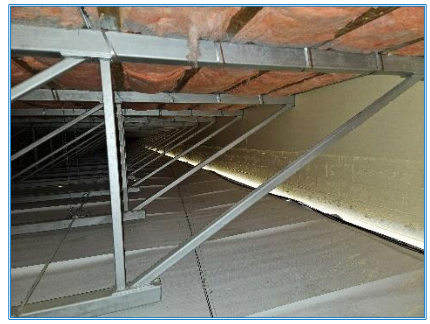
STEEL ROOF TRUSS ASSESSMENT REPORT

CITY OF NELSON – CURLING CLUB

STRUCTURE **CURLING CLUB**
LOCATION **302 CEDAR STREET NELSON**



Report Date: August 29th, 2024

By: Carmen DiPasquale, P.Eng.
Reviewed By: N/A

GENERAL STRUCTURE DESCRIPTION:

Reference Drawings: Fairbanks, Sawyer, Architects & Community Planners, Job 7124, Sheet 1 to 11, 14 January 1972

Reference Inspections: None provided

Year Built: 1972 (assumed)

BACKGROUND AND EXISTING CONDITION:

Sam Ellison, Facilities Manager for the City of Nelson contacted SNT Engineering Ltd. to perform a detailed review and capacity assessment of a typical roof truss above the main curling rink ice area. Carmen DiPasquale, P.Eng., of SNT Engineering reviewed the roof trusses on February 22nd, 2024 and March 25th, 2024.

The structure appears as-designed from the provided architectural drawings, though they do not contain any details or specifications for the roof trusses. No detailed structural drawings have been provided.

The requested review was limited to the typical 90’ span roof truss over the main rink area. The review did not include an analysis of the roof decking, roof purlins, walls, other roof or floor assemblies (lounge or viewing area, etc.), lateral stability, connections, foundations, or loading other than dead, snow, and wind (live, equipment, seismic, etc. not considered).

The roof structure is largely inaccessible without a motorized lift or other specialized access equipment. The field review was limited to one half of a single roof truss accessed with a ladder and safety harness.

The truss observed was painted steel, all members were Hollow Structural Section (HSS). No defects, distress, or deformation was observed in the reviewed truss half.

As all members were HSS with end caps, wall thickness is unknown. The City provided a digital ultrasonic thickness measurement device which was used to confirm wall thickness.

STRUCTURAL ASSESSMENT OF STEEL ROOF TRUSS:

The *Structural Commentaries User's Guide* of the National Building Code 2015 (2020 guide not yet published) allow reduced loading for evaluating existing buildings. The intent of the evaluation factors would apply to the original building only (i.e. not for any modifications, equipment changes, or any current or future upgrade work). Reduced load factors used are detailed below.

The assessment is based on the following:

- Dead Load evaluation factor 1.2 (reduced from 1.25), counteractive 0.92 (reduced from 0.95)
- Snow load evaluation factor 1.4 (reduced from 1.5)
- Wind load evaluation factor 1.3 (reduced from 1.40)
- Wind load companion factor 0.4 (no reduction permitted)
- The factors are based on:
  - System Behaviour – Failure likely to lead to collapse and likely to impact people
  - Risk Category – High (tournaments may bring large numbers of participants and spectators – could be reduced based on information from owner about average occupancy)
  - Past Performance – Over 20 years reported satisfactory past performance.
- Importance Category: Normal (not high or post-disaster, assumed not a community gathering/sheltering location, to be reviewed).
- Loading considered: 3.9 kPa ground snow load and 0.1 kPa associated rain load estimated from similar-location site reports from Environment Canada modified with BCBC 2024 guidance appropriate to the roof shape and exposure.
- Estimated roof dead load with gravel 0.83 kPa (0.8 kPa, 17PSF, is noted on the original Architect's drawings).
- BCBC 2024 1/50 hourly wind pressure for Nelson 0.33 kPa
- 1830mm (6') tributary width typical
- 27,432mm (90') span

HSS is produced in 1/8" (3.2mm) thickness increments with an allowable variation in wall thickness of approximately +/- 10% (depending on the specification the members are produced to). Some of the measured thicknesses were below the expected thickness for a standard size. The nearest 1/64" size below the measured thickness was used to model the truss. A full review of the roof system, including measuring a statistically significant number of remaining trusses would help determine the appropriate design section size for further refined evaluation.

HSS was also produced to various specifications in various grades over the preceding half century. CSA S16 *Design of Steel Structures* requires unidentified steel yield strength to be taken as 210 MPa in the absence of coupons being taken for testing. The likely range of actual steel yield strength in the 1960's/1970's is 230 to 300 MPa based on material standards of that era. Most current HSS has a yield strength of 345 MPa. As such, the 210 MPa assumption is likely conservative.

STRUCTURAL ANALYSIS OF STEEL ROOF TRUSS:

An assumed-typical roof truss was computer assessed using SAP2000 analysis software based on the observed member size, loads and strengths discussed above, and following assumptions:

- The truss web diagonal members align concentrically at the chord centerline and the vertical member centerline (no eccentricity accounted for);
- The welded and bolted connections are all stronger than the connected members (no connections were checked); and
- The bracing system of five rows of angle cross bracing (every 2nd node) can adequately braced the truss top and bottom chords and transfer any out-of-plane loads to the wall/foundation structure.

The assumptions above are potentially non-conservative and should be verified prior to performing an independent review and finalizing of this report.

The truss is overstressed when modelled with the design dead, snow, and wind loads as prescribed by the 2024 BC Building Code (2020 National Building Code) with the allowable reductions in the *Structural Commentaries User's Guide* of the National Building Code 2015.

The demand/capacity utilization ratios (UR), which should be <1.0 in a new building, are approximately noted in the table below:

Member	Modelled Sizes (inches)	Utilization Ratio (Demand/Capacity)
Top Chord	5x5x15/64 (midspan), 5x5x5/32 (ends)	1.9 to >2
Bottom Chord	4x4x15/64 (midspan), 4x4x5/32 (ends)	0.8 to 1.8
Wed Members (diagonal and vertical)	Various sizes 2.5x2.5 to 1x1	0.5 to 1.7

Reducing the snow load to approximately 25% of the design values, and neglecting the companion wind load, reduces all utilization ratios below 1.0. Further analysis would be required to determine if that is an appropriate safe working load to use for administrative occupancy decisions.

CODE REVIEW AND CONCERNS:

This report has not been formally independently reviewed. It was based on several assumptions, many of which are potentially non-conservative, which must be checked prior to a final conclusion being reached. This would represent significant additional work and expense for The City. It is unlikely that further analysis will determine the utilization ratios of the truss members are less than or equal to 1.0.

The necessity of continued evaluation should be considered. Evaluating historic buildings against the current Building Code is inherently challenging and often produces results as above (overstressed members UR>1). As noted in the 2024 BCBC:

It is generally recognized that the present British Columbia Building Code was primarily written for new construction and provides for a performance level that is significantly higher than what exists with many older buildings.

Structural Commentaries User's Guide of the National Building Code 2015 does not dictate or provide an exhaustive list of circumstances when evaluations of existing buildings are recommended, but they do note:

…examples include circumstances where the use of the building changes, where the building experiences damage or deterioration, and where the safety of the building becomes a concern because of known or potential defects.

Furthermore, the *Structural Commentaries* do allow evaluation based on satisfactory past performance (emphasis added):

Buildings and components designed and built according to earlier codes than the benchmark editions, or design and ***build in accordance with good construction practice*** *when no codes applied,* ***are considered to have demonstrated satisfactory capacity to resist loads (other than earthquake loads),*** *provided the following conditions are met:*

- *Careful examination by a professional engineer does not reveal any evidence of significant damage, distress or deterioration;*
- *The structural system is reviewed, and critical details are examined and checked for load transfer;*
- *The building has demonstrated satisfactory performance for at lease 30 years; and*
- *There have been no changes within the past 30 years that could significantly increase the loads on the building or affect its durability , and no such changes are contemplated.*

It is not considered prudent to rely on past performance for this structure for the following reasons:

The investigation was limited by access; the majority of the structure has not been investigated. An informal independent review indicated the roof truss to wall connection has been problematic on similar buildings in Nelson. A complete review of the roof system would require removing the ceiling, scaffolding or other specialized access equipment, and likely removing finish or structural elements to expose connections.

As stated in the previous section, the roof trusses are braced laterally, as required for their ability to withstand load. However, the braces tie to the masonry walls which have little out-of-plane strength. Further investigation would be required to determine the braces effectiveness. The braces also tie to the wall above the observed void below the foundation, which may further destabilize the wall and roof system.

The building is lightly reinforced masonry and does not have an effective roof diaphragm. As such, the seismic performance and safety are very poor. Any planned repairs should address this. Recent City projects can provide insight into cost and complexity of such upgrades.

The July 15, 2024 AtkinsRealis geotechnical report found substantial issues (soft soils, void) and made good recommendations for further investigation and repair options. As they discuss, pressure grouting or underpinning are the only means to stop further movement. These are expensive options. The fact that in a limited investigation, a void was found implies the likelihood of finding further voids is high.

While no detailed crack monitoring has been setup, photos and wall markings indicate the cracks are growing annually. Wall movement has the potential to destabilize the roof system.

CONCLUSION:

Based on the limited review and analysis, as detailed in this report, it is unlikely that further investigation, analysis, or formal independent review would determine the roof system can safely support the design snow load in the current state.

While sudden collapse is also unlikely, The City should consider the structural and geotechnical upgrades that would be required to ensure the roof and building system can safely support the design loads including seismic.

Further analysis would be required to determine the maximum safe snow load to be used for administrative occupancy decisions.

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August 29 2024

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