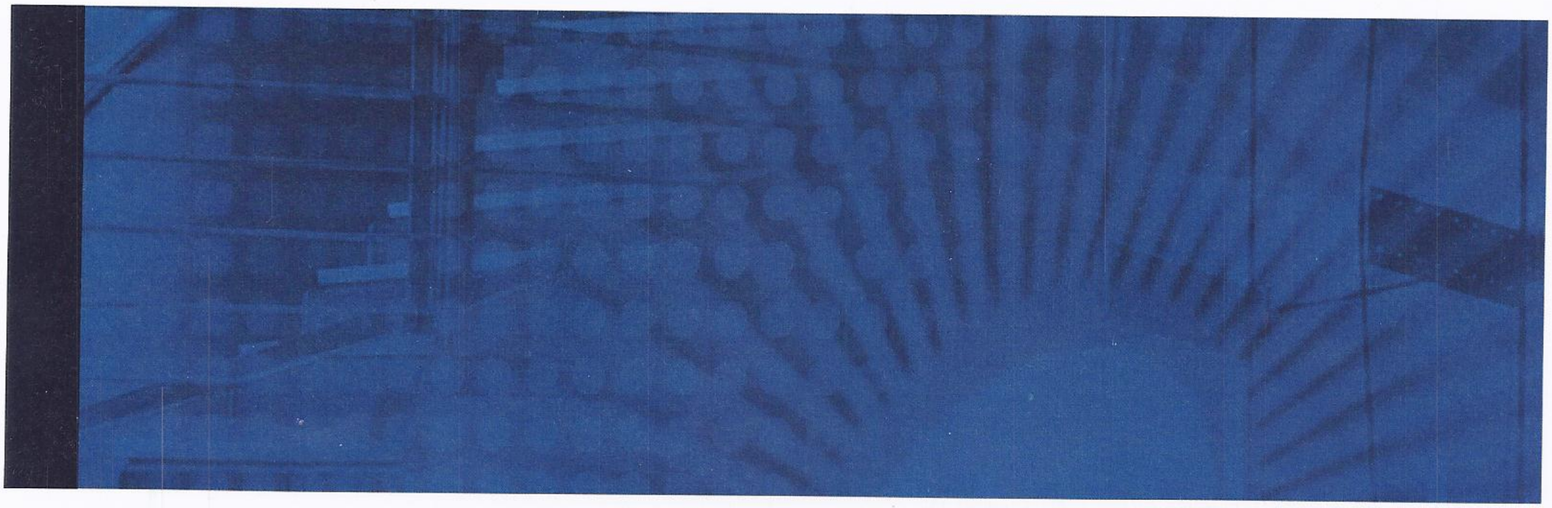
E-Header/Sill™

Cold-Formed Insulated Composite Structural Elements

Engineering/Analysis Report



January 2012

kpff Consulting Engineers

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January 12, 2012

Mr. Duane Den Adel
Evolution 1, LLC
309 Noble Cliff
Langley, WA 98260

Subject: E-Header/Sill Testing Report

Dear Duane:

Enclosed is our engineering report which documents the testing program conducted at Mayes Testing Engineer Laboratories on December 6, 2011. The purpose of these tests was to establish the bending strength of the E-Header/Sill cold-formed, pre-insulated header and sill elements.

The appendix of the report includes the table of section properties and bending strengths as established by this testing program.

Our report may be used in conjunction with the Mayes Testing report dated December 6, 2011.

We appreciate the opportunity to assist you in the effort. If you have any questions, please call me at (206) 622-5822.

Sincerely,

GREGORY L. SCHINDLER
18375

Greg Schindler, SE
Associate

1/12/12

kkh:kjn

Enclosure

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Engineering/Analysis Report

January 2012

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Introduction

The E-Header/Sill™, as manufactured by Evolution 1, LLC, is a pre-insulated boxed member made of a gauge metal structural shell surrounding a core of polystyrene insulation. The two outer track-like cold-formed steel sections are adhered to the foam core with glue and are attached to each other along their length with either pneumatic drive pins or steel rivets at 10" on center. The resulting composite member exhibits increased strength over that provided by the individual steel sections alone. Figure 1 in the Appendix depicts the standard E-Header/Sill shapes that were tested.

The purpose of this product is to provide an insulated single piece member as a substitution for built-up beams, typically used for window header and sill members in cold-formed framed structures. Field assembled built-up beams are typically not insulated and since the hollow cells created within built-up elements are not accessible to the insulation installer, this results in a thermal gap in the exterior wall of structures where they are used. E-Header/Sill head and sill members provide a one-piece structural element that does not require the build up and connection of individual cold-formed studs and the labor involved with field insulating them.

Purpose of Testing

Since the E-Header/Sill is a custom shaped structural element that is not made of standard shapes established in the cold-formed industry, the design section properties must be established by calculation or testing. The purpose of the beam testing program was to establish the bending strength of these elements and to document the effect that the foam core has in increasing the available strength of these sections, which can be derived from calculation alone. The results of this testing program were then used to develop a methodology to determine, by calculation, the section properties, and bending strengths of the whole family of E-Header/Sill shapes.

Testing Setup

The tests were configured in accordance with the American Iron and Steel Institute Testing Standard AISI 911-08 and were conducted by Mayes Testing Engineers, Inc. at their lab in Lynnwood, Washington. Refer to the Mayes Testing Report dated December 6, 2011. The test specimens consisted of 8-foot-6-inch-long E-Header/Sill sections of varying steel gauges. Two types of members were tested; the standard section with a 1-1/2-inch inner flange and 3-1/2-inch outer flange, and the Heavy Duty "HD" section with a 2-inch inner flange and 3-1/2-inch outer flange.

The specimens were placed in a hydraulic compression testing machine (see Figure 2 in the Appendix) so as to have an 8-foot-0-inch span between the centers of the support bearings. Those bearings consisted of a rocker bearing of a round bar. The beams were loaded in a two-point configuration with steel plate and round bar bearings at the load points which were set 22 inches apart, straddling the mid-span of the member. The beams were tested in both the strong and weak axis. A steel spreader beam spanned between the load points and was in turn loaded at a single mid-point location with a 30,000 pound capacity load cell. A dial gauge was used to determine the deflection of the beam at mid-span. This configuration develops a constant bending moment in the center area between load points.

The beams were loaded continuously until failure, while load and deflection readings were taken at 200 pound increments of load. Failure was indicated when the beam would no longer resist increasing load. Load/deflection curves were then plotted in the Mayes Testing report.

Three identical specimens were tested for each of the strong axis bending and weak axis bending configurations for the standard section in two steel gauges, 33 mil (33 ksi steel) and 54 mil (50 ksi steel). A single 54 mil 50 ksi HD section was tested for each of the strong axis and weak axis bending configurations. A total of 14 beams were tested.

To control lateral deflection and torsional distortion, lateral bracing was provided near the two load points and at the end supports. At the load points, this bracing consisted of vertical rollers so as to prevent resistance to vertical movement.

Test Results

Strong axis bending is about the x-x axis as shown in Figures 1 and 6, located in the Appendix. In a typical window head type installation this bending direction would resist out-of-plane loading on the wall, such as wind loading. Weak axis bending is about the y-y axis and would typically result from vertical gravity loading of the wall above an opening. Figure 3 shows a test of bending in the weak axis direction.

For bending in the weak axis direction, all E-Header/Sill test specimens exhibited the same mode of distortion and failure. When loaded, the outer compression flanges yielded and buckled between the fasteners (see Figure 4 in the Appendix). Failure occurred in all specimens when the web of the inner member buckled into the foam core (see Figure 5 in the Appendix). All specimens failed in flexure within or at the start of the constant bending moment region of the beam.

For bending in the strong axis direction, all E-Header/Sill test specimens exhibited the same mode of distortion and failure. When loaded, the outer compression flange yielded and buckled between the fasteners. Failure occurred in all specimens when the compression flange of the inner member buckled into the foam core (see Figure 7 in the Appendix). At the failure plane, distortion also occurred in the web of both the inner member and the outer member (see Figure 8 in the Appendix).

Use of Test Results

The North American Specification of the Design of Cold-Formed Steel Structural Members (AISI S100-2007) sets forth in Section F a methodology by which testing results can be used to establish member strength. The average of the three failure loads for each group of specimens was used as the representative loading capacity at failure. The failure moment was then determined from that load and the beam loading configuration. The HD specimens were for comparison only and the results were not used to develop the capacity charts.

The effective moment for the different test specimens was developed based on Section F1.2 of the AISI S100-2007 code: Allowable Strength Design by reducing the tested failure moment by a safety factor. The safety factor of 1.85 was determined in accordance with Eq F1.2-2. Effective section properties producing allowable moments were then calculated for the individual pieces considering them as track type elements with stiffened flanges. The plate buckling coefficient, k, for each flange of the composite structural elements was established such that the allowable moment would not exceed the effective moment from testing. Sets of k values for the inner and outer flanges were determined individually for the strong axis bending and weak axis bending of the 33 mil and 54 mil specimens. These were then used to determine the allowable section properties and bending moments for three thicknesses (33 mil, 43 mil, and 54 mil) for 4-inch, 6-inch, and 8-inch deep members. The test data showed that the E-Header/Sill members are stronger than an equivalent shape with no foam core.

Table A in the Appendix provides the summary of the gross and effective section properties including Allowable Moment (Ma) and Allowable Shear (Va) capacities of the entire family of E-Header/Sill sections in 4-inch, 6-inch, and 8-inch depths.

Conclusions

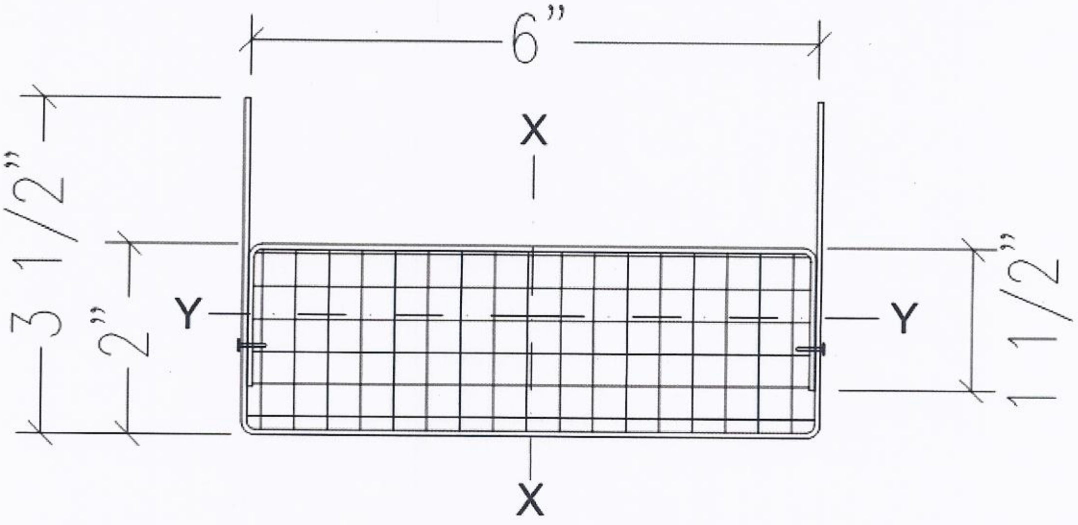
This testing program established the bending moment capacity at failure of 12 E-Header/Sill beam specimens and two HD E-Header/Sill beam specimens. The failure modes were very consistent with all members failing in the same manner – compression yielding/buckling. The load deflection curves were very linear until close to failure. While only limited data is available for the HD sections, it does not appear that the HD section is significantly stronger than the standard section.

The test results were used to establish allowable moments for 4-inch, 6-inch, and 8-inch sections. This moment capacity was compared to the calculated allowable moment for 4-inch, 6-inch, and 8-inch sections composed of bare, disconnected steel shapes with no foam core. In all cases, the moment capacity of the E-Header/Sill sections exceeded that of the bare steel shapes. This indicates that an increase in strength is provided by the combination of the foam core and the overlapped and fastened flanges by delaying the onset of compression bucking. The increase in strength is greater for the 33-mil and 43-mil 33 ksi shapes than for the 54-mil 50 ksi shapes. This indicates that the foam provides more benefit to a thinner, weaker metal section, but the foam is less beneficial as the metal section becomes thicker and stronger.

The test results also indicate that in the weak axis direction, for all gauges and strengths, the shape is acting as a structural composite shape and the increase in strength provided by the combination of the foam core and the overlapped and fastened flanges is even more significant than the increase in the strong axis direction.

Appendix

Figures, Photographs, and Tables



STANDARD ENVIRO HEAD-SILL$_{\text{TM}}$ SECTION

STANDARD WIDTHS (WALL THICKNESS) - 4", 6", 8"
STANDARD DEPTH - 3 $^{1}/_{2}$"
AVAILABLE GAUGES - 20 GA (33 mil), 18 GA (43 mil), 16 GA (54 mil)

Figure 1

Figure 2 – Testing Setup

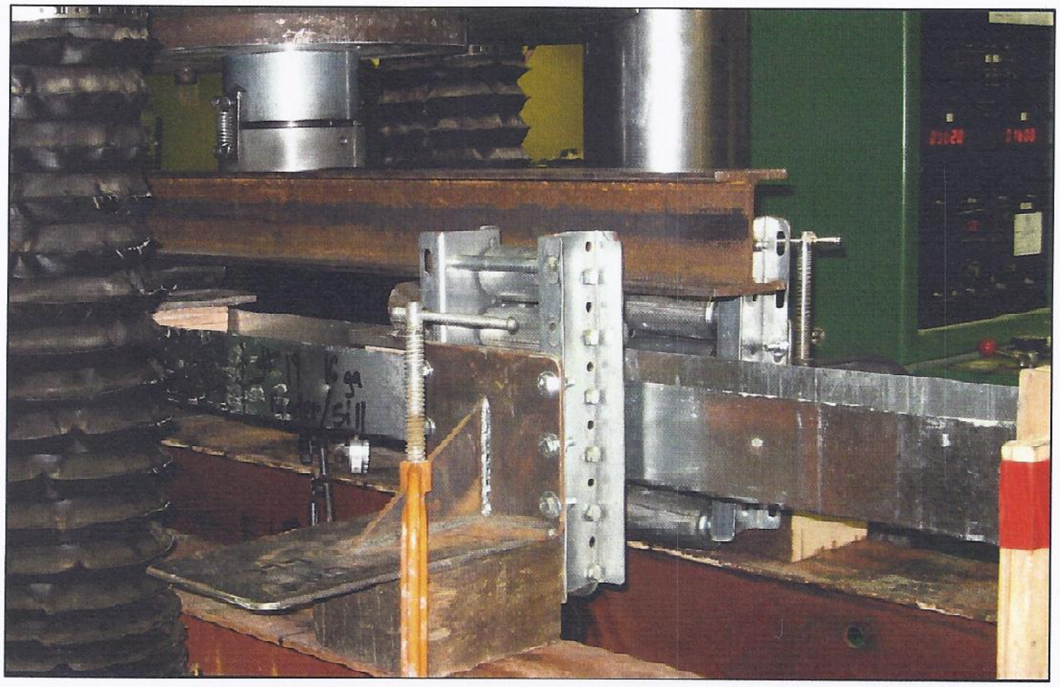


Figure 3 – Weak Axis Bending Test before Loading

Figure 4 – Weak Axis Bending, Outer Flange Buckling

Figure 5 – Weak Axis Bending, Web at Failure

Figure 6 – Strong Axis Bending Test before Loading

Figure 7 – Strong Axis Bending, Flange at Failure

Figure 8 – Strong Axis Bending, Web Distortion at Failure Plane

[redacted]

		Effective Properties					
I_{ye+}	S_{ye+}	M_{ay+}	I_{ye-}	S_{ye-}	M_{ay-}	V_{ay}
(in^4)	(in^3)	(k-in)	(in^4)	(in^3)	(k-in)	(lbs)
0.600	0.246	4.869	0.510	0.237	4.679	1899
0.779	0.354	6.991	0.648	0.324	6.411	3438
0.970	0.442	13.238	0.904	0.407	12.179	6643
0.720	0.266	5.263	0.513	0.253	4.992	1253
0.958	0.397	7.848	0.742	0.350	6.910	2766
1.196	0.497	14.886	0.936	0.439	13.140	5481
0.811	0.279	5.506	0.510	0.265	5.233	935
1.091	0.427	8.444	0.742	0.369	7.290	2066
1.363	0.535	16.030	0.937	0.463	13.868	4091

strong axis bending, k (inside flange) = 1.2 and k (outside