NELSON

FORENSICS + CONSULTING

Structural Distress Evaluation

PROJECT FILE NO.
19828

CLAIM NO.
E7K5861

STRUCTURE IDENTIFICATION
Linderman Gymnasium
312 4th Avenue East
Polson, Montana 59860

PREPARED FOR
Diana Johnston
Travelers
7103 South Redwood Road
Suite 503
West Jordan, Utah 84084

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NELSON FORENSICS

September 21, 2018

Diana Johnston
Travelers
7103 South Redwood Road
Suite 503
West Jordan, Utah 84084

File: Linderman Gymnasium
312 4th Avenue East
Polson, Montana 59860

Nelson File No.:	19828
Claim No.:	E7K5861
Date of Loss:	1/2/2018

Dear Ms. Johnston:

At your request, Nelson Forensics, LLC (Nelson) is issuing this report as a supplement to Nelson's *Structural Distress Evaluation*, dated March 2, 2018 (Report 1). The opinions in Nelson's Report 1 remain unchanged.

By signature below, this report was authored by and prepared under the direct supervision of the undersigned professional.

Please contact us if you have any questions regarding this report.

With kindest regards,

NELSON FORENSICS, LLC
Montana Certificate of Authorization PEL-EF-LIC-48741

Timothy Todd Martin
Todd Martin, M.S., P.E.
Project Director

MONTANA
TIMOTHY TODD MARTIN
No. 43383 PE
LICENSED PROFESSIONAL ENGINEER
09.21.2018

Nelson: Report2-19828.doc

REPORT

INTRODUCTION

GENERAL INFORMATION

Dates of Investigation: July 10 and August 21, 2018

Present at Investigation:

July 10, 2018

Todd Martin, P.E. (Nelson Forensics, LLC)
Diana Johnston (Travelers)
Pete Hull (Construction Services Company)
Paul Bishop (Paradigm v2 Architects, P.C.)
Austin Wright. P.E. (Aegis Engineering, Inc.)

August 21, 2018

Todd Martin, P.E. (Nelson Forensics, LLC)

Testing Performed: Plumbness Survey

AUTHORIZATION AND PURPOSE

Nelson Forensics (Nelson) was authorized by Ms. Diana Johnston with Travelers (client) to evaluate the gymnasium located at 312 4th Avenue East in Polson, Montana (subject structure) as it relates to alleged structural distress reported to Nelson by Mr. Wright of Aegis Engineering, Inc. (Aegis) on July 10, 2018.

Refer to Report 1 for additional information regarding the subject structure.

SCOPE OF INVESTIGATION

Nelson conducted a visual evaluation of the subject structure's exterior, interior, and roof, while photographically documenting general site conditions and observed distress. Additionally, Nelson reviewed received information provided to Nelson by the client. Destructive testing was outside the scope of this investigation and was not performed by Nelson.

Nelson resurveyed the plumbness of the upper portions of the concrete columns at the north and south elevations. Refer to Report 1 for Nelson's previous plumbness survey at the exterior brick masonry walls, the concrete columns at the north and south elevations, and the concrete beams at the south elevation.

This report was not prepared for use in a real estate transaction. It was prepared for the purpose and for the client as indicated above. Any and all usage or reliance upon this report by parties other than the client is expressly prohibited.

RECEIVED INFORMATION

In addition to on-site observations, the opinions presented in this report may be based on the *RISA Truss Model* output from Mr. Wright with Aegis, dated July 23, 2018, received by Nelson from the client.

REPORTED INFORMATION

Nelson conducted an informal interview with the owner's engineer, Mr. Wright of Aegis, regarding information pertaining to alleged structural distress. The reported information is Mr. Wright's account and not Nelson's opinions or observations. Mr. Wright reported the following:

- The collapse of the south parapet wall on the reported date of loss induced lateral loads at the south concrete frame, causing lateral (southward) movement of the gymnasium, resulting in the following distress:
  - Linear fractures/separations in the mortar joints throughout the field of the unreinforced masonry walls;
  - Fractures/separations in the brick masonry and the mortar joints at the north wall, adjacent to the concrete columns and trusses;
  - Horizontal fractures in the mortar joints below the windows at the north wall;
  - A stair step fracture in the mortar joints below the bleachers at the north portion of the west masonry wall;
  - Separations at the interface of the concrete bleacher stairs and the east and west masonry walls;
  - Separations at the interface of the brick masonry columns and the adjacent brick masonry walls/concrete masonry (CMU) infill wall at the gymnasium's east wall;
  - Separations at the interface of the west exterior masonry wall and the east/west oriented interior masonry walls;
  - Separations in the gypsum board ceiling finishes of the hallway at the south side of the gymnasium;

- A fracture in the gypsum board wall finish at a south-facing window in the music room;

- A survey company evaluated the gymnasium and found that the columns at the north and south elevations were leaning towards the south;
- The angle ledger attached to the concrete beams at the south elevation supported a roof located directly below the south parapet wall. When the parapet wall collapsed and impacted this lower roof, the impact load caused some of the fractures in the concrete beams;
- The parapet wall collapse resulted in the application of a tension load in the thermoplastic membrane, which was transferred to the bow-string trusses. A RISA analysis of a truss found that some of the web members were overloaded as a result of this tension load and unbalanced snow loads on the reported date of loss. This overloading condition resulted in latent damage to the web members, such as separations in the wood fibers, reducing the compression/tension capacity of the truss's web members.

REVIEW OF RECEIVED INFORMATION

RISA TRUSS MODEL OUTPUT

Nelson reviewed the RISA Truss Model output from Mr. Wright, dated July 23, 2018. The output provides some of the input parameters for the truss model (e.g., joint boundary conditions, member point loads and distributed loads, basic load cases, and load combinations) and some of the results from the truss model (e.g., joint reactions and member wood code checks). The RISA output indicates the following:

- The joint boundary conditions included the following:
  - Five joints with reactions in the x-, y-, and z-directions;
  - Five joints with reactions in the y-direction only;
  - 109 joints with reactions in the z-direction (out-of-plane) only. In an email received by Nelson, Mr. Wright indicated that the z-direction reactions are meant to represent the out-of-plane loads transferred from the trusses to the roof joists and lateral bracing between the top and bottom chords;
- The member distributed loads included an impact load (representing the tension load from the thermoplastic membrane) of 78 pounds per lineal foot (plf) applied to eight of the fourteen top chord members;
- The distributed loads also included eight different cases for snow loading;
- The load combinations include the following:
  - LC7, which included dead load, snow drift loads, and impact load;
  - LC10, which included dead load, live load, snow shedding load, and impact load;
- A maximum reaction of 512,000 pounds (512 kips or 512 k) at a z-direction only joint reaction for LC7. There is no indication of whether this is a joint reaction at the bottom or top chord;
- Multiple load combinations resulted in the overloading of some of the bottom chord members;
- Approximately 8% overloading of a web diagonal member as the result of LC7.

OBSERVATIONS

Photographic documentation and other field-obtained data of the structure are being maintained in Nelson's file. Select photographs are included within the body of this report and may be presented for information only or for a general representation of the condition of the structure.

Nelson's observations relevant to the assignment described in the **Authorization and Purpose** section of this report include the following:

- Isolated linear mortar joint separations in the fields of the brick masonry walls (**Figure 1**);
- Separations in the mortar joints at the interfaces of some of the north concrete columns and the adjacent masonry wall. The separations were aged and rounded in appearance and did not extend down the full length of the interface (**Figures 2-3**);
- Isolated fracture in a masonry brick adjacent to a north concrete column. The fracture did not extend to the adjacent mortar joints or bricks (**Figure 4**);
- Discontinuous and isolated separations in the mortar joints below the windows in the north masonry wall (**Figure 5**);
- Isolated stair step fracture in the mortar joints below the bleachers at the north portion of the west masonry wall. The stair step fracture did not continue up above the bleachers;
- Discontinuous separations at the interfaces of the concrete bleacher stairs and the adjacent masonry walls (**Figure 6**);
- Separations at the interfaces of the CMU infill wall and the adjacent brick masonry columns at the gymnasium's east wall (**Figure 7**);
- Discontinuous separations at the interfaces of the aforementioned brick masonry columns and the adjacent brick masonry walls (**Figure 8**);
- Discontinuous separations at the interfaces of the west exterior masonry wall and the east/west oriented interior masonry walls (**Figure 9**);
- Evenly spaced separations in the gypsum board ceiling finishes at the hallway located at the south side of the gymnasium. The separations created 90 degree corners where they intersected (**Figure 10**);
- Isolated diagonal fracture in the wall finishes at the bottom right-hand corner of a south-facing window at the music room (**Figure 11**);

- Vertically and diagonally oriented, evenly spaced, and discontinuous fractures in the exposed concrete beams at the south elevation. The fractures were coincident with angle ledger anchors at some isolated anchor locations. Where the fractures were coincident with anchors, the fractures did not continue into the portion of the concrete beam below the ledger (**Figures 12-13**);
- No displacement of or wrinkles in the thermoplastic membrane at the location of the missing south parapet wall (**Figures 14-15**);
- Localized tears in the thermoplastic membrane at holes along the south edge of the membrane. The holes correspond to the locations of the anchors for the parapet termination bar (**Figure 16**).

Figure 1: Isolated linear fracture in field of east masonry wall

Figure 2: Separation in mortar joint at north concrete column/masonry wall interface

Figure 3: No separation in mortar joint directly below separation shown in Figure 2

Figure 4: Isolated fracture in masonry brick adjacent to north concrete column

Figure 5: Discontinuous/isolated separation in horizontal mortar joint below east window in north masonry walls

Figure 6: Discontinuous separation at interface of concrete stair/masonry wall at southeast corner of gymnasium

Figure 7: Separation at interface of brick masonry column/CMU wall

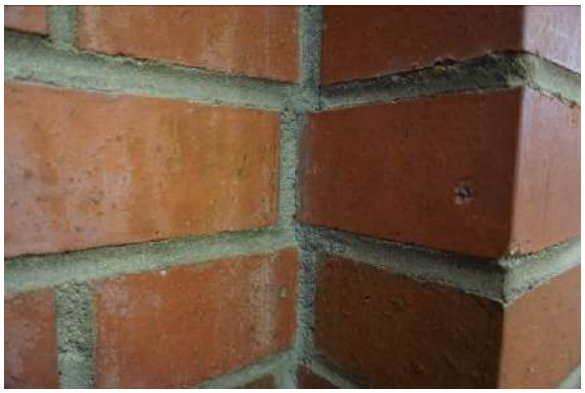

Figure 8: Condition of brick masonry column/adjacent wall interface opposite side of column shown in Figure 7

Figure 9: Discontinuous separation at interface of west exterior masonry wall and interior masonry wall

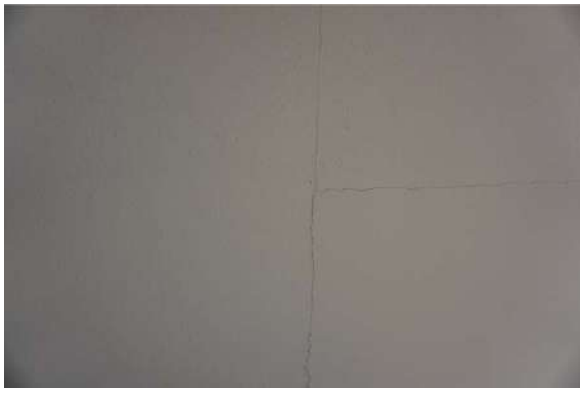

Figure 10: Separations in gypsum board ceiling finish at east end of south hallway

Figure 11: Isolated diagonal fracture in wall finishes at bottom right-hand corner of south-facing music room window

Figure 12: Vertical, discontinuous fracture in concrete beam coincident with ledger anchor

Figure 13: Fracture in concrete beam between ledger anchors

Figure 14: View of thermoplastic membrane at location of missing/collapsed parapet

Figure 15: Condition of thermoplastic membrane at pipe penetration at roof edge shown in Figure 14

Figure 16: Tears in thermoplastic membrane at holes along south edge of membrane

TESTING PERFORMED

COLUMN PLUMBNESS SURVEY

Nelson obtained plumbness measurements of the concrete columns at the gymnasium's north and south exterior walls with a Stanley® SmartTool™ level instrument. A reading of 90.0° indicates that the element is true and plumb with the vertical, whereas each 0.1° difference from 90.0° is equivalent to slightly more than 1/12" change over four feet (i.e. 89.7° is approximately 1/4" out-of-plumb over four feet). The plumbness measurements obtained by Nelson at the south concrete columns ranged from 89.5° to 89.7°, and oriented towards the south. The plumbness measurements obtained at the north concrete columns ranged from 89.8° to 90°, with no pattern of directional lean.

ANALYSIS

In Nelson's opinion, the subject structure did not experience lateral movement as a result of the south parapet wall collapse on the reported date of loss. As indicated in the review of received information in Nelson's Report 1, a GPR survey performed by others did not find reinforcing bars extending from the concrete beams/columns into the adjacent masonry walls. Nelson's analysis in Report 1 indicates that the parapet wall collapse would have been resisted by the bond of the brick masonry mortar, which is relatively weak in tension. As a result, it is Nelson's opinion that there is no load transfer mechanism for loads from the masonry parapet wall collapse capable of causing lateral movement of the subject structure. While it was reported that a survey of the structure found that the subject structure was leaning towards the south, Nelson's plumbness measurements indicate that southward movement of the structure is limited to the south exterior unreinforced masonry wall.

In Nelson's opinion, the fractures/separations indicated by Mr. Wright at the masonry elements are not indicative of lateral movement of the gymnasium, nor are they the result of the south parapet wall collapse on the reported date of loss. The fractures/separations were isolated, linear in shape, and discontinuous, which are not consistent with lateral movement of a brittle structure such as an unreinforced masonry wall. Nelson would have expected to observe stair step fractures at or adjacent to the reported locations of distress had the reported distress been the result of lateral movement of the gymnasium. The isolated and discontinuous nature of the fractures/separations are consistent with drying shrinkage of the mortar and/or normal volumetric changes (i.e., thermal expansion/contraction between dissimilar elements).

In Nelson's opinion, the fractures/separations in the ceiling and wall finishes at the south hallway and music room are not indicative of lateral movement of the gymnasium. The pattern of distress at the ceiling and the isolated diagonal fracture in the wall finishes are not characteristic of lateral structural movement. Had lateral movement occurred, Nelson would have expected to observe separations at the ceiling/wall interfaces in conjunction with the observed ceiling finish distress and fractures in the wall finishes at multiple wall opening locations.

In Nelson's opinion, the fractures in the south concrete beams are unrelated to the parapet wall collapse on the reported date of loss. As indicated in Report 1, the fractures in the concrete beams are characteristic of cracking as the result of shrinkage and thermal movement, and not consistent with an impact load as the result of the parapet wall collapse. Had the fractures been the result of the aforementioned impact load, Nelson would have expected to see a concentration of fractures at the ledger anchors adjacent to the impact location. Additionally, Nelson would have expected the fractures to extend downward from the anchor points to the bottom of the beams.

In Nelson's opinion, the parapet wall collapse on the reported date of loss did not result in the application of an impact load on the bow-string trusses. If a tensile load in the thermoplastic membrane had resulted in the aforementioned impact load, as reported by Mr. Wright, the thermoplastic membrane would have been pulled taut. This would have resulted in upward displacement of the membrane at the roof's south edge due to the geometry of the roof as shown in **Figure 14**. Once the parapet wall pulled free from the membrane, the membrane would have relaxed. However, it is unlikely that the membrane would have returned to its original installed location and Nelson would have expected areas of displaced and/or wrinkled membrane along the roof's south edge. Additionally, upward displacement of the membrane would have resulted in tearing of the membrane at roof penetrations. However, the aforementioned conditions were not observed by Nelson at the subject structure's roof. Nelson's observations indicate that tears in the thermoplastic membrane were limited to the anchor hole locations, where the membrane would have been attached to the parapet wall. This indicates that the membrane failed at the parapet connection and further corroborates that no tensile loads was transferred into the field of the thermoplastic roof as a result of the parapet wall collapse.

CONCLUSIONS

Based on reported and received information, observed conditions, testing performed, and analysis, Nelson is of the following opinions regarding the reported distress:

- The subject structure did not experience lateral movement as a result of the south parapet wall collapse on the reported date of loss;
- The fractures/separations indicated by Mr. Wright at the masonry elements are not indicative of lateral movement of the gymnasium, nor are they the result of the south parapet wall collapse on the reported date of loss;
- The fractures/separations in the ceiling and wall finishes at the south hallway and music room are not indicative of lateral movement of the gymnasium;
- The fractures in the south concrete beams are unrelated to the parapet wall collapse on the reported date of loss;
- The parapet wall collapse on the reported date of loss did not result in the application of an impact load on the bow-string trusses.

LIMITATIONS

The items observed and documented in this report are intended to be representative of the structural conditions at the subject structure. No attempt has been made to document the condition of every structural and nonstructural element. Only visible items were observed and documented. Destructive testing was not performed by Nelson.

This document is the rendering of a professional service, the essence of which is the provision of advice, judgment, opinion, or professional skill.

This report was prepared in order to document distress observed at the structure. The opinions presented herein are based on site observations, field information and measurements taken, written and verbal information, and experience, where applicable. No complete review of this structure's conformance to current or previously applicable building codes was performed. However, specific items that may be at issue with the applicable building code requirements may be noted.

This report should not be construed as an assessment of total damages to the structure at the time of site observation. In addition to the observed and documented items of distress, hidden defects may exist that were not readily visible. Also, some damaged areas may have been previously repaired and, unless otherwise noted, were not visible at the time of observation. However, these areas may experience future distress. No representation, guarantee, or warranty as to the future performance of this structure is made, intended, or implied.

This report has been prepared for the purpose of evaluating a claim. In the event that additional information becomes available that could affect the conclusions reached in this investigation, this office reserves the right to review, and, if required, change the opinions presented herein.

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