Enviro-King™

Cold-Formed Insulated Composite Structural Elements

Engineering/Analysis Report

June 2011

kpff Consulting Engineers

kpff Consulting Engineers

June 6, 2011

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

Subject: Enviro-King Testing Report

Dear Duane:

This is our engineering report which documents the testing program conducted at Mayes Testing Engineers Laboratories on March 15-16, 2011. The purpose of these tests was to establish the bending strength of the Enviro-King cold-formed, pre-insulated jamb 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 March 17, 2011.

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

Sincerely,

Greg Schindler, SE
Associate

GLS:kkt

111003.10

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STATE OF WASHINGTON
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REGISTERED
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Engineering/Analysis Report

June 2011

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Introduction

The Enviro-King, 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. The resulting composite member exhibits increased strength over that provided by the individual steel sections alone. Figure 1 in Appendix A depicts the standard Enviro-King shapes that were tested.

The purpose of this product is to provide an insulated member as a substitution for bundled studs, typically used for door and window jamb members in cold-formed framed structures. Bundled studs are typically not insulated and thus present a thermal gap in the exterior wall of structures where they are used. Enviro-King jamb members provide a one-piece structural element that does not require build up and connection of individual wall studs and the labor involved with field insulating them.

Purpose of Testing

Since the Enviro-King 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 affect 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 Enviro-King 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 March 17, 2011. The test specimens consisted of 10-foot, 6-inch long Enviro-King sections of varying steel gauges. Two types of members were tested; the standard section was a 1-1/2-inch inner flange and 2-3/4-inch outer flanges, and the Heavy Duty "HD" section with both inner and outer flanges of 2-3/4-inches.

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 round bar rocker bearing. The beams were loaded in a two-point configuration parallel to the strong axis with steel plate and round bar bearings at the load points which were set 28 inches apart straddling the mid-span of the member. A steel spreader beam spanned between the load points and was in turn loaded at a single mid-point location with a 10,000 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 six combinations of section and steel gauge from 33 mil. through 68 mil. A control specimen was also tested which consisted of two standard stud sections 600S162-54 welded together in the typical bundled stud configuration. In all a total of 19 specimens were tested.

To control lateral deflection and torsional distortion, lateral bracing was provided at 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

At the failure load, all Enviro-King test specimens exhibited the same mode of distortion and failure. The compression flanges yielded and buckled along with a small portion of the side webs. As compression built up in the flanges, the outer flange distorted outward between the fasteners but the inner flange was restrained from buckling by the foam and the overlap of the outer flange (see Figure 3 in Appendix A). Failure occurred in all specimens when the inner flange buckled into the foam core (see Figures 4 and 5 in Appendix A). All specimens failed in flexure in the center area between the loading points, i.e. the constant bending moment region of the beam. No distortion of any sort was noted outside the center region.

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.

Allowable Moment for the different specimens tested was developed based on Section F1.2 of the AISI S100-2007 code: Allowable Strength Design. A safety factor was determined in accordance with Eq F1.2-2 where the resistance factor from testing was used based on calculation of Eq F1.1-2. Effective section properties producing allowable moments were then calculated for the individual pieces considering them as track type elements with un-stiffened flanges. The plate buckling coefficient, k, for each flange of the composite structural elements were then determined based on the effective section properties formulas and the test data. One set of k values for the inner and outer flanges was determined for the 33 and 43 mils products while a separate set was determined for the 54 and 68 mil products based on the results of the testing. These were then used to determine the allowable properties of 4-inch, 6-inch, and 8-inch deep members. The test data showed that the Heavy Duty Enviro-King members are stronger than two bundled 600S137 studs of the same gage. Additionally, both the Standard and Heavy Duty Enviro-King members, as tested with the foam core, are stronger than calculated values of just the cold-formed steel pieces themselves. Tested members with thinner gages of 33 and 43 mils showed a minimum of a 20 percent increased moment capacity while tested members with gages of 54 and 68 mils showed a minimum increase of 8 percent.

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

Conclusions

This testing program established the bending moment capacity at failure of 18 Enviro-King beam specimens and one bundled stud beam. The failure modes were very consistent with all Enviro-King members failing in the same manner – compression flange yielding/buckling. The load deflection curves were very linear until close to failure. Using the average failure loading from each group, the moment capacity was calculated and compared to the moment capacity derived by calculation for disconnected steel sections of the same shape. In all cases, the moment capacity of the tested shapes, when reduced by appropriate safety factors, exceeded that of the bare, disconnected shapes. This indicates that significant increase in strength is provided by the combination of the foam core and the overlapped and fastened flanges. The foam core and the overlapped flange configuration serve to delay the onset of flange buckling and thus increase the overall bending strength of the composite section.

The bending strength of the Enviro-King sections also compares favorably with that of traditional jamb member made of two standard wall studs of the same gauge steel welded in a boxed configuration.

Appendix A

Figures, Photographs, and Tables

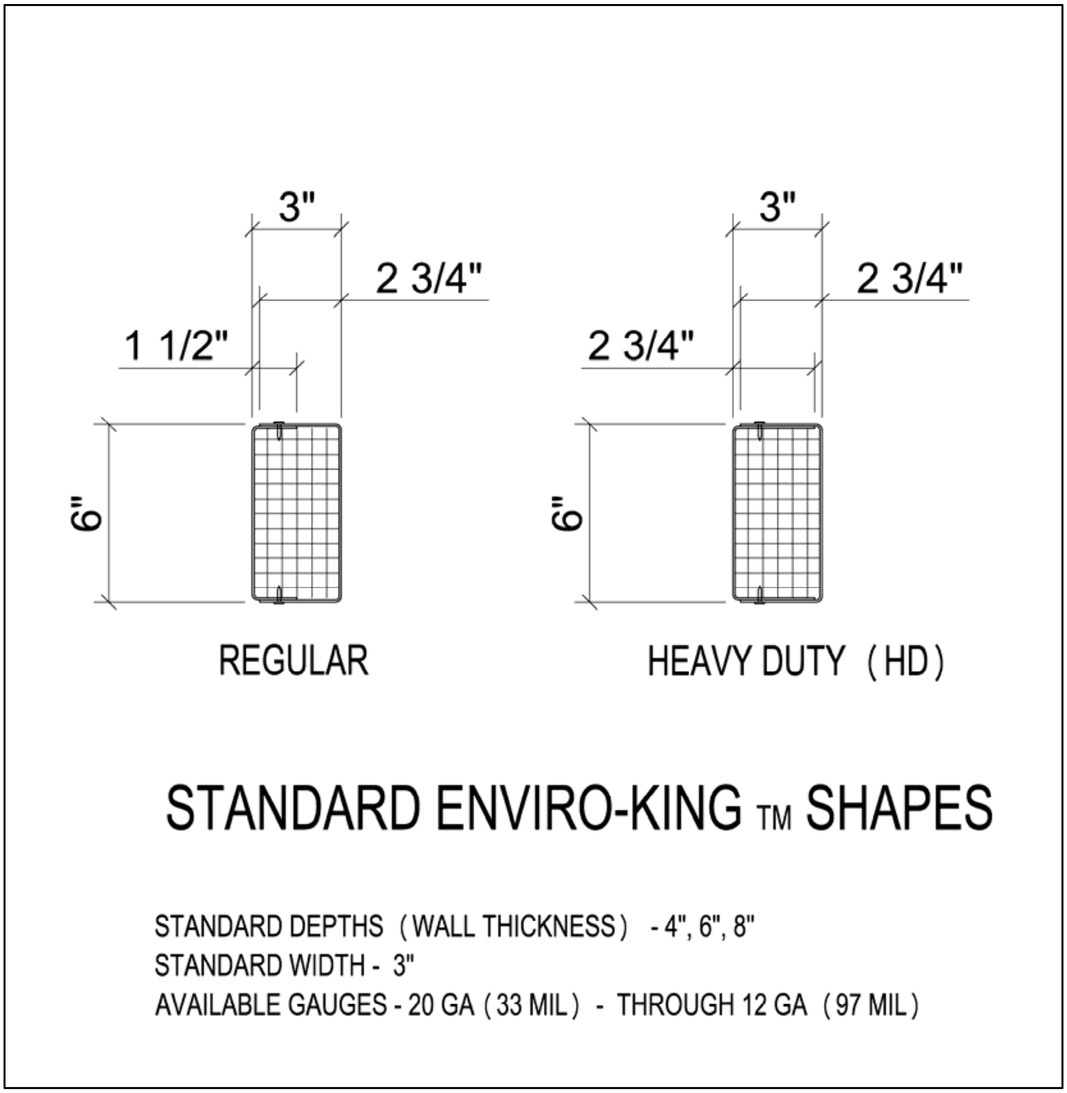
3"
2 3/4"
1 1/2"
6"
REGULAR
3"
2 3/4"
2 3/4"
6"
HEAVY DUTY (HD)
STANDARD ENVIRO-KING TM SHAPES
STANDARD DEPTHS (WALL THICKNESS) - 4", 6", 8"
STANDARD WIDTH - 3"
AVAILABLE GAUGES - 20 GA (33 MIL) - THROUGH 12 GA (97 MIL)

Figure 1

Figure 2 – Testing Setup

Figure 3 – Outer Flange Buckling

Figure 4 – Flange at Failure at Mid-Span

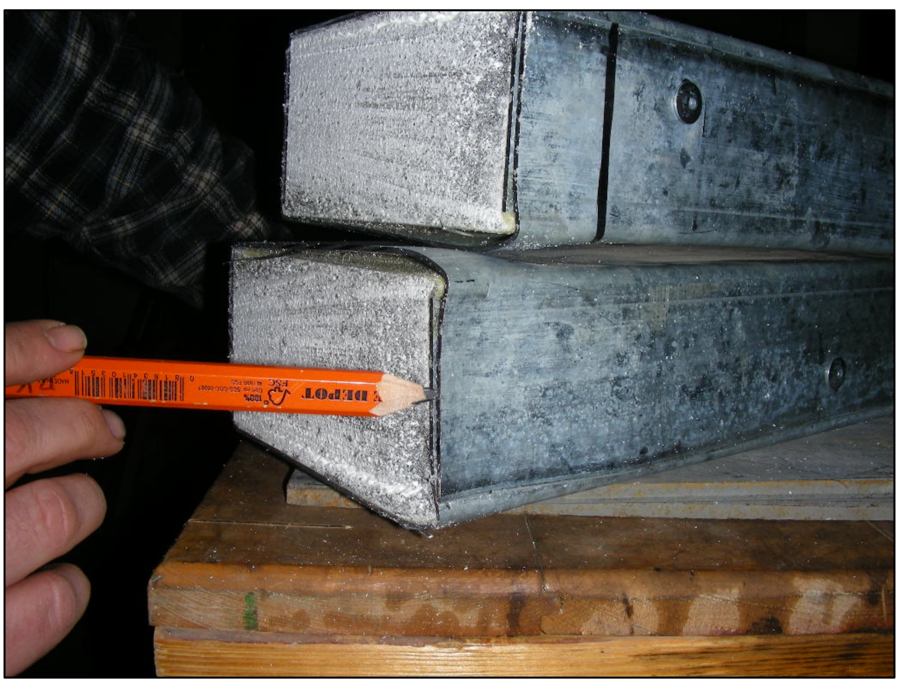

Figure 5 – Flange at Failure

ENVIRO-KING$_{TM}$ SECTION PROPERTIES TABLE

		Design	Gross Properties								Effective Properties			
		Thickness	F_y	Area	Weight	I_x	S_x	R_x	I_y	R_y	I_{xe}	S_{xe}	M_a	V_a
		(in)	(ksi)	(in^2)	(lb/ft)	(in^4)	(in^3)	(in)	(in^4)	(in)	(in^4)	(in^3)	(k-in)	(lb)
4" WALL	EK4-3-33	0.0346	33	0.558	1.899	1.461	0.735	1.618	0.776	1.179	1.155	0.469	9.266	1970
	EK4-3-33 HD	0.0346	33	0.645	2.194	1.790	0.903	1.666	0.826	1.132	1.307	0.499	9.863	1970
	EK4-3-43	0.0451	33	0.725	2.466	1.881	0.949	1.611	1.001	1.175	1.606	0.707	13.979	3478
	EK4-3-43 HD	0.0451	33	0.837	2.849	2.302	1.164	1.658	1.065	1.128	1.986	0.831	16.428	3478
	EK4-3-54	0.0566	50	0.904	3.075	2.321	1.173	1.603	1.236	1.170	1.881	0.787	23.562	6743
	EK4-3-54 HD	0.0566	50	1.045	3.557	2.840	1.440	1.648	1.317	1.122	2.168	0.851	25.487	6743
	EK4-3-68	0.0713	50	1.129	3.840	2.859	1.448	1.592	1.525	1.162	2.426	1.062	31.786	9551
	EK4-3-68 HD	0.0713	50	1.307	4.446	3.498	1.780	1.636	1.626	1.115	2.869	1.168	34.974	9551
	EK4-3-97	0.1017	50	1.581	5.378	3.891	1.982	1.569	2.080	1.147	3.526	1.599	47.879	12928
	EK4-3-97 HD	0.1017	50	1.835	6.243	4.759	2.439	1.611	2.222	1.101	4.297	1.859	55.644	12928
6" WALL	EK6-3-33	0.0346	33	0.697	2.370	3.728	1.248	2.313	1.082	1.246	3.034	0.762	15.064	1284
	EK6-3-33 HD	0.0346	33	0.783	2.665	4.480	1.502	2.392	1.130	1.201	3.396	0.767	15.147	1284
	EK6-3-43	0.0451	33	0.905	3.080	4.815	1.614	2.307	1.396	1.242	4.209	1.256	24.813	2854
	EK6-3-43 HD	0.0451	33	1.018	3.463	5.784	1.942	2.384	1.459	1.197	5.085	1.450	28.652	2854
	EK6-3-54	0.0566	50	1.130	3.845	5.965	2.003	2.298	1.728	1.237	5.000	1.421	42.533	5703
	EK6-3-54 HD	0.0566	50	1.272	4.327	7.168	2.412	2.374	1.807	1.192	5.677	1.531	45.842	5703
	EK6-3-68	0.0713	50	1.414	4.811	7.387	2.485	2.286	2.138	1.230	6.431	1.920	57.486	10701
	EK6-3-68 HD	0.0713	50	1.592	5.417	8.879	2.994	2.362	2.237	1.186	7.473	2.097	62.791	10701
	EK6-3-97	0.1017	50	1.987	6.762	10.167	3.433	2.262	2.937	1.216	9.347	2.871	85.944	20556
	EK6-3-97 HD	0.1017	50	2.242	7.627	12.229	4.144	2.336	3.077	1.172	11.177	3.286	98.377	20556
8" WALL	EK8-3-33	0.0346	33	0.835	2.841	7.388	1.853	2.975	1.387	1.289	5.599	0.972	19.211	952
	EK8-3-33 HD	0.0346	33	0.922	3.136	8.736	2.193	3.079	1.435	1.248	6.244	1.025	20.261	952
	EK8-3-43	0.0451	33	1.086	3.694	9.559	2.401	2.968	1.790	1.284	8.358	1.658	32.766	2115
	EK8-3-43 HD	0.0451	33	1.198	4.077	11.302	2.841	3.071	1.853	1.244	10.074	2.005	39.613	2115
	EK8-3-54	0.0566	50	1.357	4.616	11.870	2.984	2.958	2.219	1.279	10.024	1.883	56.387	4214
	EK8-3-54 HD	0.0566	50	1.498	5.097	14.039	3.534	3.061	2.298	1.239	11.422	2.076	62.154	4214
	EK8-3-68	0.0713	50	1.699	5.781	14.743	3.712	2.946	2.751	1.272	13.042	2.875	86.088	8522
	EK8-3-68 HD	0.0713	50	1.877	6.387	17.444	4.400	3.048	2.849	1.232	14.962	3.227	96.620	8522
	EK8-3-97	0.1017	50	2.394	8.147	20.417	5.156	2.920	3.793	1.259	18.965	4.420	132.336	21771
	EK8-3-97 HD	0.1017	50	2.648	9.012	24.181	6.121	3.022	3.932	1.219	22.309	4.995	149.552	21771

Notes:

1. Section properties are based on direct testing in accordance with AISI 911-08 and the AISI S100-2007 Specification. k values used are representative of the direct testing.
   For 33 mils, k (inside flange) = 1.2 and k (outside flange) = 0.8. For 43 mils, k (inside flange) = 4 and k (outside flange) = 0.8.
   For 54 & 68 mils, k (inside flange) = 1.2 and k (outside flange) = 0.43. For 97 mils, k (inside flange) = 1.0 and k (outside flange) = 0.43.
2. User should check end reaction for web crippling.
3. Bending capacities are based on the assumption that the compression flange is adequately laterally braced on both sides.
4. 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.
5. Strength increase due to cold work of forming has not been incorporated.
6. The effective Moment of Inertia has been calculated for deflection based on Procedure 1 of the AISI S100-2007 Specification by using the stress at the effective section modulus of the allowable bending moment.
7. 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.
8. If punch-outs are used in members, values may be smaller than those listed above and shall be per the AISI S100-2007 Specification.

Table A– Section Properties