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SUBJECT: KOA Clip™ Thermal Modelling Results

Busque Engineering Ltd. (“BEL”) is pleased to provide you with this update to our previous thermal modelling report dated October 2021.

Introduction:

The KOA Clip™ is a steel clip system for attaching cladding system onto various exterior insulated wall assemblies. BEL based our modelling on structural spacing tables provided by KOA Manufacturing Inc. for steel stud and cast-in-place concrete substrates. BEL has included a copy of the shop drawings we have based our modelling on at the end of this report.

The KOA Clip™ is comprised of a polypropylene thermal spacer pad with an 18-gauge (1.2mm) G90 galvanized steel clip fastened through the spacer pad and into the substrate. This configuration of the clip is available with the metal portion spanning whole inch intervals from 2 to 6 inches and is referred to in this report as the “single pad” configuration.

An second configuration is possible by providing a second thermal spacer pad on the exterior face of the steel clip. This second configuration spans covers the half inch intervals between 2.5 to 6.5 inches and is referred to in this report as the “double pad” configuration. BEL has modelled both the single and double thermal spacer pad configurations.

Additionally, this report contains an appendix which introduces a third configuration which will be referred to as the “alternate configuration”

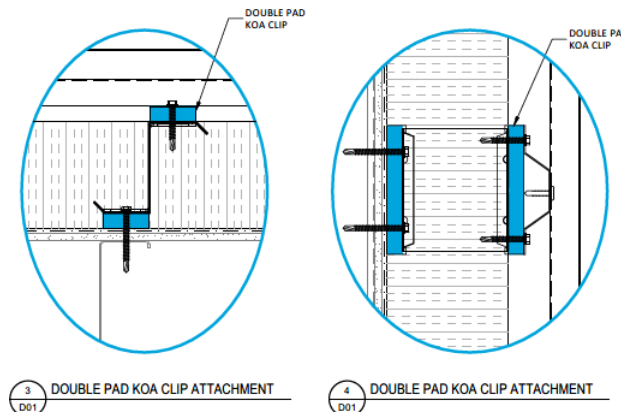


Image 1.0 – KOA Clip™ in double pad configuration



Image 2.0 – KOA Clip Samples and Thermal Pads

BEL utilized Heat3 version 9.0 to create a model of each KOA Clip™ spacing and substrate configuration. Heat3 is a finite element analysis software capable of steady-state heat transfer calculations in three dimensions.

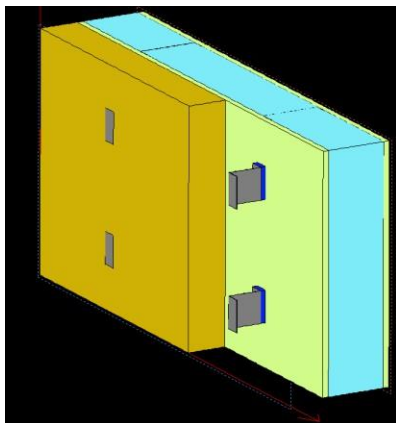


Figure 1.0 – 3D View of Typical Single Pad Model
(Insulation cut back for image capture)

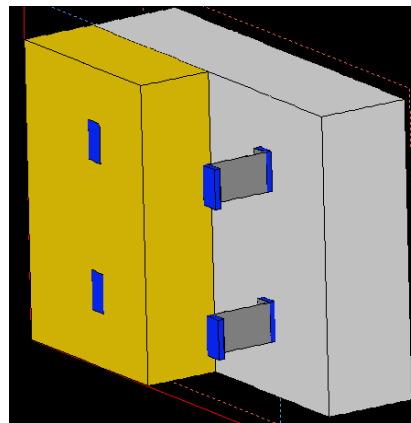


Figure 1.1 – 3D View of Typical Double Pad Model
(Insulation cut back for image capture)

Modelling Constraints:

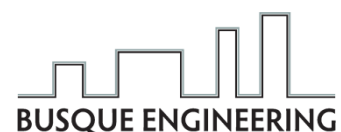
- The exterior face of the KOA Clip™ was modelled flush with the exterior insulation surface.
- No exterior cladding, exterior z girts, or exterior ventilated cavity was included in our models.
- The stiffening flanges on both ends of the steel clip were not included in the thermal models.
- Typical ASHRAE winter exterior and interior boundary temperature and film coefficient conditions are utilized:
 - Exterior Boundary: -18°C and 0.03 m^2K/W
 - Interior Boundary: 21 °C and 0.12 m^2K/W
- Studs were modelled with full webs, no conduit cut outs included. No return lip modelled on the steel studs.
- All values are for center of wall field and do not consider closer clips spacing which may be required around typical details such windows, penetrations, slab edges and corners.
- The modelling results have not been validated against physical hot box testing.

The material conductivities used in the models are provided in Table 1 below:

Material	Thermal Conductivity (W/mK)	Thickness (m)
Mineral Wool (R4.2/Inch)	0.0343	Varies from 2 to 6.5 in half inch increments
Fibreglass Batt (R20)	0.0433	152mm
Thermal Spacer Pad (Polypropylene)	0.195	.013
Galvanized Steel	0.62	18 Ga (1.2mm) Stud and Clip 152mm Stud Depth (600S) ¼ inch dia fasteners
Int and Ext Gypsum (5/8")	0.14	0.016
Concrete (incl. reinf.)	2.0	0.203
Steel Stud Air Cavity	0.925	0.152

Table 1 – Material Modelling Conductivities

The tables below are for thermal performance only, they are based on the lightest structural loading tables by the manufacturer. Structural performance must be verified using the latest structural loading tables by KOA Manufacturing Inc and each project should specifically be reviewed by a structural engineer to confirm compliance. The tables below are reported to two significant figure U-SI values then converted to R values.



Modelling Results: 92mm (3 5/8") Steel Stud (no cavity insulation) – Single Thermal Spacer Pad

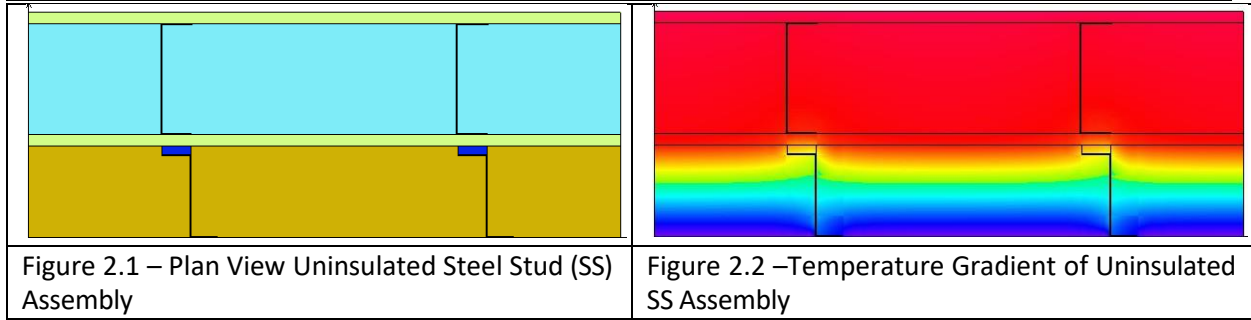


Figure 2.1 – Plan View Uninsulated Steel Stud (SS) Assembly

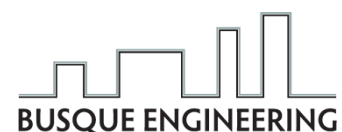
Figure 2.2 –Temperature Gradient of Uninsulated SS Assembly

3 5/8" Uninsulated Steel Stud - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.62	0.49	0.41	0.36	0.31
16	24	0.62	0.48	0.40	0.34	0.30
16	32	0.60	0.45	0.37	0.32	0.28
16	48	0.57	0.43	0.35	0.29	0.25
24	16	0.62	0.48	0.40	0.34	0.30
24	24	0.59	0.44	0.36	0.31	0.27
24	32	0.57	0.43	0.35	0.29	0.25
24	36	0.56	0.41	0.33	0.28	0.24
24	48	0.55	0.40	0.33		
32	16	0.59	0.45	0.37	0.32	0.28
32	24	0.57	0.43	0.35	0.29	0.25
32	32	0.53	0.40	0.32	0.27	0.23

Table 2 – Uninsulated 3 5/8" Steel Stud Assembly – U Values (W/m²K)

3 5/8" Uninsulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	9.2	11.6	13.8	15.8	18.3
16	24	9.2	11.8	14.2	16.7	18.9
16	32	9.5	12.6	15.3	17.7	20.3
16	48	10.0	13.2	16.2	19.6	22.7
24	16	9.2	11.8	14.2	16.7	18.9
24	24	9.6	12.9	15.8	18.3	21.0
24	32	10.0	13.2	16.2	19.6	22.7
24	36	10.2	13.7	17.0	20.1	23.4
24	48	10.4	14.1	17.2		
32	16	9.6	12.6	15.3	17.7	20.3
32	24	10.0	13.2	16.2	19.6	22.7
32	32	10.7	14.2	17.7	21.4	24.7

Table 3 – Uninsulated 3 5/8" Steel Stud Assembly – R Values (hrft²F/BTU)



Modelling Results: 92m (3 5/8") Steel Stud (R13 Cavity Insulation) – Single Thermal Spacer Pad

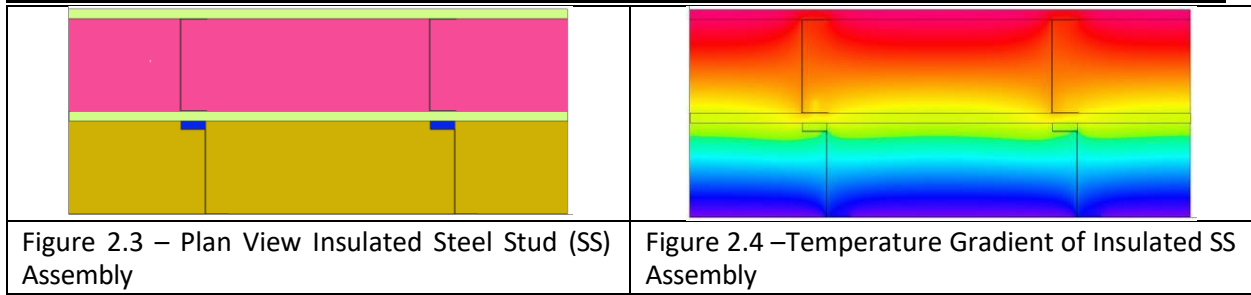


Figure 2.3 – Plan View Insulated Steel Stud (SS) Assembly

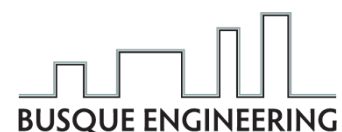
Figure 2.4 – Temperature Gradient of Insulated SS Assembly

3 5/8" Insulated Steel Stud - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.40	0.35	0.31	0.27	0.25
16	24	0.39	0.33	0.29	0.26	0.24
16	32	0.37	0.32	0.28	0.25	0.22
16	48	0.36	0.30	0.26	0.23	0.20
24	16	0.36	0.32	0.27	0.25	0.23
24	24	0.35	0.29	0.26	0.23	0.21
24	32	0.34	0.28	0.25	0.22	0.20
24	36	0.33	0.27	0.24	0.21	0.19
24	48	0.32	0.27	0.23		
32	16	0.34	0.29	0.26	0.23	0.21
32	24	0.32	0.27	0.24	0.21	0.19
32	32	0.31	0.26	0.22	0.20	0.18

Table 4 – Insulated 3 5/8" Steel Stud Assembly – U Values (W/m²K)

3 5/8" Insulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	14.2	16.2	18.3	21.03	22.7
16	24	14.6	17.2	19.6	21.8	23.7
16	32	15.3	17.7	20.3	22.7	25.8
16	48	15.8	18.9	21.8	24.7	28.4
24	16	15.8	17.7	21.0	22.7	24.7
24	24	16.2	19.6	21.8	24.7	27.0
24	32	16.7	20.3	22.7	25.8	28.4
24	36	17.4	20.9	23.7	27.2	29.9
24	48	17.8	21.4	24.7		
32	16	16.7	19.6	21.8	24.7	27.0
32	24	17.7	21.0	23.7	27.0	29.9
32	32	18.3	21.8	25.8	29.0	32.4

Table 5 – Insulated 3 5/8" Steel Stud Assembly – R Values (hr ft²F/BTU)



Modelling Results: 152mm (6") Steel Stud (no cavity insulation) – Single Thermal Spacer Pad

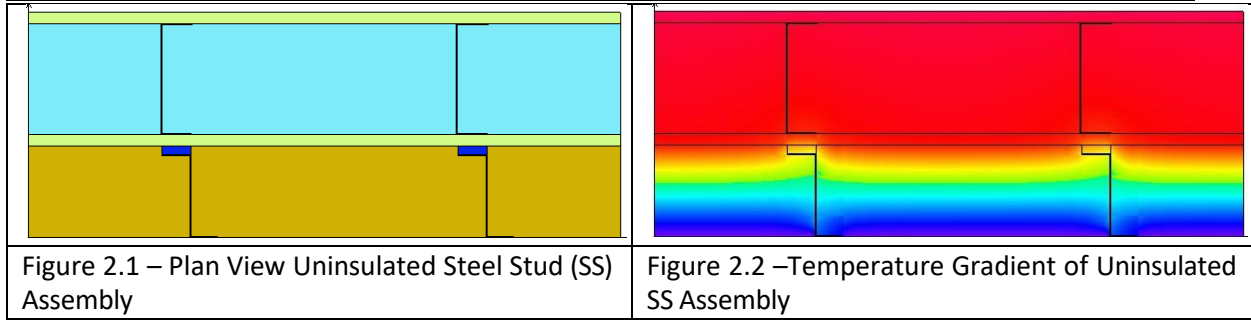


Figure 2.1 – Plan View Uninsulated Steel Stud (SS) Assembly

Figure 2.2 –Temperature Gradient of Uninsulated SS Assembly

6" Uninsulated Steel Stud - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.63	0.49	0.42	0.36	0.32
16	24	0.58	0.46	0.39	0.33	0.29
16	32	0.57	0.44	0.36	0.31	0.27
16	48	0.55	0.41	0.34	0.29	0.24
24	16	0.58	0.46	0.39	0.33	0.29
24	24	0.57	0.43	0.36	0.30	0.26
24	32	0.55	0.41	0.34	0.29	0.25
24	36	0.54	0.40	0.33	0.28	0.24
24	48	0.52	0.39	0.32		
32	16	0.57	0.44	0.36	0.31	0.27
32	24	0.55	0.41	0.34	0.29	0.25
32	32	0.53	0.40	0.33	0.28	0.24

Table 6 – Uninsulated 6" Steel Stud Assembly – U Values (W/m²K)

6" Uninsulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	9.0	11.6	13.5	15.8	17.7
16	24	9.8	12.3	14.6	17.2	19.6
16	32	10.0	12.9	15.8	18.3	21.0
16	48	10.3	13.8	16.7	19.6	23.7
24	16	9.8	12.3	14.6	17.2	19.6
24	24	10.0	13.2	15.8	18.9	21.8
24	32	10.3	13.8	16.7	19.6	22.7
24	36	10.6	14.1	17.2	20.3	23.7
24	48	10.9	14.4	17.7		
32	16	10.0	12.9	15.8	18.3	21.0
32	24	10.3	13.8	16.7	19.6	22.7
32	32	10.7	14.2	17.2	20.3	23.7

Table 7 – Uninsulated 6" Steel Stud Assembly – R Values (hrft²°F/BTU)

Modelling Results: 152mm (6") Steel Stud (R20 Cavity Insulation) – Single Thermal Spacer Pad

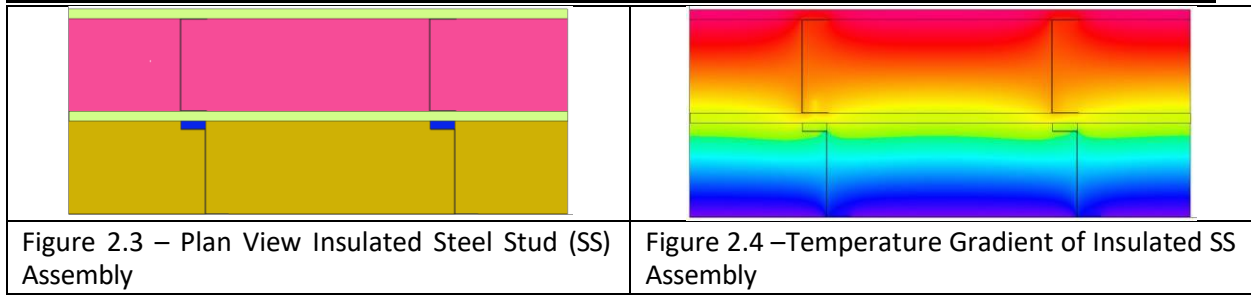


Figure 2.3 – Plan View Insulated Steel Stud (SS) Assembly

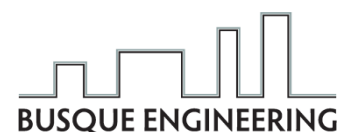
Figure 2.4 –Temperature Gradient of Insulated SS Assembly

6" Insulated Steel Stud - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.34	0.30	0.28	0.25	0.23
16	24	0.33	0.30	0.26	0.24	0.22
16	32	0.32	0.28	0.25	0.22	0.20
16	48	0.31	0.26	0.23	0.21	0.19
24	16	0.30	0.27	0.24	0.22	0.20
24	24	0.29	0.25	0.23	0.20	0.19
24	32	0.28	0.24	0.22	0.19	0.18
24	36	0.27	0.23	0.21	0.19	0.17
24	48	0.26	0.23	0.20		
32	16	0.28	0.25	0.22	0.20	0.19
32	24	0.27	0.23	0.21	0.19	0.17
32	32	0.26	0.22	0.20	0.18	0.16

Table 8 – Insulated 6" Steel Stud Assembly – U Values (W/m²K)

6" Insulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	16.7	18.9	20.3	22.7	24.7
16	24	17.2	18.9	21.8	23.7	25.8
16	32	17.7	20.3	22.7	25.8	28.4
16	48	18.3	21.8	24.7	27.0	29.9
24	16	18.9	21.0	23.7	25.8	28.4
24	24	19.6	22.7	24.7	28.4	29.9
24	32	20.3	23.7	25.8	29.9	31.5
24	36	20.9	24.4	27.0	30.5	33.4
24	48	21.6	25.0	28.4		
32	16	20.3	22.7	25.8	28.4	29.9
32	24	21.0	24.7	27.0	29.9	33.4
32	32	21.8	25.8	28.4	31.5	35.5

Table 9 – Insulated 6" Steel Stud Assembly – R Values (hrft²F/BTU)



Modelling Results: 152mm (6") Cast in Place Concrete – Single Thermal Spacer Pad

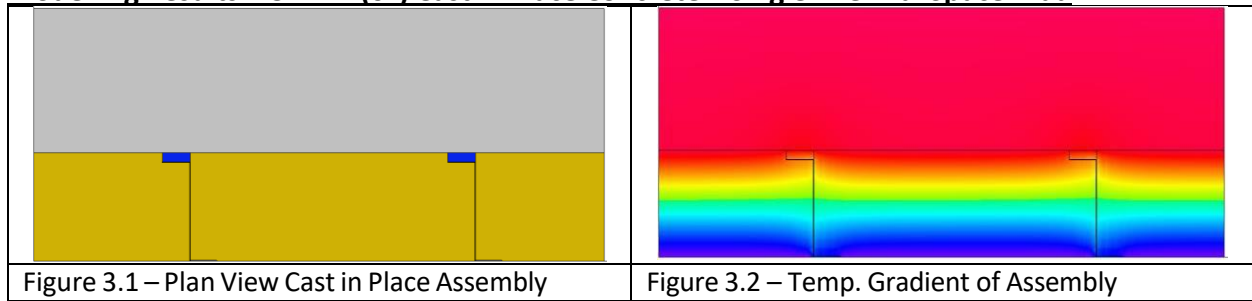


Figure 3.1 – Plan View Cast in Place Assembly

Figure 3.2 – Temp. Gradient of Assembly

6" Cast in Place - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.80	0.61	0.50	0.43	0.38
16	24	0.73	0.54	0.44	0.37	0.32
16	32	0.69	0.51	0.41	0.34	0.30
16	48	0.66	0.48	0.38	0.32	0.27
24	16	0.73	0.54	0.44	0.37	0.32
24	24	0.68	0.50	0.40	0.34	0.29
24	32	0.66	0.48	0.38	0.32	0.27
24	36	0.65	0.46	0.37	0.30	0.26
24	48	0.64				
32	16	0.69	0.51	0.41	0.34	0.30
32	24	0.66	0.48	0.38	0.32	0.27
32	32	0.64	0.46	0.36		

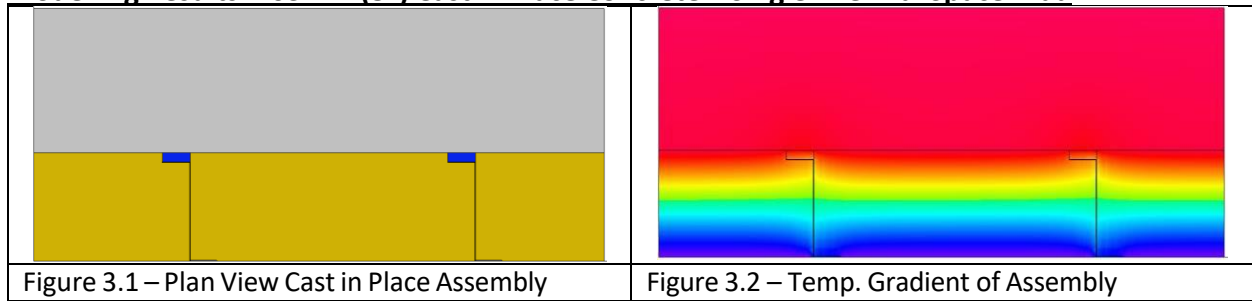
Table 10 – 6" Cast in Place Assembly Single Pads – U Values (W/m²K)

6" Cast in Place - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	7.1	9.3	11.4	13.2	14.9
16	24	7.8	10.5	12.9	15.3	17.7
16	32	8.2	11.1	13.8	16.7	18.9
16	48	8.6	11.8	14.9	17.7	21.0
24	16	7.8	10.5	12.9	15.3	17.7
24	24	8.4	11.4	14.2	16.7	19.6
24	32	8.6	11.8	14.9	17.7	21.0
24	36	8.8	12.5	15.3	18.9	21.8
24	48	8.9				
32	16	8.2	11.1	13.8	16.7	18.9
32	24	8.6	11.8	14.9	17.7	21.0
32	32	8.9	12.3	15.8		

Table 11 – 6" Cast in Place Assembly Single Pads – R Values (hrft²*F/BTU)



Modelling Results: 203mm (8") Cast in Place Concrete – Single Thermal Spacer Pad

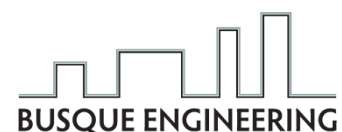


8" Cast in Place - Effective U Values (W/m ² K) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.77	0.59	0.49	0.42	0.37
16	24	0.71	0.53	0.43	0.37	0.32
16	32	0.68	0.50	0.40	0.34	0.29
16	48	0.64	0.46	0.37	0.31	0.27
24	16	0.71	0.53	0.43	0.37	0.32
24	24	0.66	0.49	0.39	0.33	0.28
24	32	0.64	0.47	0.37	0.31	0.27
24	36	0.63	0.45	0.36	0.30	0.26
24	48	0.62				
32	16	0.68	0.50	0.40	0.34	0.29
32	24	0.64	0.47	0.37	0.31	0.27
32	32	0.63	0.45	0.36		

Table 12 – 8" Cast in Place Assembly Single Pads – U Values (W/m²K)

8" Cast in Place - Effective R Values (hr*ft ² *F/BTU) (Single Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	7.4	9.6	11.6	13.5	15.3
16	24	8.0	10.7	13.2	15.3	17.7
16	32	8.4	11.4	14.2	16.7	19.6
16	48	8.9	12.3	15.3	18.3	21.0
24	16	8.0	10.7	13.2	15.3	17.7
24	24	8.6	11.6	14.6	17.2	20.3
24	32	8.9	12.1	15.3	18.3	21.0
24	36	9.0	12.6	15.8	18.9	21.8
24	48	9.2				
32	16	8.4	11.4	14.2	16.7	19.6
32	24	8.9	12.1	15.3	18.3	21.0
32	32	9.0	12.6	15.8		

Table 13 – 8" Cast in Place Assembly Single Pads – R Values (hrft²°F/BTU)



Modelling Results: 92mm (3 5/8") Steel Stud (no cavity insulation) – Double Thermal Spacer Pad

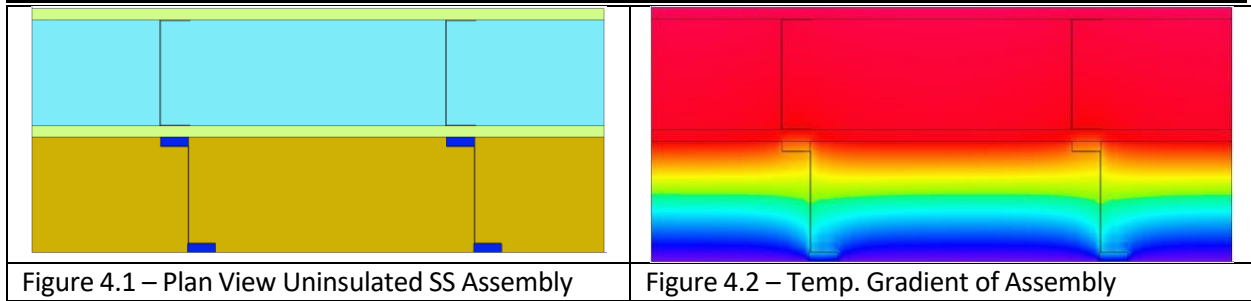


Figure 4.1 – Plan View Uninsulated SS Assembly

Figure 4.2 – Temp. Gradient of Assembly

3 5/8" Uninsulated Steel Stud - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.52	0.44	0.38	0.33	0.3
16	24	0.51	0.39	0.33	0.30	0.26
16	32	0.49	0.38	0.32	0.28	0.24
16	48	0.47	0.36	0.30	0.26	0.23
24	16	0.50	0.40	0.33	0.30	0.26
24	24	0.48	0.38	0.32	0.27	0.24
24	32	0.47	0.37	0.30	0.26	0.23
24	36	0.45	0.35	0.29	0.25	0.22
24	48	0.44	0.35	0.29		
32	16	0.49	0.38	0.32	0.28	0.24
32	24	0.47	0.36	0.30	0.26	0.23
32	32	0.46	0.36	0.29	0.25	0.22

Table 14 – 3 5/8" Uninsulated Steel Stud Assembly Double Pads – U Values (W/m²K)

3 5/8" Uninsulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	10.9	12.9	14.9	17.2	18.9
16	24	11.1	14.7	17.1	18.9	21.8
16	32	11.6	14.9	17.7	20.3	23.7
16	48	12.1	15.8	18.9	21.8	24.7
24	16	11.4	14.3	17.2	18.9	21.8
24	24	11.8	14.9	17.7	21.0	23.7
24	32	12.1	15.3	18.9	21.8	24.7
24	36	12.7	16.3	19.6	22.7	25.8
24	48	12.8	16.3	19.6		
32	16	11.6	14.9	17.7	20.3	23.7
32	24	12.1	15.8	18.9	21.8	24.7
32	32	12.3	15.8	19.6	22.7	25.8

Table 15 – 3 5/8" Uninsulated Steel Stud Assembly Double Pads – R Values (hrft²°F/BTU)



Modelling Results: 92mm (3 5/8") Steel Stud (R13 cavity insulation) – Double Thermal Spacer Pad

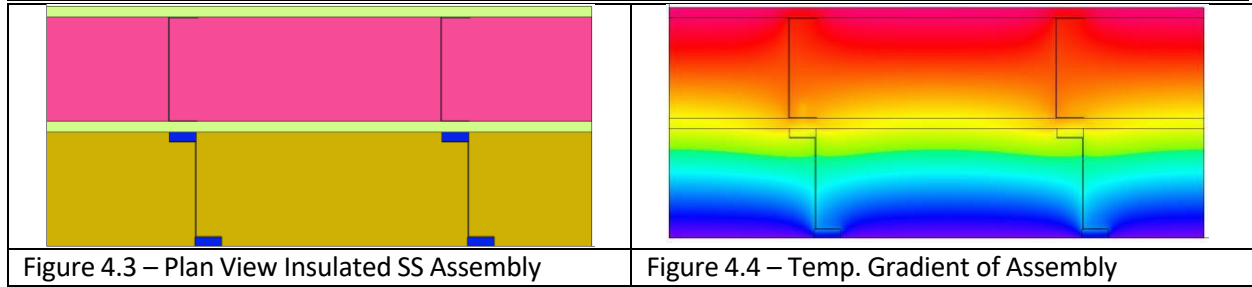


Figure 4.3 – Plan View Insulated SS Assembly

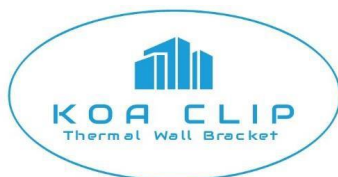
Figure 4.4 – Temp. Gradient of Assembly

3 5/8" Insulated Steel Stud - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.35	0.32	0.29	0.26	0.24
16	24	0.34	0.28	0.25	0.23	0.21
16	32	0.33	0.27	0.24	0.22	0.20
16	48	0.31	0.26	0.23	0.21	0.18
24	16	0.32	0.28	0.24	0.23	0.20
24	24	0.30	0.26	0.23	0.21	0.19
24	32	0.29	0.25	0.22	0.20	0.18
24	36	0.28	0.24	0.21	0.19	0.17
24	48	0.28	0.24	0.21		
32	16	0.30	0.26	0.23	0.21	0.19
32	24	0.29	0.25	0.22	0.20	0.18
32	32	0.28	0.24	0.21	0.19	0.17

Table 16 – 3 5/8" Insulated Steel Stud Assembly Double Pads – U Values (W/m²K)

3 5/8" Insulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	16.2	17.7	19.6	21.8	23.7
16	24	16.7	20.3	22.7	24.7	27.0
16	32	17.2	20.7	23.7	25.8	28.4
16	48	18.3	21.8	24.7	27.0	31.5
24	16	17.7	20.3	23.7	24.7	28.4
24	24	18.9	21.8	24.7	27.0	29.9
24	32	19.4	22.7	25.8	28.4	31.5
24	36	20.3	23.7	27.0	29.9	33.4
24	48	20.4	23.8	27.0		
32	16	18.9	21.8	24.7	27.0	29.9
32	24	19.6	22.7	25.8	28.4	31.5
32	32	20.3	23.7	27.0	29.9	33.4

Table 17 – 3 5/8" Insulated Steel Stud Assembly Double Pads – R Values (hrft²°F/BTU)



Modelling Results: 152mm (6") Steel Stud (no cavity insulation) – Double Thermal Spacer Pad

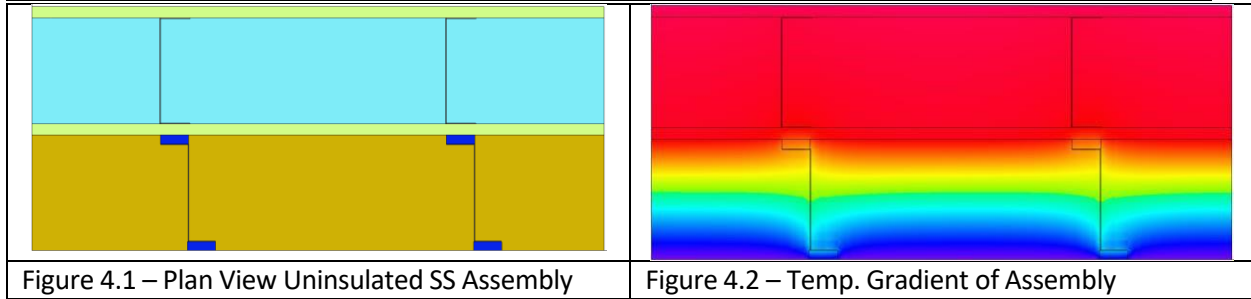


Figure 4.1 – Plan View Uninsulated SS Assembly

Figure 4.2 – Temp. Gradient of Assembly

6" Uninsulated Steel Stud - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	0.50	0.42	0.37	0.32	0.29
16	24	0.49	0.39	0.32	0.29	0.26
16	32	0.47	0.37	0.31	0.27	0.24
16	48	0.45	0.36	0.30	0.26	0.22
24	16	0.48	0.39	0.32	0.29	0.26
24	24	0.46	0.37	0.31	0.26	0.23
24	32	0.45	0.36	0.30	0.25	0.22
24	36	0.44	0.35	0.29	0.24	0.21
24	48	0.43	0.34	0.28		
32	16	0.47	0.37	0.31	0.27	0.24
32	24	0.45	0.36	0.30	0.25	0.22
32	32	0.44	0.35	0.29	0.24	0.21

Table 12 – Steel Stud Assembly Double Pads – U Values (W/m²K)

6" Uninsulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	11.4	13.5	15.3	17.7	19.6
16	24	11.6	14.6	17.7	19.6	21.8
16	32	12.1	15.3	18.3	21.0	23.7
16	48	12.6	15.8	18.9	21.8	25.8
24	16	11.8	14.6	17.7	19.6	21.8
24	24	12.3	15.3	18.3	21.8	24.7
24	32	12.6	15.8	18.9	22.7	25.8
24	36	12.9	16.2	19.6	23.7	27.0
24	48	13.1	16.7	20.3		
32	16	12.1	15.3	18.3	21.0	23.7
32	24	12.6	15.8	18.9	22.7	25.8
32	32	12.9	16.2	19.6	23.5	27.0

Table 13 – Steel Stud Assembly Double Pads – R Values (hrft²°F/BTU)

Modelling Results: 152mm (6") Steel Stud (R20 cavity insulation) – Double Thermal Spacer Pad

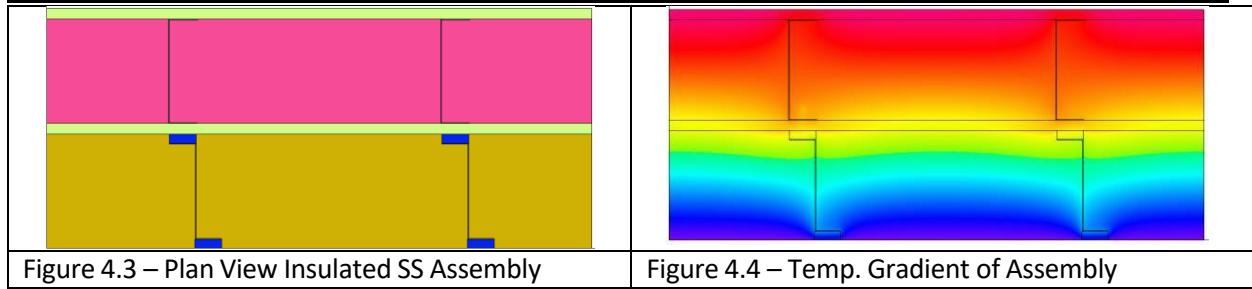


Figure 4.3 – Plan View Insulated SS Assembly

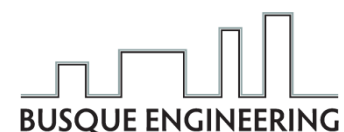
Figure 4.4 – Temp. Gradient of Assembly

6" Insulated Steel Stud - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	0.31	0.28	0.26	0.24	0.22
16	24	0.30	0.25	0.24	0.21	0.20
16	32	0.29	0.25	0.22	0.20	0.18
16	48	0.27	0.24	0.21	0.19	0.17
24	16	0.27	0.24	0.21	0.20	0.19
24	24	0.26	0.23	0.20	0.18	0.17
24	32	0.25	0.22	0.19	0.17	0.16
24	36	0.24	0.21	0.18	0.17	0.15
24	48	0.23	0.21	0.18		
32	16	0.25	0.22	0.20	0.18	0.17
32	24	0.24	0.21	0.19	0.17	0.16
32	32	0.23	0.20	0.18	0.16	0.15

Table 14 – Steel Stud Assembly Double Pads – U Values (W/m²K)

6" Insulated Steel Stud - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	18.3	20.3	21.8	23.7	25.8
16	24	18.9	22.7	23.7	27.0	28.4
16	32	19.6	23.2	25.8	28.4	31.5
16	48	21.0	23.7	27.0	29.9	33.4
24	16	21.0	23.7	27.0	28.4	29.9
24	24	21.8	24.7	28.4	31.2	33.4
24	32	22.7	25.8	29.6	32.6	35.5
24	36	23.7	27.0	31.0	33.0	37.9
24	48	24.3	27.4	31.0		
32	16	22.7	25.8	28.4	31.5	33.4
32	24	23.7	27.0	29.9	33.4	35.5
32	32	24.7	28.4	31.5	35.0	37.9

Table 15 – Steel Stud Assembly Double Pads – R Values (hrft²°F/BTU)



Modelling Results: 152mm (6") Cast in Place Concrete – Double Thermal Spacer Pad

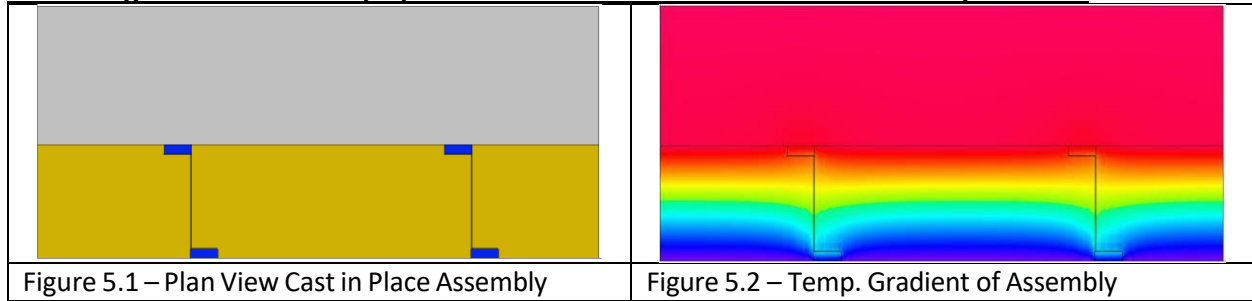


Figure 5.1 – Plan View Cast in Place Assembly

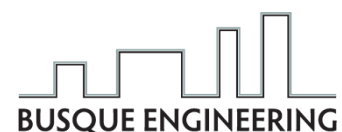
Figure 5.2 – Temp. Gradient of Assembly

6" Cast in Place - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	0.61	0.48	0.41	0.36	0.32
16	24	0.57	0.44	0.37	0.32	0.28
16	32	0.55	0.42	0.35	0.30	0.26
16	48	0.52	0.40	0.32	0.28	0.24
24	16	0.57	0.44	0.37	0.32	0.28
24	24	0.54	0.41	0.34	0.29	0.25
24	32	0.52	0.40	0.33	0.28	0.24
24	36	0.51	0.38	0.32	0.27	0.24
24	48	0.51				
32	16	0.55	0.42	0.35	0.30	0.26
32	24	0.52	0.40	0.33	0.28	0.24
32	32	0.51	0.39	0.32		

Table 16 – 6" Cast in Place Assembly Double Pads – U Values (W/m²K)

6" Cast in Place - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2	3	4	5	6
16	16	9.3	11.8	13.8	15.8	17.7
16	24	10.0	12.9	15.3	17.7	20.3
16	32	10.3	13.5	16.2	18.9	21.8
16	48	10.9	14.2	17.7	20.3	23.7
24	16	10.0	12.9	15.3	17.7	20.3
24	24	10.5	13.8	16.7	19.6	22.7
24	32	10.9	14.2	17.2	20.3	23.7
24	36	11.2	14.9	17.7	21.0	23.7
24	48	11.1				
32	16	10.3	13.5	16.2	18.9	21.8
32	24	10.9	14.2	17.2	20.3	23.7
32	32	11.1	14.6	17.7		

Table 17 – 6" Cast in Place Assembly Double Pads – R Values (hrft²°F/BTU)



Modelling Results: 203mm (8") Cast in Place Concrete – Double Thermal Spacer Pad

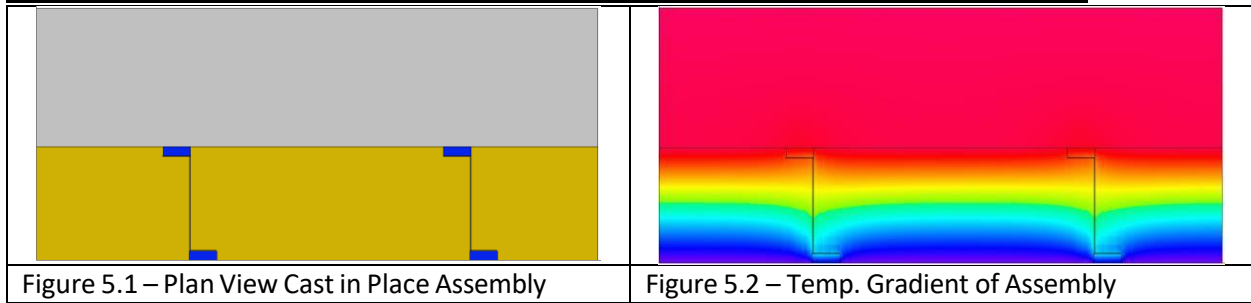


Figure 5.1 – Plan View Cast in Place Assembly

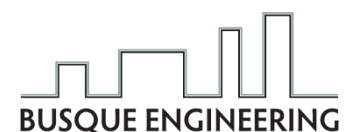
Figure 5.2 – Temp. Gradient of Assembly

8" Cast in Place - Effective U Values (W/m ² K) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	0.60	0.47	0.40	0.35	0.31
16	24	0.56	0.43	0.36	0.31	0.27
16	32	0.54	0.41	0.34	0.29	0.26
16	48	0.51	0.39	0.32	0.27	0.24
24	16	0.56	0.43	0.36	0.31	0.27
24	24	0.53	0.40	0.33	0.29	0.25
24	32	0.52	0.39	0.32	0.27	0.24
24	36	0.50	0.38	0.31	0.26	0.23
24	48	0.50				
32	16	0.53	0.41	0.34	0.29	0.26
32	24	0.52	0.39	0.32	0.27	0.24
32	32	0.50	0.38	0.31		

Table 18 – 8" Cast in Place Assembly Double Pads – U Values (W/m²K)

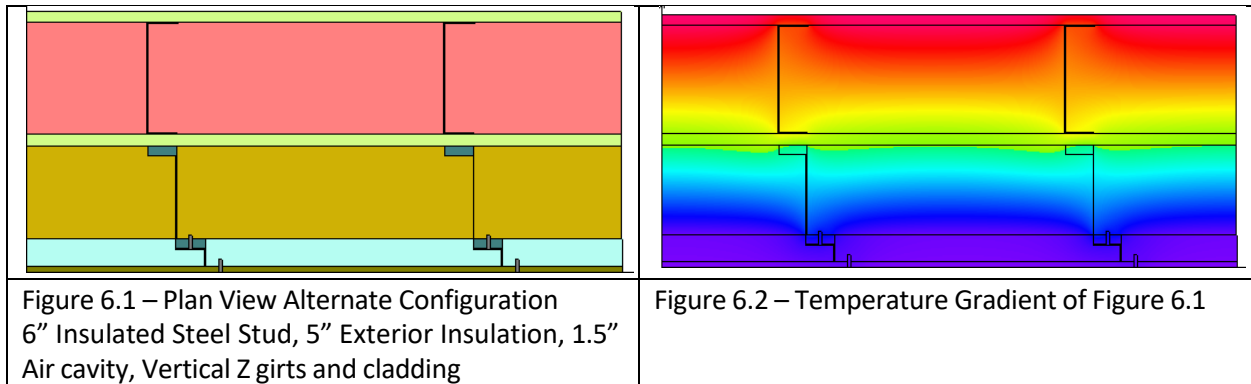
8" Cast in Place - Effective R Values (hr*ft ² *F/BTU) (Double Pad)						
Spacing (in)		Clip Size (In)				
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5
16	16	9.5	12.1	14.2	16.2	18.3
16	24	10.1	13.2	15.8	18.3	21.0
16	32	10.5	13.8	16.7	19.6	21.8
16	48	11.1	14.6	17.7	21.0	23.7
24	16	10.1	13.2	15.8	18.3	21.0
24	24	10.7	14.2	17.2	19.6	22.7
24	32	10.9	14.6	17.7	21.0	23.7
24	36	11.4	14.9	18.3	21.8	24.7
24	48	11.4				
32	16	10.7	13.8	16.7	19.6	21.8
32	24	10.9	14.6	17.7	21.0	23.7
32	32	11.3	14.9	18.3		

Table 19 – 8" Cast in Place Assembly Double Pads – R Values (hrft²F/BTU)



Alternate Configuration – Additional Pad on Single Pad

At the request of KOA Manufacturing, we have analyzed the effects of a widely used configuration which consists of adding an exterior thermal pad to the single pad configuration. This new analysis also includes the effects of an external 1.5" ventilated air cavity and Z-girts with light weight cladding. This configuration will be referred to as the "alternate configuration" and an insulated steel stud back up wall variation of this configuration is illustrated in the Figures 6.1 and 6.2 below.



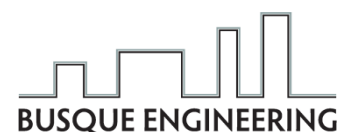
Currently, this is a limited analysis which does not include full thermal tables for all spacings and thicknesses of this alternate configuration. Only the 16"x16" and 32"x32" spacings have been modelled at this time, these results are presented in the following page. It is anticipated that eventually full thermal tables will also be developed for this alternate configuration.

On these tables we also present the average of the percent improvement of each alternate configuration spacing / thickness against its corresponding single pad counter pad spacing / thickness. We emphasize this is an average improvement, as insulation increases and clip spacing increases the percent improvement trends downwards. This means that for thicker insulation and further spacings the actual improvement will be a few percentage points lower than the average improvement provided.

We emphasize that the average percent improvement is provided as an approximation to assist designers during the conceptual design stage considering the alternate configuration as they can refer to the existing single pad thermal tables. We recommend utilizing the information below during the conceptual design stage. It is still necessary to perform specific simulations for the alternate assembly at the determined project spacing and insulation thickness as a project moves into detailed design to properly confirm the thermal value achieved.

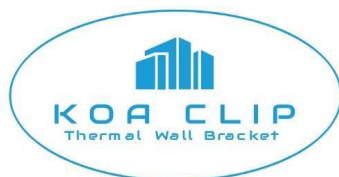
Uninsulated 3 5/8" Metal Stud Backup Wall							Average % Improvement over single pad
Steel Stud - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	4%
16	16	0.58	0.47	0.39	0.34	0.30	
32	32	0.50	0.38	0.31	0.26	0.23	
Insulated 3 5/8" Metal Stud Backup Wall+R12							Average % Improvement over single pad
Steel Stud - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	3%
16	16	0.39	0.33	0.30	0.27	0.24	
32	32	0.30	0.25	0.22	0.20	0.18	
Uninsulated 6" Metal Stud Backup Wall							Average % Improvement over single pad
Steel Stud - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	6%
16	16	0.58	0.47	0.39	0.34	0.30	
32	32	0.50	0.38	0.31	0.26	0.23	
Insulated 6" Metal Stud Backup Wall+R20							Average % Improvement over single pad
Steel Stud - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	4%
16	16	0.33	0.29	0.26	0.24	0.22	
32	32	0.24	0.21	0.19	0.17	0.16	
6" Concrete Back wall							Average % Improvement over single pad
Concrete Wall - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	8%
16	16	0.71	0.55	0.45	0.39	0.33	
32	32	0.60	0.44	0.35			
8" Concrete Back wall							Average % Improvement over single pad
Concrete Wall - U Values (W/m ² K)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	8%
16	16	0.71	0.53	0.44	0.38	0.33	
32	32	0.59	0.43	0.34			

Table 10 – 16x16 and 32x32 Thermal U-SI values for alternate assemblies including 1.5" air cavity, Z girts and light weight cladding.



Uninsulated 3 5/8" Metal Stud Backup Wall							Average % Improvement over single pad
Steel Stud - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	9.8	12.1	14.6	16.7	18.9	4%
32	32	11.4	14.9	18.3	21.8	24.7	
Insulated 3 5/8" Metal Stud Backup Wall+R12							
Steel Stud - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	14.6	17.2	18.9	21.0	23.7	3%
32	32	18.9	22.7	25.8	28.4	31.5	
Uninsulated 6" Metal Stud Backup Wall							
Steel Stud - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	9.8	12.1	14.6	16.7	18.9	6%
32	32	11.4	14.9	18.3	21.8	24.7	
Insulated 6" Metal Stud Backup Wall+R20							
Steel Stud - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	17.2	19.6	21.8	23.7	25.8	4%
32	32	23.7	27.0	29.9	33.4	35.5	
6" Concrete Back wall							
Concrete Wall - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	8.0	10.3	12.6	14.6	17.2	8%
32	32	9.5	12.9	16.2			
8" Concrete Back wall							
Concrete Wall - R value (hr*ft²*F/BTU)							
Spacing (in)		Clip Size					
Horizontal	Vertical	2.5	3.5	4.5	5.5	6.5	
16	16	8.0	10.7	12.9	14.9	17.2	8%
32	32	9.6	13.2	16.7			

Table 11 – 16x16 and 32x32 Thermal R values for alternate assemblies including 1.5" air cavity, Z girts and light weight cladding.



Code Compliance:

New Construction:

The current code environment for new construction is performance based through energy modelling of the entire building. This approach does not have prescriptive limits on specific assembly thermal values.

In our experience with designing new construction buildings, the KOA Clip™ system is a well suited and cost-effective assembly for conventional construction of Part 5 buildings. The design professionals will be able to utilize the values provided in this report to confirm assembly thicknesses and energy model performance.

Existing Buildings:

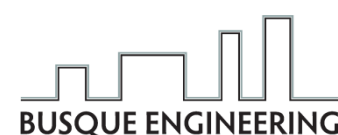
Both the 2024 British Columbia Building Code and 2019 Vancouver Building By-law require alterations or additions to existing buildings to comply with two common energy code standards: ASHRAE 90.1 – 2019 or the National Energy Building Code (“NEBC”). Below we summarize the prescriptive requirements for wall assemblies in both standards as an easy reference to the reader. The reader must determine the energy standard their project will follow and their climate zone. They will then be able to confirm assembly make up, assembly thickness and clip spacing based on cladding weight requirements.

ASHRAE 90.1-2019 Compliance:

The ASHRAE 90.1 – 2019 Standard Prescriptive U values for mass and steel frame walls are summarized below. BEL has rounded them to two significant figures to match the precision presented in our results.

ASHRAE 90.1-2019 Prescriptive Assembly Maximum U Values (W/m ² K)				
	Mass Walls		Steel Frame	
Climate Zone	Nonresidential	Residential	Nonresidential	Residential
0	3.29	0.86	0.71	0.71
1	3.29	0.86	0.71	0.71
2	0.86	0.70	0.48	0.37
3	0.70	0.59	0.44	0.37
4	0.59	0.51	0.37	0.37
5	0.51	0.45	0.32	0.32
6	0.45	0.40	0.28	0.28
7	0.40	0.40	0.28	0.24
8	0.27	0.27	0.21	0.21

Table 11 – ASHRAE 90.1 Prescriptive U Values (SI Units)
 Obtained from Tables 5.5-0 to 5.5-8 in the 90.1-2019 Standard.



NECB 2020 Compliance:

The NECB 2020 Standard Prescriptive U values for walls are summarized below. BEL has rounded them to two significant figures to match the precision presented in our results.

NECB 2020 Prescriptive Assembly Maximum U Values (W/m ² K)	
Climate Zone	Walls
4	0.29
5	0.27
6	0.24
7A	0.22
7B	0.19
8	0.17

Table 12 – NECB 2020 Prescriptive Wall U Values (SI Units)
Obtained from Table 3.2.2.2. NECB 2020

Conclusions:

The energy modelling results for the obtained KOA Clip™ system make it a well-suited solution for new construction as well as existing buildings following the ASHRAE 90.1-2019 and NECB 2020 prescriptive paths.

Project specific systems can be modelled to show specific cladding system compliance and to factor in whole building thermal bridges.

As a general good practice note, BEL recommends designers consider a higher galvanization rating of AZ150 for a longer system lifespan in coastal climate regions.

BEL recommends performing a physical hot box test to correlate modelling results with real world performance.

Additionally, we recommend completing the thermal tables for all spacings of the new alternate configuration.

Sincerely,

Busque Engineering Ltd.



Michael Lemm, P.Eng

Rosa Shams, EIT

Enclosure: KOA Manufacturing Dimension Drawing

