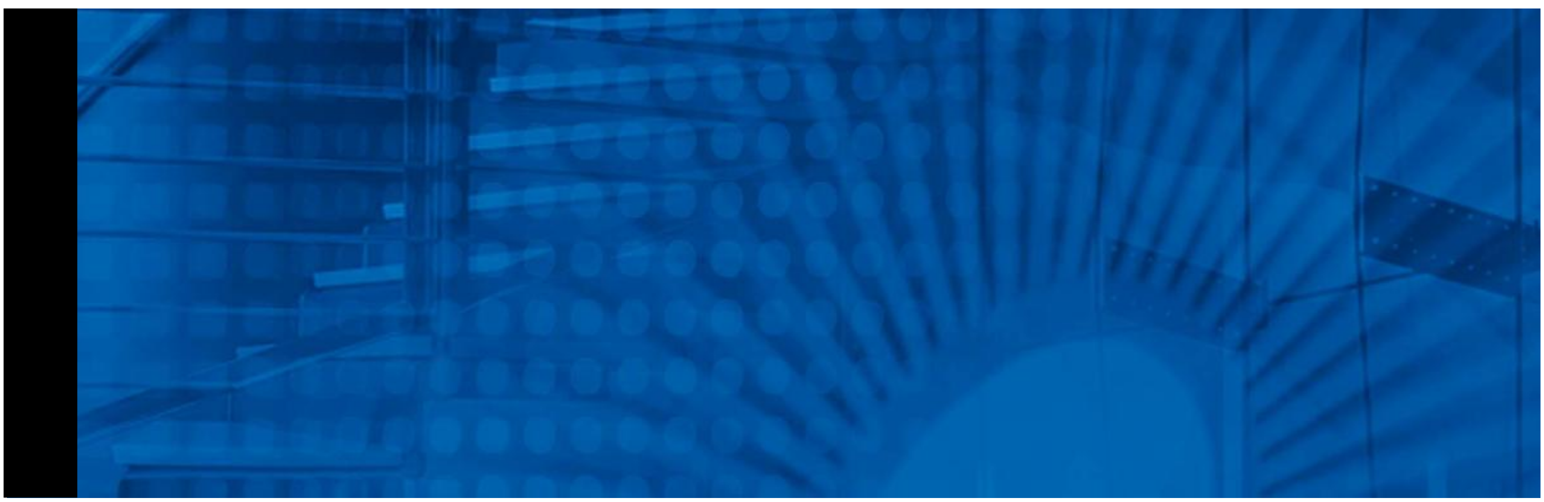
E-Beam HD™

Cold-Formed Insulated Composite Structural Elements

Engineering/Analysis Report



February 2012

kpff Consulting Engineers

kpff Consulting Engineers

March 2, 2012

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

Subject: E-Beam HD Testing Report

Dear Duane:

This 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 capacities of the E-Beam HD cold-formed, pre-insulated, header 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,

Greg Schindler, SE
Associate

KKH:kls

Enclosure

111003.20

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Engineering/Analysis Report

February 2012

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1. Introduction

The E-Beam HD™, as manufactured by Evolution 1, LLC, is a pre-insulated header element made of gauge metal structural stud shapes surrounding a core of polystyrene insulation. The two outer cold-formed steel stud shapes are adhered to the foam core with glue. The resulting member exhibits increased strength over that provided by the individual steel sections alone. Figure 1 in Appendix A depicts the standard E-Beam HD 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 members in cold-formed framed structures. Field-assembled, built-up beams are typically not insulated, 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. The E-Beam HD members provide a one-piece structural element that includes the side members and core insulation for a typical box header installation. It avoids the labor involved with installing individual pieces and field injecting foam to accomplish a fully insulated header. Top and bottom tracks would then be installed per the project requirements.

2. Purpose of Testing

Since the E-Beam HD is a custom element made of cold-formed steel with a foam core, the increase in design section properties over that of a bare steel section must be established by calculation or based on 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. 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-Beam HD shapes.

3. Testing Setup

The tests were configured in accordance with the American Iron and Steel Institute Testing Standard AISI S911-08 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 10-foot-6-inch-long E-Beam HD sections of 50 ksi 54 mil. (16 ga.) steel. Two types of members were tested; a typical E-Beam HD section with two stud shapes and the same section with top and bottom capping tracks. The stud shapes of the typical E-Beam HD section were connected with steel straps and No. 8 screws at 12 inches on center.

The specimens were placed in a hydraulic compression testing machine (see Figure 2 in Appendix A) so as to have a 10-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 28 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 and the section with top and bottom capping tracks. A single empty section (no foam core) was tested for each configuration. A total of 16 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.

4. Test Results

STRONG AXIS BENDING

Strong axis bending is about the x-x axis as shown in Figure 1 located in Appendix A. In a typical window head type installation this bending direction would typically result from vertical gravity loading of the wall above an opening.

For bending in the strong axis direction, all E-Beam HD test specimens exhibited the same mode of distortion and failure. When loaded, the stiffened compression flanges buckled inward and the compression portion of the web buckled outward (see Figures 3 and 4 in Appendix A). Figure 5 is a section cut through the failure plane that shows the web buckling and tensile failure of the foam at the failure plane of an E-Beam HD.

WEAK AXIS BENDING

Weak axis bending is about the y-y axis as shown in Figure 1 located in Appendix A. In a typical window head type installation, this bending direction would resist out-of-plane loading on the wall, such as wind loading.

For bending in the weak axis direction, the E-Beam HD test specimens without capping tracks had a different failure mode than the E-Beam HD specimens with capping tracks. When loaded, the sections without capping tracks had a shear failure in the foam adjacent to the supports (see Figure 6 in Appendix A). The deflections at failure in the sections without capping tracks were in excess of L/60. When loaded, the sections with capping tracks sheared some of the connecting screws and exhibited compression flange buckling of the capping tracks (see Figure 7 in Appendix A). The deflections at failure in the sections with capping tracks were in excess of L/80.

5. 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 for bending. 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 sections with capping tracks were tested to determine if the E-Beam HD section acted compositely with the capping tracks. From the results, it was determined that the capping tracks do not act compositely with the E-Beam HD section. The results of the tests with the capping tracks 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. This average reduced tested failure moment is referred to as the reduced tested capacity. The safety factor of 1.85 was determined in accordance with Eq F1.2-2.

Compared with the theoretical effective strong axis bending capacity of a bare steel shape, the reduced tested capacity of an 8-inch-deep by 54 mil. (16 ga.) section was 25 percent stronger. This 25 percent increase was applied to the effective bending capacity of 6-inch, 8-inch, 10-inch, and 12-inch-deep sections of 54 mil. (16 ga.) and 43 mil. (18 ga.) material. As the depth to thickness ratio increases, it is more likely that the shapes will experience local buckling so extrapolation of the results is less reliable. In addition, as heavier gauges are used, the foam is less effective in providing out of plane bracing for the steel shape. Therefore, the capacity increase as determined by the test results is not applied to sections thicker than 54 mil (16 ga.) or deeper than 12 inches.

For weak axis bending, the methodology of AISI S100-2007 Section F does not apply. Because the failure occurs in the low density foam, which is not a codified structural material, the principles of cold-formed steel design cannot be used. While an effective weak axis moment cannot be extrapolated to other E-Beam HD sizes, an effective stiffness can be determined and extrapolated. The effective stiffness of the tested E-Beam HD shapes was determined to be 27 percent greater than the effective stiffness of a bare steel section. This increase was applied to the effective stiffness of 6-inch and 8-inch shapes of 54 mil. (16 ga.) and 43 mil. (18 ga.) material.

6. Conclusions

This testing program established the strong axis bending moment capacity at failure of three 54 mil. (16 ga.) E-Beam HD specimens and three 54 mil. (16 ga.) E-Beam HD with capping track specimens. For strong axis bending, the failure modes were consistent regardless of the presence of the capping tracks. Little, if any, composite action was observed in the specimens with capping tracks. With the connecting screws located at a typical spacing of 12 inches on center, there appears to be enough slippage between the sections that effective composite action does not develop. For weak axis bending, the failure mode depended on the presence of the capping tracks. In the weak axis direction, capping tracks do provide the majority of the bending strength, which is the typical assumption most designers follow. However, because the capping tracks are not an integral part of the E-Beam HD, the added capacity in the weak axis direction from the capping tracks is not included in the E-Beam HD section properties table.

The test results in the strong axis direction were used to establish allowable bending moments for 6-inch, 8-inch, 10-inch, and 12-inch sections of 54 mil. (16 ga.) and 43 mil. (18 ga.) material. The increase in allowable bending strength over that of a bare steel shape can be attributed to the foam core delaying the onset of local buckling.

The weak axis deflection from testing was greater than L/60 and well beyond the typical accepted limits. Therefore, the lateral capacity of the bare E-Beam HD without capping tracks is governed by stiffness and not flexural strength. The test results in the weak axis direction were used to establish effective stiffnesses for 6-inch and 8-inch-deep sections of 54 mil. (16 ga.) and 43 mil. (18 ga.) material. The increase in effective stiffness can be attributed to the presence of the foam allowing the section to act compositely. Because the foam does not have any significant structural strength, the strength of the bare steel sections cannot be amplified.

The effective section properties and moment capacities developed from the testing program appear in Table A of Appendix A.

Appendix A

Figures, Photographs, and Tables

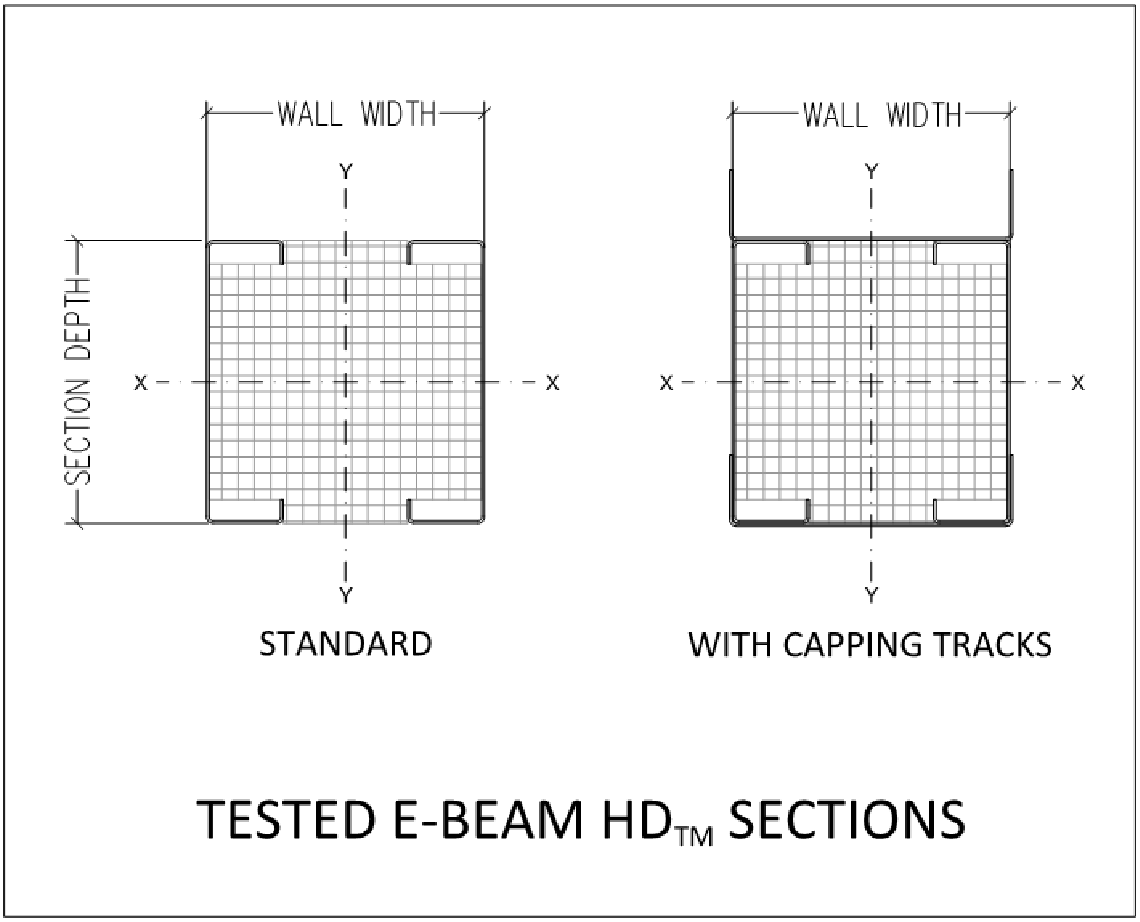

Figure 1: Tested E-Beam HD Sections

Figure 2: Testing Setup

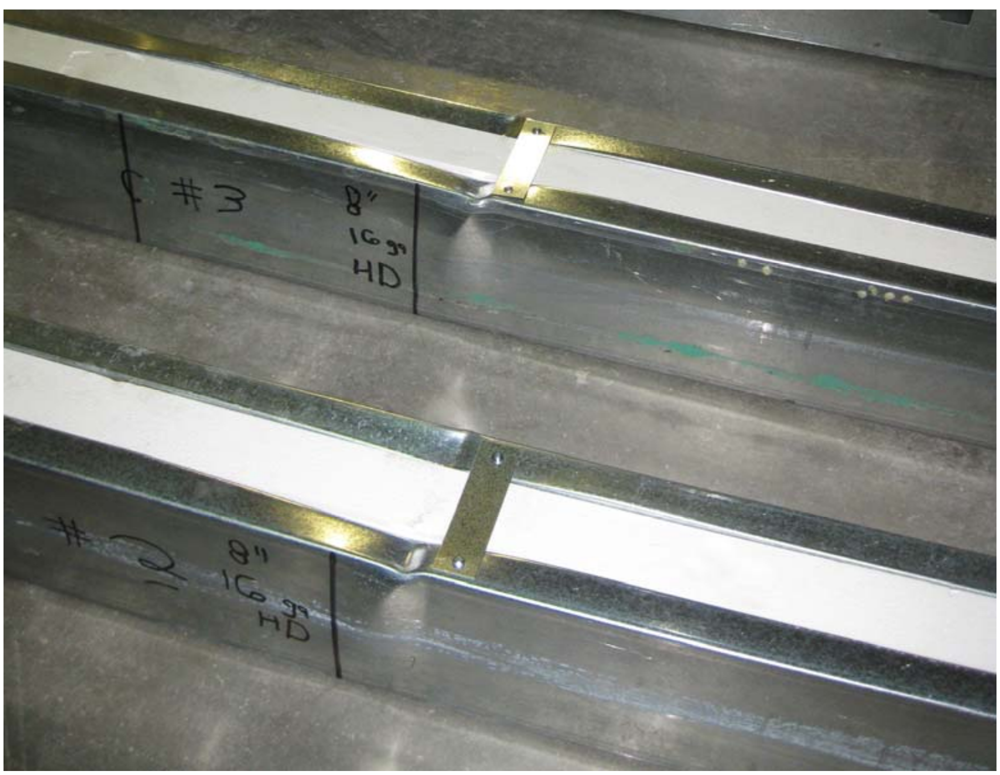

Figure 3: Strong Axis Bending Failure

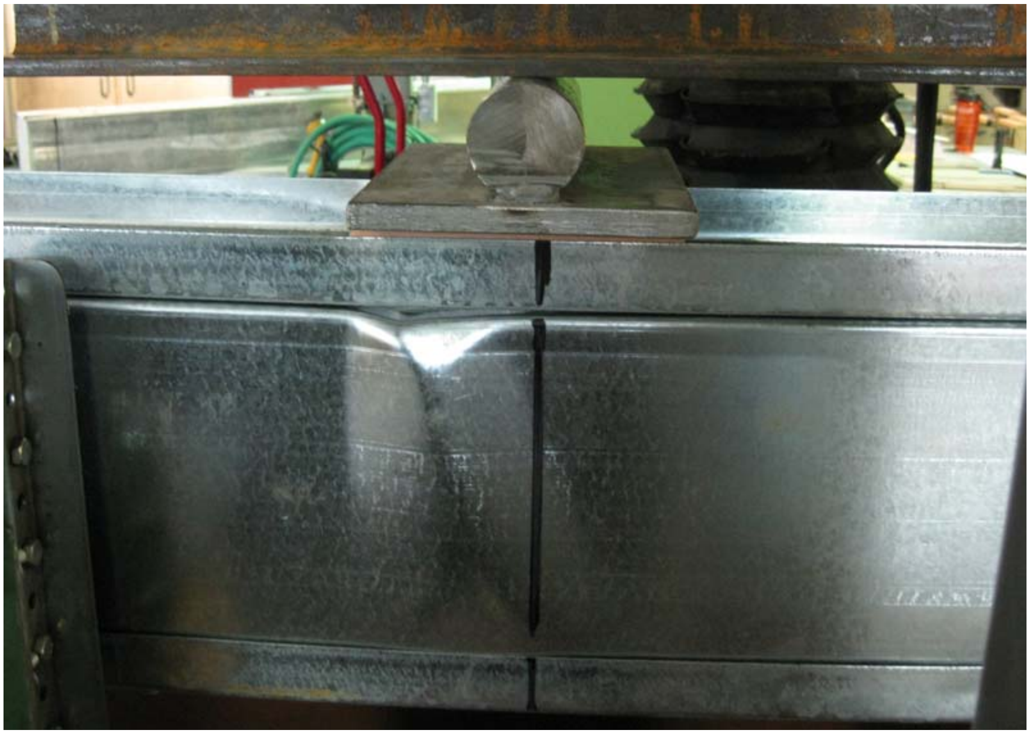

Figure 4: Strong Axis Bending at Failure: Section with Capping Tracks

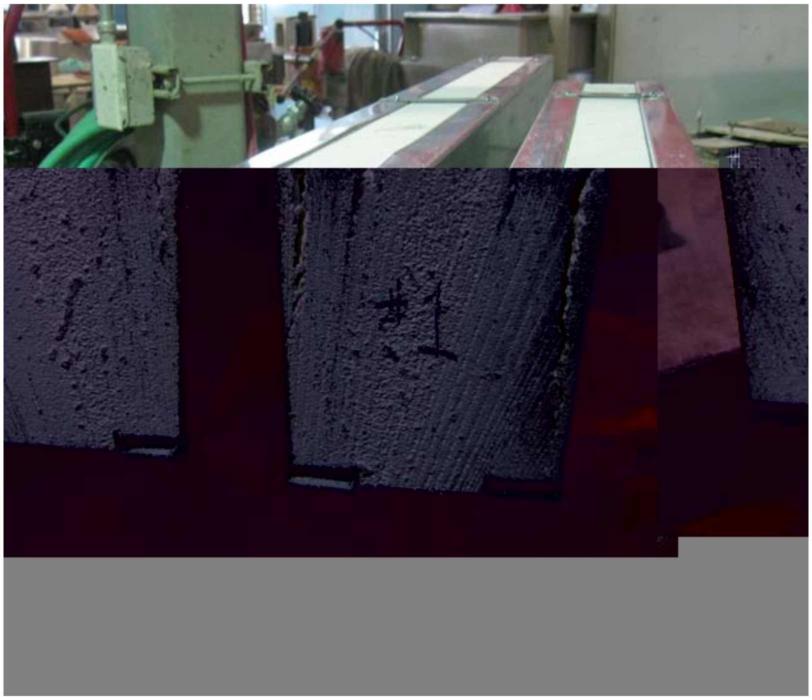

Figure 5: Strong Axis Bending at Failure: Compression Flange Buckling, Web Buckling, and Foam Cracking

Figure 6: Weak Axis Bending: Foam Shear Failure

Figure 7: Weak Axis Bending: Compression Flange Buckling of Capping Tracks

Table A: Section Properties

E-BEAM HD_{TM} SECTION PROPERTIES TABLE

	Design Thickness	Gauge	Gross Properties						Effective Properties				
			F_y	Area	Weight	I_x	S_x	R_x	I_{xe}	S_{xe}	M_{ax}	V_{ax}	$(EI)_{ye}$
	(in)	(No.)	(ksi)	(in^2)	(lb/ft)	(in^4)	(in^3)	(in)	(in^4)	(in^3)	(k-in)	(lb)	($k\text{-}in^2$)
EB6-600S162-43 HD[1]	0.0451	18	33	0.894	3.04	4.632	1.544	2.276	4.64	1.93	41.70	2832	36682
EB8-600S162-43 HD[1]													70179
EB6-600S162-54 HD[1]	0.0566	16	50	1.112	3.78	5.720	1.906	2.268	5.72	2.38	52.93	5478	45666
EB8-600S162-54 HD[1]													87026
EBD-600S162-68 HD[2]	0.0713	14	50	1.386	4.72	7.050	2.350	2.255	7.06	2.36	53.58	8694	-
EB6-800S162-43 HD[1]	0.0451	18	33	1.074	3.66	9.266	2.316	2.937	9.00	2.55	50.35	2102	40563
EB8-800S162-43 HD[1]													77102
EB6-800S162-54 HD[1]	0.0566	16	50	1.340	4.56	11.472	2.868	2.926	11.40	3.33	65.90	4182	50482
EB8-800S162-54 HD[1]													95588
EBD-800S162-68 HD[2]	0.0713	14	50	1.672	5.68	14.178	3.544	2.912	14.18	3.48	68.64	8442	-
EBD-1000S162-43 HD[1]	0.0451	18	33	1.254	4.26	16.050	3.210	3.578	15.04	3.25	64.35	1672	-
EBD-1000S162-54 HD[1]	0.0566	16	50	1.566	5.32	19.900	3.980	3.565	19.26	4.30	85.05	3322	-
EBD-1000S162-68 HD[2]	0.0713	14	50	1.956	6.66	24.650	4.930	3.550	24.52	4.56	89.96	6690	-
EBD-1200S162-54 HD[1]	0.0566	16	50	1.792	6.10	31.460	5.244	4.190	29.48	5.28	104.20	2754	-
EBD-1200S162-68 HD[2]	0.0713	14	50	2.242	7.62	39.036	6.506	4.173	37.92	5.64	111.32	5542	-
EBD-1400S162-54 HD[2]	0.0566	16	50	2.018	6.86	46.604	6.658	4.806	42.20	5.00	98.64	2354	-
EBD-1400S162-68 HD[2]	0.0713	14	50	2.526	8.60	57.904	8.272	4.788	54.72	6.72	132.66	4730	-

"D" is the wall thickness. See typical nomenclature

Notes:

1. Based on direct testing in accordance with AISI S911-08 and the AISI S100-2007 specification, an increase in effective strong axis section modulus and effective strong axis moment of approximately 25% has been applied to 6", 8", 10", and 12" deep sections with thicknesses of 43 mil and 54 mil.
2. Section properties are for two stud shapes per the SSMA Technical Catalog and have not been increased.
3. Typically, for out-of-plane (weak axis) loading, top and bottom tracks would be added to the E-Beam HD by the design engineer. However, the foam core does provide a limited amount of composite action of the E-Beam section alone. The weak axis capacity of the E-Beam HD by itself is controlled by deflection. The effective stiffness in this direction, $(EI)_{ye}$, corresponds to a deflection ratio of L/360 and is based on testing for the 6" E-Beam HD.
4. User should check end reaction for web crippling.
5. Bending capacities are based on the assumption that the compression flange is adequately laterally braced on both sides.
6. Allowable Moment and Shear Values are calculated assuming a negligible axial load. Load bearing jamb studs are to be designed for combined axial and bending loads by a qualified professional.
7. Strength increase due to cold work of forming has been incorporated per AISI 2007 Specification A7.2.
8. The effective Moment of Inertia for deflection has been calculated using Procedure 1 of the AISI S100-2007 Specification for serviceability determination.
9. The distortional buckling limit state is not considered in this table. Consideration of distortional buckling may result in lower strengths when restraint against distortional buckling is not provided.
10. If punch-outs are used in members, values may be smaller than those listed above and shall be per the AISI S100-2007 Specification.