MORRISON HERSHFIELD

October 27, 2020 MH Ref: 5105268.00

Quik-Therm Insulation Solutions Inc.
Raymond Belanger
Manager/Technical Sales Specialist
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Winnipeg, MB, R3H 0C2 raymondb@quiktherm.com

Dear Mr. Belanger:

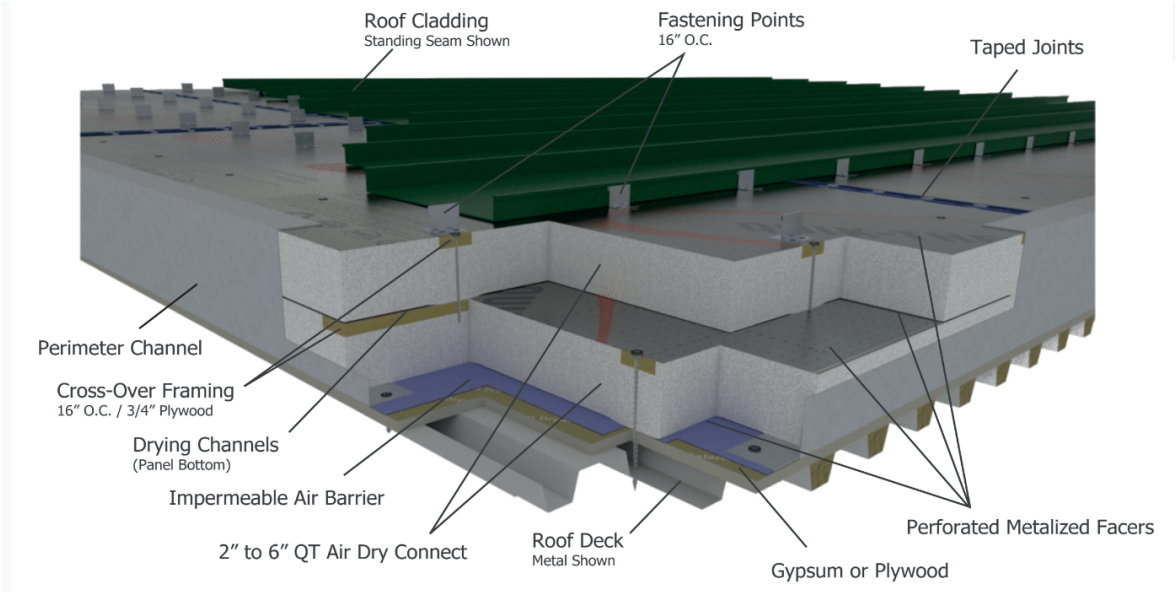
Re: Structural Review of Quik-Therm Matrix Insulated Roofing System

Morrison Hershfield Ltd. (MH) was retained by Quik-Therm Insulation Solutions Inc. (Quik-Therm) to provide a structural review for the Matrix Insulated Roofing System. This report is a summary of the review which was based on information provided to MH by Quik-Therm.

The scope of the review has been limited to structural aspects, and has not considered combustibility, durability, building science or other aspects.

SYSTEM DESCRIPTION

The Matrix Insulated Roofing System is a composite roofing system which consists of Quik-Therm's Air Dry Connect expanded polystyrene (EPS) insulation with embedded plywood or cold-formed steel battens which are installed in two orthogonal layers. The ¾" x 2½" plywood or 2½" x ½" 18ga steel C-channel battens are spaced at 16" on center and are embedded so that they are flush with the insulation. The lowest layer of insulation is secured through the battens to the roof sheathing or metal decking and upper layer is secured to the layer below it. See Quik-Therm's literature for a complete system description.



STRUCTURAL REVIEW

The structural review was primarily focused on the ability of the system presented to MH to resist wind uplift and snow loads for typical buildings as outlined in the National Building Code of Canada. Part of this review included a structural analysis of the sample system configuration outlined below. MH has also recently undertaken hygrothermal analysis and Mark Lawton, P.Eng. of MH performed an R-value review for the Quik-Therm Solar Dry System.

Sample Systems evaluated:

- Roof Substrates: ¾" plywood sheathing and 18ga metal fluted deck.
- Two layers of Quik-Therm Air Dry Connect EPS insulation installed in orthogonal directions with ¾" x 2½" plywood battens embedded at 16" spacing. Insulation layers with thicknesses of 2", 3", 4", 5" and 6" were considered.
- Generic fasteners in a range of sizes fully penetrating the plywood roof sheathing and embedded battens (sizes #8 to #14).
- Roofing material.

Analysis Assumptions:

- The location of the fastener from the upper layer into the lower layer coincides closely with the location of the fastener from the lower layer into the roof sheathing. A maximum offset of 6" was assumed.
- Point loads from roofing hold-down clips (if applicable) are similarly installed within 6" to the top layer fasteners.
- The self-weight of the system is ignored.
- The roofing material does not contribute to the uplift resistance.

Due to the high compressive strength of the Quik-Therm EPS insulation (19.7 kPa (411 psf)) will not crush under typical snow loads.

Table 1: Allowable Pull-Out Fastener Loads for Generic Fasteners Used in Analysis:

	Allowable Pull-Out Resistance (ASD) (lbf)			
Screw Diameter	#8	#10	#12	#14
20 gauge steel	50.6	58.6	66.6	74.7
18 gauge steel	65.9	76.4	86.8	97.3
16 gauge steel	125.4	145.3	165.2	185.1
3/4" plywood	71.0	83.0	94.0	105.0

**Values for steel stud allowable withdrawal are based on a safety factor of 3.0 in accordance to CSA S136.*
**Values for plywood allowable withdrawal are based on a recommended safety factor of 5.0 in accordance with APA Technical Note #E830E*

Table 2: Windload Resistance (Uplift) for Matrix System with Plywood Battens Installed Over ¾" Thick Plywood Sheathing

	Screw Size Used in System			
	#8	**#10**	**#12**	**#14**
Maximum Uplift (Unfactored) **kPa** (psf)	**1.9** (40)	**2.2** (46)	**2.5** (52)	**2.8** (58)
Maximum Uplift (Factored) **kPa** (psf)	**2.6** (54)	**3.0** (63)	**3.5** (73.0)	**3.9** (81)

Table 3: Windload Resistance (Uplift) for Matrix System with Plywood Battens Installed Over 18-gauge Metal Fluted Decking

	Screw Size Used in System			
	#8	**#10**	**#12**	**#14**
Maximum Uplift (Unfactored) **kPa** (psf)	**1.7** (36)	**2.0** (42)	**2.3** (48)	**2.6** (54)
Maximum Uplift (Factored) **kPa** (psf)	**2.3** (48)	**2.8** (58)	**3.2** (67)	**3.6** (75)

The results of Tables 2 and 3 are intended to give an understanding of the uplift resistance for typical system build-ups. It should be noted that battens spaced at 12" x 12" and/or additional fasteners would achieve higher windload resistances.

If using the Air Dry Connect panels with plywood battens, care and planning should be taken during the installation to ensure the load path from the roofing through the fasteners and into the roof structure is as direct as possible to reduce the potential for bending and deflection in the battens. If the fasteners of the various layers are not close to coincident, the embedded plywood battens would be subjected to bending under wind uplift loads which could affect the performance. Fasteners should be less than 6" away from the fastener below to minimize the bending induced on the embedded battens.

Depending on the project specific wind uplift, the size and spacing of fasteners and the type and spacing of embedded battens used in the system should be evaluated by a professional registered in the project jurisdiction.

REVIEW OF SNOW LOADS ON SLOPED ROOFS – DRAG EFFECT

The Matrix Insulated Roofing System was reviewed for the effects of sliding snow on sloped roofs in what is termed the drag effect. Snow load is a gravity load which when acting on a sloped roof, has load components which act down-slope and normal to the roof. See Figure 1 below. This down-slope component, or 'drag force', may cause issues with roofing systems if not taken into account.

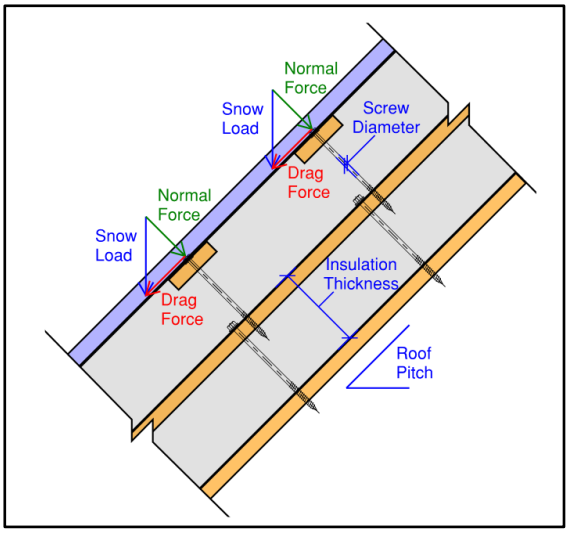


Figure 1 – "Drag Effect" from Snow Loads on the Matrix Insulated Roofing System

Tables 4A and 4B below are intended to provide an indication of the maximum snow load when the system is installed without an anti-sliding structural member to retain the insulation at the bottom perimeter of the roofs. The tables show the maximum snow load for a variety of roof slopes, insulation thicknesses and fastener diameters.

Standing seam metal roofing to be installed so that the connection which prevents the roof cladding from sliding down the slope (i.e.: the 'fixed' connection) is independent from the Matrix System. In other words, the Matrix System should not be used to resist large, concentrated, down-slope loads such as those imparted by the 'fixed' connections of standing seam metal roofing. This fixed connection should be detailed to transfer the down-slope load directly to the roof structure. The analysis and results in Tables 4A and 4B are based on the assumption that the standing seam metal roofing does not impart such large concentrated loads into the Matrix System.

For projects where the design snow load is higher than the maximum outlined in the table, it is recommended that an appropriately sized bottom retaining angle or channel be installed to prevent any down-slope movement of the insulation layers. See Figure 2 below. While this report does not quantify the effects of installing this structural member, it is clear that the capacity of the system would be increased if this member is installed. A registered professional should be consulted to size this member and its connection to the structure based on the snow loads, roof size and roof slope.

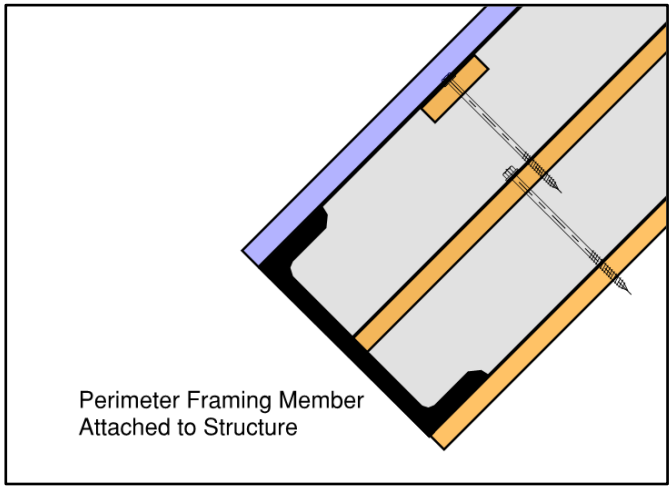


Figure 2 – Example of an Anti-Sliding Structural Member Installed at Base of Roof Slope

Drag Effect Analysis Assumptions:

- Snow on the roof imparts a uniformly distributed down-slope load on the insulation at the top of the upper layer of insulation.
- In the absence of an anti-sliding member to buttress the insulation at the base of the roof slope, the down-slope load is resisted by both friction and the bending resistance of the fasteners.
- The fasteners used to install the system impart clamping forces which ensure there is friction between the layers of insulation as well as the insulation and the substrate.
- The screws used in the system are subjected to double bending due to the rotational restraint provided by the compressive resistance of the insulation.
- The maximum snow load of 160 psf (7.7 kPa) is based on limiting the compressive load on the system to around 40% of the compressive yield strength of the EPS.

Table 4A: *Maximum Factored Snow Load for Matrix System Without Anti-Sliding Framing (kPa)*

		Insulation Thickness (in.) Installed in a Single or (Double) layer																			
		2 (4)				3 (6)				4 (8)				5 (10)				6 (12)			
		Fastener Size																			
		#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14
Roof Pitch (x/12)	0	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	1	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
	2	7.7	7.7	7.7	7.7	7.1	7.7	7.7	7.7	6.3	7.7	7.7	7.7	5.8	7.1	7.7	7.7	5.4	6.7	7.7	7.7
	3	6.0	7.7	7.7	7.7	4.8	6.1	7.7	7.7	4.3	5.3	6.8	7.7	3.9	4.8	6.1	7.2	3.7	4.5	5.7	6.6
	4	4.6	5.9	7.7	7.7	3.7	4.7	6.1	7.3	3.3	4.1	5.3	6.2	3.0	3.7	4.7	5.5	2.8	3.5	4.4	5.1
	5	3.8	4.9	6.5	7.7	3.0	3.9	5.1	6.0	2.7	3.4	4.3	5.1	2.5	3.1	3.9	4.5	2.3	2.9	3.6	4.2
	6	3.2	4.2	5.6	6.7	2.6	3.3	4.3	5.2	2.3	2.9	3.7	4.4	2.1	2.6	3.3	3.9	2.0	2.5	3.1	3.6
	7	2.9	3.7	5.0	6.0	2.3	2.9	3.9	4.6	2.1	2.6	3.3	3.9	1.9	2.3	3.0	3.5	1.8	2.2	2.7	3.2
	8	2.6	3.4	4.5	5.4	2.1	2.7	3.5	4.2	1.9	2.3	3.0	3.5	1.7	2.1	2.7	3.1	1.6	2.0	2.5	2.9
	9	2.4	3.1	4.2	5.0	2.0	2.5	3.2	3.8	1.7	2.2	2.8	3.3	1.6	2.0	2.5	2.9	1.5	1.8	2.3	2.7
	10	2.3	2.9	3.9	4.7	1.8	2.3	3.0	3.6	1.6	2.0	2.6	3.1	1.5	1.8	2.3	2.7	1.4	1.7	2.1	2.5
	11	2.2	2.8	3.7	4.4	1.7	2.2	2.9	3.4	1.5	1.9	2.5	2.9	1.4	1.7	2.2	2.6	1.3	1.6	2.0	2.4
	12	2.1	2.6	3.6	4.2	1.7	2.1	2.7	3.3	1.5	1.8	2.3	2.8	1.3	1.7	2.1	2.5	1.3	1.6	1.9	2.3

Table 4B: *Maximum Factored Snow Load for Matrix System Without Anti-Sliding Framing (psf)*

Roof Pitch (x/12)	Insulation Thickness (in.) Installed in a Single or (Double) layer																			
	2 (4)				3 (6)				4 (8)				5 (10)				6 (12)			
	Fastener Size																			
	#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14	#8	#10	#12	#14
0	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160
1	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160
2	160	160	160	160	149	160	160	160	131	160	160	160	121	149	160	160	113	139	160	160
3	125	160	160	160	101	128	160	160	89	111	143	160	82	101	128	150	77	95	118	138
4	96	124	160	160	77	98	128	152	68	85	110	129	63	78	98	115	59	72	91	106
5	79	102	136	160	64	81	106	125	56	70	90	106	52	64	81	95	49	60	75	87
6	68	87	117	140	55	69	91	108	48	60	78	91	44	55	70	81	42	51	64	75
7	60	78	104	124	49	62	81	95	43	54	69	81	39	49	62	72	37	45	57	67
8	55	70	95	113	44	56	73	87	39	49	63	74	36	44	56	66	34	41	52	60
9	51	65	87	105	41	52	68	80	36	45	58	68	33	41	52	61	31	38	48	56
10	47	61	82	98	38	48	63	75	34	42	54	64	31	38	49	57	29	36	45	52
11	45	58	78	93	36	46	60	71	32	40	51	60	29	36	46	54	28	34	43	50
12	43	55	74	89	35	44	57	68	31	38	49	58	28	35	44	52	26	32	41	47

CONCLUSIONS

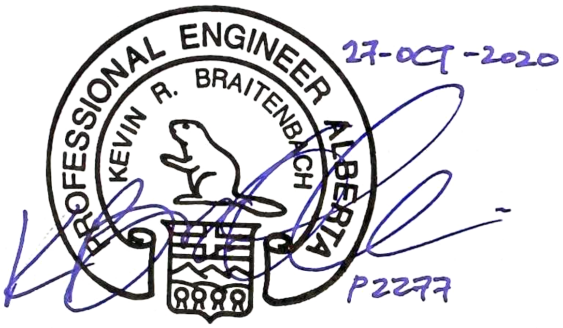
Based on our review, The Quik-Therm Matrix Insulated Roofing System will be able to resist the loads as outlined in the National Building Code of Canada for typical, moderately tall buildings throughout Canada. Buildings with high roof uplift wind loads could still potentially use the system with concerted detailing of the fasteners and embedded battens.

The system will be able to resist drag effects caused by moderate snow loads depending on the insulation thickness, fastener size and roof pitch. The drag effect on the system can be mitigated and the overall capacity of the roof system can be increased by installing an appropriately sized structural member around the perimeter of the base of the roof to buttress the insulation against sliding forces. Consult a registered professional to size this member.

The system should perform well if installed correctly. The orthogonal support provided by the cross-over framing will aid in the overall stability of the system. The thermal bridging would be minimal as we have seen for similar mechanically fastened roof systems (for example See detail 9.1.9 in BETB Guide Version 3) with an effective thermal performance similar to the system's nominal value.

We trust that this report meets your objectives for evaluating the structural performance of the Quik-Therm Matrix Insulated Roofing System. If you have any questions or comments related to the above, please do not hesitate to contact the undersigned.

Yours truly,
MORRISON HERSHFIELD



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