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# Thermal Analysis of U-Kon System LT-147

Presented to:

**U-Kon Systems North America**

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# 1. INTRODUCTION AND BACKGROUND

The U-Kon System LT-147 is an aluminum thermal clip system for attaching exterior cladding to different types of backup walls. Morrison Hershfield was contracted by U-Kon System North America to evaluate the thermal performance of their cladding attachment system for various scenarios. This report is a summary of the analysis.

The U-Kon System LT-147 consists of an intermittent aluminum L-bracket with a plastic thermal isolator placed behind the back flange. A continuous vertical L or T sub girt is attached to the L-brackets outboard of the insulation, which in turn support the cladding. The exterior insulation is fit between the brackets. Different levels of insulation are accommodated by providing a varying depths of the L-bracket. The L-bracket and thermal isolator is fastened directly to the substrate. For the steel stud assembly modelled, the L-brackets are fastened in line with the studs. The arrangement of the components are shown below in Figure 1.

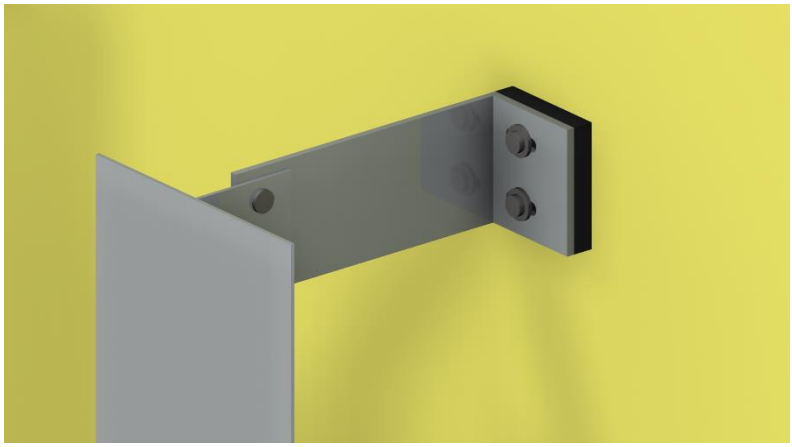
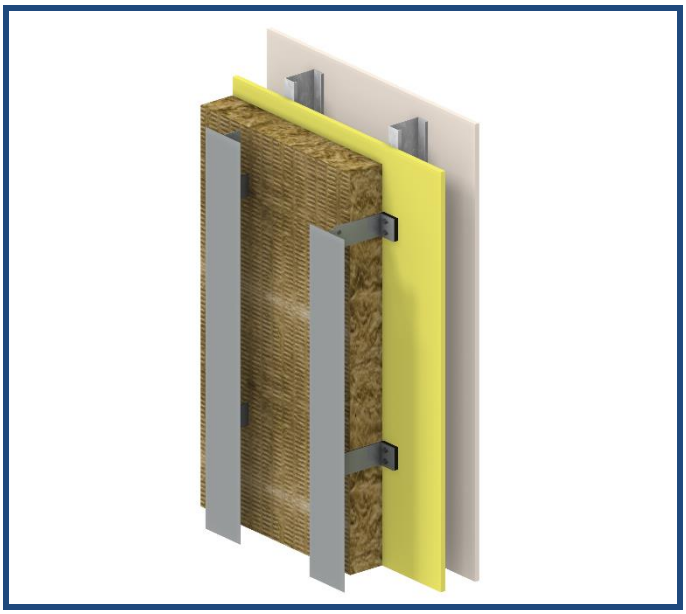


**Figure1.1**: Simplified Rendering of U-Kon Clip

For this analysis, the U-Kon System LT-147 was analyzed for use with the following assemblies:

### Exterior Insulated Steel Stud Wall

- 1/2” Gypsum
- 3 5/8” Steel Stud Cavity, 16”o.c.
- 5/8” Exterior Sheathing
- Varying Mineral Wool Insulation
- U-Kon Aluminum L-Clip with PVC Thermal Break, Steel Fasteners and Aluminum Vertical T-Girts
- Generic Cladding (not shown)



# 2. MODELING PROCEDURES

The thermal performance of the assemblies with U-kon cladding attachments were evaluated by 3D thermal modelling using the Nx software package from Siemens, which is a general purpose computer aided design (CAD) and finite element analysis (FEA) package. The thermal solver and modelling procedures utilized for this study were extensively calibrated and validated for *ASHRAE Research Project 1365-RP Thermal Performance of Building Envelope Details for Mid- and High-Rise Construction* and for the *Building Envelope Thermal Bridging Guide*[1].

The thermal analysis utilized steady-state conditions, published thermal properties of materials and information provided by U-Kon. Additional modeling assumptions for the thermal analyses are summarized in Appendix A.

[1] https://www.bchydro.com/thermalguide

# 3. U-KON SYSTEM LT-147 THERMAL RESULTS

The following section presents the thermal performance results (U-values and effective R-values that include thermal bridging) for the evaluated assembly described in Section 1. The thermal performance of the U-Kon System LT-147 with different backup wall types was evaluated at 16”o.c. horizontal spacing and varying vertical spacing of the clips, from 24”o.c. to 48”o.c. Varying depths of clip were evaluated to support 3”, 4”, 5” and 6” of exterior mineral wool insulation. The variation in configuration of the clips for varying depths is summarized below in Figure 3.1:

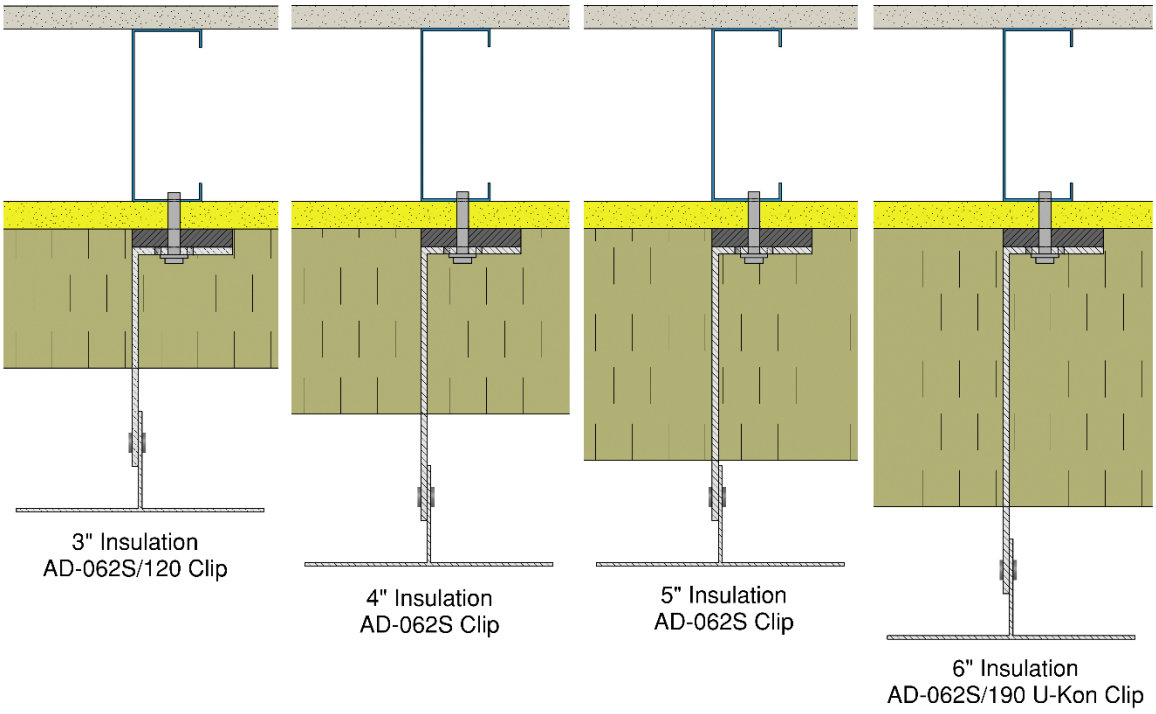



**Figure 3.1**: Clip Arrangement for Varying Insulation Thicknesses

The results tables in the following sections provide the spacing of components, exterior insulation thickness, nominal R-value of the insulation and the determined assembly U- and effective R-Value including the impact of thermal bridging by the structural components, including studs and cladding attachments.

Note, the tables list the nominal R-value of the exterior insulation, however the sheathings, airspaces, and air films also all contribute towards the R-value of the assembly. Further assembly information, including dimensions and materials are given in Appendix B. Example temperature profiles for each system are provided in Appendix C.

## 3.1 Exterior Insulated Steel Stud Wall

3 5/8" Steel Studs, 16"o.c. with 3/8" Gypsum Sheathing and 1/2" Drywall

**Figure 3.2**: Cladding Attachment Configuration

The thermal transmittance U-value results of the U-Kon System LT-147 with a Steel Stud Wall are presented in Table 3.1.

The results include spacing of the clips ranging from 24" to 48" o.c. vertically and 16" o.c. horizontally at the studs. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The steel stud backup wall includes 3 5/8" steel stud cavity and 5/8" exterior sheathing and 1/2" interior gypsum. The clips with 10mm PVC thermal isolator pad are fastened with two carbon steel bolt into the studs. The exterior vertical T-bar is fastened to the clips outboard of the insulation.

**Table 3.1:** Clear Field Thermal Transmittance for Steel Stud System

| Vertical Spacing **in** | Exterior Insulation Thickness **in** | Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)** | Assembly U-Value **BTU/ hr°Fft² (W/m²K)** | Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)** |
|---|---|---|---|---|
| 24 | 3 | R-12.6 (2.22) | 0.082 (0.467) | R-12.2 (2.14) |
| | 4 | R-16.8 (2.96) | 0.070 (0.398) | R-14.3 (2.51) |
| | 5 | R-21.0 (3.70) | 0.062 (0.354) | R-16.0 (2.82) |
| | 6 | R-25.2 (4.44) | 0.056 (0.321) | R-17.7 (3.12) |
| 36 | 3 | R-12.6 (2.22) | 0.076 (0.431) | R-13.2 (2.32) |
| | 4 | R-16.8 (2.96) | 0.063 (0.360) | R-15.8 (2.78) |
| | 5 | R-21.0 (3.70) | 0.055 (0.315) | R-18.0 (3.18) |
| | 6 | R-25.2 (4.44) | 0.049 (0.281) | R-20.2 (3.56) |
| 48 | 3 | R-12.6 (2.22) | 0.073 (0.413) | R-13.7 (2.42) |
| | 4 | R-16.8 (2.96) | 0.060 (0.341) | R-16.7 (2.93) |
| | 5 | R-21.0 (3.70) | 0.052 (0.295) | R-19.3 (3.39) |
| | 6 | R-25.2 (4.44) | 0.046 (0.261) | R-21.8 (3.84) |

# 4. SENSITIVITY ANALYSIS

A sensitivity analysis of the modelled system was performed to allow designers to interpolate the thermal performance values for other types on insulation.

## 4.1 Insulation Type

The base modelling assumed semi-rigid insulation (R-4.2/in) for the exterior insulation. Other conductivities were evaluated to allow the thermal transmittance values for the U-Kon clip system to be utilized for other types of insulation. In order to characterized the range of exterior insulation values, the modelled assembly was re-calculated using R-5/in (RSI-0.88/in) and R-6/in (RSI-1.06/in) insulation. Figure 4.1 shows the graphical results for effective assembly R-value for a vertical clip spacing of 24" for the varying insulation materials. The values for continuous exterior insulation are also graphed as a reference.

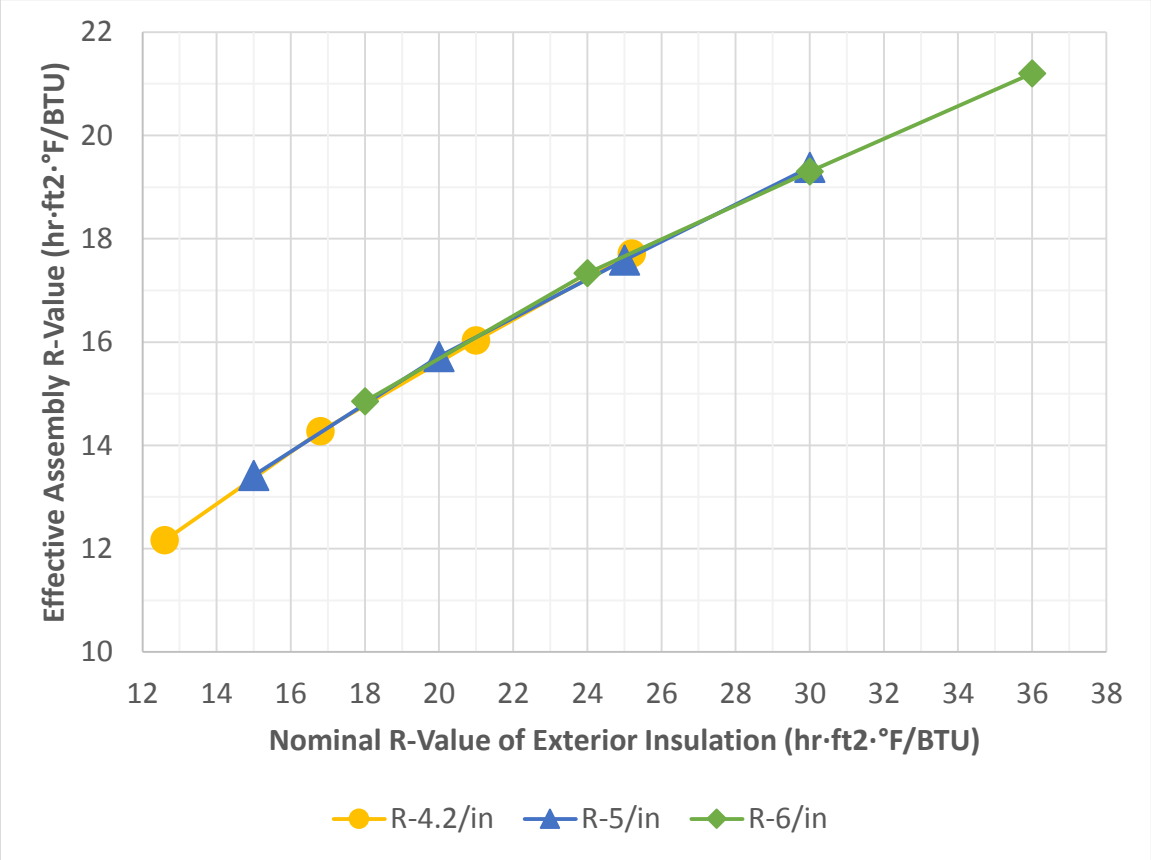



**Figure 4.1**: Effective Assembly R-value vs. Nominal Insulation R-value for a variety of insulation materials for 24" vertical clip spacing

The results show that the effective R-value is largely independent of the thickness of insulation (and length of the clip) for a given nominal thermal resistance. Therefore, the results can be character sized by the R-value of the exterior insulation and can be applied to any material. The results from Section 3 and 4 can be used to interpolate results for additional R-Values. Table 4.1 provides the performance data shown in the graph for reference.

**Table 4.1:** Clear Field Thermal Transmittance for Steel Stud System with varying Exterior Insulation Types

| Vertical Spacing **in** | Exterior Insulation Thickness **in** | Exterior Insulation Type **R/in** | Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)** | Assembly U-Value **BTU/ hr°Fft² (W/m²K)** | Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)** |
|---|---|---|---|---|---|
| 24 | 3 | 4.2 | R-12.6 (2.22) | 0.082 (0.467) | R-12.2 (2.14) |
| | 3 | 5 | R-15.0 (2.64) | 0.075 (0.423) | R-13.4 (2.36) |
| | 4 | 4.2 | R-16.8 (2.96) | 0.070 (0.398) | R-14.3 (2.51) |
| | 3 | 6 | R-18.0 (3.17) | 0.067 (0.382) | R-14.9 (2.62) |
| | 4 | 5 | R-20.0 (3.52) | 0.064 (0.361) | R-15.7 (2.77) |
| | 5 | 4.2 | R-21.0 (3.70) | 0.062 (0.354) | R-16.0 (2.82) |
| | 4 | 6 | R-24.0 (4.23) | 0.058 (0.328) | R-17.3 (3.05) |
| | 5 | 5 | R-25.0 (4.40) | 0.057 (0.323) | R-17.6 (3.10) |
| | 6 | 4.2 | R-25.2 (4.44) | 0.056 (0.321) | R-17.7 (3.12) |
| | 6 | 5 | R-30.0 (5.28) | 0.052 (0.293) | R-19.4 (3.41) |
| | 5 | 6 | R-30.0 (5.28) | 0.052 (0.294) | R-19.3 (3.40) |
| | 6 | 6 | R-36.0 (6.34) | 0.047 (0.268) | R-21.2 (3.73) |

# 5. CONCLUSIONS

From this report, the following conclusions can be made:

- For an exterior insulated steel stud backup wall with steel fasteners, the assembly U-Value varies between U-0.083 (USI-0.474) and U-0.049 (USI-0.275) depending on the amount of exterior insulation and bracket spacing.

- Thermal performance is dependent on nominal exterior insulation R-value, regardless of insulation type.

The U-values provided in this report can be used for compliance calculations through any of the compliance paths set forth in relevant energy codes and standards such as ASHRAE 90.1, IECC, and/or NECB as of the published date of this report.

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# APPENDIX A–
# MODELLING PARAMETERS AND ASSUMPTIONS

## A.1 General Modeling Approach

For this report, a steady-state conduction model was used. The following parameters were also assumed:

- Air cavity conductivities were taken from ISO 10077 and Table 3, p. 26.13 of 2013 ASHRAE Handbook – Fundamentals
- Interior/exterior air films were taken from Table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation. The exterior air films were based on a vented air cavity to account for exterior cladding
- Cladding materials and secondary structures outboard of the insulation can vary widely. It has been found in ASHRAE 1365, for rainscreen cavity systems most lightweight claddings have an insignificant impact on the thermal performance other than shielding the insulation from direct wind exposure. To provide general information for the system, the cladding, secondary structure and rainscreen cavity were not explicitly modelled, but was incorporated into the exterior film coefficient.
- Material properties were taken from information provided by U-Kon and published material information from Lawrence Berkeley National Laboratory and ASHRAE Handbook – Fundamentals for common materials (such sheathings, studs etc)
- From the calibration in 1365-RP, contact resistances between materials were modeled. This varied between R-0.01 and R-0.2 depending on the materials and interfaces.
- The temperature difference between interior and exterior was modeled as a dimensionless temperature index between 0 and 1 (see Appendix A.3). These values, along with other modeling parameters, are given in ASHRAE 1365-RP, Chapter 5.
- As per standard U-value evaluation, no solar heating impacts were included.
- Placement of weather barriers and membranes were assumed not to impact the thermal conduction through the system and were not included in the analysis.

## A.2 Thermal Transmittance

The methodology presented in the Building Envelope Thermal Bridging Guide separates the thermal performance of clear field assemblies and details in order to simplify heat loss calculations. For the assemblies, a characteristic area is modeled and the heat flow through that area is found. To find the effects of thermal bridges in transition details (such as slab edges, parapets etc), the assembly is modeled with and without the detail. The difference in heat loss between the two models is then prescribed to that detail. This allows the thermal transmittances to be divided into three categories: clear field, linear and point transmittances.

For this report, only clear field transmittances for this system were evaluated, and not the details. The presented U-values in the Tables in Section 3 contain only uniform repeating thermal bridges, such as studs and clips, and do not include any interface details, such as slab intersections with top and bottom tracks.

## A.3 Temperature Index

The temperature index is the ratio of the surface temperature relative to the interior and exterior temperatures. The temperature index has a value between 0 and 1, where 0 is the exterior temperature and 1 is the interior temperature. If $T_i$ is known, Equation 1 can be rearranged for $T_{surface}$. This arrangement allows the modelled surface temperatures to be applicable to any climate.

$$T_i = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}} \qquad \text{EQ 1}$$

Note, these indices shown in the temperature profiles for this analysis are for general information only and are **not** intended to predict in-service surface temperatures subject to transient conditions, variable heating systems, and/ or interior obstructions that restrict heating of the assembly. For full limitations of this modeling approach, see ASHRAE 1365-RP

## A.4 Boundary Conditions

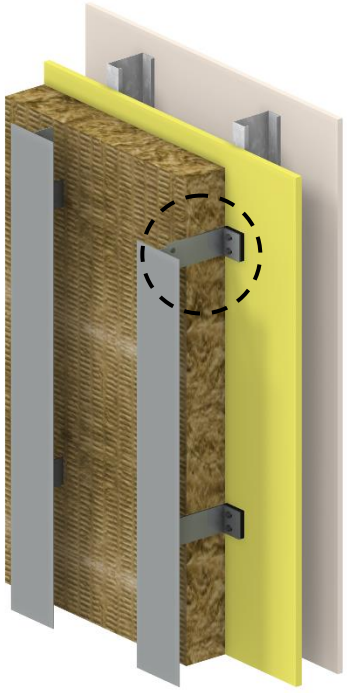
**Table A-1:** Boundary Conditions

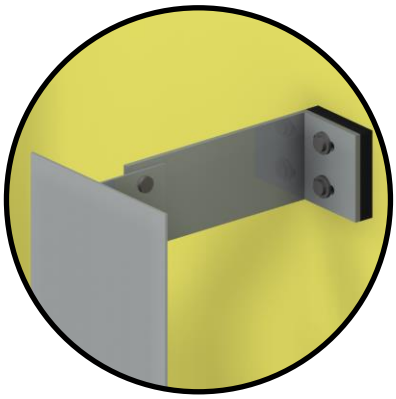
| **Boundary Location** | **Convective and Radiation Heat Transfer Coefficient** BTU/hft²°F (W/m²K) |
|---|---|
| Exterior (15mph wind) | 6.0 (34.0) |
| Interior Walls | 1.5 (8.3) |

# APPENDIX B – ASSEMBLY INFORMATION AND MATERIAL PROPERTIES

## U-Kon Cladding Support System

# Exterior Insulated Steel Stud Wall





| Component | Thickness<br>Inches<br>(mm) | Conductivity<br>Btu·in / ft²·hr·°F<br>(W/m K) | Nominal Resistance<br>hr· ft²· °F/BTU<br>(m²K/W) |
|---|---|---|---|
| Interior Film | - | - | R-0.7 (RSI-0.12) |
| Gypsum Board | 1/2" (13) | 1.1 (0.16) | R-0.5 (RSI-0.08) |
| Air Cavity | 3 5/8" (92) | - | R-0.9 (RSI-0.16) |
| 3 5/8" x 1 5/8" Steel Studs, 16"o.c. | 18 gauge | 430 (62) | - |
| Exterior Sheathing | 5/8" (15) | 1.1 (0.16) | R-0.6 (RSI-0.1) |
| Exterior Insulation (Mineral Wool) | 3" to 6" (76 to 152) | 0.24 (0.034) | R-12.6 to R-25.2 (RSI-2.22 to RSI-4.44) |
| PVC Thermal Break | - | 0.49 (0.07) | - |
| Aluminum Clip | 0.16-0.1 (4-2.5) | 1387 (200) | - |
| Steel Fasteners | ¼" dia. | 430 (62) | - |
| Aluminum T-girt | 12 gauge | 1387 (200) | - |
| Cladding with 1" to 2" (25 mm to 51 mm) vented air space is incorporated into exterior heat transfer coefficient | | | |
| Exterior Film | - | - | R-0.7 (RSI-0.12) |

# APPENDIX C – SIMULATED TEMPERATURE PROFILES

**Figure C1: Exterior Insulation Steel Stud Wall with U-Kon Aluminum clip and girt – 4" Mineral Wool, 24" vertical clip spacing**

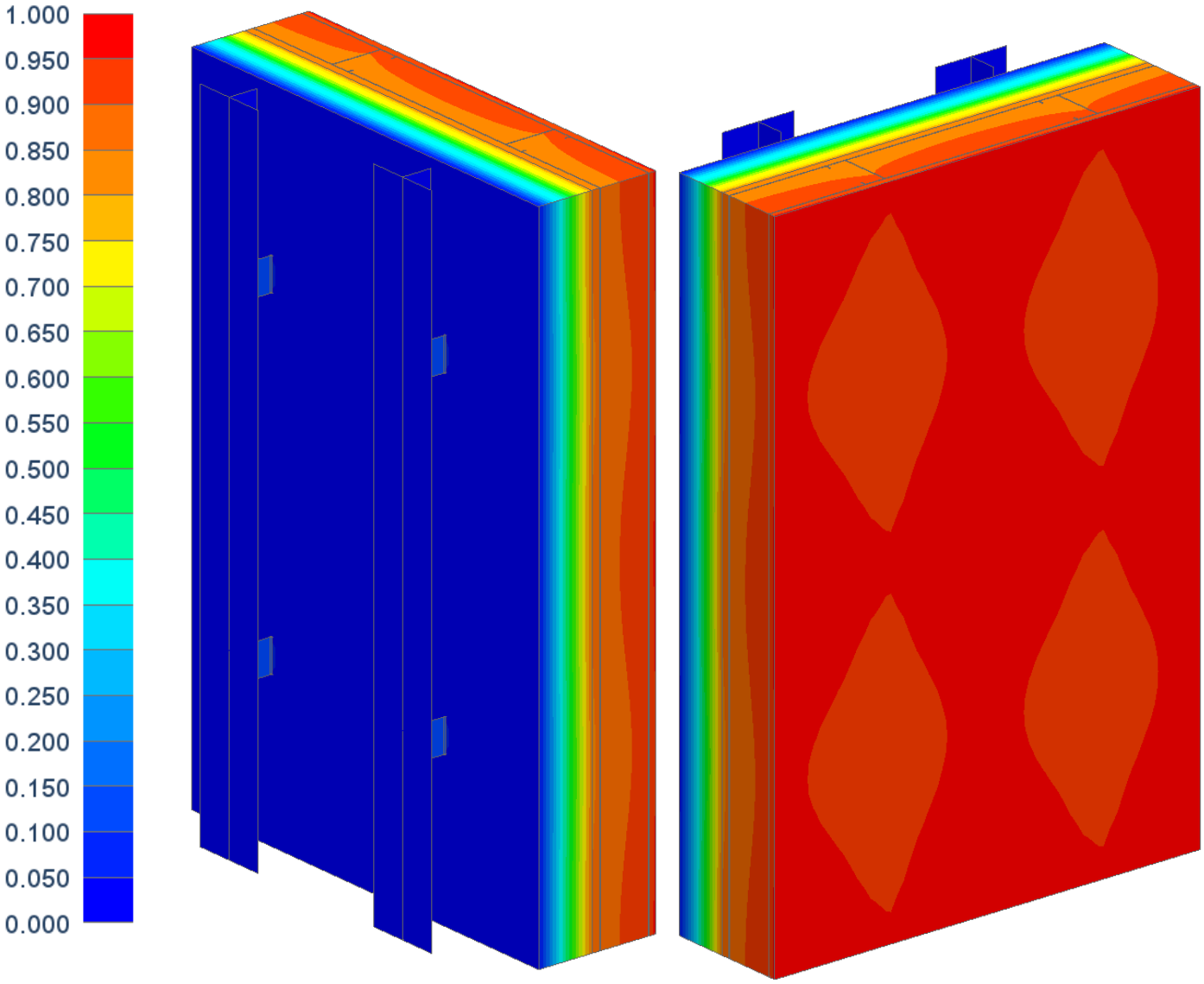


**Figure C2: Close up of U-Kon clip with Steel Fastener**