Structural Evaluation Report

Date:	**November 16th, 2022**	**Project: No.**	**747022**
To:	**Burkhart Gilchrist Architects**		
Attn:	**Ruth Burkhart**		
Re:	**Structural Evaluation – 7989 Brooke Line #7 – Brooke Central P.S., Alvinston, Ontario**		

No. of Pages: **24**

See attached,

1. Structural Evaluation Report

If you require any further information, please contact me at the office.
Thank you,

Distribution:

PER: Dwayne C. Buck, P.Eng.

To:	Burkhart Gilchrist Architects	Re:	Structural Evaluation
	836 Upper Canada Drive		7989 Brooke Line #7 - Brooke Central P.S.
	Sarnia, Ontario		Alvinston, Ontario
Attn:	Ruth Burkhart		Brooke Central Public School
	Project No. 747022	Date:	Wednesday, November 16, 2022

Structural Evaluation Report

DC Buck Engineering was contacted to provide a Structural Evaluation of the existing roof framing of two (2) areas of the Brooke Central public School located at the above address to verify the existing loading on the roof and determine the feasibility of increasing the roofing materials.

Burkhart Gilchrist Architects Incorporated (BGAI) provided us with the original Structural Drawings.

One of the areas that is to be evaluated was built on 1960. The drawings for this area were prepared by Frederick W. H. Dawes, Architect, M.R.A.I.C – Chatham Ontario, and are titled "Brooke T.W.P. Central School, Alvinston, Ontario". The Drawings have a job Number 6026 and are dated October 1960. The drawings used for the analysis are the Structural Plan with Drawing No.S1, and the Sections Drawing with Drawing No.5. The drawings were sealed by the Architect.

The other area to be evaluated was built in 1967. The drawings for this area were also prepared by Frederick W. H. Dawes, Architect, M.R.A.I.C. – Chatham Ontario, and are titled "1967 Addition to Brooke Central School, Alvinston, Ontario". The Drawings have a job Number 6707 and are dated July 10, 1967. The drawings used for the analysis are the Structural Plan with Drawing No.S1, and the Elevations and Cross Sections Drawing with Drawing No. 3. The drawings were sealed by the Architect.

The drawings do not have any revisions shown; therefore, it is not known if these were the As-Built drawings or if any revisions were issued after these.

OBSERVATIONS, COMMENTS AND RECOMMENDATIONS:

We will refer to the two areas as 1960 Building and 1967 Building Addition.

Below are the observations and comments that we have of the items examined during the site inspection. After these, a discussion is provided and Conclusions and Recommendations are given to the client.

1.0 LOADING

Original Design Loading

The two areas will be evaluated using the old loads with a lower dead load, and a basic snow load. No wind load pressure or uplift was used for this design evaluation.

Snow drifting on buildings was beginning to be considered for design after 1963 (in the 1965 National Building Code of Canada). This was after a number of building failures from snow load had occurred. In a report published by the National Research Council of Canada published in 1963 is stated that:

> "Code requirements for snow loads must necessarily be rather general, and consequently the designer should not apply the loads given in the Code without considering the effects of the shape and exposure of the roof. The loads given in the National Building Code of Canada 1960 are minimum values only, which must be increased where he considers it necessary. The designer should, therefore, consider in each case the building site, size and shape, **where drifts are likely to occur on the roof**"

Wind pressure coefficients were first used in the 1960 National Building Code of Canada – Supplements (Handbook of Pressure Coefficients for Wind Loads 1961).

However, it is believed that snow drifting and wind loading was not considered in the design of the 1960 Building nor on the 1967 Building Addition, as it will be observed on the loading charts later on the report.

The following Original loads were used for the structural design evaluation of the roof members in both the 1960 Building and the 1967 Building Addition. The Original load on the roof used for the design evaluation is as follows:

<u>DEAD LOAD</u>
20 year bonded Tar and Gravel Roof = 0.10KPa
1 ½" 20Gauge Steel Roof Deck = 0.15Kpa
1" Rigid Insulation = 0.053KPa
Ceiling Tile = 0.10KPa
Gypsum Board = 0.10KPa
Miscellaneous (Mechanical and Electrical) = 0.25KPa
<u>Self-Weight = 0.13KPa</u>
Total Original Dead Load = 0.883KPa (18.44PSF)

<u>SNOW LOAD</u>
The snow load climatic data for Alvinston, Ontario (near Watford, Ontario) used for the analysis is as follows
Ss = 1.90KPa
Sr= 0.4KPa

Basic Snow Load = 1.92KPa (40.1PSF)

Current Design Loading

The current design load for the two areas will be evaluated using the proposed higher dead load that includes a 4-Ply built up roof with 6" of insulation, and an increased snow load. In addition to the increased snow load, a snow drifting was also considered for the 1960 Building.

The following Current loads were used for the structural design evaluation of the roof members in both the 1960 Building and the 1967 Building Addition. The current load on the roof used for the design evaluation is as follows:

DEAD LOAD
4-Ply built up roof = 0.32KPa
1 ½" 20Gauge Steel Roof Deck = 0.15Kpa
6" of Insulation = 0.105KPa
Ceiling Tile = 0.10KPa
Gypsum Board = 0.10KPa
Miscellaneous (Mechanical and Electrical) = 0.25KPa
Self-Weight = 0.13KPa
Total Current Dead Load = 1.16KPa (24.15PSF)

SNOW LOAD
The snow load climatic data for Alvinston, Ontario (near Watford, Ontario) used for the analysis is as follows
Ss = 1.90KPa
Sr= 0.4KPa
An importance factor (Is) of 1.15 was factored into the basic Snow load
Basic Snow Load = 2.21KPa (46.2PSF)

Additionally, in the Original 1960 Building, there is an area were the computer rooms are currently located. This area is approximately 1.83m (6'-0") higher than the rest of the roof. A snow drifting with a high value of 6.24KPa (130PSF) has to be considered adjacent and around the taller roof area. This snow drifting is extended to approximately 5.84m (19'-2") away from the computer rooms' area

WIND LOAD
The snow load climatic data for Alvinston, Ontario (near Watford, Ontario) used for the analysis is as follows
q(1/50) = 0.47KPa
q(1/10) = 0.36KPa
Additionally an importance factor (Iw) of 1.15 was used for the wind load calculations.

Wind Uplift = 1.34KPa (28PSF)
Wind Pressure = 0.65KPa (13.6PSF)
The Importance Factor (Is for Snow loading and drifting or Iw for wind loading) is a safety factor based on an Importance Category which is based on the intended use and occupancy. An elementary, Middle or secondary school has a HIGH importance category.

2.0 DESIGN PARAMATERS

Load Combinations

As per the Ontario Building Code, a building and its structural components shall be designed to have sufficient strength and stability so that the factored resistance (or **Capacity** as labeled on the charts) is greater than or equal to the effect of factored loads (or **Current and Original Loads** as labeled on the charts). The effect of factored loads for a building shall be determined in accordance with load combination cases. The loading combination case that governed the design of these buildings is as follows;

- 1.25 Dead Load + 1.15x (1.5 Snow Load + 0.4 Wind Pressure) – for the Current Loads
- 1.25 Dead Load + 1.5 Snow Load – for the Original Loads

This load combination for the Current Loads includes the importance factor of 1.15 for Snow and wind loads as explained in section **1.0 LOADING.**

Deflection is evaluated using unfactored loads. For the Current Loads, deflection is to be evaluated using the following load combination

- 1.0 Snow Load + 1.0 Wind Pressure

For the analysis of the beams and frames for the Original building construction, deflection was evaluated using only the effects of the unfactored snow load.

- 1.0 Snow Load

Original Construction (and Glulam Section Properties)

The roof construction of both the 1960 Original Building and the 1967 Building addition is as follows;

- 20 year bonded tar and gravel, on
- 1" rigid insulation, on
- 1 1/2" – 20 Gauge Steel Rood Deck
- Glulam beams

Since there is no structural information on the glulam structural parameters on the original drawings, the following was used for the analysis:

Species: Douglas-Fir Glued Laminated Beam
Fb (Allowable bending stress) = 2,400 psi
E (Modulus of elasticity) = 1.80 x 106 psi
Fv (Allowable horizontal shear stress) = 265 psi

3.0 AREAS TO BE EVALUATED

The two areas that are to be evaluated are the 1960 Building and the 1967 Building Addition. See Appendix 'A' for the original structural drawings for the two areas:

- Figure 1 is the Structural Drawing No. S1 for the 1960 Building, and
- Figure 2 is the Structural Drawing No. S1 for the 1967 Building Addition.

1960 BUILDING

The 1960 building is the original building constructed at the site. The roof is framed with glulam beams supported by either wood or steel columns or beams, or supported by the exterior load bearing wall (see Figure 1 on Appendix 'A).

Beams and Frames Type 'A'

The majority of roof frames in the building are labeled Type 'A' frames. These are located at the East, West and the South sides of the building.

These beams have two cross sections: a larger cross section that measures 5 1/4"x14 5/8, and a smaller cross section that measures 5 1/4"x8 1/8". These beams are two span continuous beams with a 3'- 11 ¾" cantilever on one side. The beams has the larger cross section over the larger span and then it changes to a smaller cross section at the smallest span. The large cross section changes to smaller cross section approximately 4'-0" away from the mid support.

Note on Figure 1 that most of the Frames Type 'A" are affected by the snow drifting. The Snow drifting is extended over approximately 19'-2" along the smallest cross section of the beams. Additionally, intermediate steel reinforcement has been added between some of these beams along the West and East sides of the building. The steel beams reinforcement spans only from block wall to block wall which is where the larger cross section of the beams are located. The reinforcement is not extended over to the cantilevered portion of the beam or the small cross section of the beam

There were 5 cases analysed for these beams:

- With the current load and no snow drifting,
- With current load and snow drifting,
- With current loads and snow drifting and partial intermediate reinforcement (which is currently existing as explained above),
- with current loads and snow drifting and complete intermediate reinforcement (this case assumes intermediate reinforcement is located along the entire length of the beams including the cantilevered portion), and
- With Original loads.

The results are as follows:

FRAME TYPE A

Size	width	depth	Capacity		Current Loads no Drift			Current Loads w/ Drift		
			Moment	Shear	Moment	Shear	Deflection	Moment	Shear	Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	16.59	6.84	5.94	23.51	10.76	27.5
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	50.90	10.30	15.58	71.49	15.16	11.49

Percentage Overstressed

Size	Current Loads no Drift			Current Loads w/Drift		
	Moment	Shear	Deflection	Moment	Shear	Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	44	NOT O/S	NOT O/S	103	43	93
5 1/4" X 14 5/8"	36	NOT O/S	NOT O/S	91	12	NOT O/S

Size	width	depth	Capacity		Current Loads w/Drift and Partial Intermediate Reinforcement			Current Loads w/Drift and Complete Intermediate Reinforcement		
			Moment	Shear	Moment	Shear	Deflection	Moment	Shear	Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	11.14	9.79	34.32	11.34	5.19	13.27
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	59.07	14.03	5.94	34.47	7.31	5.54

Percentage Overstressed

Size	Current Loads w/Drift and Partial Intermediate Reinforcement			Current Loads w/Drift and Complete Intermediate Reinforcement		
	Moment	Shear	Deflection	Moment	Shear	Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	NOT O/S	30	141	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	58	3	NOT O/S	NOT O/S	NOT O/S	NOT O/S

Size	width	depth	Capacity		Original Loads		
			Moment	Shear	Moment	Shear	Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	11.08	4.57	5.16
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	33.99	6.88	13.53

Percentage Overstressed

Size	Original Loads		
	Moment	Shear	Deflection
	(%)	(%)	(%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	NOT O/S	NOT O/S	NOT O/S

NOTE:
NOT O/S means the member is not Overstressed under the imposed loads

Allowable deflection (L/360) for small section of beam is =	14.25	mm
Allowable deflection (L/360) for large section of beam is =	20.88	mm

It can be observed on the above chart that the beams fail when analyses with the current loads, either with or without snow drifting. Also, note that even with the addition of the partial intermediate reinforcement the beams fail. Deflection is over 140% higher than the allowable deflection at the span with the small cross section which makes sense since this is the area with higher load. Also note on the chart that if the reinforcement is to be extended along the entire length of the beam, the beam is adequate in strength and deflection.

The beam analysed with the Original loads is also adequate in strength and deflection.

Beams and Frames Type 'B'

These beams also have two cross sections: a larger cross section that measures 5 1/4"x14 5/8, and a smaller cross section that measures 5 1/4"x8 1/8". These beams are two span continuous beams and originally had a 3'- 11 ¾" cantilever on one side. The beams has the larger cross section over the larger span and then it changes to a smaller cross section at the smallest span. The large cross section changes to smaller cross section approximately 4'-0" away from the mid support.

Note on Figure 1 that there is an area at the North side of the building that had an upgrade done in 2013. A portion of the block wall was removed along the location shown on the drawing and was replaced with two steel beams supported on steel columns and channel outriggers framed to the North of the steel beams. In order to do this the cantilevered portion of Frames Type 'B" and 'C' had their cantilevered portion removed.

There were 3 cases analysed for these beams:

- With the current load and no snow drifting,
- With current load and snow drifting, and
- With Original loads.

The results are as follows:

FRAME TYPE B

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads no Drift Moment	Current Loads no Drift Shear	Current Loads no Drift Deflection	Current Loads w/ Drift Moment	Current Loads w/ Drift Shear	Current Loads w/ Drift Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	16.49	6.69	8.67	18.17	8.41	18.02
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	49.82	12.01	19.29	59.01	12.39	15.06

Percentage Overstressed

Size	Current Loads no Drift Moment	Current Loads no Drift Shear	Current Loads no Drift Deflection	Current Loads w/Drift Moment	Current Loads w/Drift Shear	Current Loads w/Drift Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	43	NOT O/S	NOT O/S	57	12	23
5 1/4" X 14 5/8"	33	NOT O/S	NOT O/S	58	NOT O/S	NOT O/S

Size	width	depth	Capacity Moment	Capacity Shear	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	13.09	5.31	5.82
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	39.56	9.54	12.82

Percentage Overstressed

Size	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)
5 1/4" x 8 1/8"	13	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	6	NOT O/S	NOT O/S

NOTE:

NOT O/S means the member is not Overstressed under the imposed loads

Allowable deflection (L/360) for small section of beam is = 14.61 mm

Allowable deflection (L/360) for large section of beam is = 20.53 mm

Similar to beams type ‘A’, the beams fail when analyses with the current loads, either with or without snow drifting. Also, when the beam were analysed with the Original loads they are not adequate in strength. This is because the cantilevered portion of the beams was removed causing more load to redistribute along the two spans.

Beams and Frames Type 'C'

These beams also have two cross sections: a larger cross section that measures 5 1/4"x14 5/8, and a smaller cross section that measures 5 1/4"x9 3/4". These beams are two span continuous beams and similar to the beams type 'B' originally had a 3'- 11 ¾" cantilever on one side. As mentioned above the cantilevered portion of these beams had their cantilevered portion removed.
The beams has the larger cross section over the larger span and then it changes to a smaller cross section at the smallest span. The large cross section changes to smaller cross section approximately 6'-0" away from the mid support.

There were 2 cases analysed for these beams:

- With the current load and snow drifting, and
- With Original loads.

The results are as follows:

FRAME TYPE C

			Capacity		Current Loads w/Drift			Original Loads		
Size	width (in)	depth (in)	Moment (k-ft)	Shear (k)	Moment (k-ft)	Shear (k)	Deflection (mm)	Moment (k-ft)	Shear (k)	Deflection (mm)
5 1/4" x 9 3/4"	5.25	8.125	16.64	9.04	28.90	8.68	26.67	10.61	4.49	6.32
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	71.98	14.41	10.37	43.54	8.31	12.18

Percentage Overstressed

	Current Loads w/Drift			Original Loads		
Size	Moment (%)	Shear (%)	Deflection (%)	Moment (%)	Shear (%)	Deflection (%)
5 1/4" x 9 3/4"	74	NOT O/S	67	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	92	6	NOT O/S	16	NOT O/S	NOT O/S

NOTE:
NOT O/S means the member is not Overstressed under the imposed loads
Allowable deflection (L/360) for 5 1/4"x 9 3/4" beam section is = 15.98 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 20.88 mm

These beams fail when analysed with the current loads with snow drifting. Also, when the beam were analysed with the Original loads they are not adequate in strength.

Beams and Frames Type 'D' and 'E'

These beams have two cross sections: a larger cross section that measures 5 1/4"x14 5/8, and a smaller cross section that measures 5 1/4"x9 3/4". These beams are two span continuous beams with a 4'- 11 ¾" cantilever on one side. The beams has the larger cross section over the larger span and then it changes to a smaller cross section at the smallest span. The large cross section changes to smaller cross section approximately 6'-0" away from the mid support.

There were 2 cases analysed for these beams:

- With the current load and snow drifting, and
- With Original loads.

The results are as follows:

FRAMES TYPE D & E

Size	width (in)	depth (in)	Capacity Moment (k-ft)	Capacity Shear (k)	Current Loads w/Drift Moment (k-ft)	Current Loads w/Drift Shear (k)	Current Loads w/Drift Deflection (mm)	Original Loads Moment (k-ft)	Original Loads Shear (k)	Original Loads Deflection (mm)
5 1/4" x 9 3/4"	5.25	8.125	16.64	9.04	35.99	11.24	38.42	14.40	4.90	10.98
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	77.74	15.68	2.46	45.15	9.50	7.54

Percentage Overstressed

Size	Current Loads w/Drift Moment (%)	Current Loads w/Drift Shear (%)	Current Loads w/Drift Deflection (%)	Original Loads Moment (%)	Original Loads Shear (%)	Original Loads Deflection (%)
5 1/4" x 9 3/4"	116	24	128	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	108	16	NOT O/S	21	NOT O/S	NOT O/S

NOTE:
NOT O/S means the member is not Overstressed under the imposed loads
Allowable deflection (L/360) for 5 1/4"x 9 3/4" beam section is = 16.83 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 20.04 mm

Again, the beams fail when analyses with the current loads. Moment (strength) capacity of the beam is also overstressed when analysed with the original loads.

Beams and Frames Type 'F1a', 'F1b' and 'F2'

These beams have only one cross section along their entire length that measures 5 1/4"x14 5/8. These beams are simply supported. The Beams type 'F1a' and 'F1b' have a 3'-9 5/8" cantilever, while the beams type 'F2' have a 3'- 11 ¾" cantilever on one side.

There were 2 cases analysed for these beams:

- With the current load and snow drifting, and With Original loads.

The results are as follows:

FRAMES TYPE F1a & F1b

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads w/Drift Moment	Current Loads w/Drift Shear	Current Loads w/Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	93.47	17.76	61.30	50.51	8.27	26.44

Percentage Overstressed

Size	Current Loads w/Drift Moment	Current Loads w/Drift Shear	Current Loads w/Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" X 14 5/8"	150	31	189	35	NOT O/S	25

NOTE:
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 21.18 mm

FRAME TYPE F2

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads w/Drift Moment	Current Loads w/Drift Shear	Current Loads w/Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	90.35	17.35	63.03	49.41	8.09	27.55

Percentage Overstressed

Size	Current Loads w/Drift Moment	Current Loads w/Drift Shear	Current Loads w/Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" X 14 5/8"	141	28	198	32	NOT O/S	30

NOTE:
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 21.18 mm

Note on the charts above that the percentage overstressed in Moment (strength) for all these types of beams get up to a maximum of 150%. This is because the beams are simply supported with long spans.

When beams are continuous over a support they have a higher vertical load capacity and a reduced deflection at mid span, while simply supported beams will develop higher stresses and deflections at mid span.

1967 BUILDING ADDITION

The roof of this addition is framed with glulam beams supported by either wood or steel columns or beams, or supported by the exterior load bearing wall. As seen on Figure 2 (on Appendix ‘A’), beams are differentiated by the different gridlines in the area. This area does not have snow drifting on it.

There were only 2 cases analysed for all the beams in this area:

- With the current load and no snow drifting, and
- With Original loads.

Frames at Gridlines G, K, L and M

This frame consists of three beams. The beams at each end of the frame are 5 1/4”x14 5/8” glulam beams and are simply supported with a 3’-11 3/4”cantilevered at both ends. The middle beam has a 5 1/4”x8 1/8” cross section and it is a three (3) span continuous beam.

FRAMES AT GIRDLINES G, K, L & M

Size	width (in)	depth (in)	Capacity Moment (k-ft)	Capacity Shear (k)	Current Loads Moment (k-ft)	Current Loads Shear (k)	Current Loads Deflection (mm)	Original Loads Moment (k-ft)	Original Loads Shear (k)	Original Loads Deflection (mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	6.10	4.25	1.66	4.85	3.38	1.11
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	60.64	10.89	36.21	46.01	8.27	24.31

Percentage Overstressed

Size	Current Loads Moment (%)	Current Loads Shear (%)	Current Loads Deflection (%)	Original Loads Moment (%)	Original Loads Shear (%)	Original Loads Deflection (%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	62	NOT O/S	75	23	NOT O/S	18

NOTE:
NOT O/S means the member is not Overstressed under the imposed loads
Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 20.67 mm

DCBUCK ENGINEERING

Frame at Gridline I

This frame also consists of three beams. The beams at the South end is a 5 1/4”x14 5/8” glulam beams, simply supported with a 3’-11 3/4”cantilever. The middle beam has a 5 1/4”x8 1/8” cross section and it is a three (3) span continuous beam. The beam at the north end is a 5 1/4”x 9 3/4” glulam beam and it is a two (2) span continuous beam.

FRAME AT GIRDLINE I

Size	width (in)	depth (in)	Capacity Moment (k-ft)	Capacity Shear (k)	Current Loads Moment (k-ft)	Current Loads Shear (k)	Current Loads Deflection (mm)	Original Loads Moment (k-ft)	Original Loads Shear (k)	Original Loads Deflection (mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	6.10	4.25	1.66	4.85	3.38	1.11
5 1/4"X 9 3/4"	5.25	9.75	16.64	9.04	19.27	7.60	10.53	15.31	6.03	7.07
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	60.64	10.89	36.21	46.01	8.27	24.31

Percentage Overstressed

Size	Current Loads Moment (%)	Current Loads Shear (%)	Current Loads Deflection (%)	Original Loads Moment (%)	Original Loads Shear (%)	Original Loads Deflection (%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S
5 1/4"X 9 3/4"	16	NOT O/S	44	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	62	NOT O/S	73	23	NOT O/S	16

NOTE:

NOT O/S means the member is not Overstressed under the imposed loads

Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm

Allowable deflection (L/360) for 5 1/4"x 9 3/4" beam section is = 20.88 mm

Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 13.34 mm

Frame at Gridlines H

This frame consists of two beams. The beam at the South end of the frame is a 5 1/4”x14 5/8” simply supported glulam beams with a 3’-11 3/4”cantilever. The North beam is a 5 1/4”x8 1/8” glulam beam and it is a two (2) span continuous beam.

FRAME AT GIRDLINE H

Size	width (in)	depth (in)	Capacity Moment (k-ft)	Capacity Shear (k)	Current Loads Moment (k-ft)	Current Loads Shear (k)	Current Loads Deflection (mm)	Original Loads Moment (k-ft)	Original Loads Shear (k)	Original Loads Deflection (mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	7.72	4.55	1.61	6.14	3.61	1.08
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	58.53	10.45	36.66	46.51	8.30	24.63

Percentage Overstressed

Size	Current Loads Moment (%)	Current Loads Shear (%)	Current Loads Deflection (%)	Original Loads Moment (%)	Original Loads Shear (%)	Original Loads Deflection (%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	56	NOT O/S	77	24	NOT O/S	19

Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.41 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 20.67 mm

Frames at Gridlines E and F

This frame also consists of two beams. The South beam is a 5 1/4”x8 1/8” glulam beam and it is a two (2) span continuous beam. The beam at the North end of the frame is a 5 1/4”x14 5/8” simply supported glulam beams with a 3’-11 3/4”cantilever.

FRAMES AT GIRDLINES E & F

Size	width (in)	depth (in)	Capacity Moment (k-ft)	Capacity Shear (k)	Current Loads Moment (k-ft)	Current Loads Shear (k)	Current Loads Deflection (mm)	Original Loads Moment (k-ft)	Original Loads Shear (k)	Original Loads Deflection (mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	7.65	4.51	1.53	6.14	3.61	1.08
5 1/4" X 14 5/8"	5.25	14.625	37.43	13.57	58.56	10.45	36.69	46.51	8.30	24.63

Percentage Overstressed

Size	Current Loads Moment (%)	Current Loads Shear (%)	Current Loads Deflection (%)	Original Loads Moment (%)	Original Loads Shear (%)	Original Loads Deflection (%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 14 5/8"	56	NOT O/S	77	24	NOT O/S	19

Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 20.67 mm

Frame at Gridline J

This frame consists of only one beam. The beam is a 5 1/4”x8 1/8” glulam beam and it is a three (3) span continuous beam.

FRAME AT GIRDLINE J

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads Moment	Current Loads Shear	Current Loads Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	6.10	4.25	1.66	4.85	3.38	1.11

Percentage Overstressed

Size	Current Loads Moment	Current Loads Shear	Current Loads Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S

Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm

Frames at Gridlines C, D, and N

These frame consists of only one beam. The beam is a 5 1/4”x8 1/8” simply supported glulam beam.

FRAMES AT GIRDLINES C, D & N

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads Moment	Current Loads Shear	Current Loads Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	7.87	3.63	3.68	6.25	2.88	2.47

Percentage Overstressed

Size	Current Loads Moment	Current Loads Shear	Current Loads Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S

Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm

Frames at Gridlines A and B

This frame consists of two beams. The South beam is a 5 1/4”x8 1/8” simply supported glulam beam. The beam at the North end of the frame is a 5 1/4”x14 5/8” two (2) span continuous beam.

FRAMES AT GIRDLINES A & B

Size	width	depth	Capacity Moment	Capacity Shear	Current Loads no Drift Moment	Current Loads no Drift Shear	Current Loads no Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(in)	(in)	(k-ft)	(k)	(k-ft)	(k)	(mm)	(k-ft)	(k)	(mm)
5 1/4" x 8 1/8"	5.25	8.125	11.55	7.54	7.87	3.63	3.68	6.25	2.88	2.47
5 1/4" X 11 3/8"	5.25	14.625	22.44	10.50	31.06	9.80	19.93	24.53	7.76	13.06

Percentage Overstressed

Size	Current Loads no Drift Moment	Current Loads no Drift Shear	Current Loads no Drift Deflection	Original Loads Moment	Original Loads Shear	Original Loads Deflection
	(%)	(%)	(%)	(%)	(%)	(%)
5 1/4" x 8 1/8"	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S	NOT O/S
5 1/4" X 11 3/8"	38	NOT O/S	16	9	NOT O/S	NOT O/S

NOTE:
NOT O/S means the member is not Overstressed under the imposed loads
Allowable deflection (L/360) for 5 1/4"x 8 1/8" beam section is = 7.34 mm
Allowable deflection (L/360) for 5 1/4"x 14 5/8" beam section is = 17.22 mm

It is noted from the analysis that the beams that are more overstressed are the ones with the largest cross section, which corresponds to the simply supported beams with the largest spans. Moment (strength) is overstressed to a maximum of 62% when loaded with the current design loads. All beams were adequate in shear, while deflections were a maximum of 77% higher than acceptable values for some frames.

When loaded with the original design loads the beams were overstressed to a maximum of 24% in Moment (strength) and 19% in deflection for most of the frames. Shear was always adequate.

STEEL ROOF DECK

It is assumed that most of the roof deck is continuous triple span deck (spanning over more than two glulam supports).

The spacing between the glulam beams for the Original 1960 Building was found to vary between 7'-8" up to 8'-3". The spacing between the glulam beams for the 1967 building addition is 8'-0".

The results are as follows;

- Using the Original design loads it was found that the deck is adequate for strength and deflection.
- Using the Current design loads without the effect of snow drifting it was found that the steel deck is overstressed in strength by about 22%. Deflection was found to be adequate.
- Using the Current design loads with the effect of snow drifting it was found that the steel deck is overstressed in strength by about 168%. Deflection was also found to be inadequate.

DISCUSSION.

One of the reasons that prompted this analysis was to know if the increase in roof dead load (including a new ballasted roof and an increase in insulation from 1" to 6") is feasible.

The original building was constructed in 1960, and the addition in 1967. These buildings have been standing for the past 60 years without any known structural issues. It is believed that one of the reasons the buildings have not have any structural issues and have been able to withstand the winter loading is the fact that the poor insulation has allowed heat from inside the building to transfer up to the roof, melting away the accumulated snow.

However, this should not be relied upon as a condition that will continue in the future. Extreme weather events can cause significant amounts of snow and wind and roof supports must be upgraded.

A disadvantage of having a flat roof is the fact that drainage is not as efficient as having a sloped roof. The lack or inadequate roof insulation is contributing to the melting of the snow; therefore, more water will be ponding in the roof. This water needs to be drained away from the roof to prevent leaks or overstressing the roof members.

CONCLUSIONS & RECOMMENDATIONS

It is concluded that it is not feasible to change the roof construction at the Original 1960 Building and the 1967 Building Addition. Roof insulation should not be upgraded with a thicker insulation nor should be it be upgraded with an insulation with an equivalent thickness: A new and equivalent insulation to the existing thin insulation will be more efficient and will then prevent the building's heat loss and hence snow melting in the roof.

It is recommended to investigate if all roof drains are working properly and are draining the rain water away from the roof.

Only the 1960 Original Building and the 1967 Building addition have been analysed; however, it is recommended to perform a full review of the entire school. This analysis must include all building not designed with the current design loads which should include the effects of snow drifting, in addition to wind pressure and uplift. Upgrades to the existing roof should be fully completed as per the current Ontario Building Code loading requirements before any roofing work is completed. Structural drawings stamped by a Professional Engineer licensed in the Province of Ontario are to be completed for this work.

We trust this report is adequate for your use for the review of the existing concerning items. This report is for recommendations only and it is based upon a structural analysis of structural members as specified on the original structural drawings. It does not include a comprehensive review of the entire building, and is limited in scope to the analysed components only. This report does not provide any warrant, either expressed or implied on the building. Therefore, DC Buck Engineering is not responsible for pre-existing deficiencies (if any) or for failure to conduct structural engineering measures requiring the identification of hidden or as-built structural conditions since such work was beyond the scope of the engineering services provided by DC Buck Engineering.

The opinions expressed on this report were based on information at the time of the writing of this report. Should new or contradictory information become available, we request the opportunity to review the same, as well as the effect on our report including conclusions and recommendations.

This report is intended for the sole use of the addressee, and as such, we are not responsible for any third-party reliance on this report, in whole, or in part.

We trust that this meets your requirements at this time; however, if you would like to discuss anything further, please do not hesitate to contact the undersigned at your convenience.

Yours truly,
DC Buck Engineering

Elizabeth Bran, P.Eng.

Dwayne C. Buck, P.Eng.
Reviewer

APPENDIX ‘A’

Figure 1

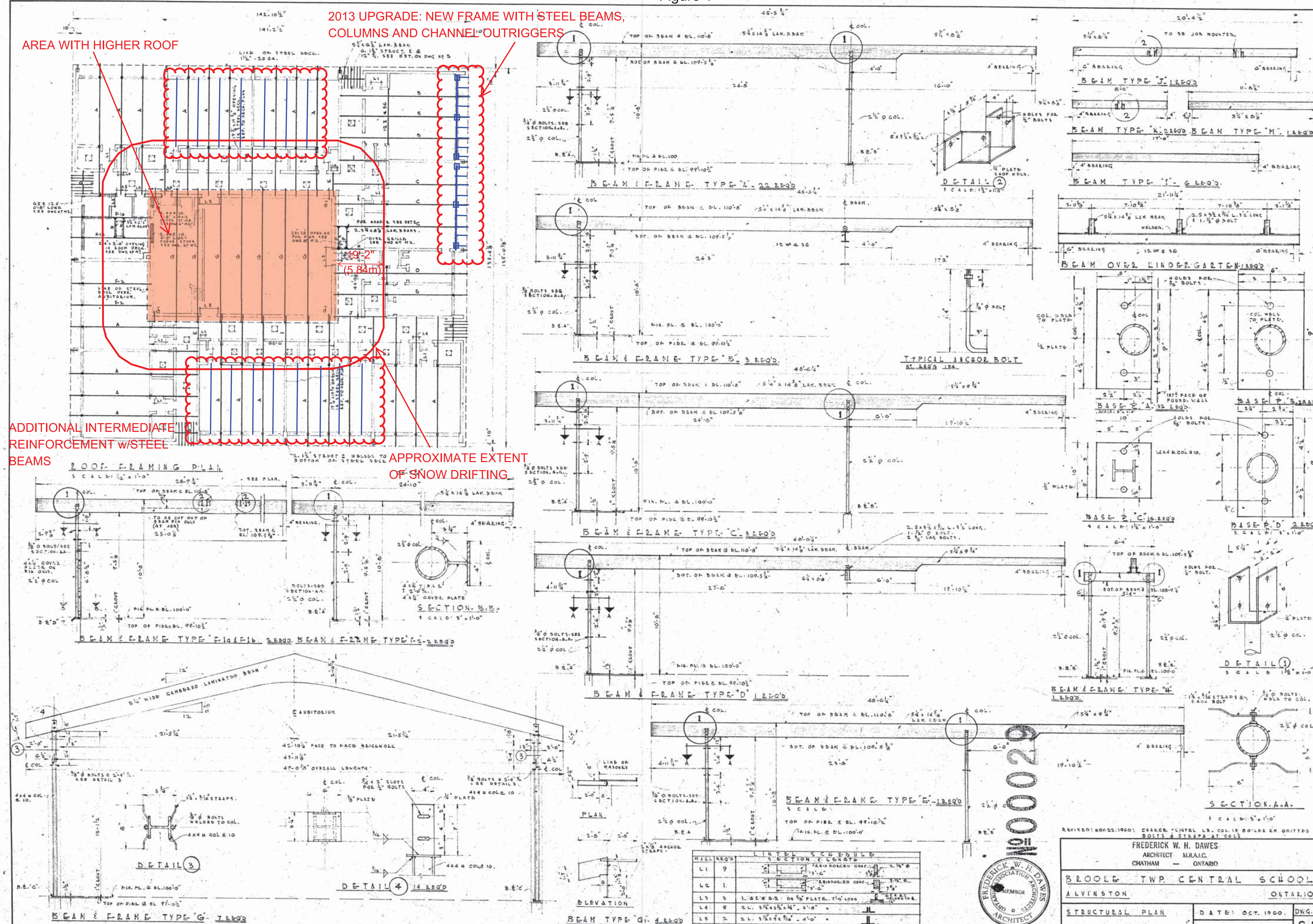
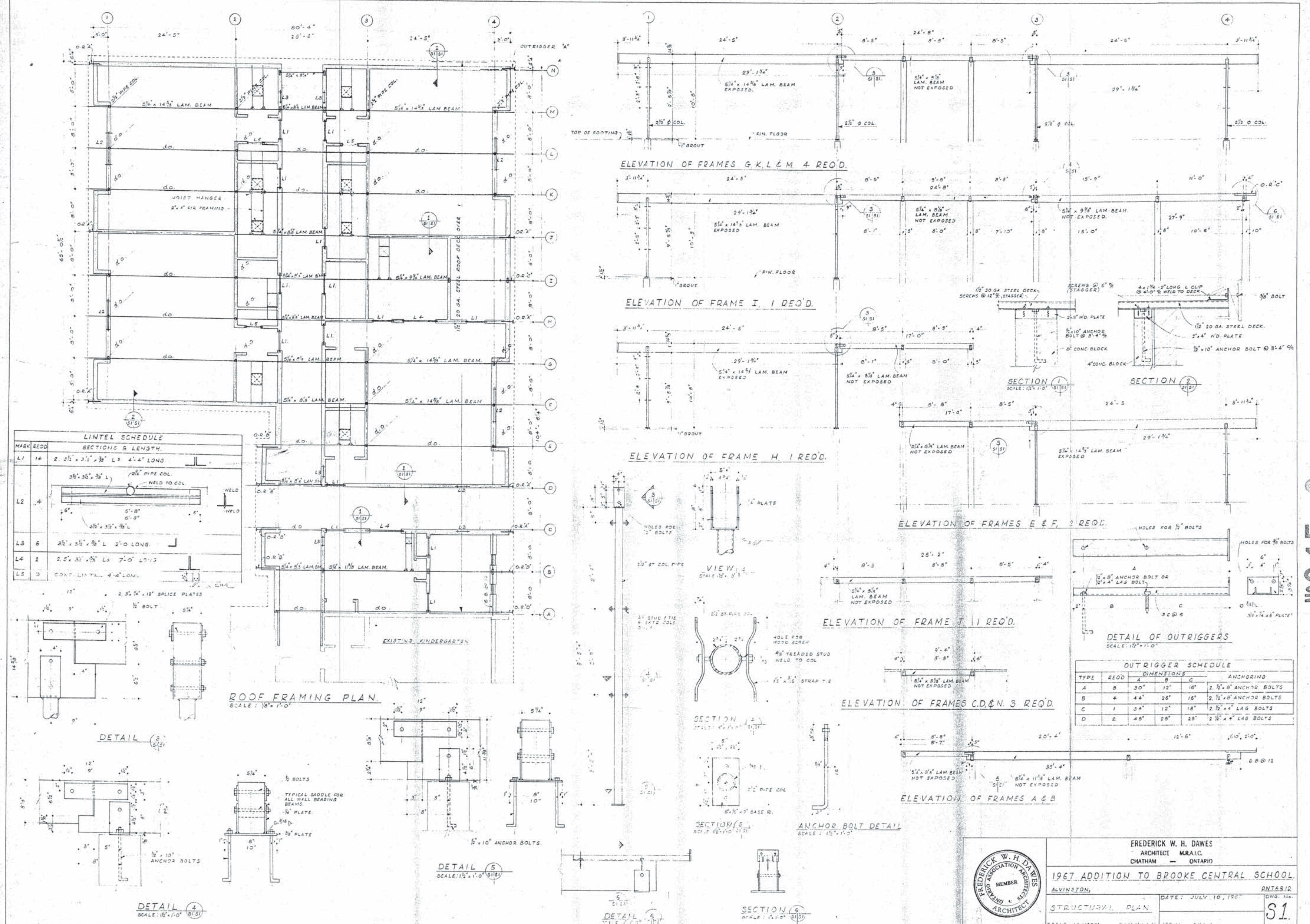

2013 UPGRADE: NEW FRAME WITH STEEL BEAMS, COLUMNS AND CHANNEL OUTRIGGERS
AREA WITH HIGHER ROOF
19'-2"
(5.84m)
ADDITIONAL INTERMEDIATE REINFORCEMENT w/STEEL BEAMS
APPROXIMATE EXTENT OF SNOW DRIFTING
ROOF FRAMING PLAN
BEAM & FRAME TYPE "A"
BEAM & FRAME TYPE "B"
BEAM & FRAME TYPE "C"
BEAM & FRAME TYPE "D"
BEAM & FRAME TYPE "E"
BEAM & FRAME TYPE "G"
BEAM & FRAME TYPE "H"
BEAM TYPE "J"
BEAM TYPE "K"
BEAM TYPE "M"
BEAM TYPE "I"
BEAM OVER KINDERGARTEN
TYPICAL ANCHOR BOLT
SECTION A.A.
SECTION B.B.
DETAIL 1
DETAIL 2
DETAIL 3
DETAIL 4
LINTEL SCHEDULE
FREDERICK W. H. DAWES
ARCHITECT M.R.A.I.C.
CHATHAM — ONTARIO
BROOKE TWP. CENTRAL SCHOOL
ALVINSTON ONTARIO
STRUCTURAL PLAN
DATE: OCT. 1960
JOB No 6026
DWG. No S1
No 00029

Figure 2


ELEVATION OF FRAMES G,K,L & M 4 REQ'D.
ELEVATION OF FRAME I. 1 REQ'D.
ELEVATION OF FRAME H 1 REQ'D.
ELEVATION OF FRAMES E & F, 2 REQ'D.
ELEVATION OF FRAME J 1 REQ'D.
ELEVATION OF FRAMES C,D,& N. 3 REQ'D.
ELEVATION OF FRAMES A & B
SECTION 1
SECTION 2
DETAIL OF OUTRIGGERS
OUTRIGGER SCHEDULE
LINTEL SCHEDULE
ROOF FRAMING PLAN
SCALE: 1/8" = 1'-0"
EXISTING KINDERGARTEN
DETAIL 3
DETAIL 4
DETAIL 5
DETAIL 6
SECTION 4
SECTION 5
SECTION 6
VIEW
ANCHOR BOLT DETAIL
FREDERICK W. H. DAWES
ARCHITECT M.R.A.I.C.
CHATHAM — ONTARIO
1967 ADDITION TO BROOKE CENTRAL SCHOOL.
ALVINSTON, ONTARIO
STRUCTURAL PLAN
DATE: JULY 10, 1967
DWG. No. S1.
SCALE: AS NOTED
No 015-6