension rods to the tops and bottoms of column members in both primary directions of the building. Diaphragm bracing was also present, similarly formed by connecting horizontal tension rods to perpendicular wide-flange girder members directly below the rooftop metal deck.

Vertical bracing systems were generally observed to be damaged and in need of engineered repair. Knott noted multiple instances of tension elements sagging and/or buckling, as well as the failure of multiple connections from the tension elements to their

supporting load-bearing columns. See “*Repair Recommendations*” for the locations and extents of these repairs. Horizontal bracing systems were generally observed to be intact and functional. Isolated instances of buckled or missing horizontal braces, or poor connections from braces to supporting girders that require repair or monitoring are listed in “*Repair Recommendations*.”

The foundation system, observed to be pier foundations of unknown depth, varied between 18” and 24” in diameter. The pier foundations supported both the gravity and lateral systems of the building through baseplates and anchorage at the base of column elements. Knott recorded multiple instances of post-installed repairs or modifications to the baseplates and anchorages throughout both “C” Hangar buildings.

The foundation system, including baseplates and anchorages, were generally observed to be damaged and in need of engineered repair. Many baseplates were in various stages of deterioration, and Knott recorded multiple instances of missing or detached anchorages as stated previously.

## **5.2. Repair Recommendations**

As stated previously, due to the nondestructive nature of Knott’s investigation, any interior finishes and/or obstructions installed by the tenants of the hangar units (e.g. insulation, gypsum wallboard, furniture) were not removed. See Section 5.2.4 for “*Items Not Reviewed*.” Additionally, due to the limited intended remaining service period (3-5 years), elements pertaining only to serviceability criteria (e.g. exterior door supports) were not evaluated.

Based upon Knott Laboratory’s inspection, the available information, and these engineers’ education, training, and experience, the following recommendations have been reached within a reasonable degree of engineering certainty:

### **5.2.1. Engineered Repair Recommendations**

The subsequent recommendations are provided as conceptual, general repairs of the items discussed herein. The intent of the following is that all repairs shall be provided in whole. It is Knott’s opinion that it is necessary for qualified design professionals to perform additional work to prepare construction documents, details, calculations, and specifications for construction of these repairs:

- **Gravity System:**
  - Engineered detail to repair missing/detached angle kickers bracing the bottom flange of the tapered wide-flange girder members. Knott estimates a minimum of (10) instances of this repair (**Figures 10 and 11**).



- **Importance:** Medium
- **Building 1:**
  - Unit 17 (1)
  - Unit 19 (2)
  - Unit 20 (1)
- **Building 2:**
  - Unit 2 (3)
  - Unit 4 (1)
  - Unit 10 (1)
  - Unit 15 (1)
- **Lateral System:**
  - Engineered detail to repair damaged/detached lateral tension tie plate connection to restore a continuous load path for the building's lateral system. Knott estimates a minimum of (15) instances of this repair (**Figures 12-14**).
- **Importance:** High
- **Building 1:**
  - Storage unit adjacent to Unit 1 (1)
  - Storage unit adjacent to Unit 20 (1)
  - Unit 1 (3)
  - Unit 3 (1)
  - Unit 7 (1)
  - Unit 8 (1)
  - Unit 9 (1)
  - Unit 11 (1)
- **Building 2:**
  - Storage unit adjacent to Unit 19 (1)
  - Unit 2 (1)
  - Unit 3 (1)
  - Unit 15 (2)
- **Foundation System:**
  - Engineered detail to repair damaged, detached or missing column anchorages. Knott estimates a minimum of (24) instances of this repair (**Figures 15-17**).
- **Importance:** High
- **Building 1:**



- Unit 2 (1)
- Unit 4 (1)
- Unit 8 (1)
- Unit 12 (1)
- Unit 14 (1)
- Unit 16 (1)
- Unit 18 (2)
- **Building 2:**
  - Unit 1 (2)
  - Unit 4 (1)
  - Unit 5 (2)
  - Unit 6 (1)
  - Unit 7 (1)
  - Unit 8 (1)
  - Unit 9 (1)
  - Unit 10 (1)
  - Unit 11 (1)
  - Unit 12 (1)
  - Unit 13 (1)
  - Unit 15 (1)
  - Unit 17 (1)
  - Unit 19 (1)

#### 5.2.2. Contractor/General Repair Recommendations

The subsequent recommendations are provided as conceptual, general repairs of the items discussed herein. It is Knott's opinion that the following repairs may be undertaken by a qualified contractor without additional construction documents, details, calculations, and specifications from a qualified design professional.

- **Gravity System:**
  - Cleaning and inspection of (1) primary girder member to evaluate extent of rust/deterioration damage. Knott is available to provide an engineering evaluation after cleaning is complete. Knott recommends the following candidates as "worst-case" scenarios that may be used to judge the suitability of the remaining girders (**Figures 18 and 19**):
    - **Importance:** Medium
    - **Building 1:**
      - Unit 8

- Unit 10
  - Manually reversing out-of-plumb/rotated columns back to straight. Knott estimates a minimum of (4) instances of this repair (**Figures 20 and 21**).
    - **Importance:** Medium
    - **Building 1:**
      - Unit 2 (1)
    - **Building 2:**
      - Unit 9 (1)
      - Unit 13 (1)
      - Unit 20 (1)
  - Tightening of existing bolts to a snug-tight condition, and replacement of any bolt not capable of being tightened, or with inadequate thread count above tightening nut. A minimum of (2) threads are required to protrude above the tightening nut. This is a common condition throughout the “C” Hangars (**Figure 22 and 23**).
  - Re-attachment/addition of missing bolts in structural bolted connections where a bolt previously existed. This is a common condition throughout the “C” Hangars (**Figure 24 and 25**).
- **Lateral System:**
  - Replacement of vertical tension rod elements, to match existing, where current brace is missing or buckled. Knott estimates a minimum of (14) instances of this repair (**Figure 26 and 27**).
    - **Importance:** High
    - **Building 1:**
      - Unit 1 (1)
      - Unit 15 (3)
      - Unit 17 (2)
      - Unit 20 (2)
    - **Building 2:**
      - Unit 3 (2)
      - Unit 7 (2)
      - Unit 13 (2)

- Replacement of horizontal/diaphragm tension rod elements, to match existing, where current brace is missing or buckled. Knott estimates a minimum of (5) instances of this repair (**Figure 28 and 29**).
  - **Importance:** High
  - **Building 1:**
    - Unit 18 (2)
  - **Building 2:**
    - Storage unit next to Unit 2 (2)
    - Unit 4 (1)
- Snug hand tightening of existing brace turnbuckles and column connections, and replacement of any brace not capable of being tightened. This is a common condition throughout the “C” Hangars (**Figure 30 and 31**).
  - **Importance:** Medium
- See “Gravity System” recommendations where applicable to the lateral system.
- **Foundation System:**
  - None.

### 5.2.3. Monitoring Recommendations

The subsequent recommendations are provided as conceptual, general repairs of the items discussed herein. It is Knott’s opinion that the following items may be monitored by qualified maintenance or engineering personnel and are not required to be repaired for continued life-safety of the “C” Hangars in the next 3-5 years.

- **Gravity System:**
  - Monitor gravity framing for excessive deflection and/or continued “rolling.” Monitor gravity column elements with existing section loss and/or deformation for excessive deflection (**Figure 32-36**)
    - **Importance:** General Maintenance
- **Lateral System:**
  - Monitor diaphragm bracing connections to tapered wide-flange girder members to ensure bracing members and connections are taut, particularly where a sharp angle occurs between the bracing connection and the brace line. This is a common condition throughout the “C” Hangars (**Figure 37**).

- **Importance:** General Maintenance
  - Monitor diaphragm bracing splices to ensure bracing members are taut, where an eccentric welded connection occurs between two tension members. This is a common condition throughout the “C” Hangars (**Figure 38**).
- **Importance:** General Maintenance
- **Foundation System:**
  - None.

#### 5.2.4. Items Not Inspected

As stated previously, due to the nondestructive nature of Knott’s investigation, any interior finishes and/or obstructions installed by the tenants of the hangar units (e.g. insulation, gypsum wallboard, furniture) were not removed. Additionally, due to the limited intended remaining service period (3-5 years), elements pertaining only to serviceability criteria (e.g. exterior door supports) were not evaluated.

A list of hangar units with intermittent or full wall coverings is listed below. Unknown conditions may exist at the following units that may require additional recommendations or engineered repairs. Knott is available to provide a follow-up investigation if interior finishes are removed in some or all of these units:

- **Fully Obscured (Unable to Inspect)**
  - **Building 1:**
    - None
  - **Building 2:**
    - Unit 11
  - **General:**
    - Foundation elements and connections obscured by concrete/soil. All foundation elements should be uncovered and inspected during repairs.
- **Intermittently Obscured (Partially Inspected)**
  - **Building 1:**
    - Unit 15
    - Unit 17
    - Unit 18
  - **Building 2:**
    - Unit 1
    - Unit 2
    - Unit 8

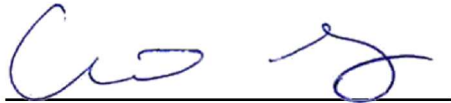
- Unit 9
- Unit 12
- Unit 20
- Storage Unit adjacent to Unit 19

## **6. Closure**

The opinions and findings expressed in this report are based upon the information available to these writers as of the date of this report and are the result of limited non-destructive visual inspections of the exposed building components. As such, Knott Laboratory reserves the right to modify the conclusions contained herein upon receipt or discovery of additional information. Due to the limited access and the non-destructive nature of the investigation, Knott Laboratory cannot be held responsible for any hidden defects that may negatively impact the performance of the structure. This report is intended to provide an overview of the existing conditions and should not be used as an indicator of future performance; no expressed or implied warranties or guarantees of any kind are given.

Respectfully submitted,

KNOTT LABORATORY, LLC



Austin D. Friday, M.S., P.E.  
Project Engineer



Scott B. Hargrove, M.S., P.E.  
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Appendix A: Figures

### **Appendix A: Figures**

Photographs taken during Knott Laboratory's inspection, which have not been included in this report, have been retained on file and can be made available upon request. Note the brightness and/or contrast of some photographs may have been enhanced for purposes of clarity. Some photographs may be cropped from their original sizes to emphasize a specific item or feature. No significant changes to any photographs were made that would alter factual representations.



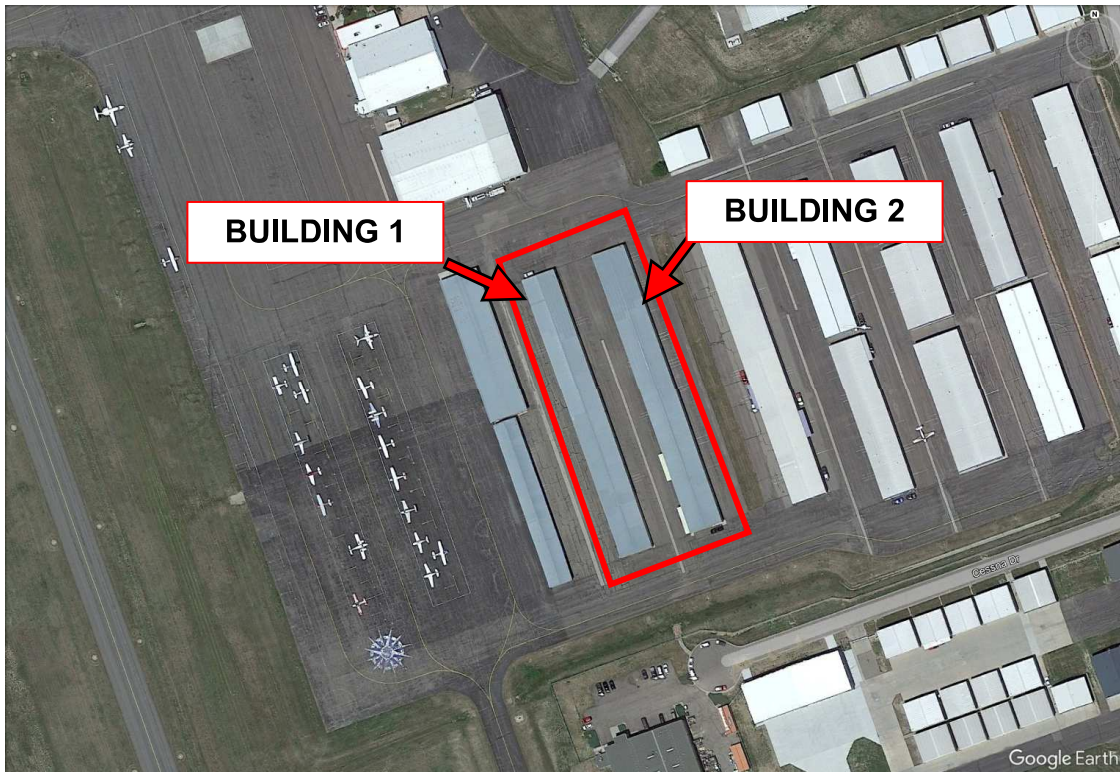


Figure 1 – Aerial overview of subject property (Google Earth). Emphasis added by Knott.

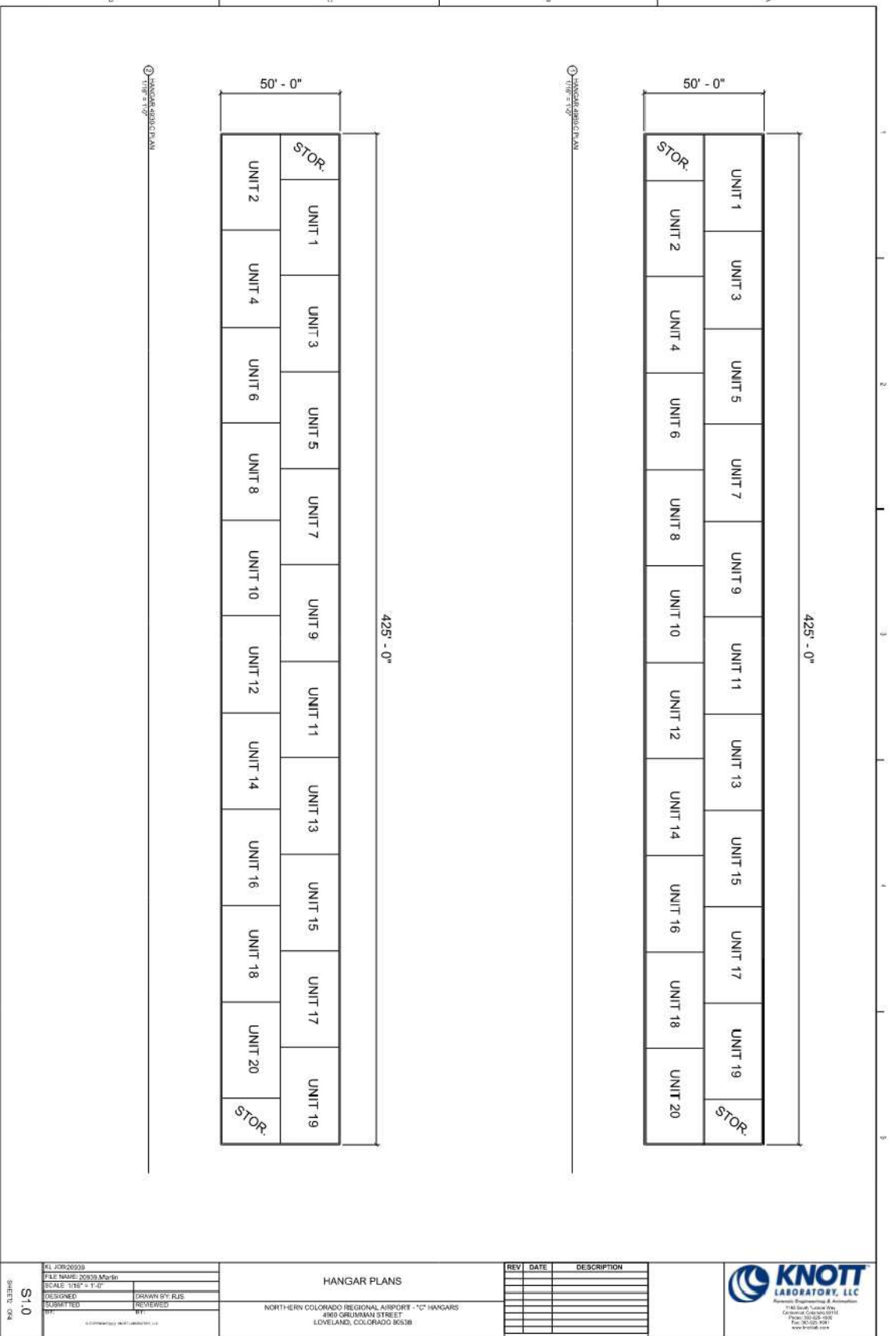


Figure 2 – Overview of hangar layout in Buildings 1 and 2.

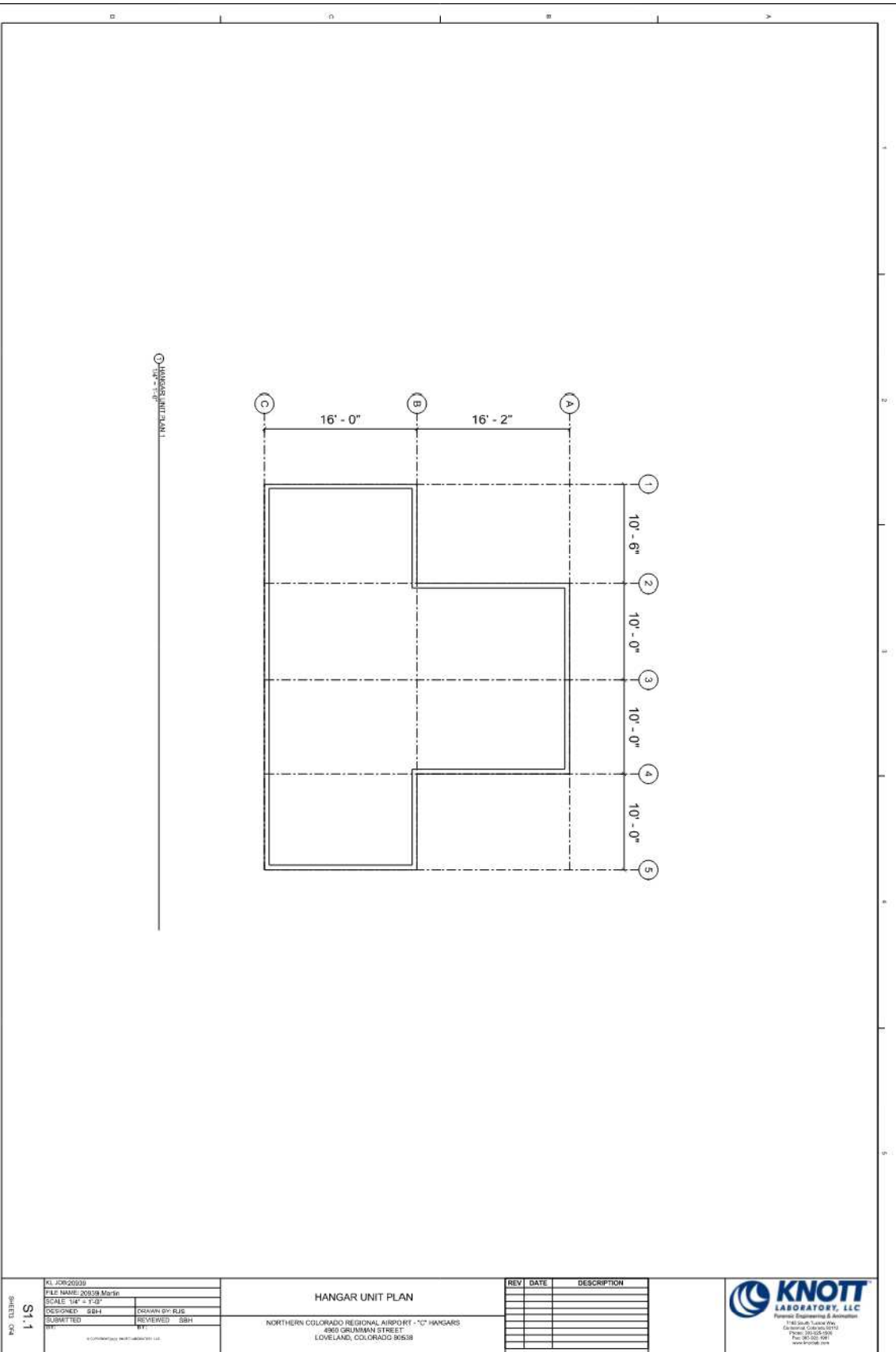


Figure 3 – Exemplar plan of "T" shaped individual hangar units.

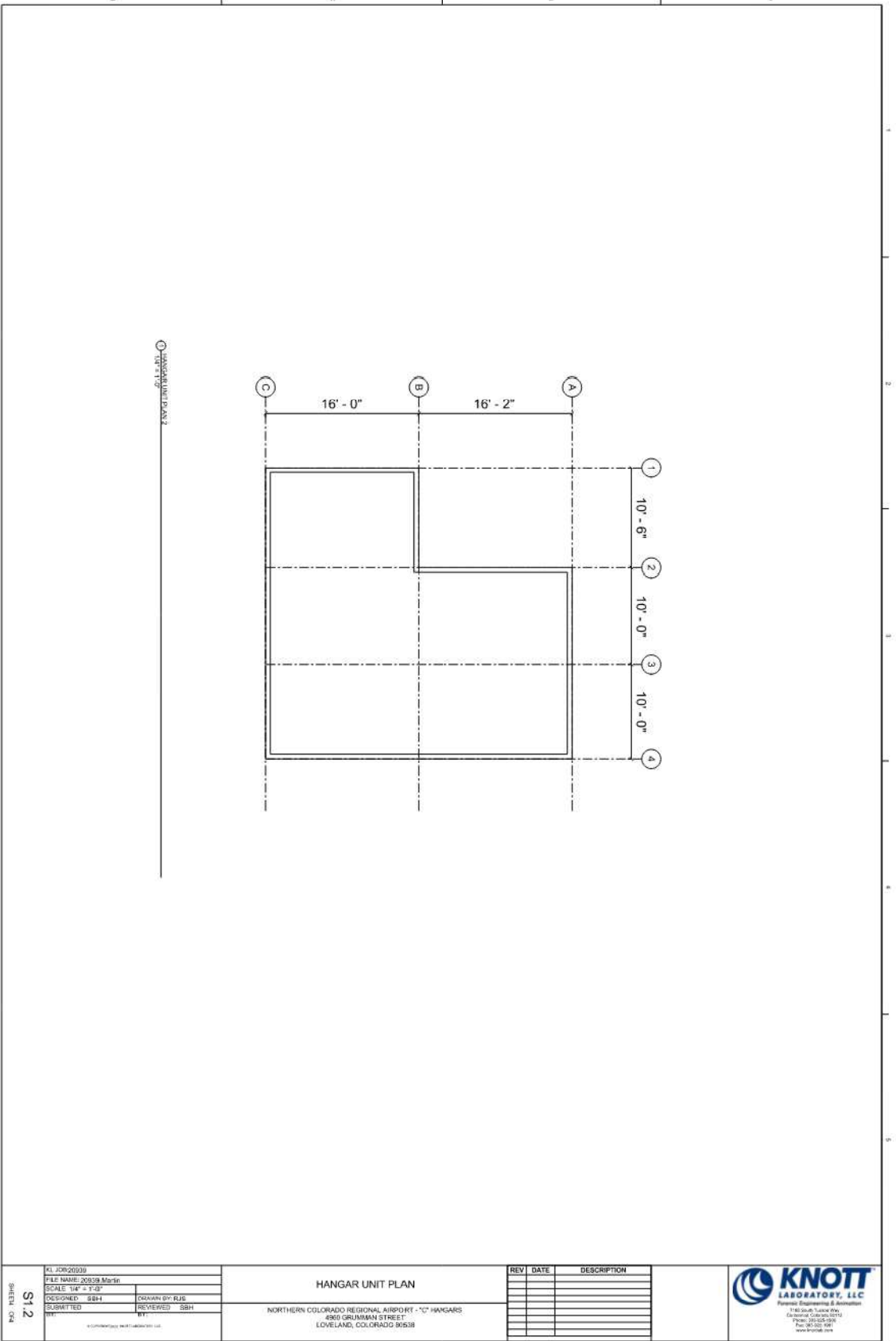


Figure 4 – Exemplar plan of storage units.





Figure 5 – IMG\_5135 – Building 1, Unit 2 – Exemplar overview of “T” hangar.



Figure 6 – IMG\_5136 – Building 1, Unit 2 – Exemplar overview of “T” hangar.



Figure 7 – IMG\_5137 – Building 1, Unit 2 – Exemplar overview of “T” hangar.



Figure 8 – IMG\_5166 – Building 2, Storage unit adjacent to Unit 19 – Exemplar overview of storage unit.





Figure 9 – IMG\_5170 – Building 2, Storage unit adjacent to Unit 19 – Exemplar overview of storage unit.



Figure 10 – IMG\_6620 – Building 1, Unit 20 – Exemplar photograph of detached angle kicker bracing bottom flange of tapered wide-flange girder member.





Figure 11 – IMG\_5236 – Building 2, Unit 10 – Exemplar photograph of missing angle kicker bracing bottom flange of tapered wide-flange girder member.



Figure 12 – IMG\_5167 – Building 2, Storage unit adjacent to Unit 19 – Damaged lateral tension tie connection at column.



Figure 13 – IMG\_6513 – Building 1, Unit 7 – Exemplar photograph of detached lateral brace plate connection to top of supporting column.





Figure 14 – IMG\_6733 – Building 2, Unit 3 – Exemplar photograph of detached lateral brace plate connection to base of supporting column.



Figure 15 – IMG\_6666 – Building 1, Unit 12 – Exemplar condition of damaged anchorage (threads not protruding above nut due to column sitting on shims installed during, or post, construction).





Figure 16 – IMG\_6751 – Building 2, Unit 7 – Exemplar condition of detached anchorage (anchor bolt originally placed too near edge of plate and subject to corrosion).



Figure 17 – IMG\_5163 – Building 2, Unit 7 – Exemplar condition of detached anchorage (anchor connection failed due to corrosion; threads not protruding above nut due to column sitting on shims installed during, or post, construction; or both).





Figure 18 – IMG\_6674 – Building 1, Unit 10 – Example wide-flange girder candidate for cleaning and inspection to evaluate extent of rust/deterioration damage.

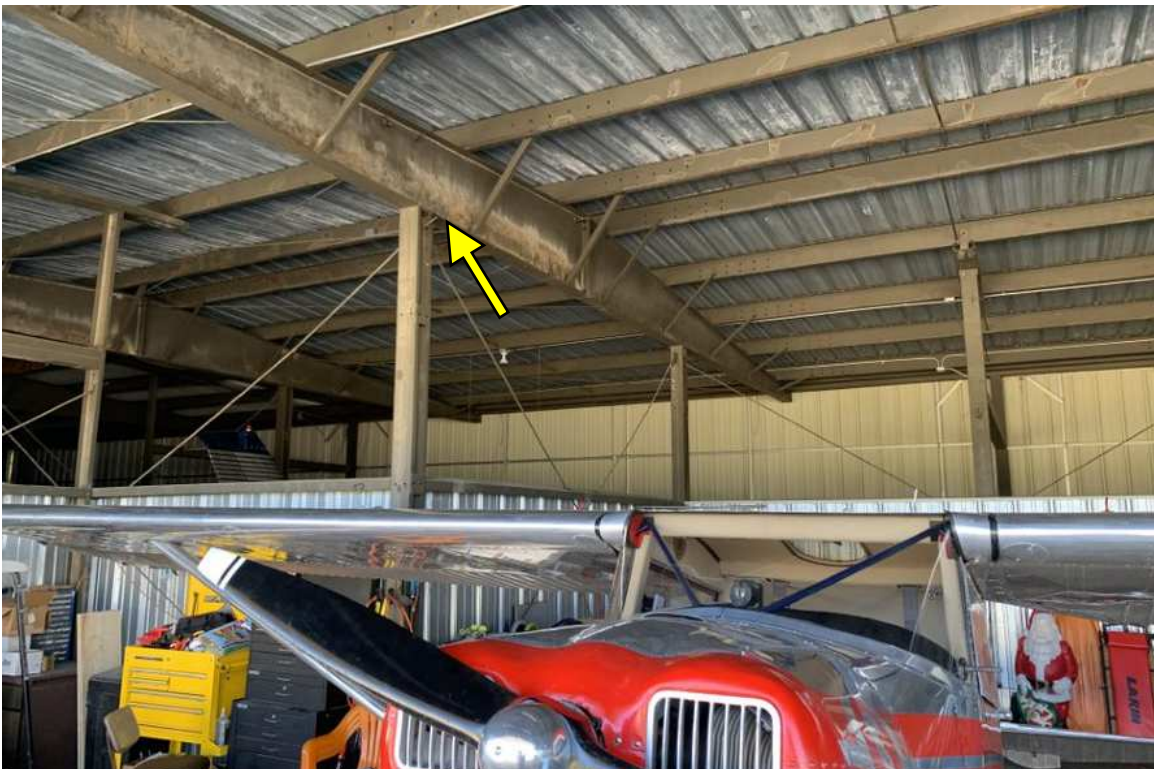


Figure 19 – IMG\_6688 – Building 1, Unit 8 – Example wide-flange girder candidate for cleaning and inspection to evaluate extent of rust/deterioration damage.



Figure 20 – IMG\_5129 – Building 1, Unit 2 – Exemplar photograph of out-of-plumb column.



Figure 21 – IMG\_6790 – Building 2, Unit 13 – Exemplar photograph of rotated column.



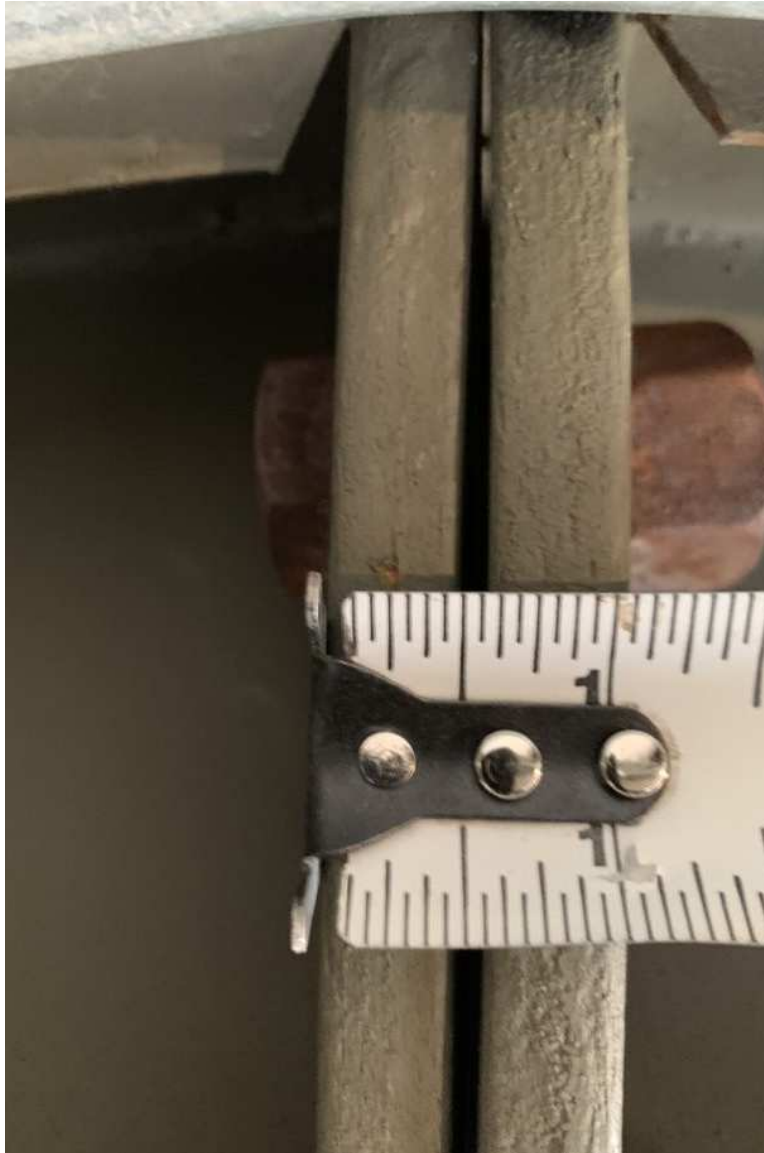


Figure 22 – IMG\_6465 – Building 1, Storage unit adjacent to Unit 1 – Exemplar photograph of bolts requiring tightening to snug-tight condition.



Figure 23 – IMG\_6461 – Building 1, Storage unit adjacent to Unit 1 – Exemplar photograph of inadequate thread count above tightening nut.





Figure 24 – IMG\_6554 – Building 1, Unit 13 – Exemplar photograph of missing bolts in structural bolted connections.



Figure 25 – IMG\_6654 – Building 1, Unit 14 – Exemplar photograph of missing bolts in structural bolted connections.



Figure 26 – IMG\_6563 – Building 1, Unit 15 – Exemplar photograph of missing vertical tension rod element.





Figure 27 – IMG\_6732 – Building 2, Unit 3 – Exemplar photograph of missing vertical tension rod element.



Figure 28 – IMG\_5288 – Building 2, Storage unit adjacent to Unit 2 – Exemplar photograph of missing diaphragm bracing.





Figure 29 – IMG\_5276 – Building 2, Unit 4 – Exemplar photograph of buckling of diaphragm bracing.



Figure 30 – IMG\_6470 – Building 1, Storage unit adjacent to Unit 1 – Exemplar photograph of turnbuckle requiring snug hand tightening.



Figure 31 – IMG\_6481 – Building 1, Storage unit adjacent to Unit 1 – Exemplar photograph of tension rod column connection requiring tightening.



Figure 32 – IMG\_6456 – Building 1, Storage adjacent to Unit 1 - Isolated roof framing members exhibiting deviations from the vertical ("rolling") -ongoing monitoring required.





Figure 33 – IMG\_6492 – Building 1, Unit 3 – Section loss in structural member - ongoing monitoring required.





Figure 34 – IMG\_5125 – Building 1, Unit 4 – Section loss in structural member - ongoing monitoring required.



Figure 35 – IMG\_6555 – Building 1, Unit 13 – Deformation, presumably due to impact, in structural member - ongoing monitoring required.



Figure 36 – IMG\_6621 – Building 1, Unit 20 – Deformation, presumably due to impact, in structural member - ongoing monitoring required.



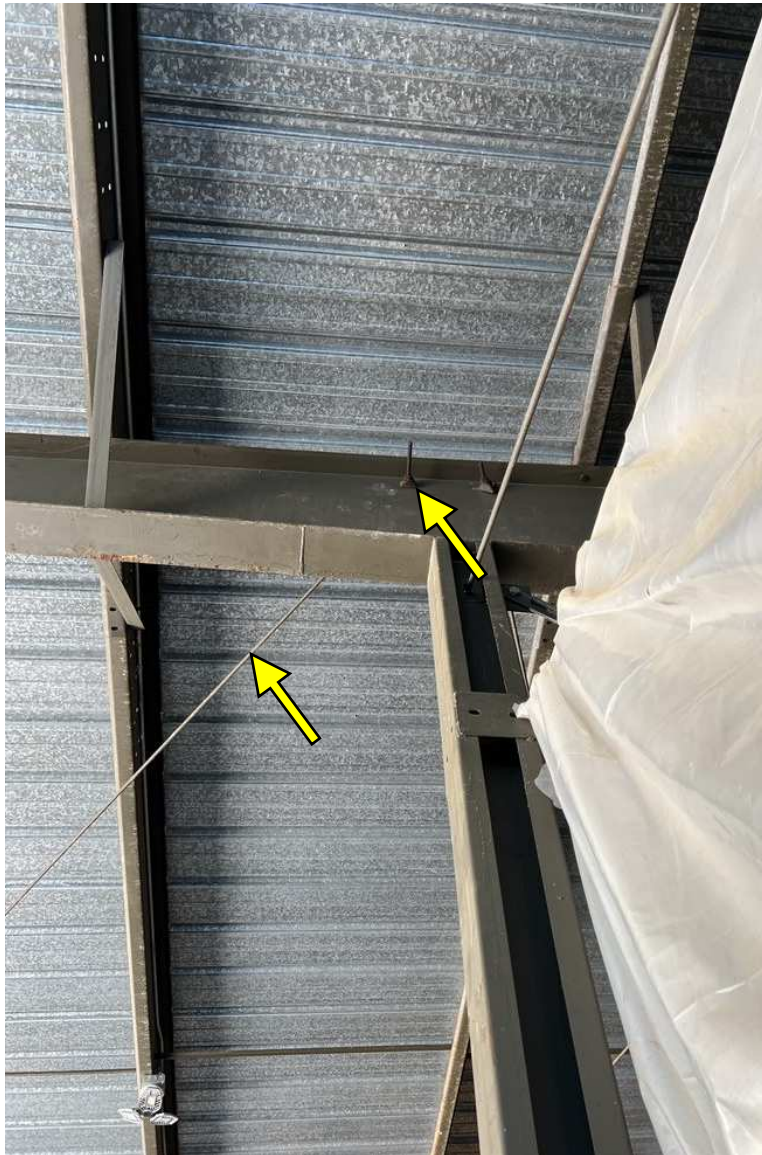


Figure 37 – IMG\_5235 – Building 2, Unit 10 – Exemplar photograph of sharp angle created between diaphragm bracing connection and brace line.



Figure 38 – IMG\_6606 – Building 1, Unit 19 – Exemplar photograph of eccentric welded connection between two tension members in diaphragm bracing.