November 1st, 2023

Sam Ellison
City of Nelson
80 Lakeside Dr.
Nelson, BC V1L 6B9

Attn: Sam Ellison
SEllison@nelson.ca

EffiStruc
Consulting Inc.
EFFICIENT STRUCTURAL
DESIGN & ENGINEERING
250-505-5269
info@effistruc.ca
1223 Mtn. Station Rd.
Nelson, BC, V1L 2J3

Re: Structural Analysis Report - Civic Centre Roof Structure, 719 Vernon St., Nelson, BC

Sam Ellison, Facilities Manager at the City of Nelson, contracted EffiStruc Consulting Inc. to complete a preliminary structural analysis of the existing upper roof structure of the Nelson Civic Centre located at 719 Vernon Street, Nelson, BC. The existing upper roof structure reviewed in this report is located above the theatre, stage, and gymnasium, and consists of wood decking, timber purlins, timber framed trusses, and wood ceiling framing. The lower sloped roof above the arena was not included in this review.

This report summarizes the results of our visual investigation and preliminary structural analysis to confirm the existing roof structure capacity for gravity loads. Our attention was focused on the following items with regards to structural capacity and condition:

- Existing wood decking
- Existing timber purlins
- Existing timber trusses

Material testing, destructive testing, hazardous material identification, geotechnical engineering, structural design services, and lateral load (wind analysis & seismic analysis) review services are not included in this report.

Site Investigation Methodology

Our site investigation included visual inspection, photo documentation and collection of approximate dimensions (for capacity calculations) of the existing roof structure. These inspections were completed on October 10, 2023. General condition of the existing structure was observed and noted where readily visible. Measurements of exact timber bearing and steel connection geometry was not verified for all connections during our site investigation, due to the presence of framing, services and finishes (ceiling framing).

Structural Analysis Methodology

The existing roof structure was analyzed for gravity loads only, in accordance with the British Columbia Building Code (BCBC) 2018, and material codes referenced within (concrete, steel, wood and timber). The following design loads and parameters were used to analyze the structural capacity of the existing structure:

Nelson, BC:

Snow:	Ss =	4.2 kPa	(BCBC published ground snow load) *
Rain:	Sr =	0.1 kPa	

Gravity Design Loads:

Area	*Dead Load (Assumed)*	*Snow Load (Part 4)*
Roof	DL = 0.7 kPa (15 psf)	SL= 3.5 kPa (73 psf)
Ceiling	DL = 0.5 kPa (10 psf)	n/a

The gravity loads shown above include dead and snow loads. Dead load includes the weight of the permanent roof structure that does not move, including roofing membrane, decking, purlins, trusses, ceiling framing, mechanical (ducting), plumbing, sprinklers, and electrical wiring. Snow load includes the weight of snow and rain on the roof.

Assumptions of material grades for the observed structure were made based on the date of construction and building materials available to this area. For the purpose of our calculations, all wood and timber members were assumed to be of D.Fir-L No. 1 and all steel bolts and rods were assumed to have yield strength of 210 MPa (30 ksi).

* *As discussed with Sam Ellison, it may be possible to design the roof structure for a slightly lower snow load, as was used for recent renovations to the Baldface Office Building located at*
410 Stanley Street, Nelson, BC
Environment Canada Site Specific Snow Study, Aug. 13, 2019:
Ground snow load, Ss = 3.9 kPa

Site Investigation of Existing Structure

The existing building appears to have been built around 1935 and has a footprint of approximately 200’ x 188’. The upper roof under review is approximately 70’ x 180’ and is located above the existing theatre, stage, and gymnasium areas. The roof is supported by reinforced concrete walls and foundations.

The roof framing consists of 2 ½” thick wood decking supported by 4”x19” or 5”x17” timber purlins at roughly 8’- 8” on centre. The purlins are supported by timber trusses that span roughly 68’, bearing on concrete pilasters. There were three different timber truss types that vary in spacing from 10’ to 22’-6”. Between the timber trusses, were timber diagonal braces. The general geometry for each of the three types of timber trusses were the same; however, truss chords and webs varied in size. Each of the timber trusses consisted of timber top chords, timber bottom chords, timber diagonal webs, vertical steel tension rods, and steel bearing and splice connections.

The decking, purlin framing, and timber bracing was observed in several locations for general condition. Framing around roof penetrations was not reviewed. Upon preliminary visual inspection, the decking and purlins appear to be in fair condition where inspected. The timber bracing appeared to be in fair condition, except at several locations, it appeared that some bracing had been removed. This may have occurred to make space for mechanical upgrades (equipment and ducting) or other renovations such as sprinklers, etc...

Each timber truss was reviewed for its condition where visible. The entirety of each truss was not visible due to splice connections, wall framing between the stage and gymnasium area or the mechanical equipment and ducting within the roof cavity. The timber trusses appeared to show some signs of stress and splitting in the bottom chord at the bearing locations for several trusses. Additionally, three trusses appeared to have either strengthening or repairs completed to the top and/or bottom chords. This included a top chord repair to one Type 1 truss and the Type 2 truss and a bottom chord repair to a Type 3 truss. The repairs for all three trusses consisted of steel plates and bolts which left the critical section of the bottom chord unobservable. The condition of the truss at the repair area could not be observed or recorded at this time, due to the presence of large steel plates that obscured observations.

Results of Structural Analysis of Existing Structure

The structural capacity of the wood decking, timber purlins and the individual members and connections of all three truss types were analyzed for the dead and snow load listed above in accordance with the BCBC 2018. Below is a summary of our findings:

- The decking was found to have adequate structural capacity.
- The purlins were found to have insufficient structural capacity in bending strength, shear and deflection.
- Truss top chords of truss types 1 & 2 were found to have insufficient compression resistance (buckling).
- Truss top chord of truss type 3 was found to have sufficient compression resistance.
- Truss bottom chords of all three truss types were found to have insufficient tension resistance with the least amount of resistance found at the bottom chord splice locations.
- 6 out of 8 truss diagonal timber members of all three truss types were found to have insufficient compression and bearing resistance.
- 2 out of 8 truss diagonal timber members of all three truss types were found to have sufficient compression and bearing resistance.
- 2 out of 7 truss steel tension rods of truss types 1 & 2 were found to have insufficient tension resistance.
- 5 out of 7 truss steel tension rods of truss types 1 & 2 were found to have sufficient tension and bearing resistance.
- All truss steel tension rods in truss type 3 were found to have sufficient tension and bearing resistance.
- The steel bottom chord splice connection was found to have insufficient steel to wood bearing capacity for all three truss types.

In general, all three truss types were found to have insufficient capacity to support the loads specified by the BCBC 2018. Various members have insufficient capacity, but the critical member with the least capacity was the truss bottom chord at the splice connection for all three truss types. If this member were to fail in tension, it would likely be an abrupt brittle failure most likely not showing signs of distress prior to failure. In the attached Appendix A, Tables 1, 2 and 3 breakdown our results for each truss type, for each of the truss members, and we provide the corresponding maximum snow load capacity.

Recommendations

The structural capacity of the existing roof structure has been determined in accordance with the BC Building Code 2018, as noted above. This capacity includes both dead loads and live loads (snow loads); therefore, we need to confirm the existing dead load so that we can determine how much live load capacity remains to support snow and rain on the roof. As previously discussed, we should confirm the existing roof buildup, as to confirm the dead load assumptions made in this report.

The components of the roof buildup that need to be confirmed will vary across the length of the roof as the roof differs in construction depending on the location. The three different areas of the roof are above the theatre, stage, and gymnasium. The ceiling and roof buildup will need to be confirmed for each of these three areas. Additional loads that are supported by the roof will also need to be confirmed. This includes but is not limited to any roof top mechanical units, mechanical equipment within the roof cavity that may or may not be in operation, sprinkler system, stage lighting equipment, curtains, other stage equipment or props, architectural bulkheads, fire walls, and any gymnasium equipment supported by the roof.

Additionally, we recommend that a maintenance and monitoring program be developed to ensure that the roof structure is not over loaded with snow and rain while the building is occupied. For the maintenance and roof load monitoring program, we recommend the following:

1. Regular cleaning of roof drains.
2. Monitor snow depth on roof through video surveillance or other means such as drone footage, due to the difficulty of accessing the roof level.
3. Record the actual snow depth on the roof at 5 locations: near the 4 corners and in the middle of the roof area (daily during storms, or weekly otherwise).
4. Installation of snow pillow(s) or other system to confirm the actual weight of snow and rain on the roof structure.
5. Monitor weather forecasts, and close the building when substantial rain and snow are predicted (see below).
6. Assess the actual snow load on the roof, after new snow and rain events, and close the building when the actual depth of accumulated snow exceeds 8" (assuming a density of 3.5 kN/m^3 which corresponds to "heavy snow").
7. After the building has been closed due to excessive snow, and the snow has substantially melted, the building can be reopened provided the following:
   A) When the **accumulated snow on the roof did not exceed 12"** since the building was closed: perform a **visual review** of the roof structure.
   B) When the **accumulated snow on the roof has exceeded 12"** since the building was closed: perform a **rigorous review** of the roof structure.

We are available to assist the City of Nelson with the formulation of the maintenance and roof load monitoring program as required.

We further recommend that the existing roof structure should actually be strengthened or replaced in order to maintain and preserve the existing Nelson Civic Centre building. The maintenance and roof load monitoring program that is noted above, should only be implemented for this winter 2023 – 2024, if at all possible.

Feel free to contact our office if you have any questions.

Sincerely,

EffiStruc Consulting Inc.
P#1002608

2023-11-01

Don Willems, P.Eng, LEED AP
Structural Engineer

Appendix A – Structural Results

Figure 1 – Typical Truss

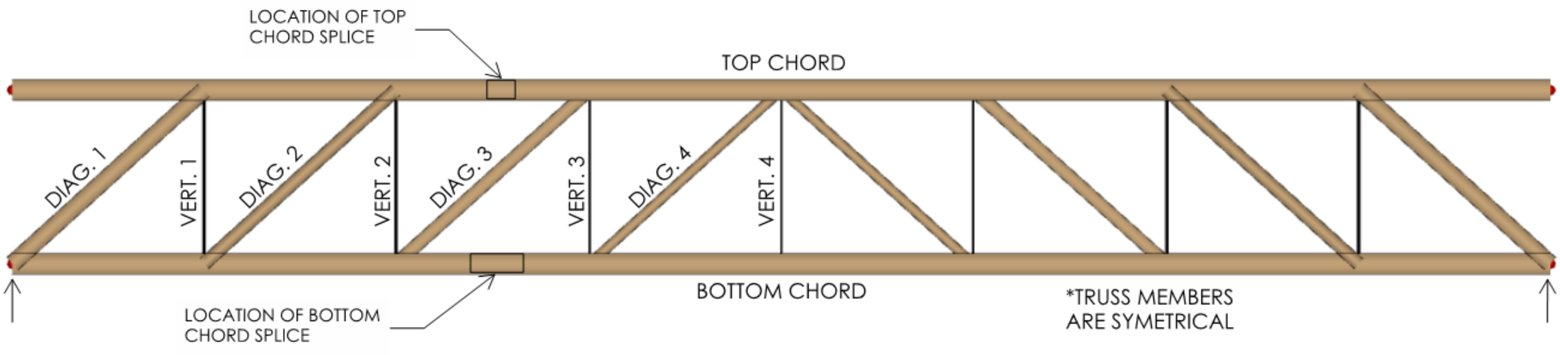

Table 1 – Truss Type 1

Truss Type 1 (5 total)									
Design Loads: LL = 3.5 kPa, DL=1.2 kPa; Snow Density: 3.5 kN/m3									
Truss Member	Tension or Compression Resistance (kN)	Bearing Resistance (kN)	Factored Axial Load (kN)	Tension or Compression Resistance over Factored Axial Load	Bearing Reistance over Factored Axial Load	Maximum Live Load Capacity (kPa)	Maximum Live Load Capacity (psf)	Maximum Snow Depth (m)	Maximum Snow Depth (in)
Diag. 1	663	277	653	1.02	0.42	0.91	19	0.3	10
Diag. 2	433	215	464	0.93	0.46	1.08	23	0.3	12
Diag. 3	277	119	279	0.99	0.43	0.94	20	0.3	11
Diag. 4	149	n/a	90	1.66	n/a	6.63	139	1.9	75
Vert. 1	242	329	309	0.78	1.06	2.53	53	0.7	28
Vert. 2	192	225	189	1.02	1.19	3.59	75	1.0	40
Vert. 3	73	79	57	1.28	1.39	4.69	98	1.3	53
Vert. 4	37	n/a	1	37.00	n/a	n/a	n/a	n/a	n/a
Top Chord	893	n/a	1037	0.86	n/a	2.88	60	0.8	32
Bot. Chord	506	n/a	1103	0.46	n/a	1.06	22	0.3	12
B.C. Splice	310	n/a	1037	0.30	n/a	0.35	7	0.1	4

Table 2 – Truss Type 2

Truss Type 2 (1 total)									
Design Loads: LL = 3.5 kPa, DL=1.2 kPa; Snow Density: 3.5 kN/m3									
Truss Member	Tension or Compression Resistance (kN)	Bearing Resistance (kN)	Factored Axial Load (kN)	Tension or Compression Resistance over Factored Axial Load	Bearing Reistance over Factored Axial Load	Maximum Live Load Capacity (kPa)	Maximum Live Load Capacity (psf)	Maximum Snow Depth (m)	Maximum Snow Depth (in)
Diag. 1	435	241	629	0.69	0.38	0.73	15	0.2	8
Diag. 2	357	143	447	0.80	0.32	0.44	9	0.1	5
Diag. 3	149	94	269	0.55	0.35	0.59	12	0.2	7
Diag. 4	99	n/a	87	1.14	n/a	4.27	89	1.2	48
Vert. 1	242	308	298	0.81	1.03	2.66	56	0.8	30
Vert. 2	192	183	182	1.05	1.01	3.54	74	1.0	40
Vert. 3	73	71	55	1.33	1.29	4.75	99	1.4	53
Vert. 4	37	n/a	1	37.00	n/a	n/a	n/a	n/a	n/a
Top Chord	737	n/a	999	0.74	n/a	2.33	49	0.7	26
Bot. Chord	425	n/a	1063	0.40	n/a	0.80	17	0.2	9
B.C. Splice	282	n/a	999	0.28	n/a	0.27	6	0.1	3

Table 3 – Truss Type 3

Truss Type 3 (2 total)									
Design Loads: LL = 3.5 kPa, DL=1.2 kPa; Snow Density: 3.5 kN/m3									
Truss Member	Tension or Compression Resistance (kN)	Bearing Resistance (kN)	Factored Axial Load (kN)	Tension or Compression Resistance over Factored Axial Load	Bearing Reistance over Factored Axial Load	Maximum Live Load Capacity (kPa)	Maximum Live Load Capacity (psf)	Maximum Snow Depth (m)	Maximum Snow Depth (in)
Diag. 1	389	203	453	0.86	0.45	1.02	21	0.3	11
Diag. 2	192	132	322	0.60	0.41	0.84	18	0.2	9
Diag. 3	149	81	193	0.77	0.42	0.90	19	0.3	10
Diag. 4	111	n/a	63	1.76	n/a	7.19	150	2.1	81
Vert. 1	242	270	214	1.13	1.26	4.08	85	1.2	46
Vert. 2	192	152	131	1.47	1.16	4.24	88	1.2	48
Vert. 3	54	54	40	1.35	1.35	5.07	106	1.4	57
Vert. 4	37	n/a	1	37.00	n/a	n/a	n/a	n/a	n/a
Top Chord	737	n/a	719	1.03	n/a	3.62	76	1.0	41
Bot. Chord	425	n/a	765	0.56	n/a	1.50	31	0.4	17
B.C. Splice	243	n/a	719	0.34	n/a	0.52	11	0.1	4