Appendix A: Preliminary Calculations

Included below are the preliminary yield limit calculations and the calculations of the expected failure loads for each connection configuration. These calculations are based on NDS sections 11.3 and 10.3 respectively (AF&PA, 2001).

Bolt Bending Yield Strength (F_{yb})

6" BOLTS: SAE J429 Grade 2 bolts (manufacturer's stamp: HKT)

Cantilever Method-

$M_y = P*x$

$S = D^3/6$

$F_{yb} = M_y/S$

where

M_y = bending yield moment (in.*lbs)

P = 5% offset yield load (lbs)

x = moment arm (in.)

S = the section modulus ($in.^3$)

D = measured bolt diameter (in.)

F_{yb} = bolt bending yield strength (psi)

Average P = 164 lbs

x = 3.5 in.

Average M_y = 164 lbs * 3.5 in. = 574 in.*lbs

Average D = 0.37093 in.

$$S = \frac{0.37093^3}{6} = 0.008506\ in.^3$$

$$Fyb = \frac{574}{0.008506} = \mathbf{67{,}500\ psi}$$

3-Point Bending Method-

$My = (P*s_{bp})/4$

where

s_{bp} = span length (in.)

Average P = 613.9 lbs

s_{bp} = 4.3 in.

$$\text{Average } M_y = \frac{613.9\ lbs * 4.3\ in.}{4} = 659.943\ in.*lbs$$

Average D = 0.37073 in.

$$S = \frac{037073^3}{6} = 0.008492\ in.^3$$

$$F_{yb} = \frac{659.943}{0.008492} = \mathbf{77{,}700\ psi}$$

8" BOLTS: SAE J429 Grade 2 bolts (manufacturer's stamp: BL)

Cantilever Method-

Average P = 96.4 lbs

x = 5 in.

Average M_y = 96.4 lbs * 5 in. = 482 in.*lbs

Average D = 0.37241 in.

$$S = \frac{0.37241^3}{6} = 0.008608\ in.^3$$

$$F_{yb} = \frac{482}{0.008608} = \mathbf{56{,}000\ psi}$$

3-Point Bending Method-

Average P = 614.2 lbs

s_{bp} = 4.3 in.

$$\text{Average } M_y = \frac{614.2\ lbs * 4.3\ in.}{4} = 660.265\ in.*lbs$$

Average D = 0.37173 in.

$$S = \frac{0.37173^3}{6} = 0.008561\ in.^3$$

$$F_{yb} = \frac{660.265}{0.008561} = \mathbf{77{,}100\ psi}$$

To be conservative in the yield mode calculations, it is necessary to assume high bolt strength and low wood strength. Thus, a bending yield strength of 78,000 psi will be assumed for both the 6-in. and 8-in. bolts.

Dowel Embedment Strength (F_e)

F_e = 5% Offset Load / (test member thickness * bolt diameter)

4x6's:

Average 5% Offset Load = 2190 lbs

Test Member Thickness = 1.5 in.

Average Bolt Diameter = 0.372 in.

$F_e = \frac{2190}{1.5 * 0.372}$ = **3920 psi**

2x6's:

Average 5% Offset Load = 3330 lbs

Test Member Thickness = 1.5 in.

Average Bolt Diameter = 0.372 in.

$F_e = \frac{3330}{1.5 * 0.372}$ = **5970 psi**

To be conservative, a dowel embedment strength of 3900 psi will be assumed for 4x6 members, and a dowel embedment strength of 5800 psi will be assumed for 2x6 members.

Yield Limit Calculations

The following calculations were made using the yield limit equations included in Table 2.1 of section 2.2.1.

Proposed MODE III_s Configuration: 4x6 main member, 2x6 side member

MODE II-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 1.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37083 in.

Fe_m = 3900 psi

Fe_s = 5800 psi

$R_e = Fe_m/Fe_s$ = 3900 / 5800 = 0.6724

$Rt = l_m / l_s$ = 2.333

$$k_1 = \frac{\sqrt{0.6724 + 2(0.6724)^2(1 + 2.333 + 2.333^2) + (2.333)^2(0.6724)^3} - 0.6724(1 + 2.333)}{(1 + 0.6724)}$$

= 0.57547

$$Z_{II} = \frac{(0.57547)(0.37083)(1.5)(5800)}{(1.0)} = \mathbf{1860\ lbs}$$

MODE III_s-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 1.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37083 in.

Fe_m = 3900 psi

Fe_s = 5800 psi

$R_e = Fe_m/Fe_s$ = 3900 / 5800 = 0.6724

$$k_3 = -1 + \sqrt{\frac{2(1 + 0.6724)}{0.6724} + \frac{2(78000)(2 + 0.6724)(0.37083)^2}{3(3900)(1.5)^2}} = 1.67435$$

$$Z_{IIIs} = \frac{(1.67435)(0.37083)(1.5)(3900)}{(2 + 0.6724)(1.0)} = \mathbf{1360\ lbs}$$

MODE III_m-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 1.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37083 in.

Fe_m = 3900 psi

Fe_s = 5800 psi

$R_e = Fe_m/Fe_s = 3900 / 5800 = 0.6724$

$$k3 = -1 + \sqrt{2(1+0.6724) + \frac{2(78000)[1+2(0.6724)](0.37083)^2}{3(3900)(3.5)^2}} = 0.87473$$

$$Z_{IIIm} = \frac{(0.87473)(0.37083)(3.5)(3900)}{[1+2(0.6724)](1.0)} = \mathbf{1890\ lbs}$$

MODE IV-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 1.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37083 in.

Fe_m = 3900 psi

Fe_s = 5800 psi

$R_e = Fe_m/Fe_s = 3900 / 5800 = 0.6724$

$$Z_{IV} = \frac{(0.37083)^2}{(1.0)}\sqrt{\frac{2(3900)(78000)}{3(1+0.6724)}} = \mathbf{1510\ lbs}$$

Proposed MODE IV Configuration: 4x6 main member, 4x6 side member

MODE II-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 3.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37207 in.

Fe_m = 3900 psi

Fe_s = 3900 psi

$R_e = Fe_m/Fe_s$ = 3900 / 3900 = 1.0

$Rt = l_m / l_s$ = 1.0

$$k_1 = \frac{\sqrt{1.0 + 2(1.0)^2(1+1.0+1.0^2) + (1.0)^2(1.0)^3} - 1.0(1+1.0)}{(1+1.0)} = 0.4142$$

$$Z_{II} = \frac{(0.4142)(0.37207)(3.5)(3900)}{(1.0)} = \mathbf{2100\ lbs}$$

MODE III_s, MODE III_m-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 3.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37207 in.

Fe_m = 3900 psi

Fe_s = 3900 psi

$R_e = Fe_m/Fe_s$ = 3900 / 3900 = 1.0

$$k_3 = -1 + \sqrt{\frac{2(1+1.0)}{1.0} + \frac{2(78000)(2+1.0)(0.37207)^2}{3(3900)(3.5)^2}} = 1.10998$$

$$Z_{IIIs} = \frac{(1.10998)(0.37207)(3.5)(3900)}{(2+1.0)(1.0)} = \mathbf{1880\ lbs}$$

MODE IV-

R_d = 1.0 for parallel to grain loading

l_m = 3.5 in.

l_s = 3.5 in.

F_{yb} = 78,000 psi

D_{avg} = 0.37207 in.

Fe_m = 3900 psi

Fe_s = 3900 psi

$R_e = Fe_m/Fe_s$ = 3900 / 3900 = 1.0

$$Z_{IV} = \frac{(0.37207)^2}{(1.0)}\sqrt{\frac{2(3900)(78000)}{3(1+1.0)}} = \mathbf{1390\ lbs}$$

Expected Connection Failure Loads

$Z' = Z * (C_D*C_M*C_t*C_g*C_\Delta*C_{eg}*C_{di}*C_{tn})$

Expected Failure Load = $Z'*n$

where

C_D = Load Duration Factor = 1.6 for 10 minute duration

C_M = Wet Surface Factor = 1.0 for moisture content ≤ 19%

C_t = Temperature Factor = 1.0 for below 100ºF

C_g = Group Action Factor (see the following calculations)

C_Δ = Geometry Factor = 1.0

C_{eg} = End Grain Factor = 1.0

C_{di} = Diaphragm Factor = 1.0

C_{tn} = Toe-nail Factor = 1.0

n = number of fasteners per row

Group Action Factor (C_g)-

The calculation of the group action factors followed from NDS section 10.3.6.

$$C_g = \left[\frac{m(1-m^{2n})}{n\left[(1+R_{EA}*m^n)-1+m^{2n}\right]} \right] * \left[\frac{1+R_{EA}}{1-m} \right]$$

where

n = number of fasteners in a row = 5

R_{EA} = the lesser of $\frac{E_s A_s}{E_m A_m}$ or $\frac{E_m A_m}{E_s A_s}$

$A_m = 3.5 * 5.5 = 19.25$ in.^{2}

$A_s = 1.5 * 5.5 = 8.25$ in.^{2} for mode III

$= 3.5 * 5.5 = 19.25$ in.^{2} for mode IV

E_m = modulus of elasticity of main member, psi

E_s = modulus of elasticity of side member, psi

$m = u - \sqrt{u^2 - 1}$

$$u = 1 + \gamma\left(\frac{s}{2}\right)\left[\frac{1}{E_m A_m} + \frac{1}{E_s A_s}\right]$$

s = center-to-center spacing between adjacent fasteners

$\gamma = (180{,}000)(D^{1.5})$ lbs/in. for dowel-type fasteners in wood-to-wood connections

D = nominal diameter

Note: E_m and E_s were calculated using the following formula from Table 4-11b of the Forest Product Laboratory's Wood Handbook (USDA, 2002). This formula applies to softwoods at 12% MC.

$$\text{Modulus of Elasticity} = 2.97*(\text{Specific Gravity})^{0.84}$$

This yielded the following values for E_m and E_s.

$E_m = 2.97(0.471)^{0.84} = 1.578\text{x}10^6$ psi (for modes III and IV)
$E_s = 2.97(0.545)^{0.84} = 1.784\text{x}10^6$ psi (for mode III)
$= 2.97(0.471)^{0.84} = 1.578\text{x}10^6$ psi (for mode IV)

MODE III_s-

n = 5

$$\frac{E_s A_s}{E_m A_m} = \frac{1.784*10^6(8.25)}{1.578*10^6(19.25)} = 0.4845$$
$$\frac{E_m A_m}{E_s A_s} = \frac{1.578*10^6(19.25)}{1.784*10^6(8.25)} = 2.0639$$

Thus, $R_{EA} = 0.4845$

For s = 7D:

s = 7*(3/8) = 2.625 in.
$\gamma = (180{,}000)(3/8)^{1.5} = 41{,}335$ lbs/in.
$E_mA_m = 30.377*10^6$ lbs
$E_sA_s = 14.718*10^6$ lbs

$$u = 1 + 41335\left(\frac{2.625}{2}\right)\left[\frac{1}{30.377*10^6} + \frac{1}{14.718*10^6}\right] = 1.00547$$

$$m = 1.00547 - \sqrt{1.00547^2 - 1} = 0.901$$

$$C_g = \left[\frac{0.901(1-0.901^{2(5)})}{5\left[(1+0.4845(0.901)^5)(1+0.901) - 1 + 0.901^{2(5)}\right]}\right] * \left[\frac{1+0.4845}{1-0.901}\right] = \mathbf{0.9716}$$

For s = 8D:

s = 8*(3/8) = 3.0 in.
$\gamma = (180{,}000)(3/8)^{1.5} = 41{,}335$ lbs/in.
$E_mA_m = 30.377*10^6$ lbs
$E_sA_s = 14.718*10^6$ lbs

$$u = 1 + 41335\left(\frac{3.0}{2}\right)\left[\frac{1}{30.377*10^6} + \frac{1}{14.718*10^6}\right] = 1.00625$$

$$m = 1.00625 - \sqrt{1.00625^2 - 1} = 0.894$$

$$C_g = \left[\frac{0.894(1-0.894^{2(5)})}{5\left[(1+0.4845(0.894)^5)(1+0.894)-1+0.894^{2(5)}\right]}\right]*\left[\frac{1+0.4845}{1-0.894}\right] = \mathbf{0.9675}$$

MODE IV-

n = 5

$$\frac{E_sA_s}{E_mA_m} = \frac{1.578*10^6(19.25)}{1.578*10^6(19.25)} = 1.0$$

$$\frac{E_mA_m}{E_sA_s} = \frac{1.578*10^6(19.25)}{1.578*10^6(19.25)} = 1.0$$

Thus, $R_{EA} = 1.0$

For s = 7D:

s = 7*(3/8) = 2.625 in.
$\gamma = (180{,}000)(3/8)^{1.5} = 41{,}335$ lbs/in.
$E_mA_m = 30.377*10^6$ lbs
$E_sA_s = 30.377*10^6$ lbs

$$u = 1 + 41335\left(\frac{2.625}{2}\right)\left[\frac{1}{30.377*10^6} + \frac{1}{30.377*10^6}\right] = 1.00357$$

$$m = 1.00357 - \sqrt{1.00357^2 - 1} = 0.919$$

$$C_g = \left[\frac{0.919(1-0.919^{2(5)})}{5\left[(1+1.0(0.919)^5)(1+0.919)-1+0.919^{2(5)}\right]}\right]*\left[\frac{1+1.0}{1-0.919}\right] = \mathbf{0.9929}$$

For s = 8D:

s = 8*(3/8) = 3.0 in.

$\gamma = (180{,}000)(3/8)^{1.5} = 41{,}335$ lbs/in.

$E_mA_m = 30.377*10^6$ lbs

$E_sA_s = 30.377*10^6$ lbs

$$u = 1 + 41335\left(\frac{3.0}{2}\right)\left[\frac{1}{30.377*10^6} + \frac{1}{30.377*10^6}\right] = 1.00408$$

$$m = 1.00408 - \sqrt{1.00408^2 - 1} = 0.914$$

$$C_g = \left[\frac{0.914(1-0.914^{2(5)})}{5\left[(1+1.0(0.914)^5)(1+0.914)-1+0.914^{2(5)}\right]}\right] * \left[\frac{1+1.0}{1-0.914}\right] = \mathbf{0.9920}$$

EXPECTED FAILURE LOAD = $Z(C_D)(C_g)(n)$

MODE III_s:

(7D): Expected Failure Load = 1359(1.6)(0.9716)(5) = **10,600 lbs**

(8D): Expected Failure Load = 1359(1.6)(0.9675)(5) = **10,500 lbs**

MODE IV:

(7D): Expected Failure Load = 1394(1.6)(0.9929)(5) = **11,100 lbs**

(8D): Expected Failure Load = 1394(1.6)(0.9920)(5) = **11,100 lbs**

Appendix B: Connection Test Results

B.1: Introduction

This appendix includes all of the results related to the connection testing discussed in section 4.3. The results of the monotonic tests are included in section B.2. The results of the reverse-cyclic tests are included in section B.3. The results of the dowel embedment tests are included in section B.4. The results of the moisture content and specific gravity measurements are included in section B.5.

B.2: Monotonic Tests

Below are the results of the monotonic tests. The test data for each of the four data sets are summarized in Tables B.1-B.4. Following each of these tables are the load-deflection and E.E.P. curves for each connection in that given set. Finally, the mean values for each of the seven strength and serviceability parameters are included in Table B.5.

Table B.1: Monotonic Test Results for Mode III_s Connections, 7D Spacing

	37m1	37m2	37m3	MEAN	STDEV	COV (%)
Max Load (lbs) =	9830	8200	7720	8583	1106	12.89
Displacement (in) =	0.61	0.60	0.44	0.55	0.10	17.36
Failure Load (lbs) =	7800	5840	3260	5633	2277	40.42
Disp. @ Failure (in) =	0.64	0.60	0.45	0.56	0.10	17.77
40% Max (lbs) =	3920	3260	3060	3413	450	13.18
Displacement (in) =	0.15	0.20	0.18	0.18	0.03	14.97
E.E.P. Yield (lbs) =	8910	7710	6960	7860	984	12.51
Displacement (in) =	0.26	0.32	0.27	0.28	0.03	12.11
5% Offset Yield Load (lbs) =	6710	5990	5050	5917	832	14.07
Displacement (in) =	0.23	0.29	0.24	0.26	0.03	13.42
Elastic Stiffness (lb/in.)=	45700	37400	43000	42030	4234	10.07
Slack (in) =	0.06	0.12	0.10	0.09	0.03	28.56
E.E.P. Energy (lb*in) =	4220	2930	1820	2990	1201	40.17
Ductility Ratio =	2.45	1.86	1.68	2.00	0.40	20.24

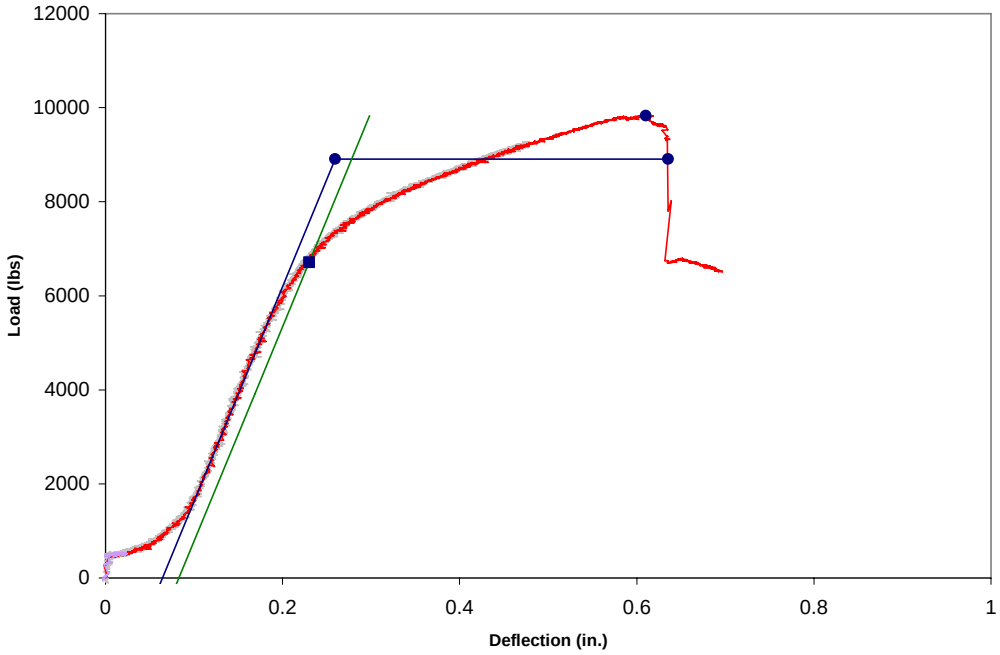

Figure B.1: Load vs. Deflection and E.E.P. Curve, 37m1

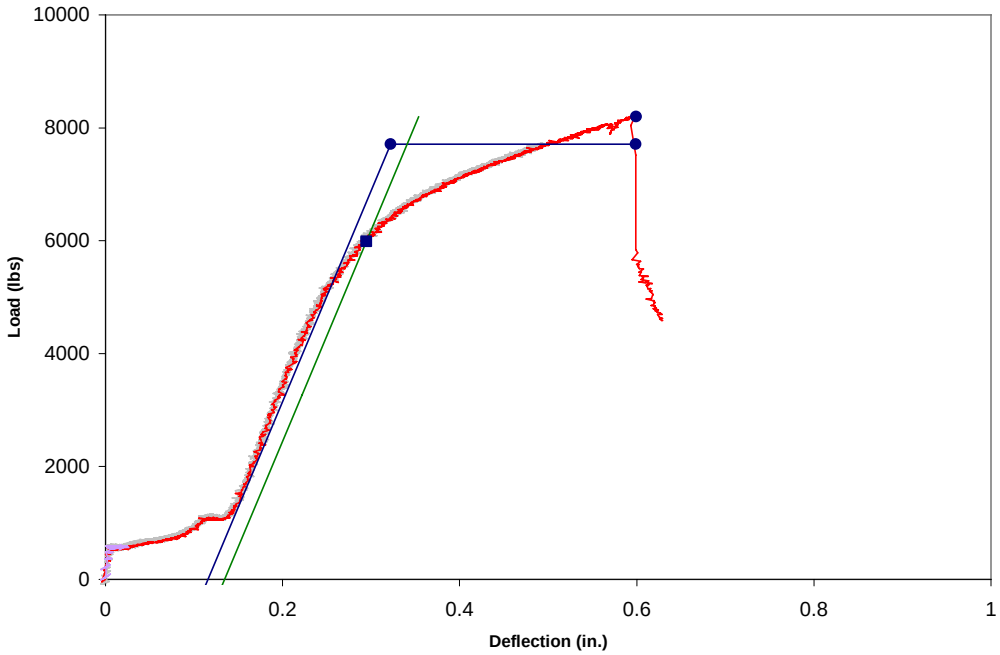

Figure B.2: Load vs. Deflection and E.E.P. Curve, 37m2

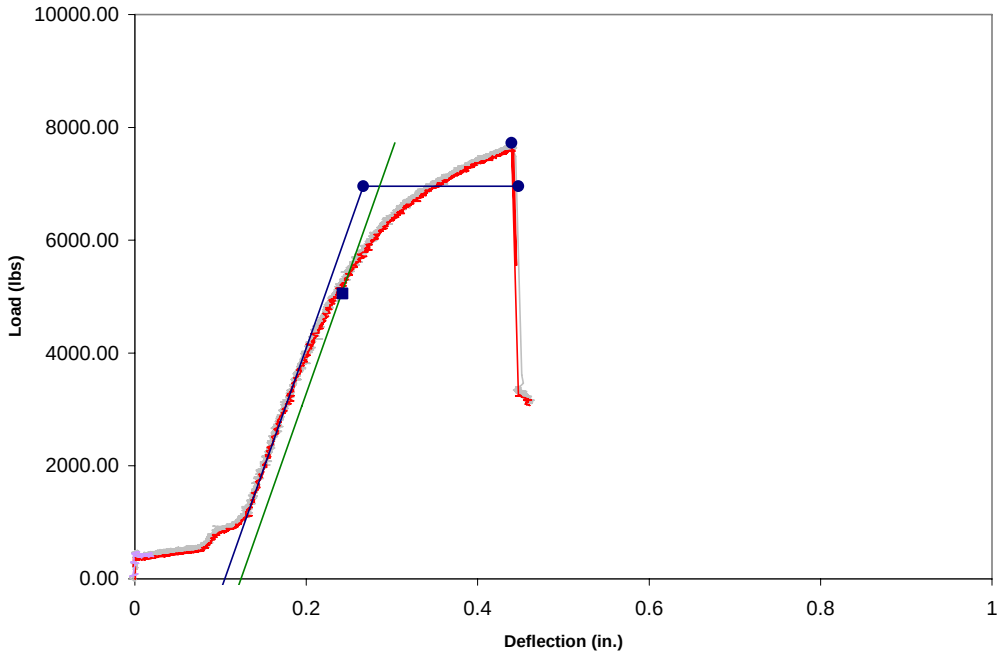

Figure B.3: Load vs. Deflection and E.E.P. Curve, 37m3

Table B.2: Monotonic Test Results for Mode III_s Connections, 8D Spacing

	38m1	38m2	38m3	MEAN	STDEV	COV (%)
Max Load (lbs) =	7950	8680	6880	7837	905	11.55
Displacement (in) =	0.55	0.55	0.51	0.54	0.02	4.03
Failure Load (lbs) =	6210	5360	3920	5163	1158	22.42
Disp. @ Failure (in) =	0.55	0.80	0.52	0.62	0.15	24.03
40% Max (lbs) =	3160	3450	2730	3113	362	11.64
Displacement (in) =	0.22	0.20	0.17	0.20	0.03	13.96
E.E.P. Yield (lbs) =	7530	7780	6150	7153	878	12.27
Displacement (in) =	0.32	0.31	0.26	0.30	0.03	10.25
5% Offset Yield Load (lbs) =	5650	5740	4570	5320	651	12.24
Displacement (in) =	0.30	0.28	0.24	0.27	0.03	11.35
Elastic Stiffness (lb/in.)=	41400	42800	34600	39600	4386	11.08
Slack (in) =	0.14	0.12	0.09	0.12	0.03	24.02
E.E.P. Energy (lb*in) =	2420	4520	2130	3023	1304	43.14
Ductility Ratio =	1.71	2.61	1.98	2.10	0.46	21.89

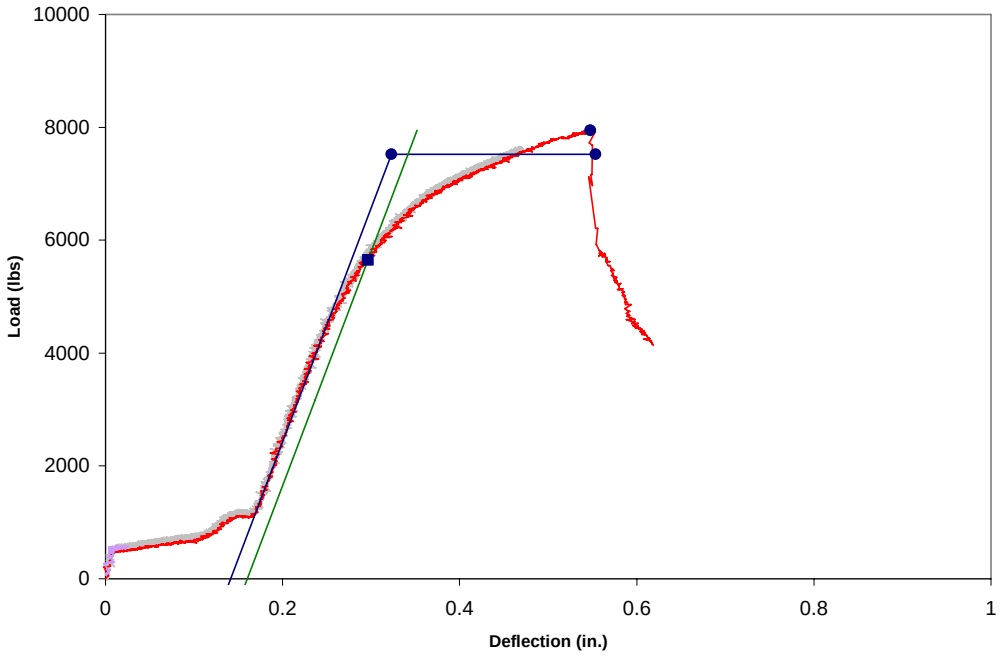

Figure B.4: Load vs. Deflection and E.E.P. Curve, 38m1

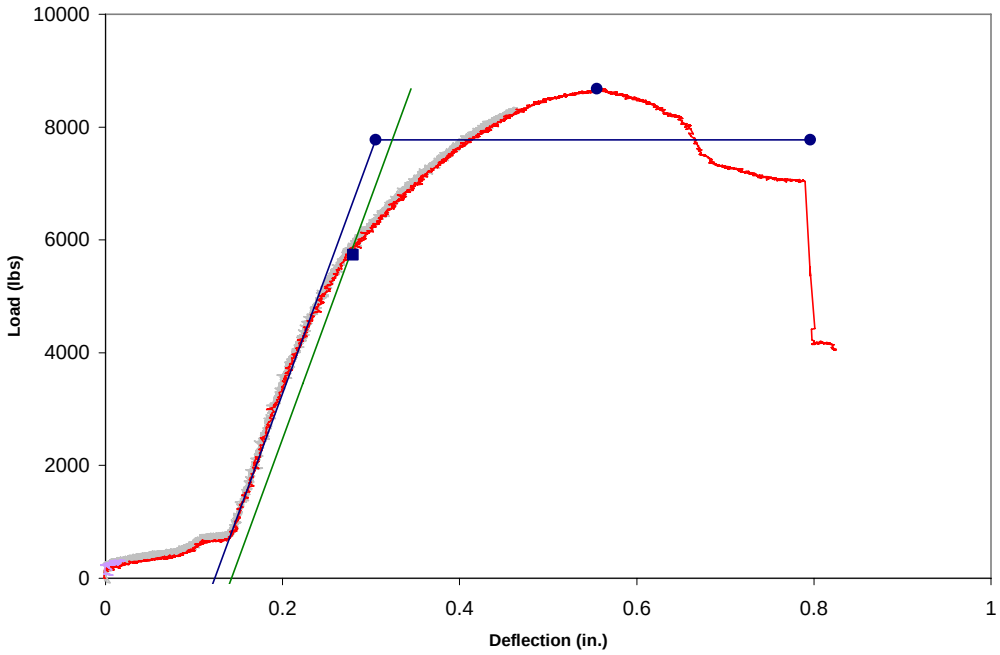

Figure B.5: Load vs. Deflection and E.E.P. Curve, 38m2

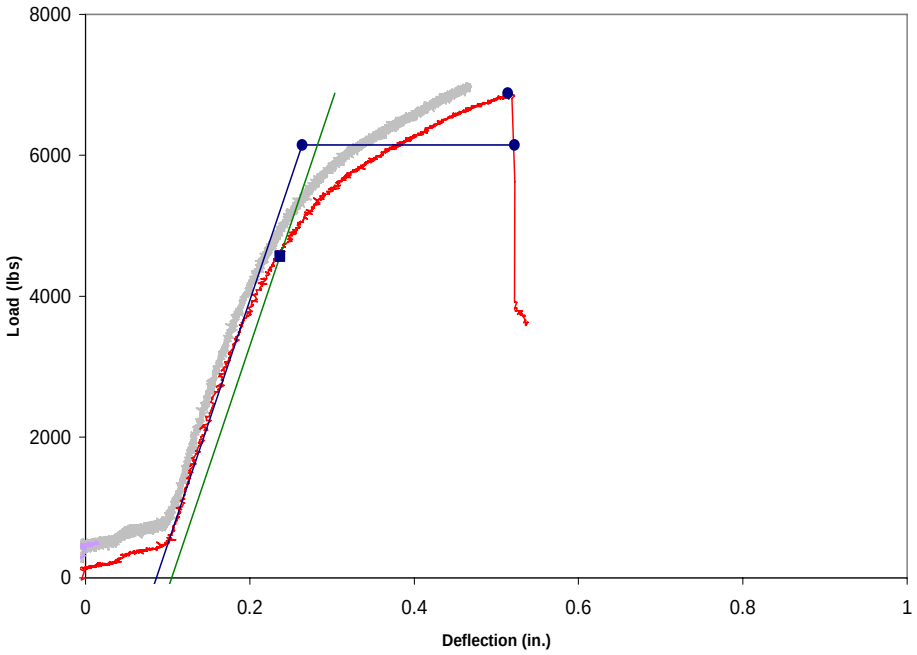

Figure B.6: Load vs. Deflection and E.E.P. Curve, 38m3

Table B.3: Monotonic Test Results for Mode IV Connections, 7D Spacing

	47m1	47m2	47m3	MEAN	STDEV	COV (%)
Max Load (lbs) =	11230	9360	9920	10170	960	9.44
Displacement (in) =	1.17	0.86	1.01	1.02	0.16	15.27
Failure Load (lbs) =	8900	7220	7870	7997	847	10.59
Disp. @ Failure (in) =	1.33	0.94	1.11	1.13	0.20	17.41
40% Max (lbs) =	4330	3480	3840	3883	427	10.99
Displacement (in) =	0.25	0.20	0.18	0.21	0.03	16.29
E.E.P. Yield (lbs) =	9640	8270	8460	8790	742	8.44
Displacement (in) =	0.38	0.31	0.30	0.33	0.05	14.32
5% Offset Yield Load (lbs) =	6720	5590	5820	6043	597	9.88
Displacement (in) =	0.33	0.27	0.25	0.28	0.04	14.59
Elastic Stiffness (lb/in.)=	38500	44200	39400	40700	3064	7.53
Slack (in) =	0.13	0.12	0.08	0.11	0.03	23.92
E.E.P. Energy (lb*in) =	10370	6010	7820	8067	2190	27.15
Ductility Ratio =	3.48	3.05	3.75	3.43	0.35	10.36

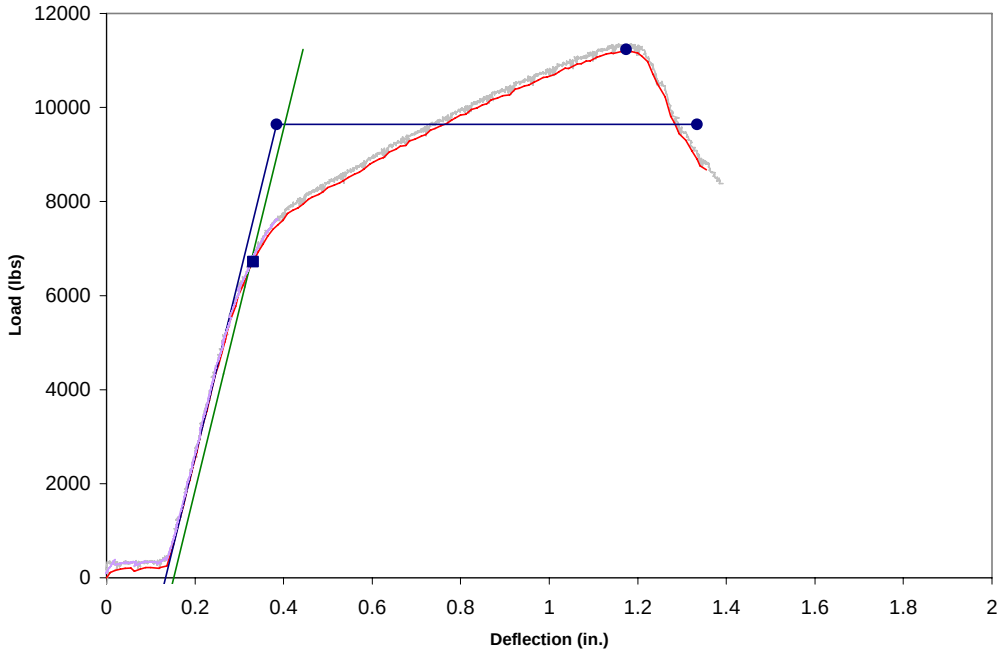

Figure B.7: Load vs. Deflection and E.E.P. Curve, 47m1

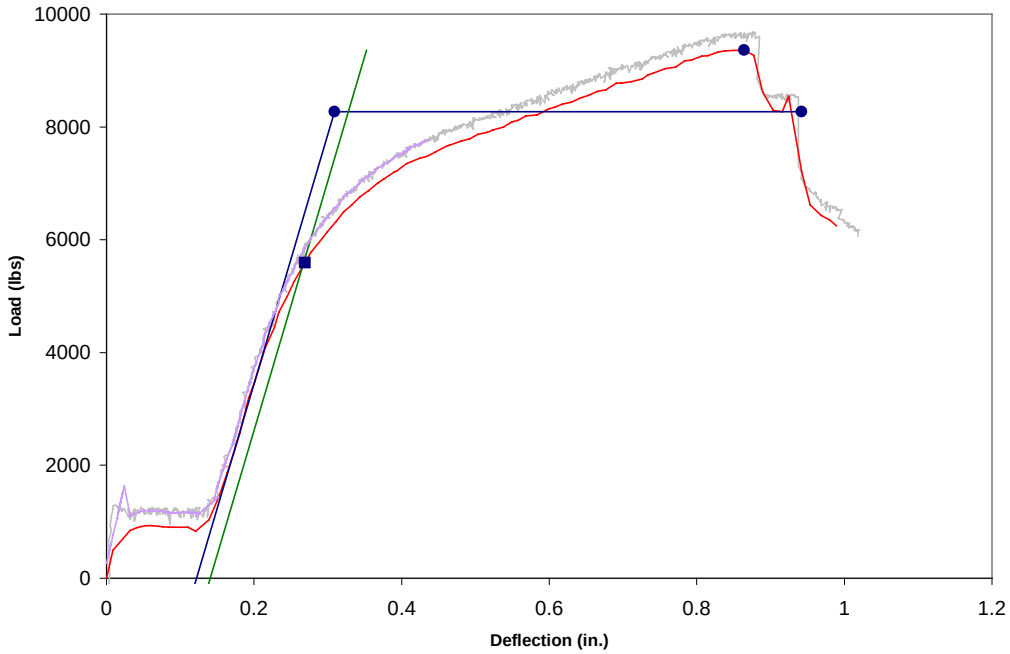

Figure B.8: Load vs. Deflection and E.E.P. Curve, 47m2

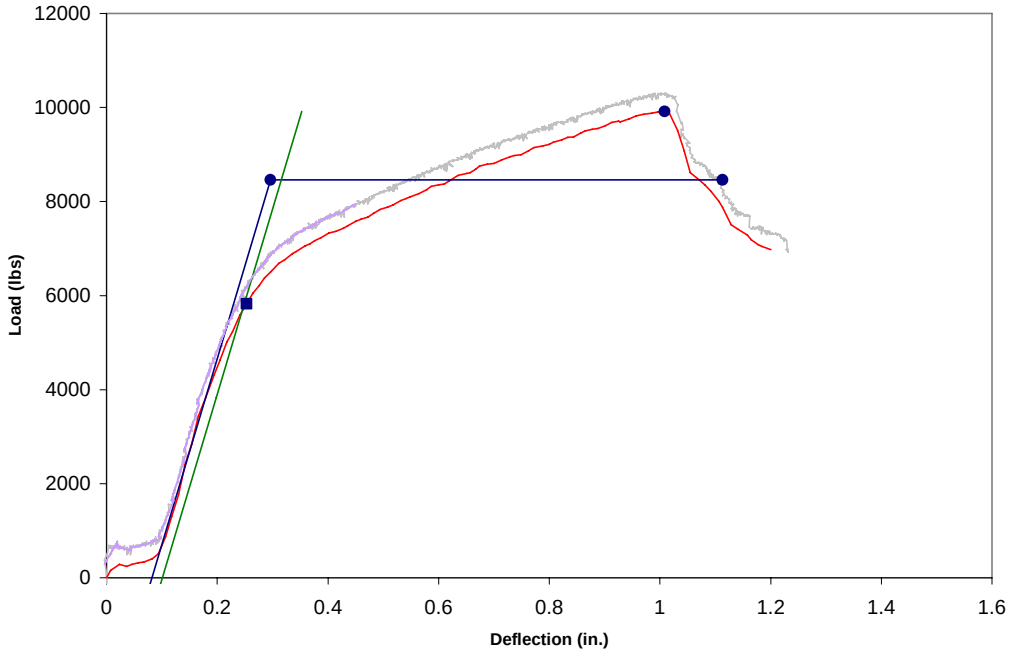

Figure B.9: Load vs. Deflection and E.E.P. Curve, 47m3

Table B.4: Monotonic Test Results for Mode IV Connections, 8D Spacing

	48m1	48m2	48m4	MEAN	STDEV	COV (%)
Max Load (lbs) =	9710	7470	9850	9010	1336	14.82
Displacement (in) =	1.14	0.38	1.19	0.90	0.45	50.20
Failure Load (lbs) =	7520	5940	7730	7063	978	13.85
Disp. @ Failure (in) =	1.61	0.51	1.36	1.16	0.58	49.82
40% Max (lbs) =	3870	2810	3760	3480	583	16.75
Displacement (in) =	0.19	0.12	0.23	0.18	0.06	32.87
E.E.P. Yield (lbs) =	9050	6730	8400	8060	1197	14.85
Displacement (in) =	0.31	0.21	0.35	0.29	0.07	25.27
5% Offset Yield Load (lbs) =	6330	5220	5670	5740	558	9.73
Displacement (in) =	0.27	0.19	0.30	0.26	0.06	22.18
Elastic Stiffness (lb/in.)=	43300	42400	39600	41770	1930	4.62
Slack (in) =	0.10	0.05	0.14	0.10	0.04	45.79
E.E.P. Energy (lb*in) =	12710	2560	9360	8210	5172	62.99
Ductility Ratio =	5.15	2.45	3.89	3.83	1.35	35.28

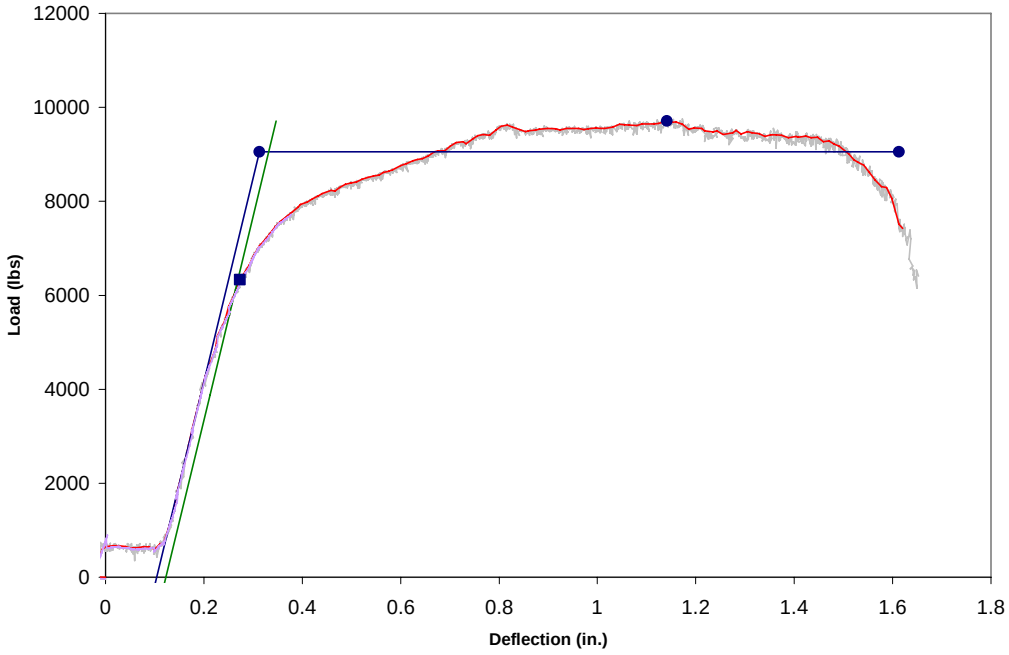

Figure B.10: Load vs. Deflection and E.E.P. Curve, 48m1

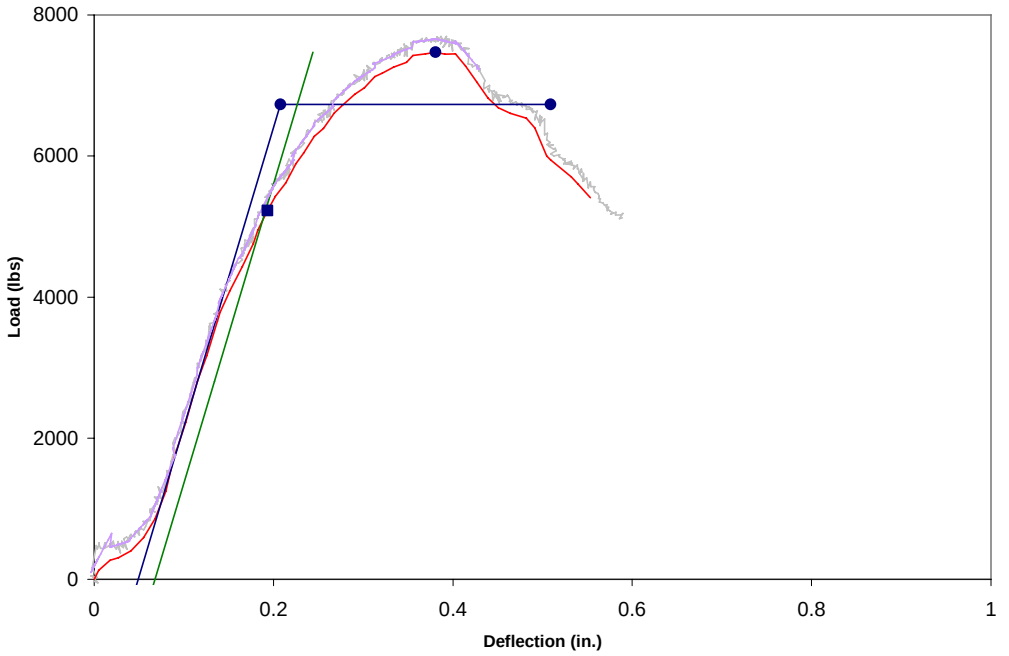

Figure B.11: Load vs. Deflection and E.E.P. Curve, 48m2

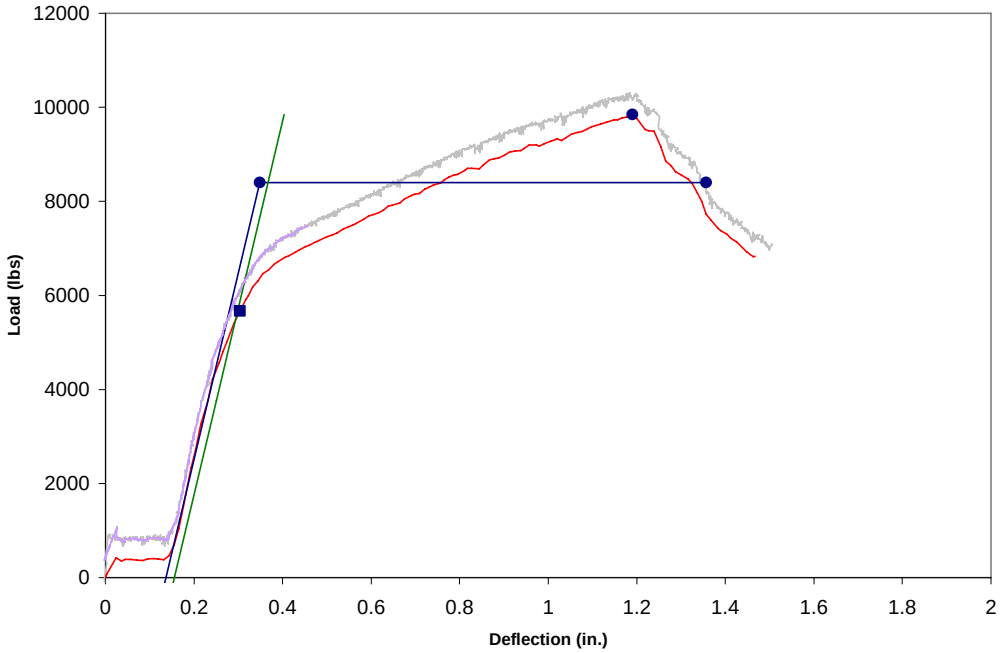

Figure B.12: Load vs. Deflection and E.E.P. Curve, 48m4

Table B.5: Summary of Mean Values for Seven Strength and Serviceability Parameters, Monotonic Tests

	37m (7D)	38m (8D)	47m (7D)	48m (8D)
Max Load (lbs) =	8583	7837	10170	9010
Failure Load (lbs) =	5633	5163	7997	7063
E.E.P. Yield (lbs) =	7860	7153	8790	8060
5% Offset Yield =	5917	5320	6043	5740
Elastic Stiffness (lb/in.)=	42030	39600	40700	41770
E.E.P. Energy (lb*in) =	2990	3023	8067	8210
Ductility Ratio =	2.00	2.10	3.43	3.83

B.3: Reverse-Cyclic Tests

Below are the results of the reverse-cyclic tests. A plot showing the load-deflection curves, E.E.P. curves, and 5% offset lines is included for each of the forty reverse-cyclic connections. In addition, a table of test values for the seven strength and serviceability parameters is included for each of these connections. The averaged values in these tables include only the significant digits.

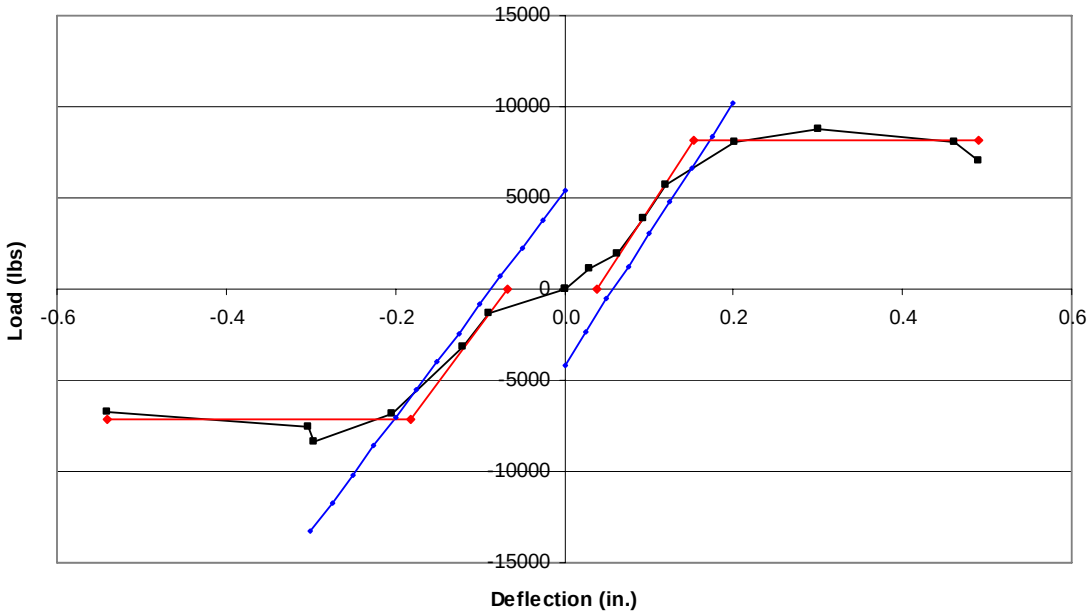

Figure B.13: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c1

Table B.6: Seven Strength and Serviceability Parameters, 37c1

	POS	NEG	AVG
Max Load (lbs)	8747.28	-8415.34	8580
Failure Load (lbs)	6997.82	-6732.27	6870
Elastic Stiffness (lbs/in.)	71573.96	62133.33	66900
5% Offset Load (lbs)	6609.42	-5874.61	6240
E.E.P. Energy (lbs*in.)	3192.55	2951.94	3070
Ductility Ratio	3.967086	4.11952	4.04
E.E.P. Yield Load (lbs)	8118.287	-7118.53	7620

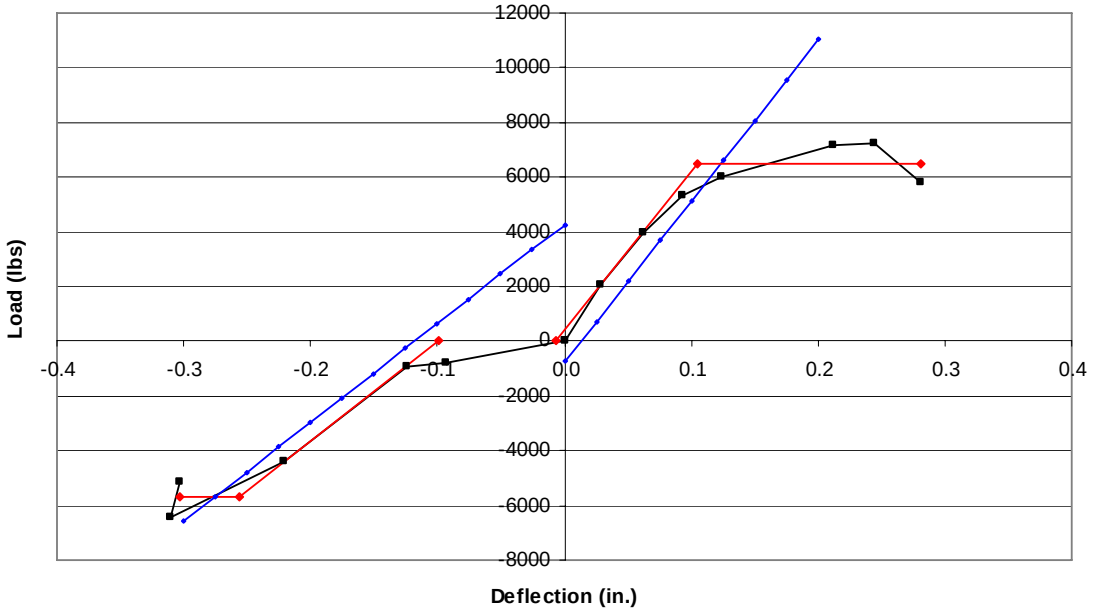

Figure B.14: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c2

Table B.7: Seven Strength and Serviceability Parameters, 37c2

	POS	NEG	AVG
Max Load (lbs)	7253.02	-6456.57	6850
Failure Load (lbs)	5802.41	-5165.25	5480
Elastic Stiffness (lbs/in.)	58816.90	36106.75	47500
5% Offset Load (lbs)	5701.09	-5594.50	5650
E.E.P. Energy (lbs*in.)	1514.40	711.15	1110
Ductility Ratio	2.602389	1.299614	1.95
E.E.P. Yield Load (lbs)	6509.018	-5666.75	6090

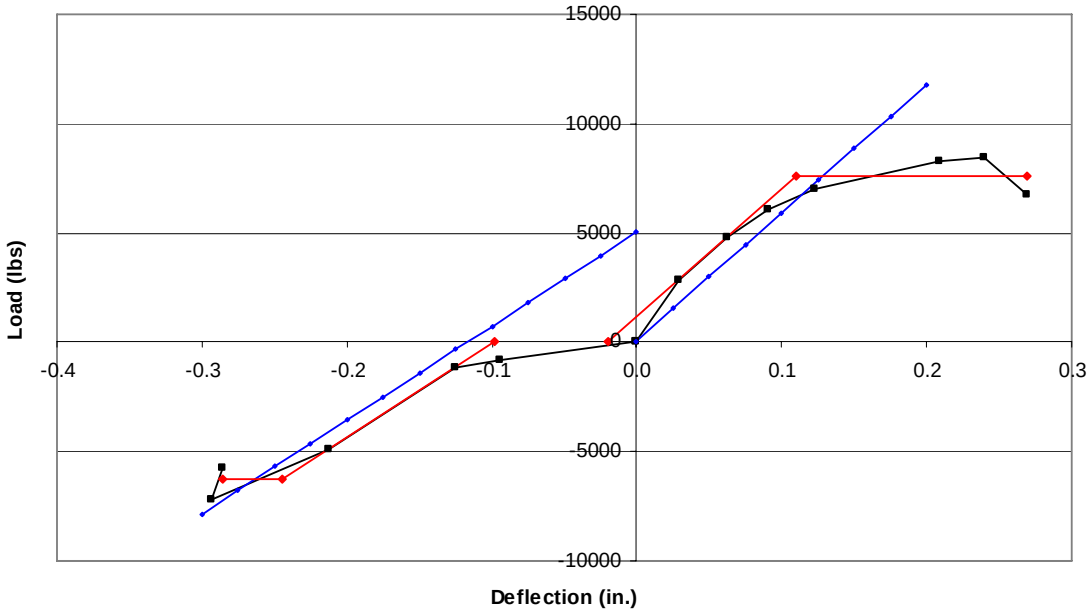

Figure B.15: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c3

Table B.8: Seven Strength and Serviceability Parameters, 37c3

	POS	NEG	AVG
Max Load (lbs)	8451.23	-7155.48	7800
Failure Load (lbs)	6760.99	-5724.38	6240
Elastic Stiffness (lbs/in.)	58720.72	43015.71	50900
5% Offset Load (lbs)	6816.35	-6394.11	6610
E.E.P. Energy (lbs*in.)	1705.33	720.64	1210
Ductility Ratio	2.235704	1.280818	1.76
E.E.P. Yield Load (lbs)	7595.609	-6300.84	6950

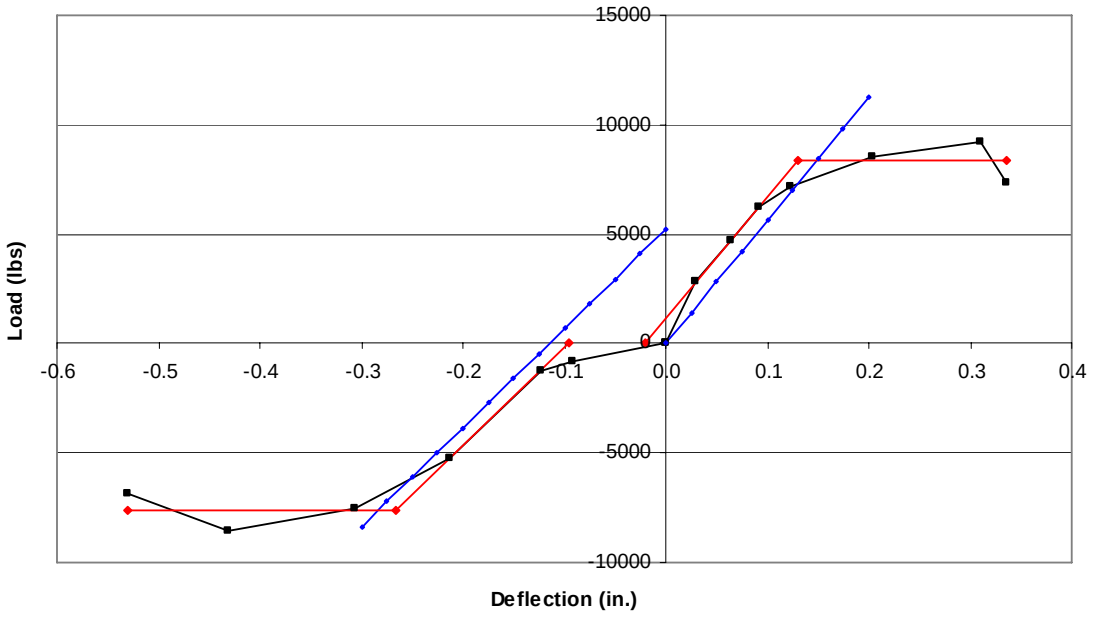

Figure B.16: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c4

Table B.9: Seven Strength and Serviceability Parameters, 37c4

	POS	NEG	AVG
Max Load (lbs)	9205.69	-8556.95	8880
Failure Load (lbs)	7364.55	-6845.56	7110
Elastic Stiffness (lbs/in.)	56022.47	45243.52	50600
5% Offset Load (lbs)	7329.09	-6231.39	6780
E.E.P. Energy (lbs*in.)	2351.27	2669.12	2510
Ductility Ratio	2.375688	2.56238	2.47
E.E.P. Yield Load (lbs)	8380.154	-7652.05	8020

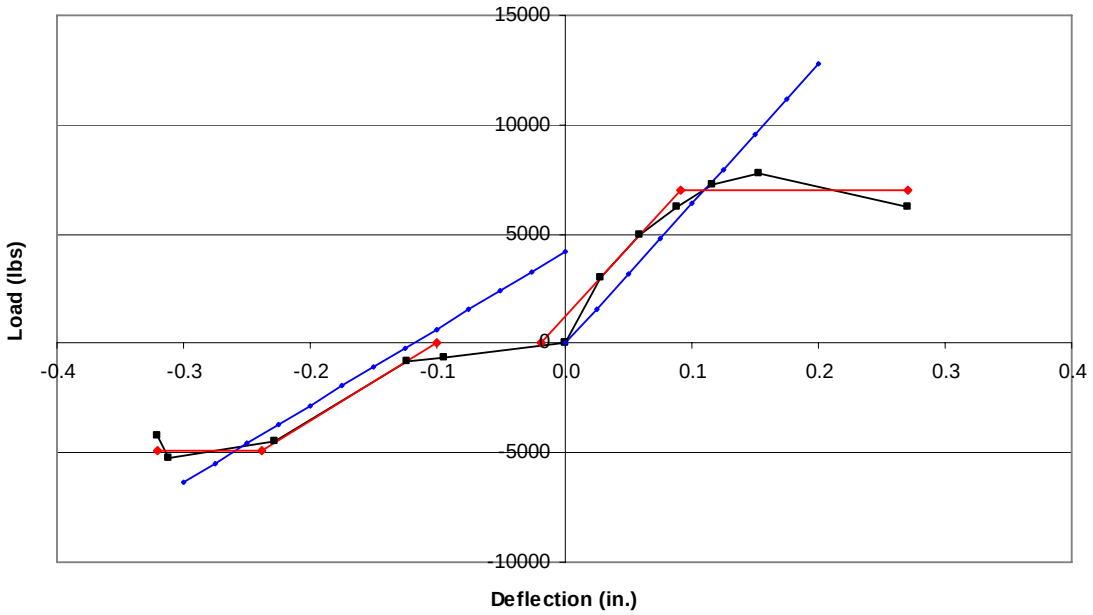

Figure B.17: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c5

Table B.10: Seven Strength and Serviceability Parameters, 37c5

	POS	NEG	AVG
Max Load (lbs)	7760.87	-5240.65	6500
Failure Load (lbs)	6208.70	-4192.52	5200
Elastic Stiffness (lbs/in.)	63820.90	35039.76	49400
5% Offset Load (lbs)	6941.15	-4698.46	5820
E.E.P. Energy (lbs*in.)	1640.34	738.19	1190
Ductility Ratio	2.635021	1.594569	2.11
E.E.P. Yield Load (lbs)	7002.402	-4861.19	5930

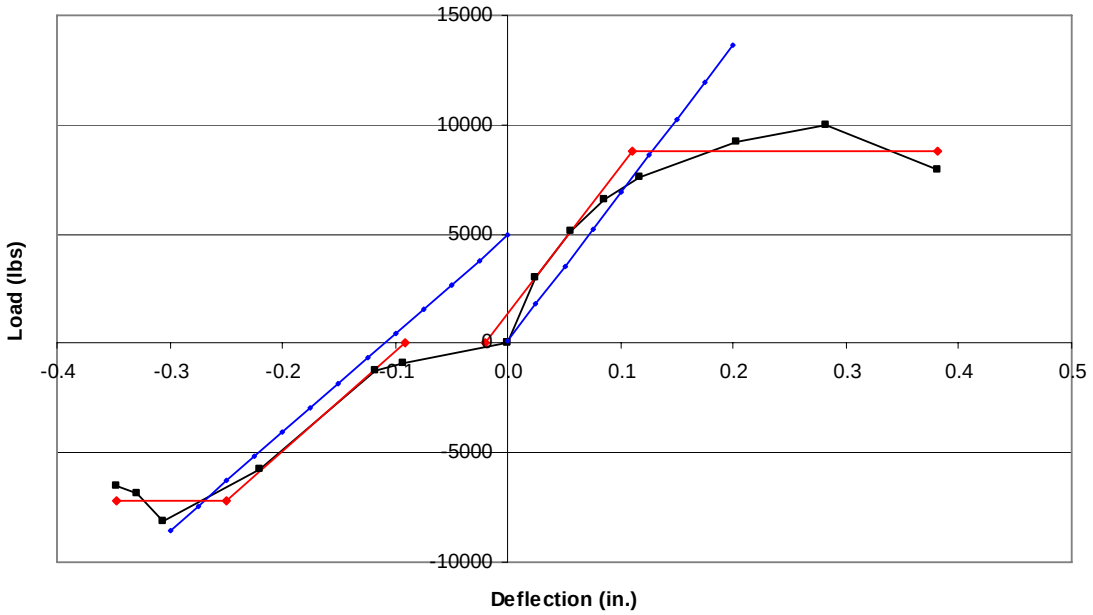

Figure B.18: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c6

Table B.11: Seven Strength and Serviceability Parameters, 37c6

	POS	NEG	AVG
Max Load (lbs)	9959.53	-8105.26	9030
Failure Load (lbs)	7967.62	-6484.21	7230
Elastic Stiffness (lbs/in.)	67782.18	44904.98	56300
5% Offset Load (lbs)	7191.13	-7041.41	7120
E.E.P. Energy (lbs*in.)	2962.36	1261.98	2110
Ductility Ratio	3.090475	1.606386	2.35
E.E.P. Yield Load (lbs)	8804.137	-7156.82	7980

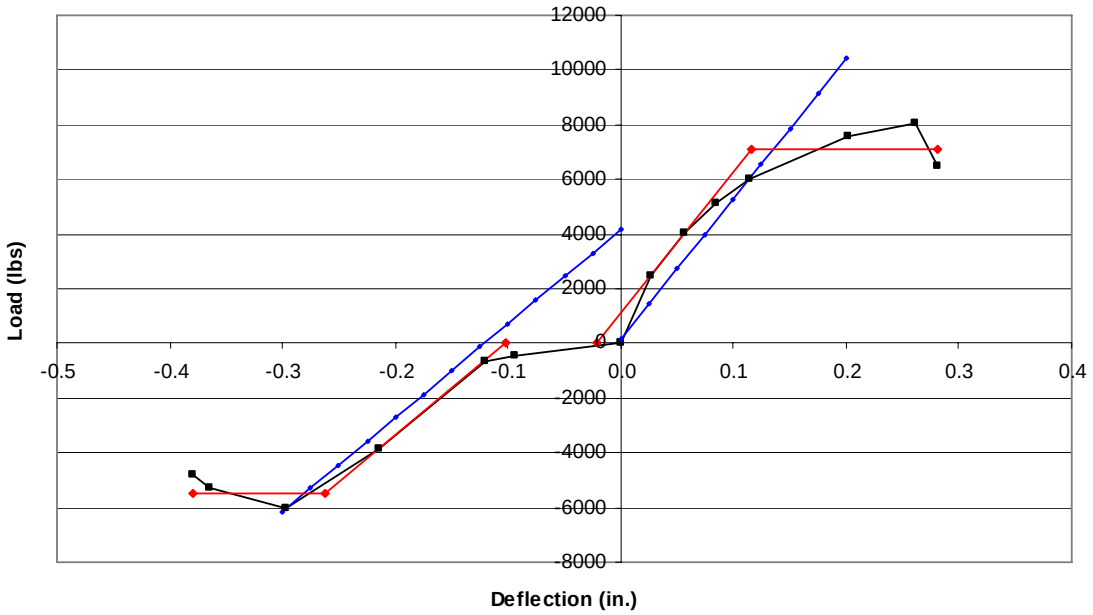

Figure B.19: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c7

Table B.12: Seven Strength and Serviceability Parameters, 37c7

	POS	NEG	AVG
Max Load (lbs)	8085.60	-6034.17	7060
Failure Load (lbs)	6468.48	-4827.34	5650
Elastic Stiffness (lbs/in.)	51313.13	34418.30	42900
5% Offset Load (lbs)	6022.58	-5973.72	6000
E.E.P. Energy (lbs*in.)	1653.86	1084.91	1370
Ductility Ratio	2.196173	1.741559	1.97
E.E.P. Yield Load (lbs)	7073.405	-5484.14	6280

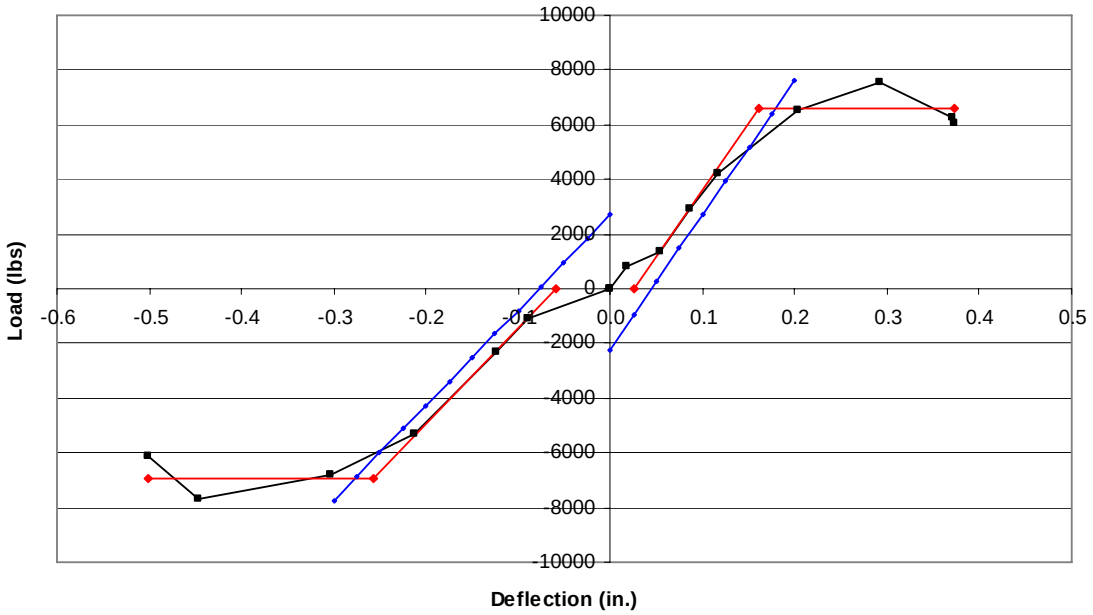

Figure B.20: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c8

Table B.13: Seven Strength and Serviceability Parameters, 37c8

	POS	NEG	AVG
Max Load (lbs)	7538.68	-7660.28	7600
Failure Load (lbs)	6030.95	-6128.22	6080
Elastic Stiffness (lbs/in.)	49223.30	34792.32	42000
5% Offset Load (lbs)	5031.61	-5871.71	5450
E.E.P. Energy (lbs*in.)	1838.47	2370.90	2100
Ductility Ratio	2.581869	2.225258	2.40
E.E.P. Yield Load (lbs)	6593.061	-6914.67	6750

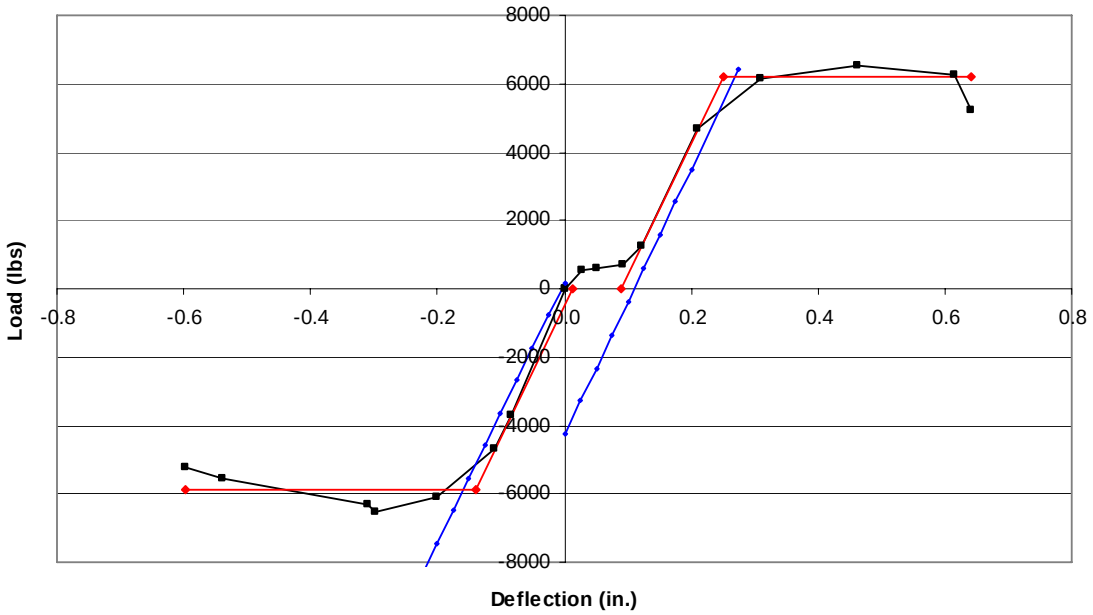

Figure B.21: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c9

Table B.14: Seven Strength and Serviceability Parameters, 37c9

	POS	NEG	AVG
Max Load (lbs)	6554.11	-6549.96	6550
Failure Load (lbs)	5243.29	-5239.97	5240
Elastic Stiffness (lbs/in.)	38783.51	37965.32	38400
5% Offset Load (lbs)	5136.00	-5182.02	5160
E.E.P. Energy (lbs*in.)	2921.71	3147.91	3030
Ductility Ratio	3.454085	3.936682	3.70
E.E.P. Yield Load (lbs)	6193.424	-5897.05	6050

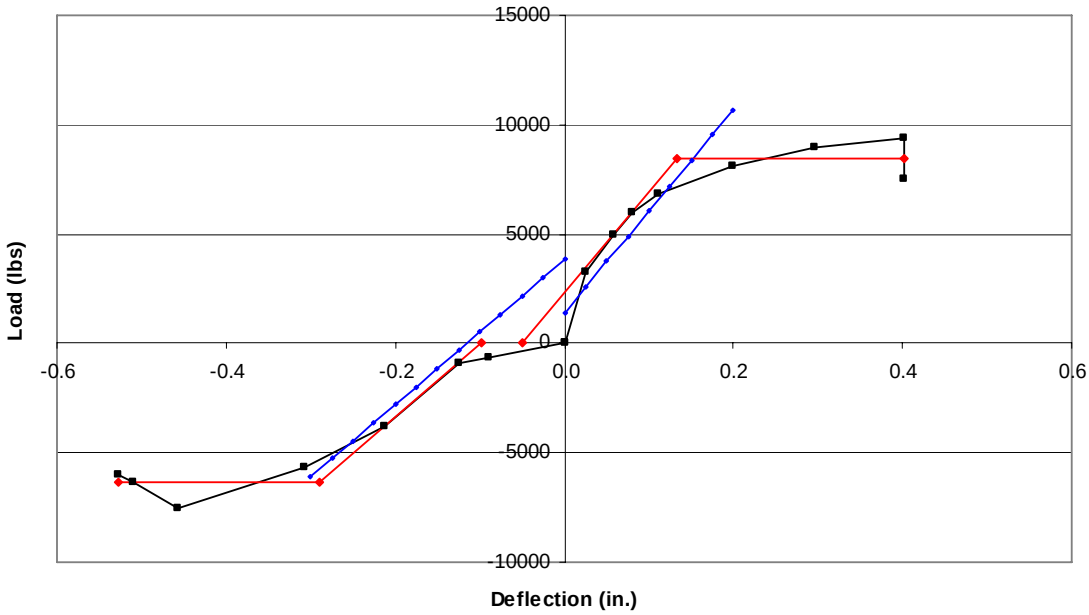

Figure B.22: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 37c10

Table B.15: Seven Strength and Serviceability Parameters, 37c10

	POS	NEG	AVG
Max Load (lbs)	9358.90	-7505.84	8430
Failure Load (lbs)	7487.12	-6004.68	6750
Elastic Stiffness (lbs/in.)	46383.56	33114.19	39700
5% Offset Load (lbs)	6938.76	-4697.30	5820
E.E.P. Energy (lbs*in.)	3043.54	2137.69	2590
Ductility Ratio	2.4812	2.240202	2.36
E.E.P. Yield Load (lbs)	8441.263	-6377.93	7410

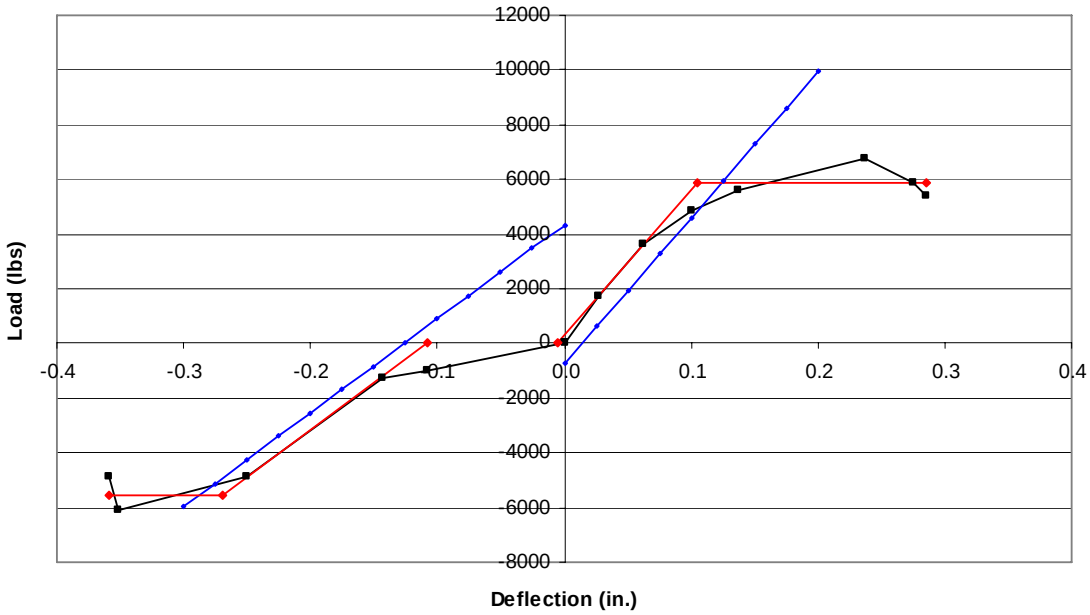

Figure B.23: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c1

Table B.16: Seven Strength and Serviceability Parameters, 38c1

	POS	NEG	AVG
Max Load (lbs)	6729.90	-6084.22	6410
Failure Load (lbs)	5383.92	-4867.38	5130
Elastic Stiffness (lbs/in.)	53339.06	34351.93	43800
5% Offset Load (lbs)	4953.45	-5229.10	5090
E.E.P. Energy (lbs*in.)	1388.88	948.34	1170
Ductility Ratio	2.625557	1.558417	2.09
E.E.P. Yield Load (lbs)	5903.633	-5547.91	5730

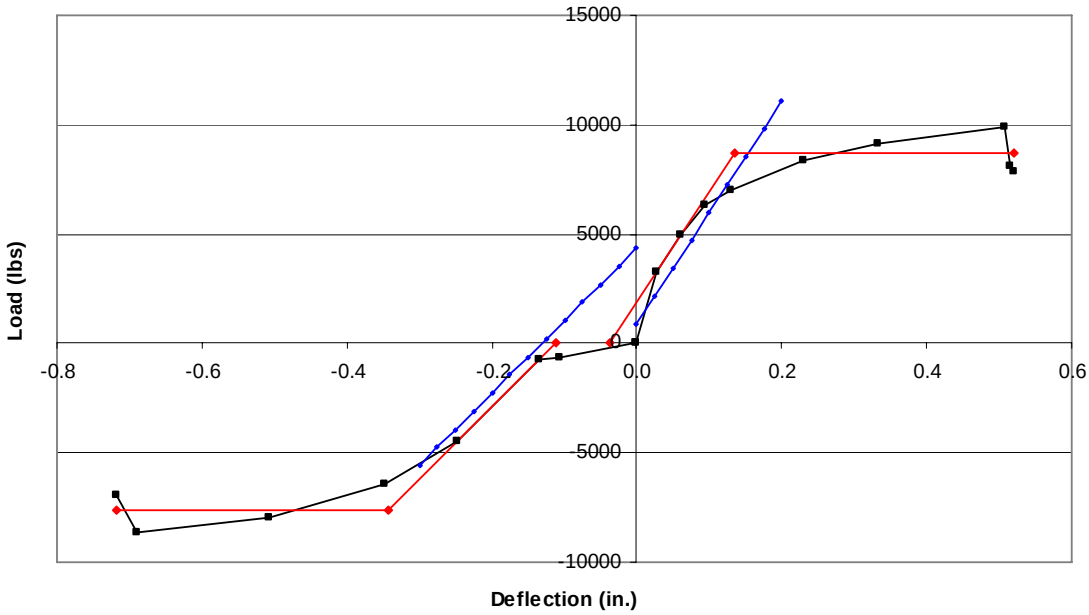

Figure B.24: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c2

Table B.17: Seven Strength and Serviceability Parameters, 38c2

	POS	NEG	AVG
Max Load (lbs)	9871.63	-8642.41	9260
Failure Load (lbs)	7897.31	-6913.93	7410
Elastic Stiffness (lbs/in.)	50785.05	33195.71	42000
5% Offset Load (lbs)	6679.20	-5350.41	6010
E.E.P. Energy (lbs*in.)	4092.44	3727.46	3910
Ductility Ratio	3.244795	2.64421	2.94
E.E.P. Yield Load (lbs)	8701.701	-7596.51	8150

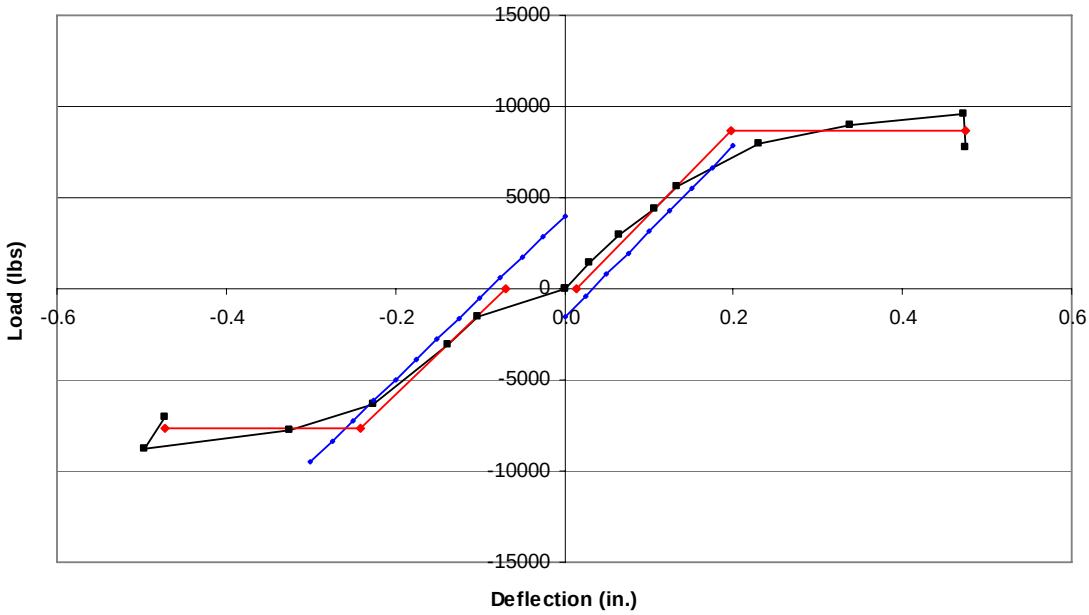

Figure B.25: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c3

Table B.18: Seven Strength and Serviceability Parameters, 38c3

	POS	NEG	AVG
Max Load (lbs)	9631.75	-8815.76	9220
Failure Load (lbs)	7705.40	-7052.61	7380
Elastic Stiffness (lbs/in.)	47113.64	45004.48	46100
5% Offset Load (lbs)	6624.58	-6358.96	6490
E.E.P. Energy (lbs*in.)	3184.40	2432.75	2810
Ductility Ratio	2.509213	2.354948	2.43
E.E.P. Yield Load (lbs)	8641.207	-7682.65	8160

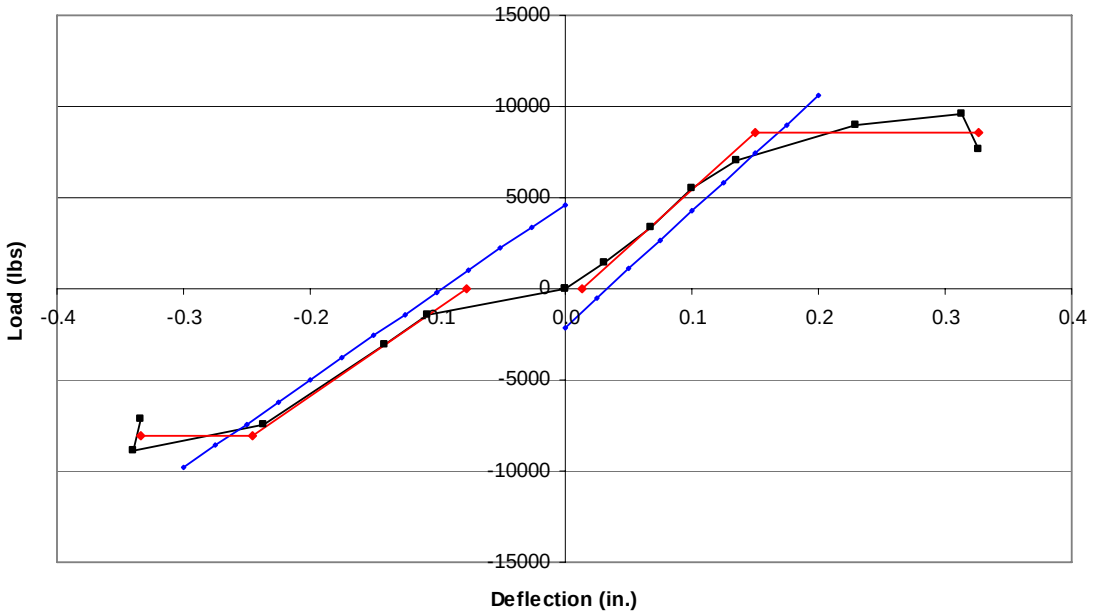

Figure B.26: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c4

Table B.19: Seven Strength and Serviceability Parameters, 38c4

	POS	NEG	AVG
Max Load (lbs)	9612.21	-8891.45	9250
Failure Load (lbs)	7689.77	-7113.16	7400
Elastic Stiffness (lbs/in.)	63611.11	48089.69	55900
5% Offset Load (lbs)	7356.13	-7720.43	7540
E.E.P. Energy (lbs*in.)	2102.74	1397.87	1750
Ductility Ratio	2.300176	1.530185	1.92
E.E.P. Yield Load (lbs)	8619.902	-8077.95	8350

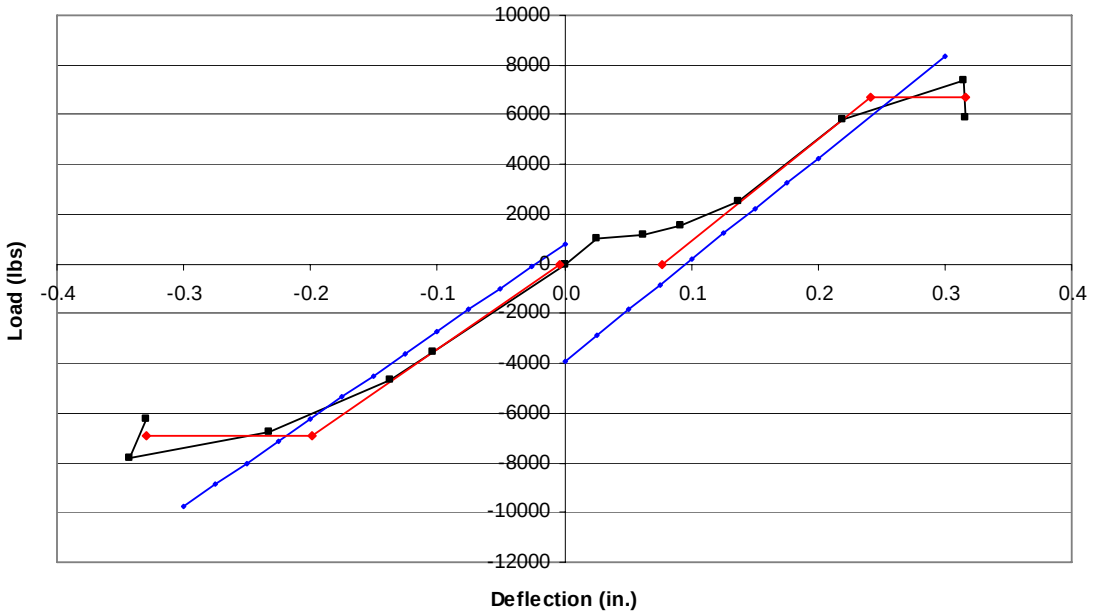

Figure B.27: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c5

Table B.20: Seven Strength and Serviceability Parameters, 38c5

	POS	NEG	AVG
Max Load (lbs)	7392.19	-7781.75	7590
Failure Load (lbs)	5913.75	-6225.40	6070
Elastic Stiffness (lbs/in.)	40753.73	35125.58	37900
5% Offset Load (lbs)	6353.55	-5754.74	6050
E.E.P. Energy (lbs*in.)	1058.81	1572.88	1320
Ductility Ratio	1.457956	1.666405	1.56
E.E.P. Yield Load (lbs)	6711.519	-6882.33	6800

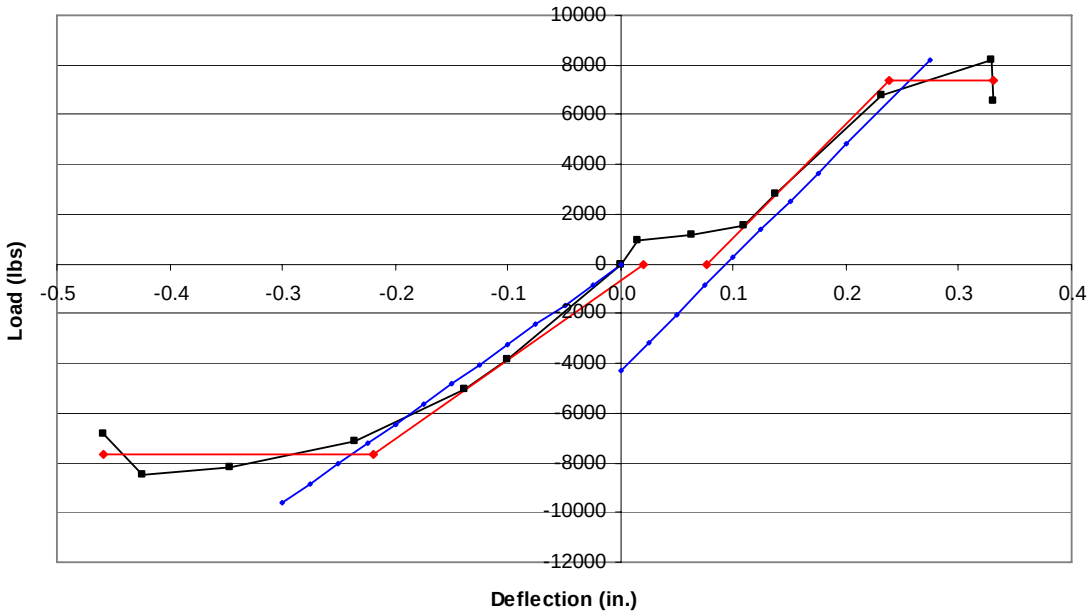

Figure B.28: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c6

Table B.21: Seven Strength and Serviceability Parameters, 38c6

	POS	NEG	AVG
Max Load (lbs)	8189.37	-8501.41	8350
Failure Load (lbs)	6551.50	-6801.13	6680
Elastic Stiffness (lbs/in.)	45521.74	31869.92	38700
5% Offset Load (lbs)	7050.74	-6232.65	6640
E.E.P. Energy (lbs*in.)	1276.22	2758.38	2020
Ductility Ratio	1.570332	1.995666	1.78
E.E.P. Yield Load (lbs)	7367.381	-7666.55	7520

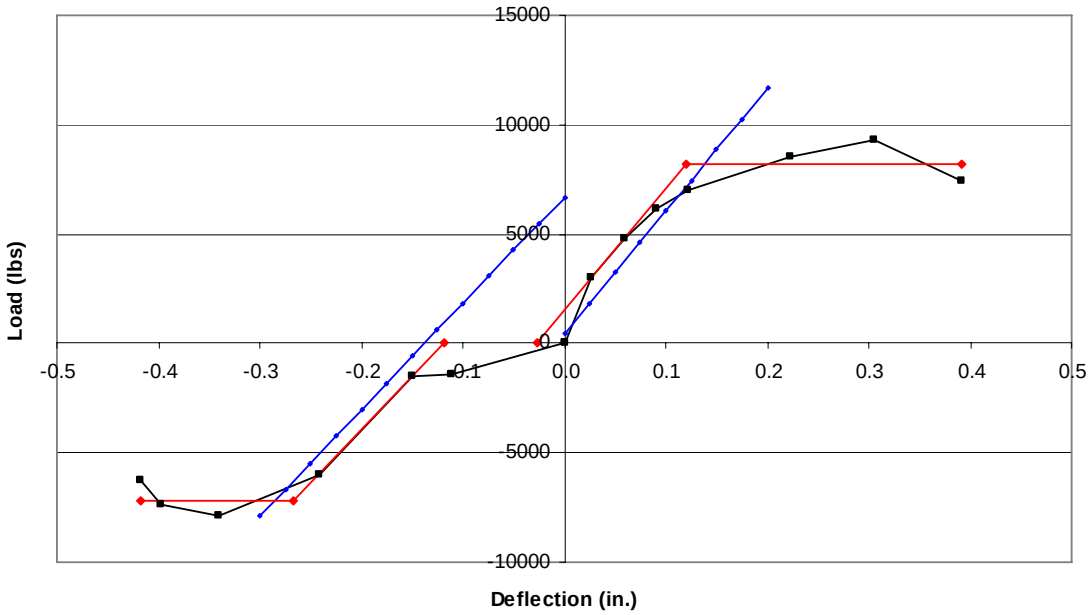

Figure B.29: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c7

Table B.22: Seven Strength and Serviceability Parameters, 38c7

	POS	NEG	AVG
Max Load (lbs)	9275.27	-7839.73	8560
Failure Load (lbs)	7420.22	-6271.79	6850
Elastic Stiffness (lbs/in.)	56092.59	48624.58	52400
5% Offset Load (lbs)	6844.66	-6551.92	6700
E.E.P. Energy (lbs*in.)	2837.93	1616.88	2230
Ductility Ratio	2.864542	2.007653	2.44
E.E.P. Yield Load (lbs)	8205.025	-7221.3	7710

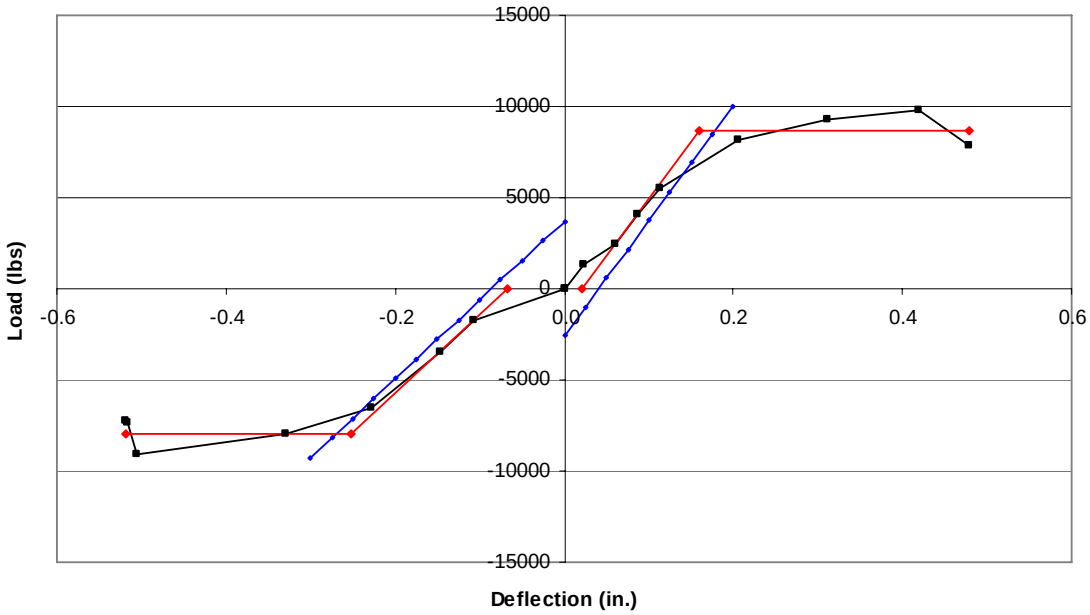

Figure B.30: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c8

Table B.23: Seven Strength and Serviceability Parameters, 38c8

	POS	NEG	AVG
Max Load (lbs)	9759.93	-9092.27	9430
Failure Load (lbs)	7807.94	-7273.82	7540
Elastic Stiffness (lbs/in.)	62928.57	43267.18	53100
5% Offset Load (lbs)	6298.01	-6657.72	6480
E.E.P. Energy (lbs*in.)	3372.23	2880.56	3130
Ductility Ratio	3.324898	2.442834	2.88
E.E.P. Yield Load (lbs)	8667.242	-8009.4	8340

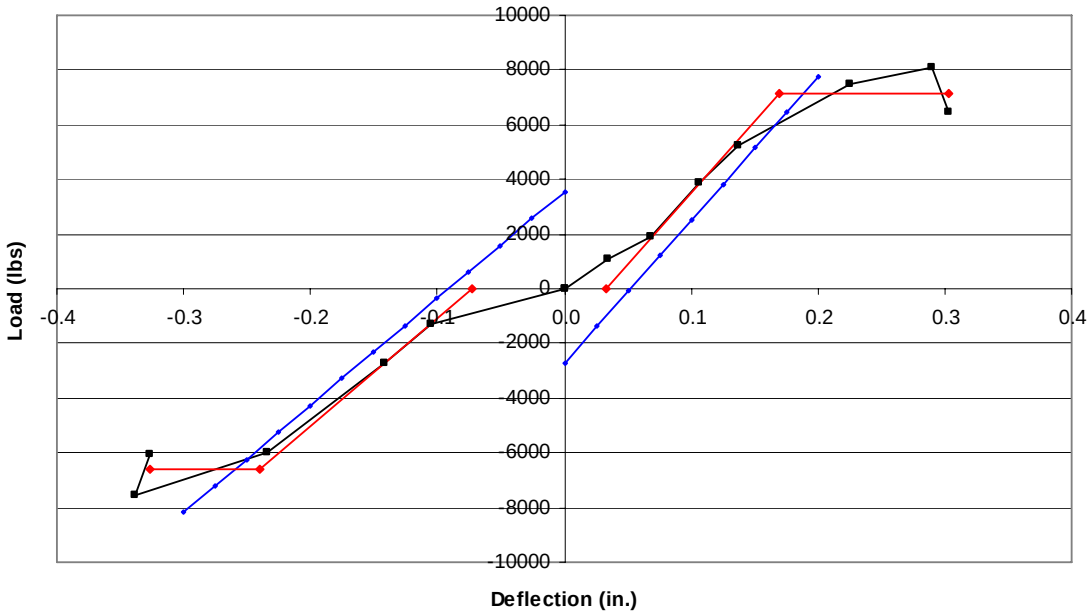

Figure B.31: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c9

Table B.24: Seven Strength and Serviceability Parameters, 38c9

	POS	NEG	AVG
Max Load (lbs)	8082.55	-7536.98	7810
Failure Load (lbs)	6466.04	-6029.58	6250
Elastic Stiffness (lbs/in.)	52274.19	39170.73	45700
5% Offset Load (lbs)	5947.19	-6228.85	6090
E.E.P. Energy (lbs*in.)	1436.57	1121.61	1280
Ductility Ratio	1.982386	1.508067	1.75
E.E.P. Yield Load (lbs)	7117.489	-6601.71	6860

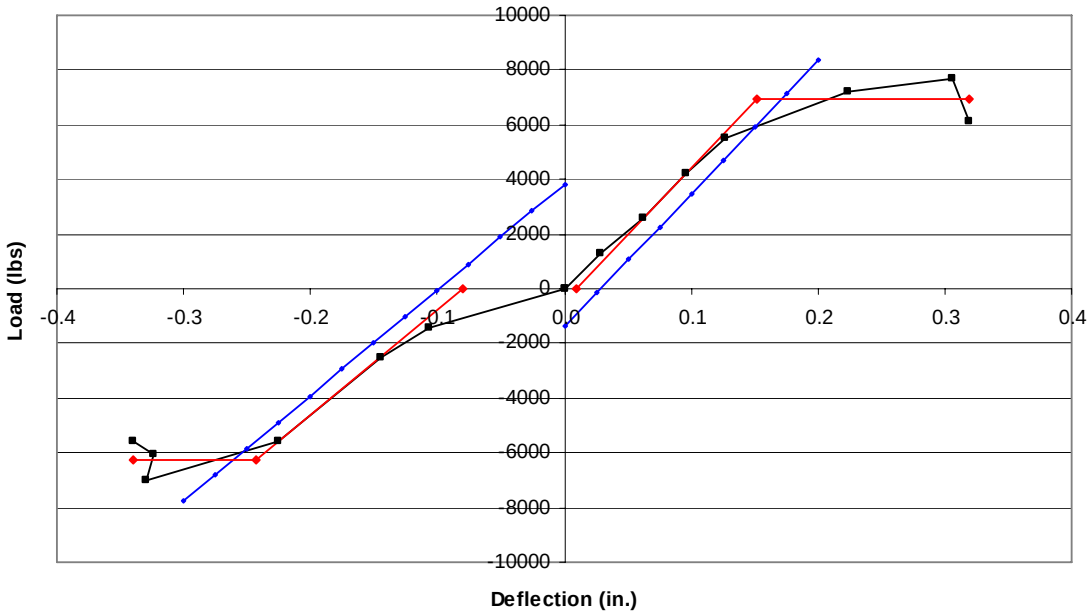

Figure B.32: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 38c10

Table B.25: Seven Strength and Serviceability Parameters, 38c10

	POS	NEG	AVG
Max Load (lbs)	7686.40	-6987.62	7340
Failure Load (lbs)	6149.12	-5590.09	5870
Elastic Stiffness (lbs/in.)	48719.30	38590.04	43700
5% Offset Load (lbs)	5904.90	-5972.83	5940
E.E.P. Energy (lbs*in.)	1654.75	1119.15	1390
Ductility Ratio	2.174889	1.598555	1.89
E.E.P. Yield Load (lbs)	6937.833	-6270.06	6600

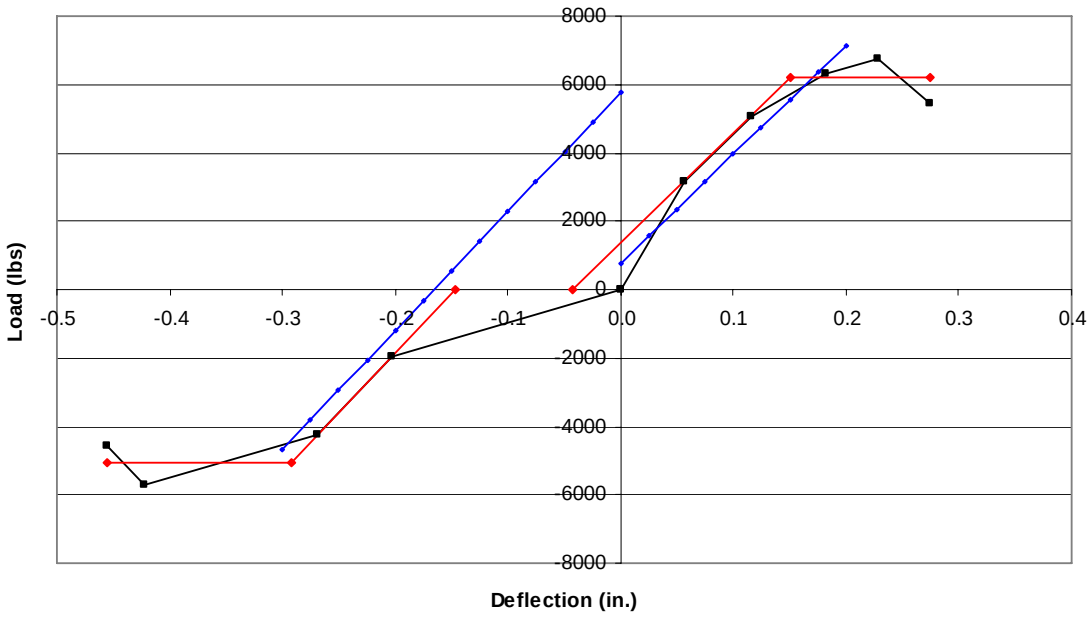

Figure B.33: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c2

Table B.26: Seven Strength and Serviceability Parameters, 47c2

	POS	NEG	AVG
Max Load (lbs)	6770.19	-5698.45	6230
Failure Load (lbs)	5416.15	-4558.76	4990
Elastic Stiffness (lbs/in.)	32000.00	34766.36	33400
5% Offset Load (lbs)	5942.90	-4488.08	5220
E.E.P. Energy (lbs*in.)	1364.19	1189.37	1280
Ductility Ratio	1.642646	2.122185	1.88
E.E.P. Yield Load (lbs)	6180.978	-5048.81	5610

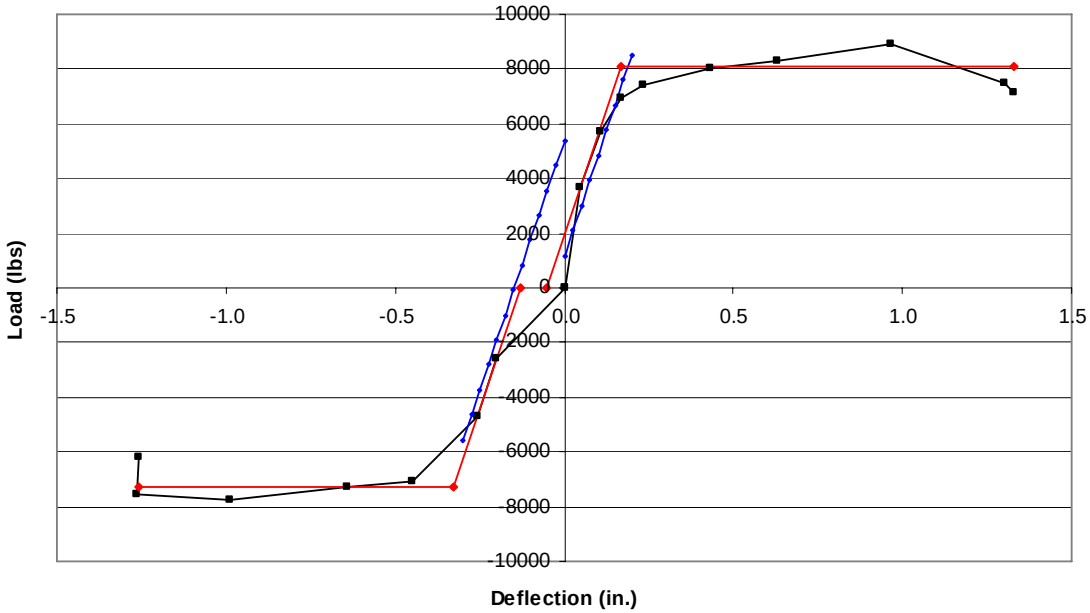

Figure B.34: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c3

Table B.27: Seven Strength and Serviceability Parameters, 47c3

	POS	NEG	AVG
Max Load (lbs)	8908.42	-7759.77	8330
Failure Load (lbs)	7126.74	-6207.82	6670
Elastic Stiffness (lbs/in.)	36713.51	36459.53	36600
5% Offset Load (lbs)	6538.34	-5065.72	5800
E.E.P. Energy (lbs*in.)	10324.71	7472.90	8900
Ductility Ratio	6.243893	5.645195	5.94
E.E.P. Yield Load (lbs)	8123.605	-7276.95	7700

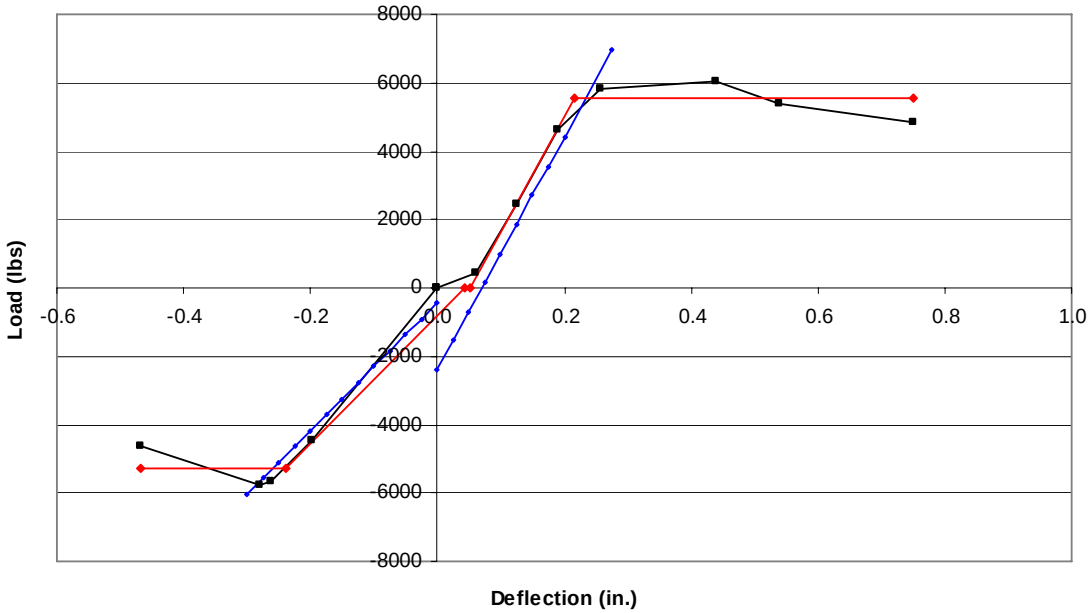

Figure B.35: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c4

Table B.28: Seven Strength and Serviceability Parameters, 47c4

	POS	NEG	AVG
Max Load (lbs)	6065.18	-5782.08	5920
Failure Load (lbs)	4852.14	-4625.66	4740
Elastic Stiffness (lbs/in.)	33942.86	18641.51	26300
5% Offset Load (lbs)	5344.83	-5753.81	5550
E.E.P. Energy (lbs*in.)	3421.04	1952.64	2690
Ductility Ratio	4.284526	1.80994	3.05
E.E.P. Yield Load (lbs)	5539.207	-5271.41	5410

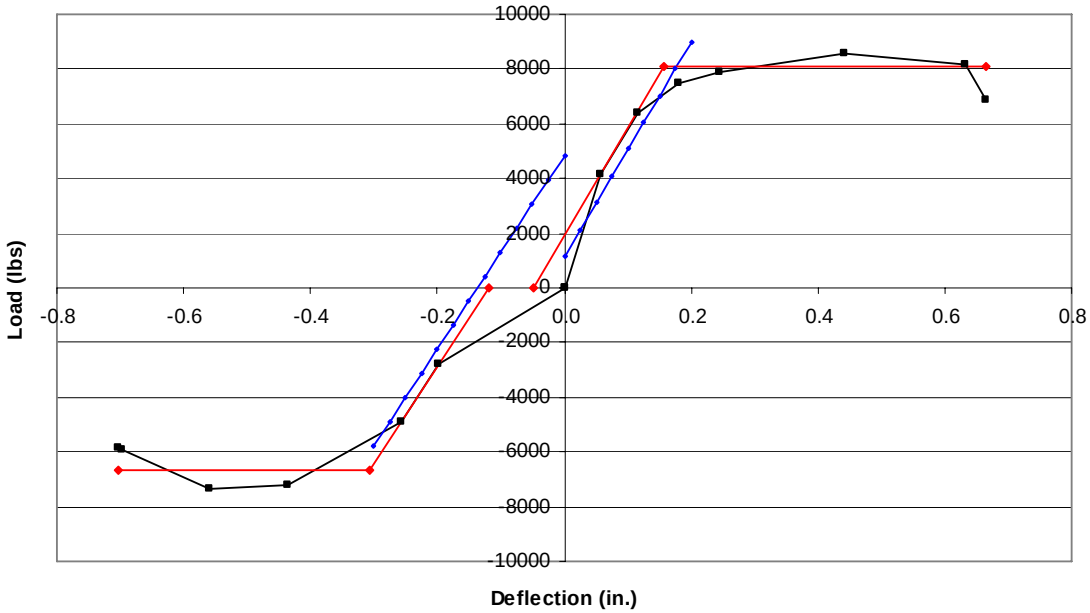

Figure B.36: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c5

Table B.29: Seven Strength and Serviceability Parameters, 47c5

	POS	NEG	AVG
Max Load (lbs)	8561.10	-7314.79	7940
Failure Load (lbs)	6848.88	-5851.83	6350
Elastic Stiffness (lbs/in.)	39136.00	35412.66	37300
5% Offset Load (lbs)	6922.74	-5303.67	6110
E.E.P. Energy (lbs*in.)	4927.76	3268.61	4100
Ductility Ratio	3.450913	3.097931	3.27
E.E.P. Yield Load (lbs)	8084.157	-6674.93	7380

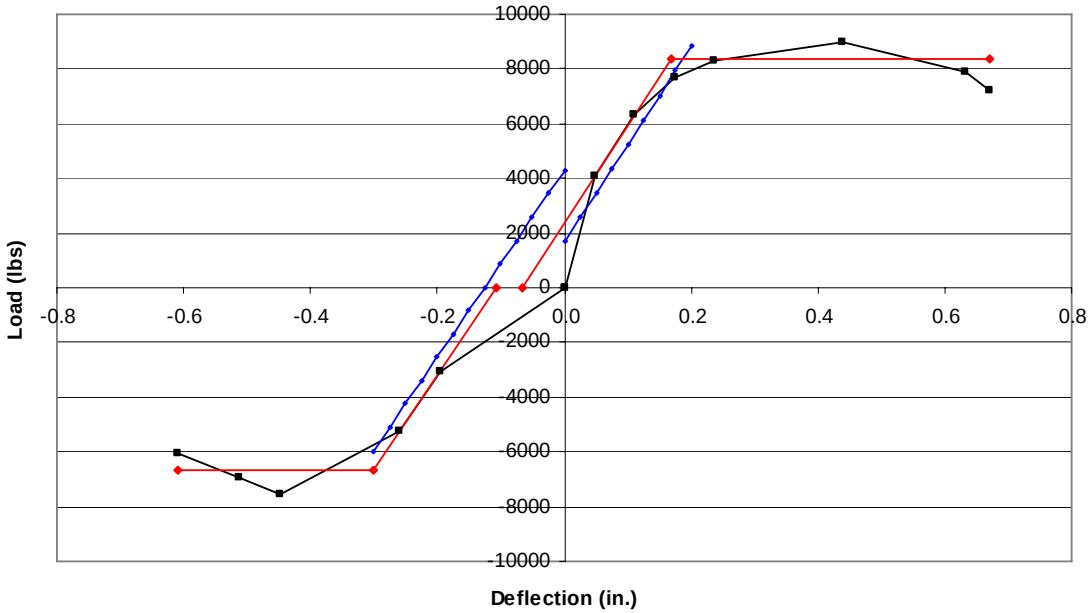

Figure B.37: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c6

Table B.30: Seven Strength and Serviceability Parameters, 47c6

	POS	NEG	AVG
Max Load (lbs)	9008.53	-7557.12	8280
Failure Load (lbs)	7206.82	-6045.69	6630
Elastic Stiffness (lbs/in.)	35514.56	34198.55	34900
5% Offset Load (lbs)	7393.71	-5585.19	6490
E.E.P. Energy (lbs*in.)	5183.76	2692.76	3940
Ductility Ratio	3.145124	2.577232	2.86
E.E.P. Yield Load (lbs)	8342.627	-6658.25	7500

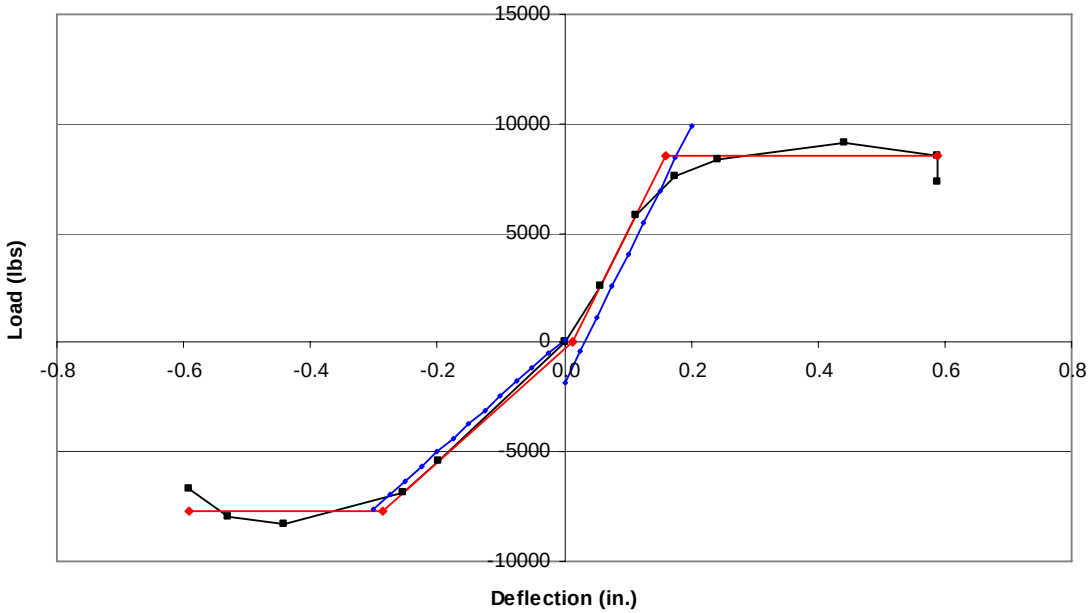

Figure B.38: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c7

Table B.31: Seven Strength and Serviceability Parameters, 47c7

	POS	NEG	AVG
Max Load (lbs)	9172.11	-8321.34	8750
Failure Load (lbs)	7337.69	-6657.07	7000
Elastic Stiffness (lbs/in.)	58415.30	25827.03	42100
5% Offset Load (lbs)	6896.80	-7090.66	6990
E.E.P. Energy (lbs*in.)	4319.14	3512.19	3920
Ductility Ratio	3.942726	2.016166	2.98
E.E.P. Yield Load (lbs)	8560.728	-7734.86	8150

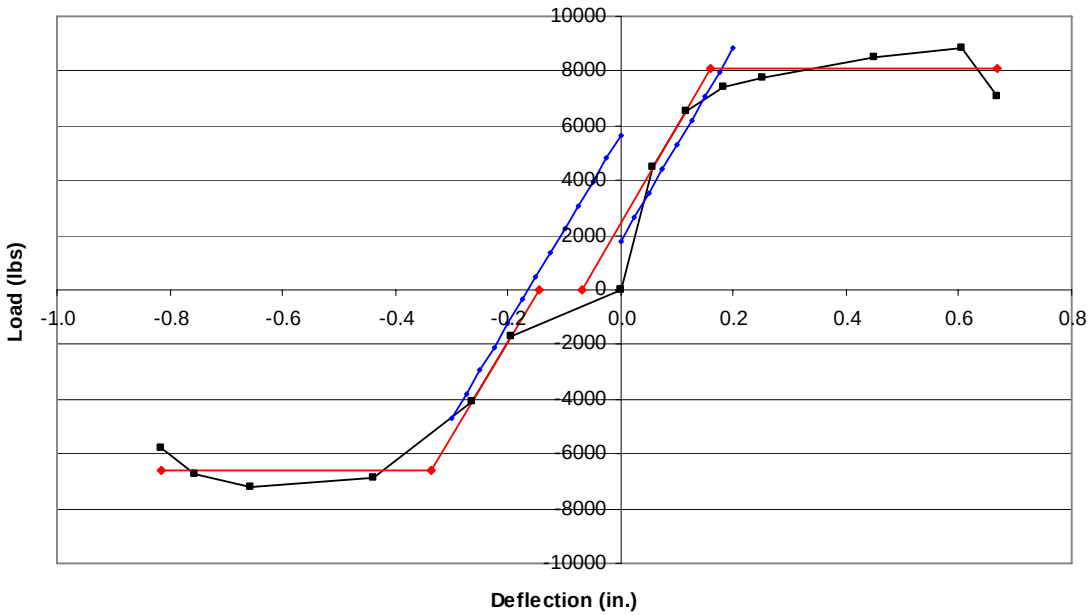

Figure B.39: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c8

Table B.32: Seven Strength and Serviceability Parameters, 47c8

	POS	NEG	AVG
Max Load (lbs)	8840.67	-7234.83	8040
Failure Load (lbs)	7072.53	-5787.86	6430
Elastic Stiffness (lbs/in.)	35614.58	34426.37	35000
5% Offset Load (lbs)	6944.81	-4647.14	5800
E.E.P. Energy (lbs*in.)	5042.27	3788.32	4420
Ductility Ratio	3.225988	3.485394	3.36
E.E.P. Yield Load (lbs)	8116.43	-6609.5	7360

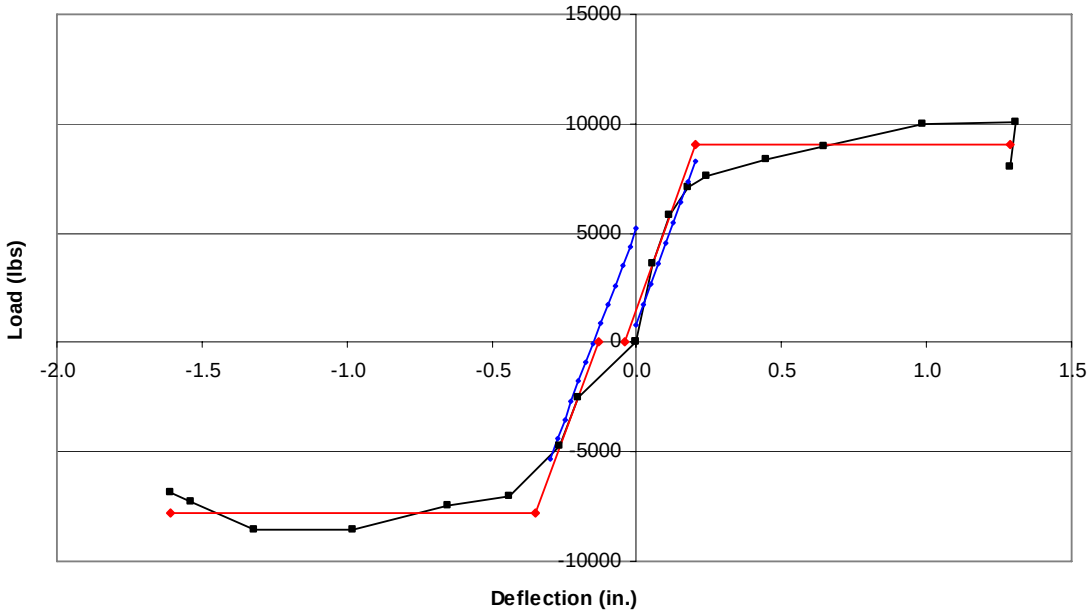

Figure B.40: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c9

Table B.33: Seven Strength and Serviceability Parameters, 47c9

	POS	NEG	AVG
Max Load (lbs)	10038.27	-8546.58	9290
Failure Load (lbs)	8030.62	-6837.26	7430
Elastic Stiffness (lbs/in.)	37408.74	35225.18	36300
5% Offset Load (lbs)	6591.61	-5093.48	5840
E.E.P. Energy (lbs*in.)	10951.39	10592.26	10770
Ductility Ratio	5.479002	6.705663	6.09
E.E.P. Yield Load (lbs)	9070.892	-7754.02	8410

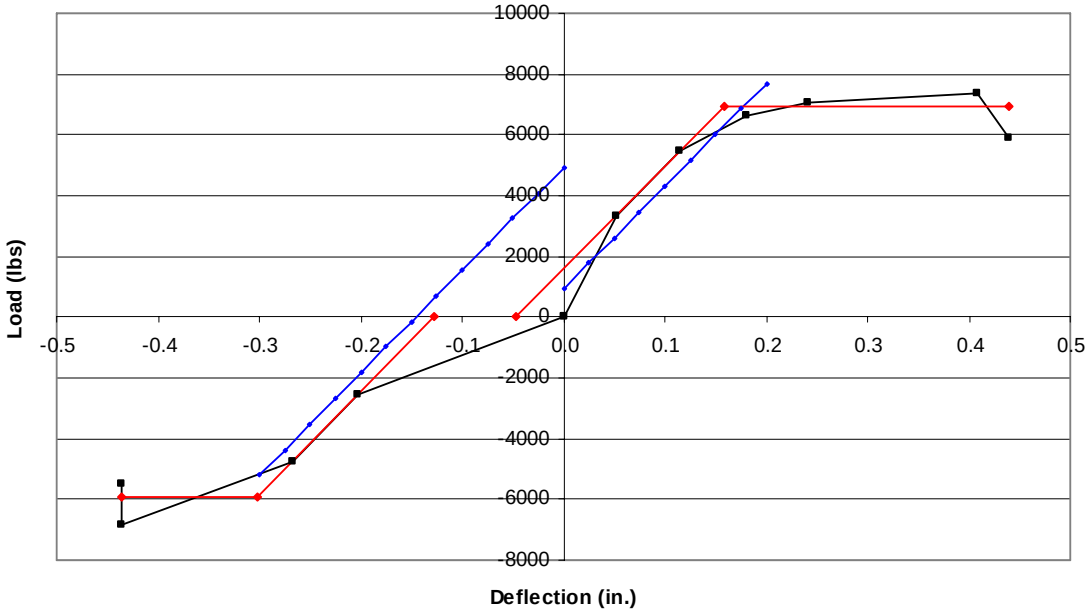

Figure B.41: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c10

Table B.34: Seven Strength and Serviceability Parameters, 47c10

	POS	NEG	AVG
Max Load (lbs)	7379.37	-6828.30	7100
Failure Load (lbs)	5903.50	-5462.64	5680
Elastic Stiffness (lbs/in.)	33873.17	33750.59	33800
5% Offset Load (lbs)	6165.99	-5112.79	5640
E.E.P. Energy (lbs*in.)	2664.81	1301.95	1980
Ductility Ratio	2.367391	1.760243	2.06
E.E.P. Yield Load (lbs)	6952.54	-5904.88	6430

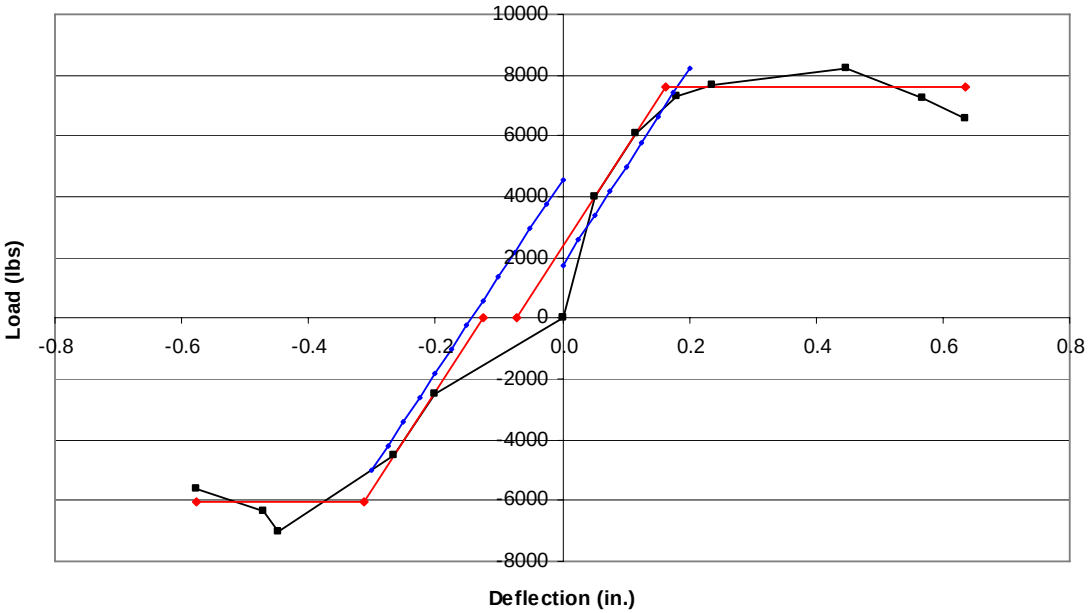

Figure B.42: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 47c11

Table B.35: Seven Strength and Serviceability Parameters, 47c11

	POS	NEG	AVG
Max Load (lbs)	8210.12	-7030.34	7620
Failure Load (lbs)	6568.10	-5624.27	6100
Elastic Stiffness (lbs/in.)	32365.34	31865.06	32100
5% Offset Load (lbs)	6909.49	-4955.64	5930
E.E.P. Energy (lbs*in.)	4497.78	2154.27	3330
Ductility Ratio	2.998423	2.38422	2.69
E.E.P. Yield Load (lbs)	7633.196	-6035.9	6830

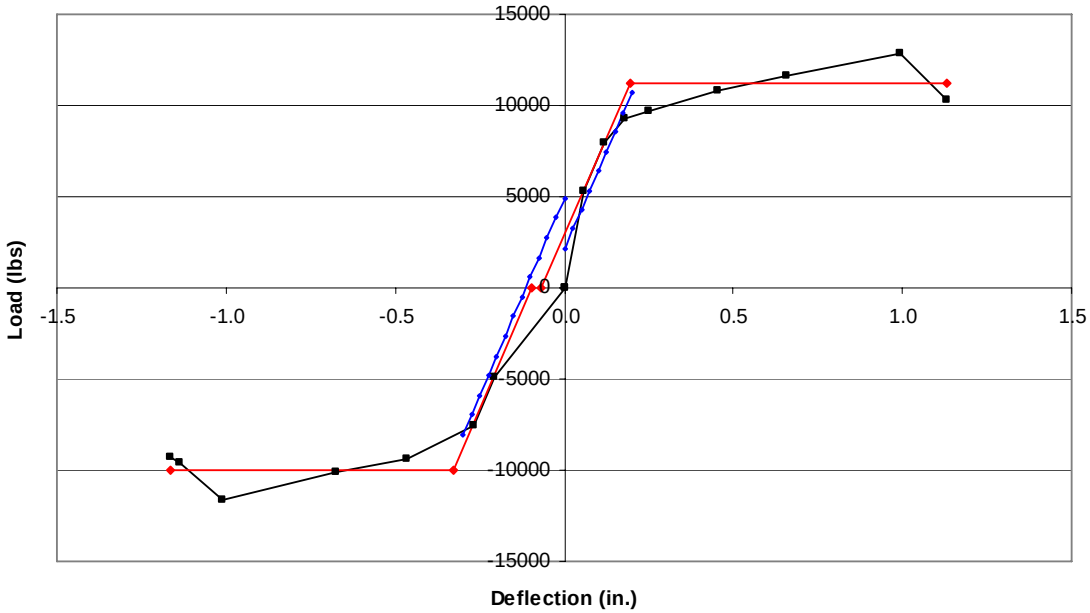

Figure B.43: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c1

Table B.36: Seven Strength and Serviceability Parameters, 48c1

	POS	NEG	AVG
Max Load (lbs)	12828.41	-11611.40	12220
Failure Load (lbs)	10262.73	-9289.12	9780
Elastic Stiffness (lbs/in.)	42521.74	43172.07	42800
5% Offset Load (lbs)	8809.16	-7735.81	8270
E.E.P. Energy (lbs*in.)	12065.92	9581.43	10820
Ductility Ratio	4.540703	4.595183	4.57
E.E.P. Yield Load (lbs)	11268.27	-10050.3	10660

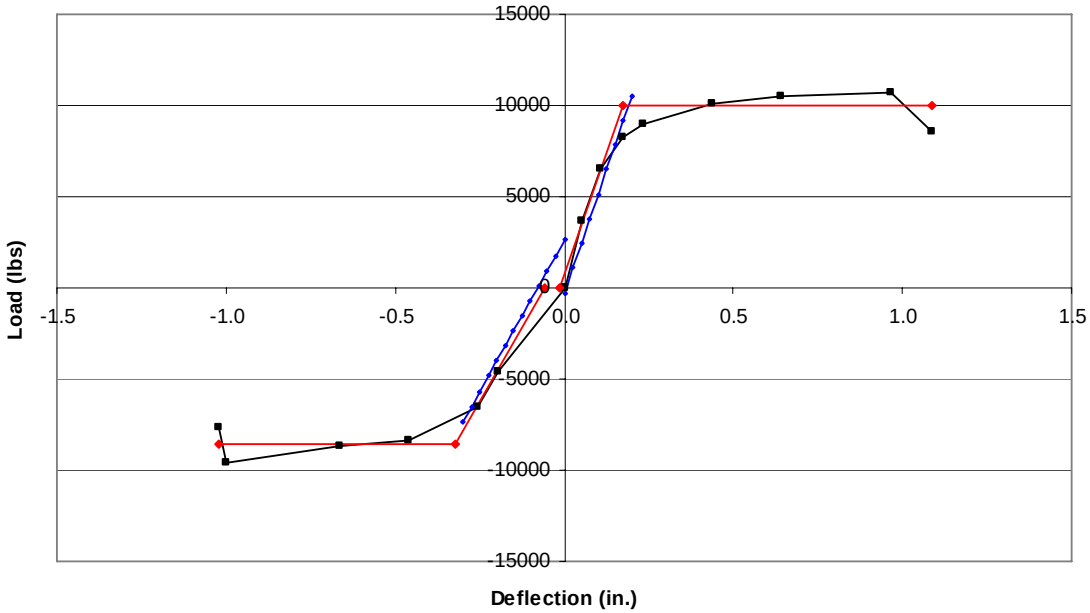

Figure B.44: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c2

Table B.37: Seven Strength and Serviceability Parameters, 48c2

	POS	NEG	AVG
Max Load (lbs)	10706.66	-9562.89	10130
Failure Load (lbs)	8565.33	-7650.31	8110
Elastic Stiffness (lbs/in.)	54040.82	33141.41	43600
5% Offset Load (lbs)	7454.48	-6789.56	7120
E.E.P. Energy (lbs*in.)	10055.65	7140.23	8600
Ductility Ratio	5.962039	3.690299	4.83
E.E.P. Yield Load (lbs)	9974.442	-8612.44	9290

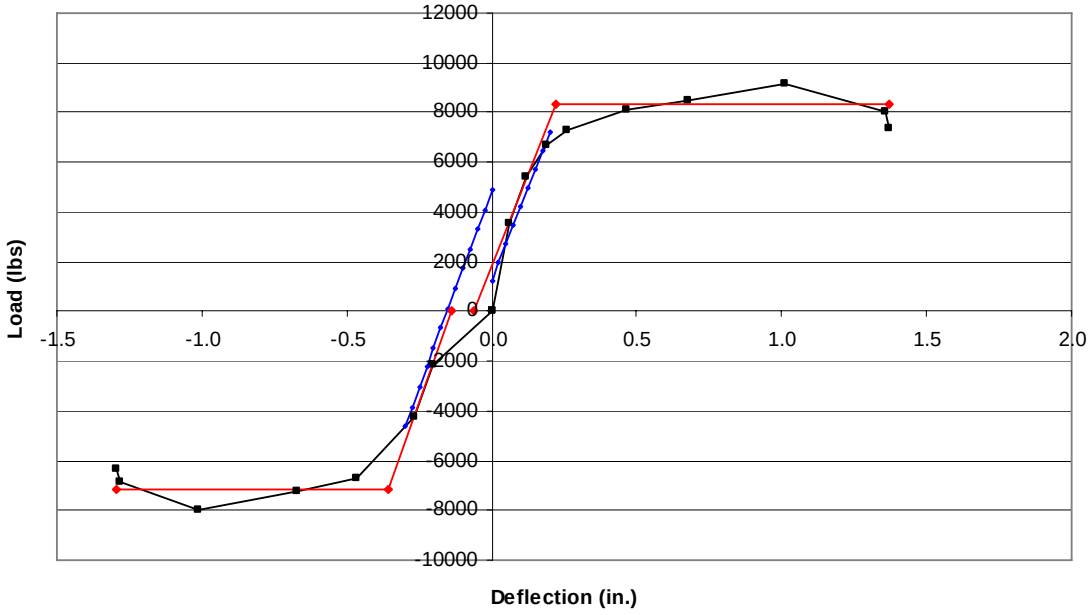

Figure B.45: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c4

Table B.38: Seven Strength and Serviceability Parameters, 48c4

	POS	NEG	AVG
Max Load (lbs)	9173.95	-7959.37	8570
Failure Load (lbs)	7339.16	-6367.50	6850
Elastic Stiffness (lbs/in.)	29867.32	31779.31	30800
5% Offset Load (lbs)	6252.76	-4659.75	5460
E.E.P. Energy (lbs*in.)	10761.45	7483.95	9120
Ductility Ratio	5.10743	5.181411	5.14
E.E.P. Yield Load (lbs)	8352.265	-7127.7	7740

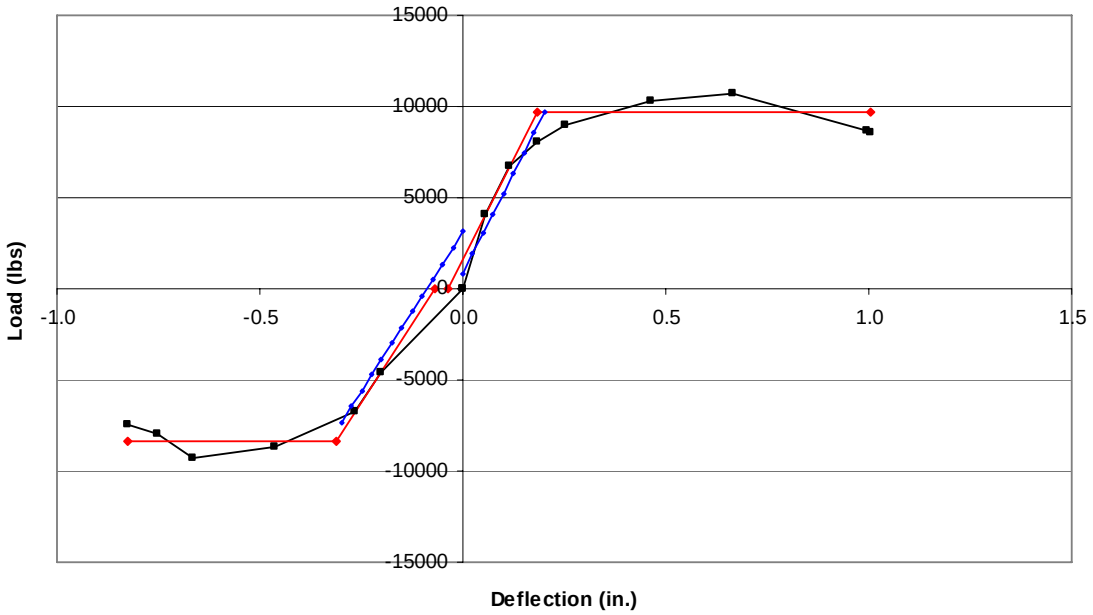

Figure B.46: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c5

Table B.39: Seven Strength and Serviceability Parameters, 48c5

	POS	NEG	AVG
Max Load (lbs)	10731.69	-9319.34	10030
Failure Load (lbs)	8585.35	-7455.47	8020
Elastic Stiffness (lbs/in.)	44423.77	34799.03	39600
5% Offset Load (lbs)	7422.24	-6990.95	7210
E.E.P. Energy (lbs*in.)	9047.31	5300.70	7170
Ductility Ratio	4.773153	3.135624	3.95
E.E.P. Yield Load (lbs)	9698.248	-8365.82	9030

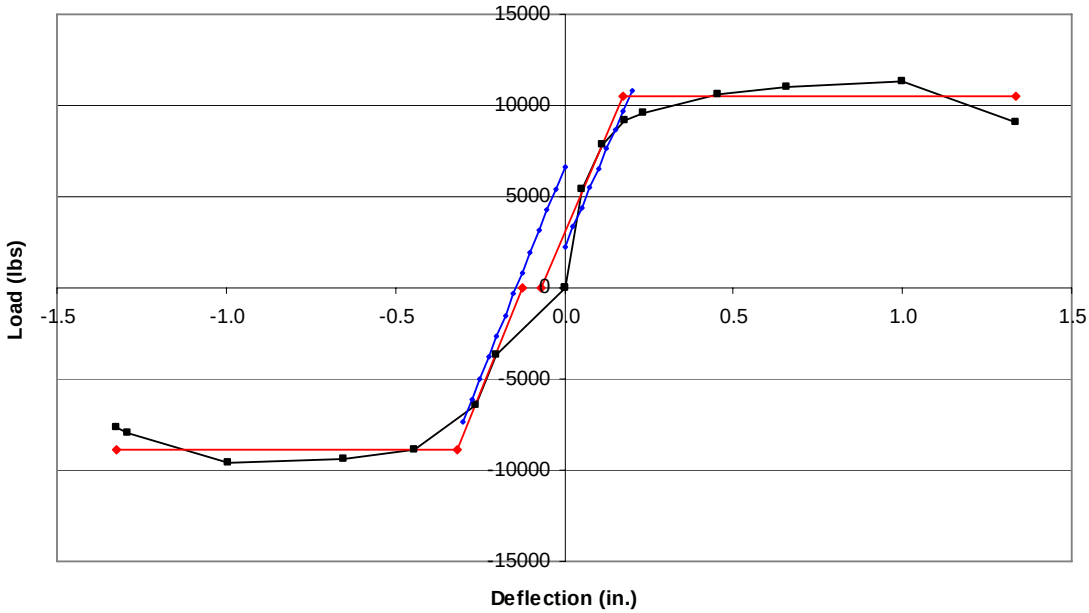

Figure B.47: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c6

Table B.40: Seven Strength and Serviceability Parameters, 48c6

	POS	NEG	AVG
Max Load (lbs)	11312.18	-9564.72	10440
Failure Load (lbs)	9049.74	-7651.78	8350
Elastic Stiffness (lbs/in.)	42813.65	46345.18	44600
5% Offset Load (lbs)	8560.47	-6825.66	7690
E.E.P. Energy (lbs*in.)	13494.53	9848.97	11670
Ductility Ratio	5.742164	6.234602	5.99
E.E.P. Yield Load (lbs)	10498.2	-8921.67	9710

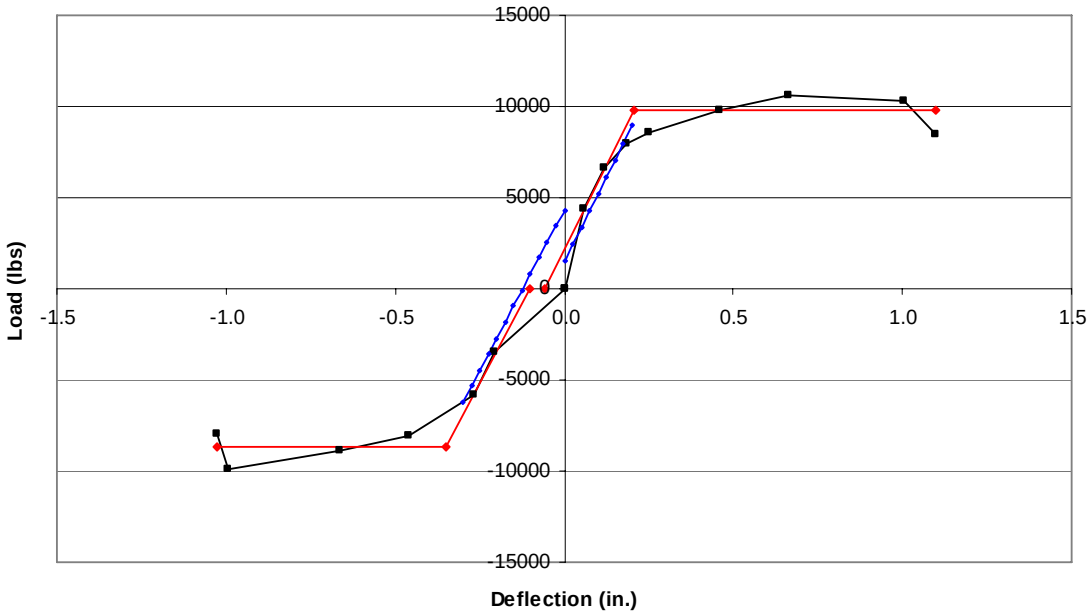

Figure B.48: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c7

Table B.41: Seven Strength and Serviceability Parameters, 48c7

	POS	NEG	AVG
Max Load (lbs)	10607.16	-9894.34	10250
Failure Load (lbs)	8485.73	-7915.47	8200
Elastic Stiffness (lbs/in.)	37213.93	35140.19	36200
5% Offset Load (lbs)	7582.60	-6127.55	6860
E.E.P. Energy (lbs*in.)	10093.08	6910.08	8500
Ductility Ratio	4.394968	3.754267	4.07
E.E.P. Yield Load (lbs)	9820.027	-8638.08	9230

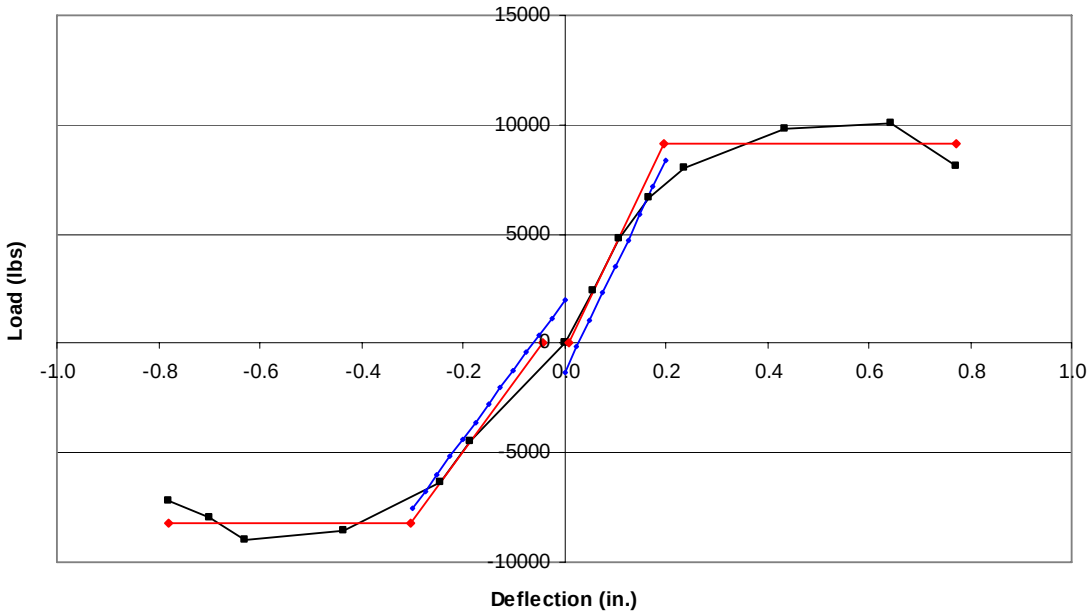

Figure B.49: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c8

Table B.42: Seven Strength and Serviceability Parameters, 48c8

	POS	NEG	AVG
Max Load (lbs)	10106.64	-9015.97	9560
Failure Load (lbs)	8085.31	-7212.78	7650
Elastic Stiffness (lbs/in.)	48473.52	31690.72	40100
5% Offset Load (lbs)	6420.45	-6677.06	6550
E.E.P. Energy (lbs*in.)	6114.48	4980.14	5550
Ductility Ratio	4.072203	2.849836	3.46
E.E.P. Yield Load (lbs)	9108.858	-8195.36	8650

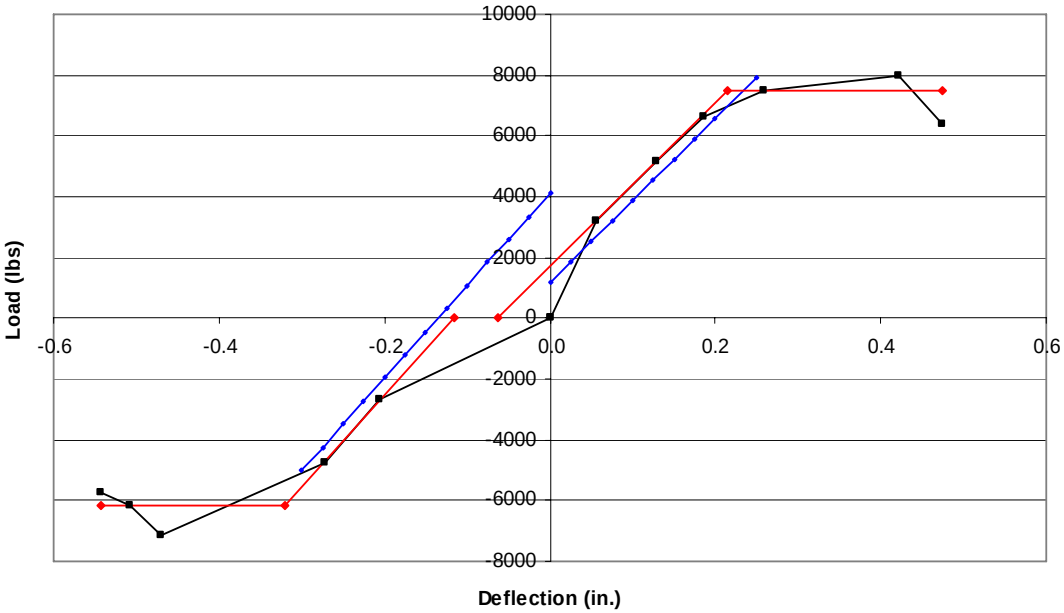

Figure B.50: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c9

Table B.43: Seven Strength and Serviceability Parameters, 48c9

	POS	NEG	AVG
Max Load (lbs)	7999.54	-7139.60	7570
Failure Load (lbs)	6399.63	-5711.68	6060
Elastic Stiffness (lbs/in.)	26945.61	30344.52	28600
5% Offset Load (lbs)	6944.16	-5125.74	6030
E.E.P. Energy (lbs*in.)	2987.91	2000.80	2490
Ductility Ratio	1.932158	2.098792	2.02
E.E.P. Yield Load (lbs)	7497.769	-6162.35	6830

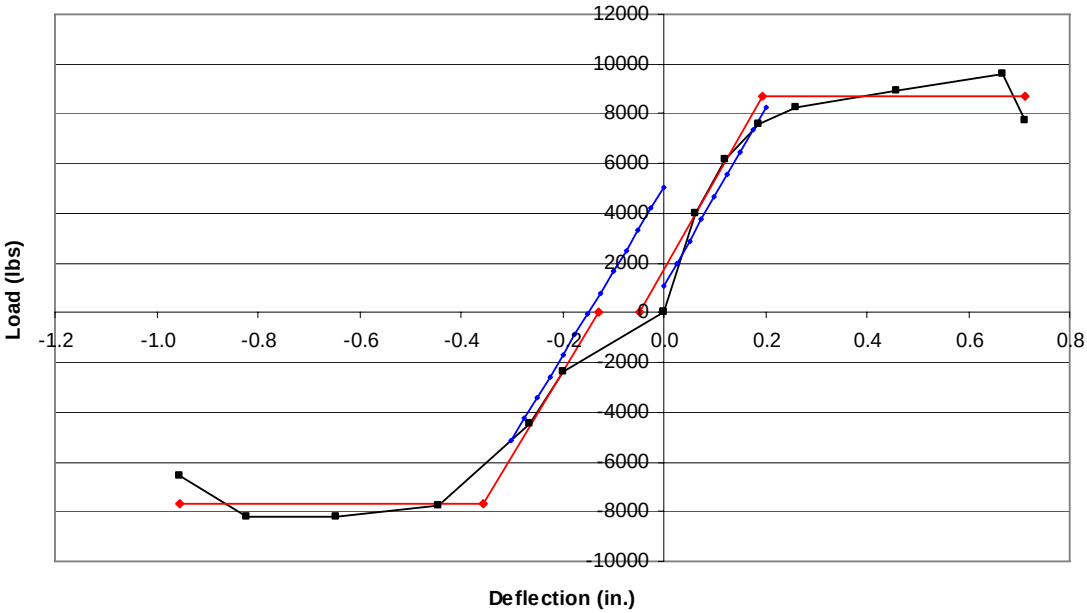

Figure B.51: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c10

Table B.44: Seven Strength and Serviceability Parameters, 48c10

	POS	NEG	AVG
Max Load (lbs)	9623.81	-8241.38	8930
Failure Load (lbs)	7699.05	-6593.10	7150
Elastic Stiffness (lbs/in.)	36010.34	33751.20	34900
5% Offset Load (lbs)	7111.26	-5217.64	6160
E.E.P. Energy (lbs*in.)	5576.93	5451.05	5510
Ductility Ratio	3.137497	3.642791	3.39
E.E.P. Yield Load (lbs)	8726	-7651.15	8190

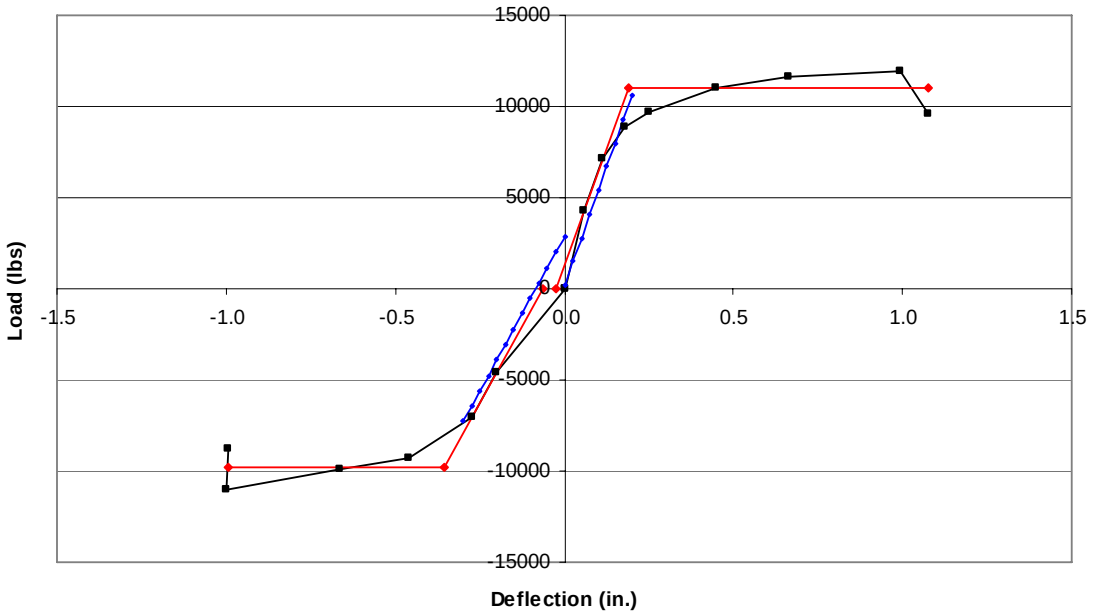

Figure B.52: Load vs. Deflection, E.E.P. Curves, and 5% Offset Lines, 48c11

Table B.45: Seven Strength and Serviceability Parameters, 48c11

	POS	NEG	AVG
Max Load (lbs)	11962.25	-11024.80	11490
Failure Load (lbs)	9569.80	-8819.84	9190
Elastic Stiffness (lbs/in.)	52173.91	33833.33	43000
5% Offset Load (lbs)	8101.01	-7345.23	7720
E.E.P. Energy (lbs*in.)	10956.79	7636.37	9300
Ductility Ratio	5.202039	3.20418	4.20
E.E.P. Yield Load (lbs)	11026.19	-9774.58	10400

B.4: Dowel Embedment Tests

Below are the complete results of the dowel embedment tests. The dowel embedment strengths of the monotonic test members are included in Tables B.46-B.49. The dowel embedment strengths of the reverse-cyclic test members are included in Tables B.50-53.

Table B.46: Dowel Embedment Strengths, 37m Data Set

Main Members

	F_e (lbs)
37m1b	2780
37m2b	3050
37m3b	3030
MEAN	2953
STDEV	150
COV %	5.1

Side Members

	F_e (lbs)
37m1t	3770
37m2t	2600
37m3t	2600
MEAN	2990
STDEV	675
COV %	22.6

Table B.47: Dowel Embedment Strengths, 38m Data Set

Main Members

	F_e (lbs)
38m1b	2440
38m2b	2680
38m3b	2340
MEAN	2487
STDEV	175
COV %	7.0

Side Members

	F_e (lbs)
38m1t	2750
38m2t	3400
38m3t	2620
MEAN	2923
STDEV	418
COV %	14.3

Table B.48: Dowel Embedment Strengths, 47m Data Set

Main Members

	F_e (lbs)
47m1b	2590
47m2b	2220
47m3b	2640
MEAN	2483
STDEV	229
COV %	9.2

Side Members

	F_e (lbs)
47m1t	2870
47m2t	2500
47m3t	2430
MEAN	2600
STDEV	236
COV %	9.1

Table B.49: Dowel Embedment Strengths, 48m Data Set

Main Members

	F_e (lbs)
48m1b	2210
48m2b	2630
48m4b	2640
MEAN	2493
STDEV	245
COV %	9.8

Side Members

	F_e (lbs)
48m1t	2370
48m2t	1670
48m4t	2090
MEAN	2043
STDEV	352
COV %	17.2

Table B.50: Dowel Embedment Strengths, 37c Data Set

Main Members

	F_e (lbs)
37c1b	2890
37c2b	2560
37c3b	2890
37c4b	2640
37c5b	2970
37c6b	2880
37c7b	2320
37c8b	2460
37c9b	1900
37c10b	2730
MEAN	2624
STDEV	331
COV %	12.6

Side Members

	F_e (lbs)
37c1t	3280
37c2t	3290
37c3t	2780
37c4t	3140
37c5t	3290
37c6t	3510
37c7t	3280
37c8t	2750
37c9t	2850
37c10t	2660
MEAN	3083
STDEV	295
COV %	9.6

Table B.51: Dowel Embedment Strengths, 38c Data Set

Main Members

	F_e (lbs)
38c1b	2640
38c2b	1970
38c3b	2760
38c4b	3120
38c5b	2680
38c6b	2220
38c7b	3100
38c8b	3320
38c9b	2230
38c10b	2890
MEAN	2693
STDEV	441
COV %	16.4

Side Members

	F_e (lbs)
38c1t	2120
38c2t	3740
38c3t	2770
38c4t	3110
38c5t	2860
38c6t	2640
38c7t	2500
38c8t	2100
38c9t	2950
38c10t	2880
MEAN	2767
STDEV	480
COV %	17.3

Table B.52: Dowel Embedment Strengths, 47c Data Set

Main Members

	F_e (lbs)
47c2b	1900
47c3b	2520
47c4b	2600
47c5b	2590
47c6b	2890
47c7b	2180
47c8b	2080
47c9b	2280
47c10b	1910
47c11b	1960
MEAN	2291
STDEV	343
COV %	15.0

Side Members

	F_e (lbs)
47c2t	1900
47c3t	2520
47c4t	2600
47c5t	2590
47c6t	2890
47c7t	2180
47c8t	2080
47c9t	2280
47c10t	1910
47c11t	1960
MEAN	2291
STDEV	343
COV %	15.0

Table B.53: Dowel Embedment Strengths, 48c Data Set

Main Members

	F_e (lbs)
48c1b	2780
48c2b	2570
48c4b	2270
48c5b	2850
48c6b	3810
48c7b	3200
48c8b	2580
48c9b	2060
48c10b	1600
48c11b	2340
MEAN	2606
STDEV	614
COV %	23.5

Side Members

	F_e (lbs)
48c1t	3030
48c2t	2690
48c4t	1990
48c5t	2500
48c6t	2630
48c7t	1780
48c8t	2300
48c9t	2540
48c10t	2890
48c11t	2200
MEAN	2455
STDEV	391
COV %	15.9

B.5: Moisture Content and Specific Gravity

Below are the complete results of the moisture content and specific gravity measurements. The measurements pertaining to the monotonic test members are included in Tables B.54-B.57. The measurements pertaining to the reverse-cyclic test members are included in Tables B.58-61.

Table B.54: Moisture Content and Specific Gravity, 37m Data Set

Side Members

	MC (%)	SG
37m1t	12.55	0.67
37m2t	10.87	0.55
37m3t	10.90	0.51
MEAN	11.44	0.58
STDEV	0.96	0.08
COV %	8.40	13.86

Main Members

	MC (%)	SG
37m1b	16.22	0.52
37m2b	17.37	0.55
37m3b	17.23	0.55
MEAN	16.94	0.54
STDEV	0.63	0.02
COV %	3.72	3.13

Table B.55: Moisture Content and Specific Gravity, 38m Data Set

Side Members

	MC (%)	SG
38m1t	11.63	0.55
38m2t	11.17	0.54
38m3t	14.84	0.53
MEAN	12.54	0.54
STDEV	2.00	0.01
COV %	15.93	2.23

Main Members

	MC (%)	SG
38m1b	16.81	0.47
38m2b	16.46	0.53
38m3b	17.16	0.50
MEAN	16.81	0.50
STDEV	0.35	0.03
COV %	2.08	5.83

Table B.56: Moisture Content and Specific Gravity, 47m Data Set

Side Members

	MC (%)	SG
47m1t	16.82	0.51
47m2t	16.77	0.47
47m3t	16.97	0.49
MEAN	16.85	0.49
STDEV	0.11	0.02
COV %	0.64	4.20

Main Members

	MC (%)	SG
47m1b	15.38	0.56
47m2b	15.95	0.60
47m3b	17.74	0.60
MEAN	16.36	0.59
STDEV	1.23	0.02
COV %	7.51	3.66

Table B.57: Moisture Content and Specific Gravity, 48m Data Set

Side Members

	MC (%)	SG
48m1t	17.63	0.52
48m2t	16.17	0.39
48m4t	17.34	0.49
MEAN	17.04	0.46
STDEV	0.77	0.07
COV %	4.54	14.62

Main Members

	MC (%)	SG
48m1b	17.15	0.41
48m2b	17.38	0.52
48m4b	17.44	0.49
MEAN	17.32	0.47
STDEV	0.15	0.06
COV %	0.88	12.53

Table B.58: Moisture Content and Specific Gravity, 37c Data Set

Side Members

	MC (%)	SG
37c1t	14.10	0.65
37c2t	12.31	0.53
37c3t	15.14	0.60
37c4t	12.42	0.60
37c5t	14.14	0.57
37c6t	11.17	0.59
37c7t	14.79	0.64
37c8t	14.54	0.55
37c9t	13.86	0.56
37c10t	14.22	0.55
MEAN	13.67	0.58
STDEV	1.27	0.04
COV %	9.32	6.87

Main Members

	MC (%)	SG
37c1b	17.47	0.55
37c2b	16.61	0.48
37c3b	17.61	0.49
37c4b	16.95	0.51
37c5b	17.67	0.63
37c6b	16.15	0.54
37c7b	16.73	0.45
37c8b	16.51	0.50
37c9b	16.64	0.41
37c10b	17.60	0.57
MEAN	17.00	0.51
STDEV	0.55	0.06
COV %	3.24	12.15

Table B.59: Moisture Content and Specific Gravity, 38c Data Set

Side Members

	MC (%)	SG
38c1t	14.89	0.45
38c2t	13.59	0.62
38c3t	12.93	0.56
38c4t	14.35	0.61
38c5t	14.93	0.52
38c6t	13.35	0.52
38c7t	14.20	0.52
38c8t	14.84	0.62
38c9t	12.15	0.55
38c10t	14.15	0.42
MEAN	13.94	0.54
STDEV	0.92	0.07
COV %	6.63	12.47

Main Members

	MC (%)	SG
38c1b	16.75	0.50
38c2b	16.99	0.43
38c3b	16.97	0.53
38c4b	17.30	0.59
38c5b	17.51	0.49
38c6b	17.13	0.56
38c7b	16.63	0.57
38c8b	17.06	0.55
38c9b	15.06	0.50
38c10b	16.17	0.54
MEAN	16.76	0.53
STDEV	0.70	0.05
COV %	4.19	8.98

Table B.60: Moisture Content and Specific Gravity, 47c Data Set

Side Members

	MC (%)	SG
47c2t	18.04	0.43
47c3t	17.21	0.45
47c4t	16.60	0.43
47c5t	17.28	0.49
47c6t	18.53	0.50
47c7t	16.87	0.49
47c8t	17.30	0.51
47c9t	17.53	0.47
47c10t	16.32	0.48
47c11t	16.45	0.44
MEAN	17.21	0.47
STDEV	0.70	0.03
COV %	4.06	6.52

Main Members

	MC (%)	SG
47c2b	17.21	0.39
47c3b	17.27	0.52
47c4b	17.96	0.43
47c5b	18.18	0.54
47c6b	17.34	0.51
47c7b	17.59	0.43
47c8b	16.96	0.46
47c9b	17.67	0.50
47c10b	16.99	0.40
47c11b	17.16	0.47
MEAN	17.43	0.46
STDEV	0.41	0.05
COV %	2.34	11.32

Table B.61: Moisture Content and Specific Gravity, 48c Data Set

Side Members

	MC (%)	SG
48c1t	14.97	0.59
48c2t	14.33	0.56
48c4t	16.20	0.43
48c5t	16.56	0.46
48c6t	16.54	0.45
48c7t	16.89	0.46
48c8t	16.51	0.46
48c9t	16.09	0.47
48c10t	16.14	0.55
48c11t	16.94	0.54
MEAN	16.12	0.50
STDEV	0.78	0.05
COV %	4.84	9.78

Main Members

	MC (%)	SG
48c1b	16.45	0.56
48c2b	15.88	0.53
48c4b	15.80	0.46
48c5b	16.65	0.52
48c6b	19.48	0.65
48c7b	17.73	0.59
48c8b	15.76	0.50
48c9b	16.51	0.41
48c10b	15.46	0.38
48c11b	16.59	0.60
MEAN	16.63	0.52
STDEV	1.19	0.08
COV %	7.17	16.05

Appendix C: Bolt Test Results

C.1: Introduction

This appendix includes all of the results related to the bolt bending tests discussed in section 4.4. The results of the 3-point bending tests are included in section C.2. The results of the reverse-cyclic tests are included in section C.3.

C.2: 3-Point Bending Tests

Below are the results of the 3-point bending tests. The test data for each of the eight data sets are summarized in Tables B.1-B.8. Following each of these tables are the load-deflection curves and 5% offset lines for each bolt specimen in that given set. See section 4.4.3 for the resulting values of bolt bending yield strength (F_{yb}).

Table C.1: Test Results for E4s Data Set

$E4s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	1330	748
S2	1390	782
S3	1420	799
S4	1380	776
S5	1380	776
S6	1390	782
S7	1300	731
S8	1390	782
S9	1340	754
S10	1450	816
AVG	**1377**	**775**
Standard Dev.	**44**	**25**
COV (%)	**3.2**	**3.2**

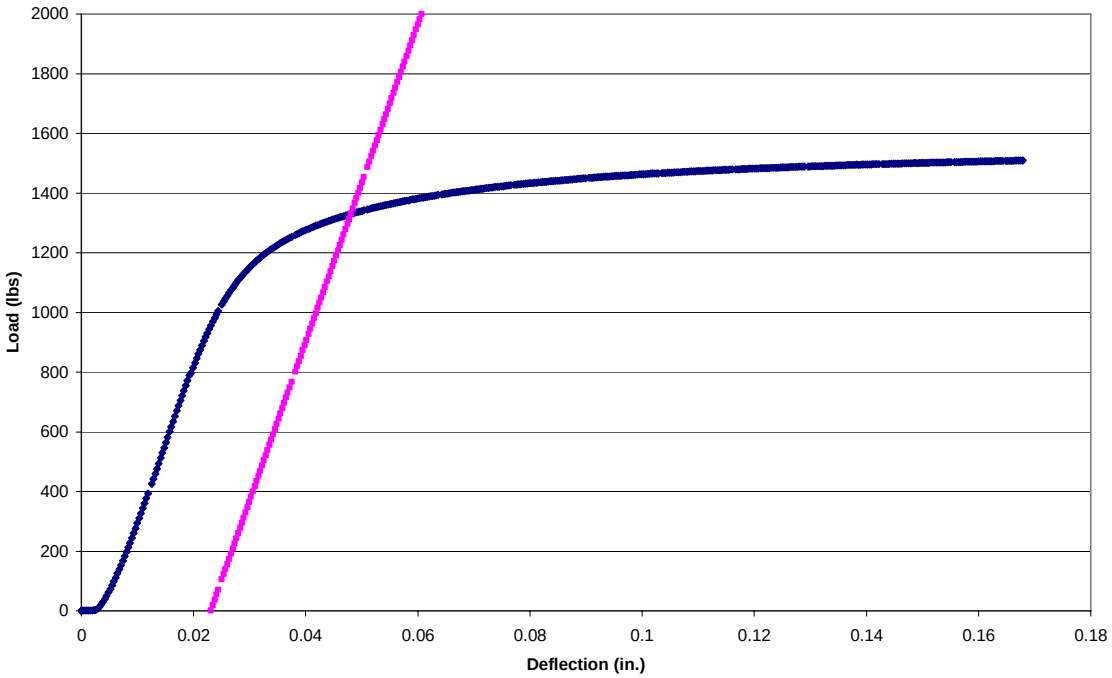

Figure C.1: Load vs. Deflection Curve and 5% Offset Line, E4s1

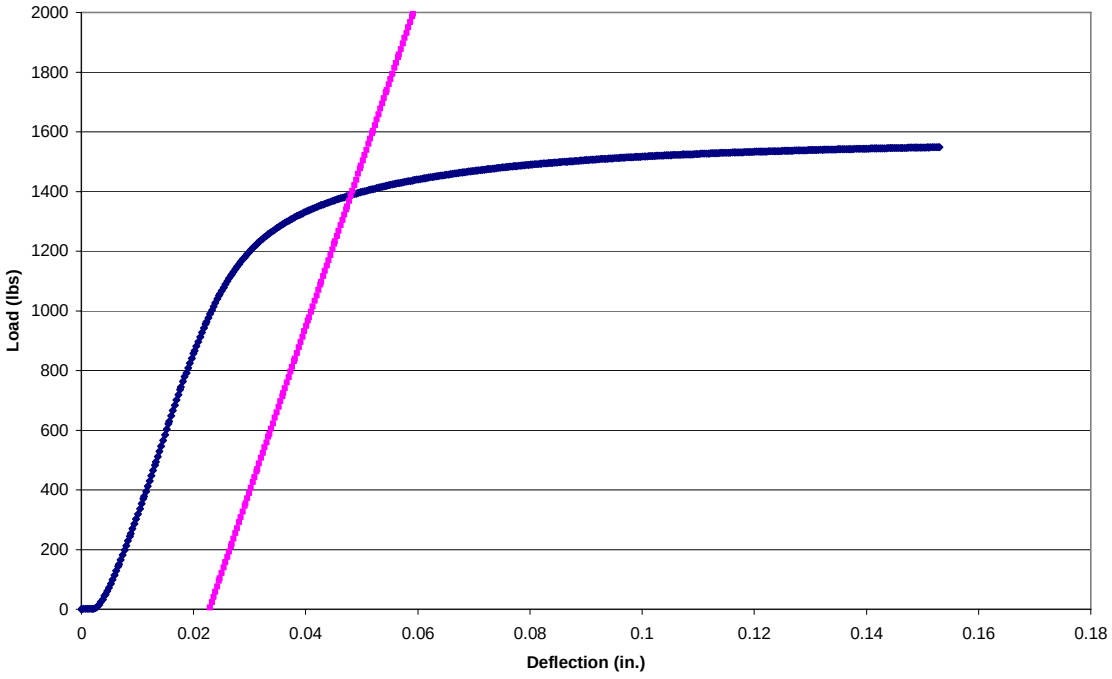

Figure C.2: Load vs. Deflection Curve and 5% Offset Line, E4s2

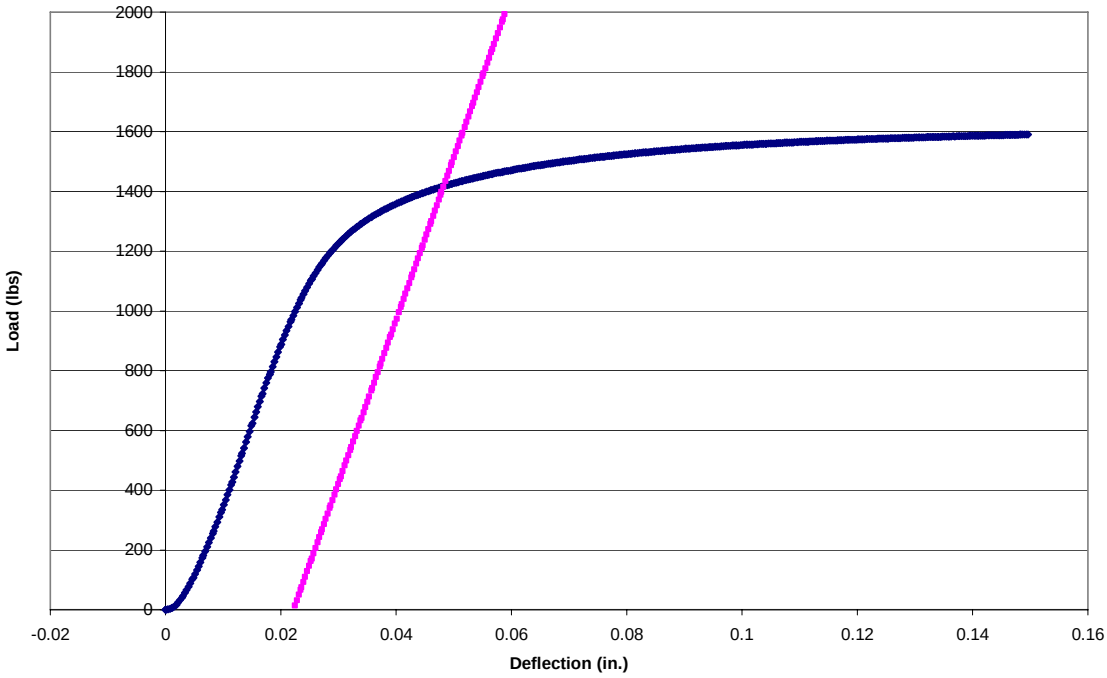

Figure C.3: Load vs. Deflection Curve and 5% Offset Line, E4s3

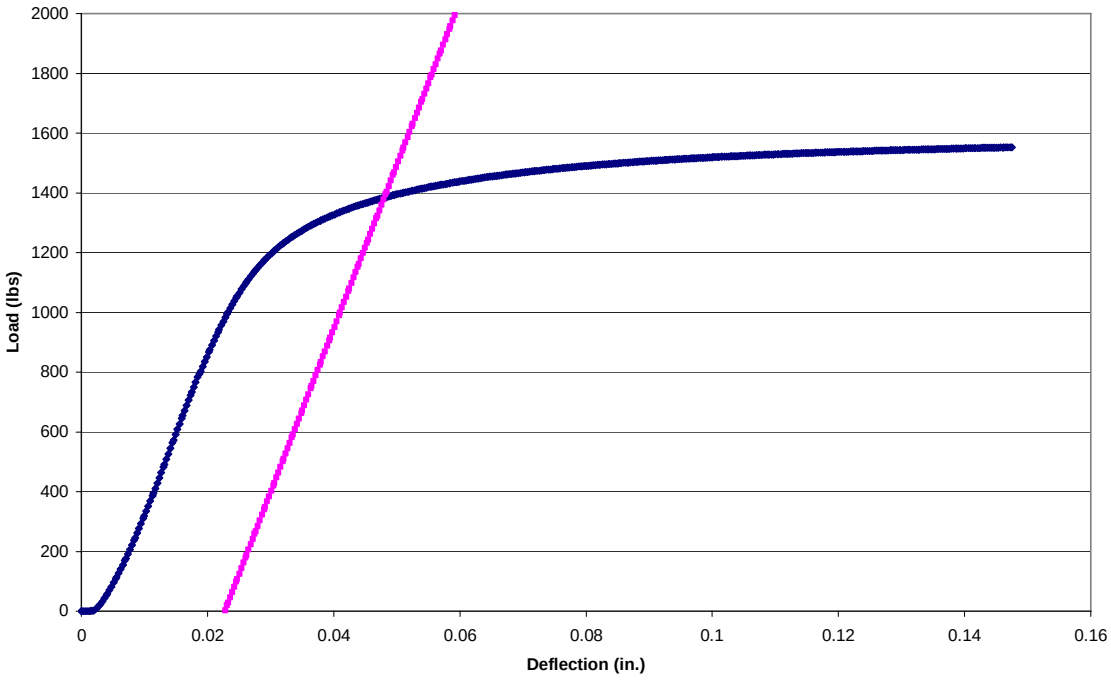

Figure C.4: Load vs. Deflection Curve and 5% Offset Line, E4s4

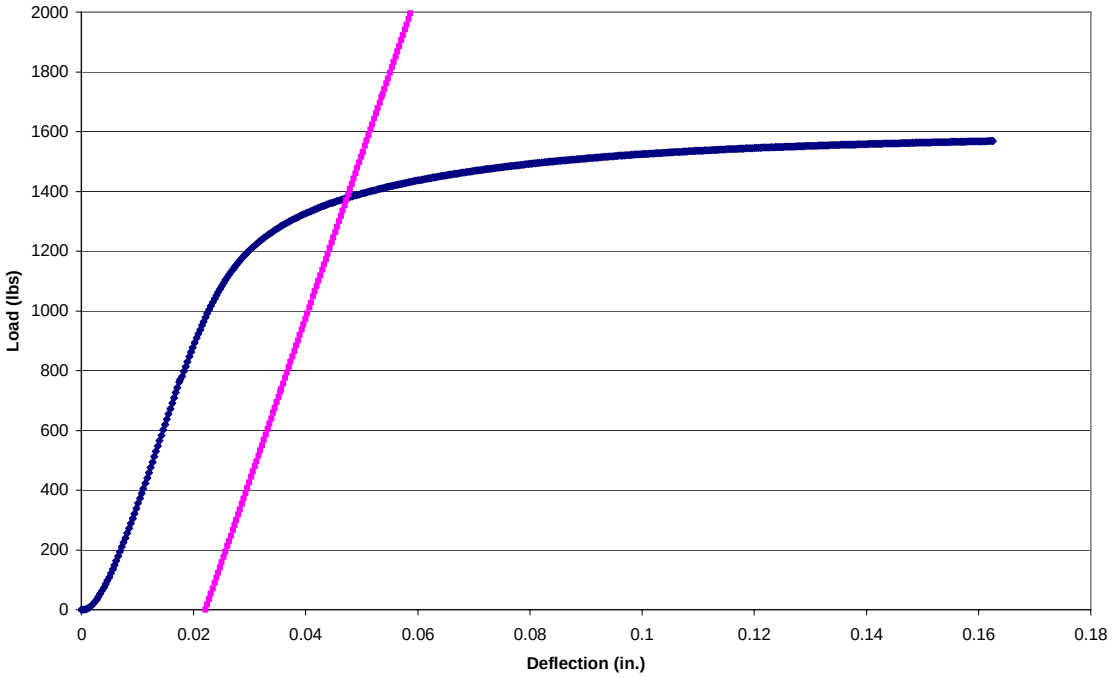

Figure C.5: Load vs. Deflection Curve and 5% Offset Line, E4s5

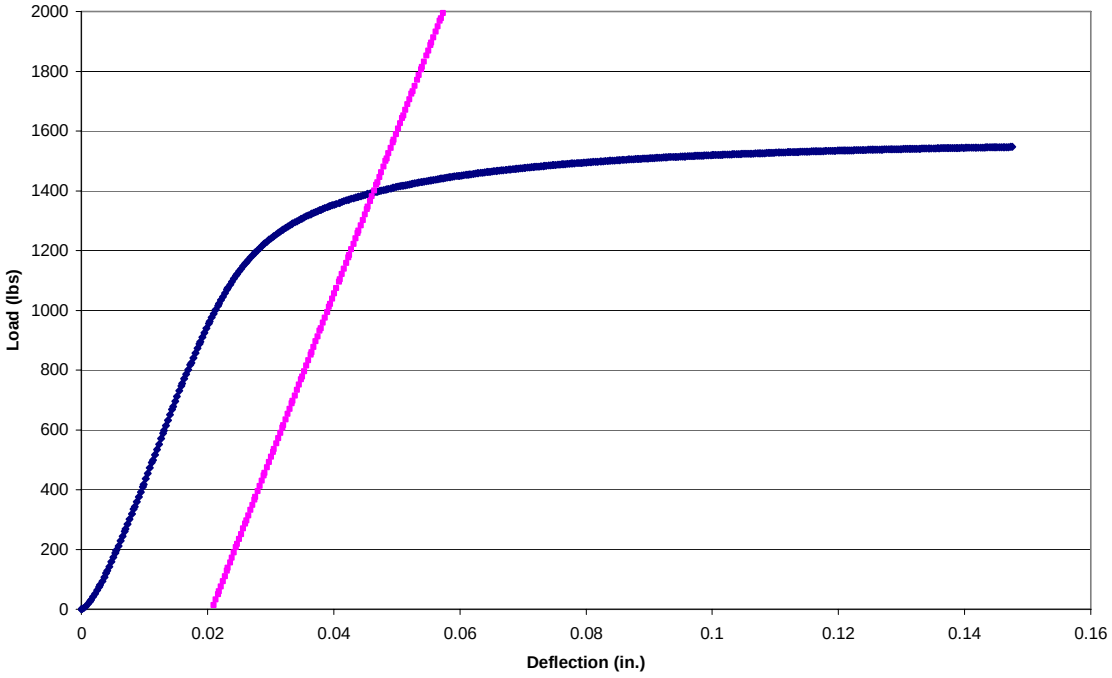

Figure C.6: Load vs. Deflection Curve and 5% Offset Line, E4s6

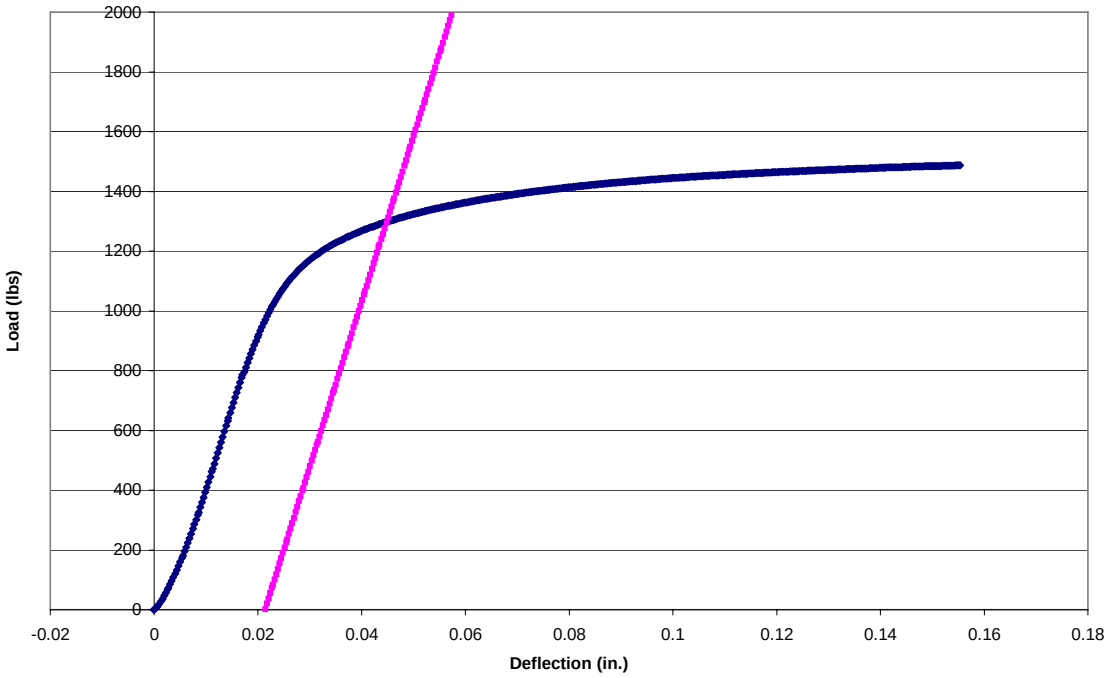

Figure C.7: Load vs. Deflection Curve and 5% Offset Line, E4s7

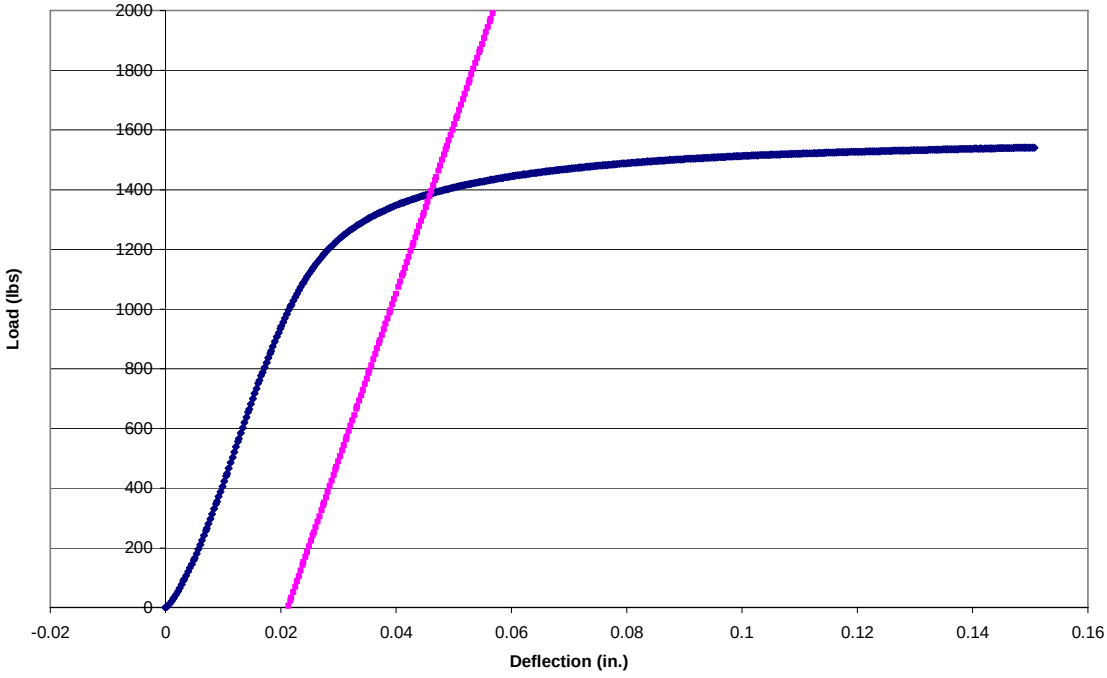

Figure C.8: Load vs. Deflection Curve and 5% Offset Line, E4s8

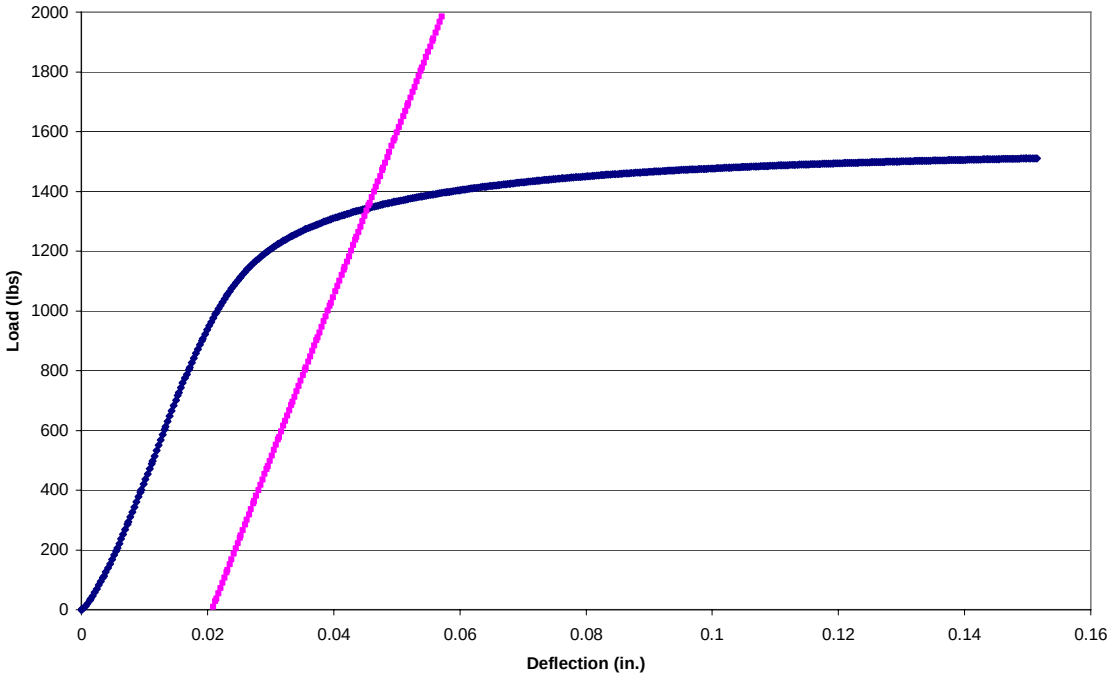

Figure C.9: Load vs. Deflection Curve and 5% Offset Line, E4s9

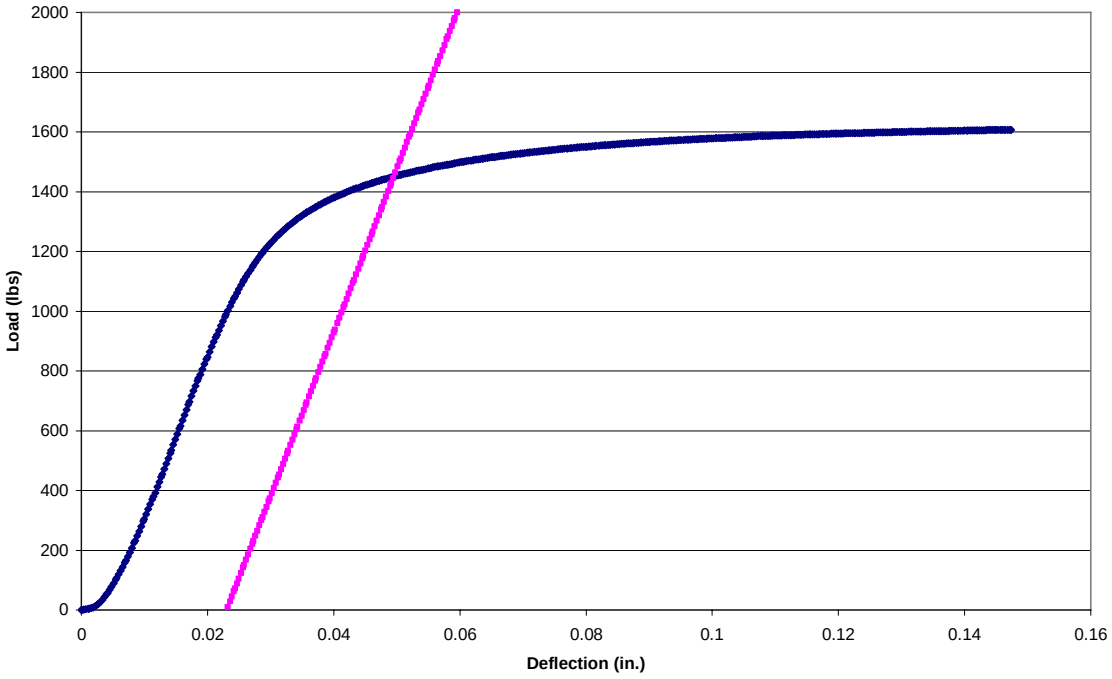

Figure C.10: Load vs. Deflection Curve and 5% Offset Line, E4s10

Table C.2: Test Results for E6s Data Set

$E6s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	577	620
S2	628	675
S3	566	608
S4	560	602
S5	606	651
S6	633	680
S7	592	636
S8	631	678
S9	543	584
S10	803	863
AVG	**614**	**660**
Standard Dev.	**74**	**79**
COV (%)	**12.0**	**12.0**

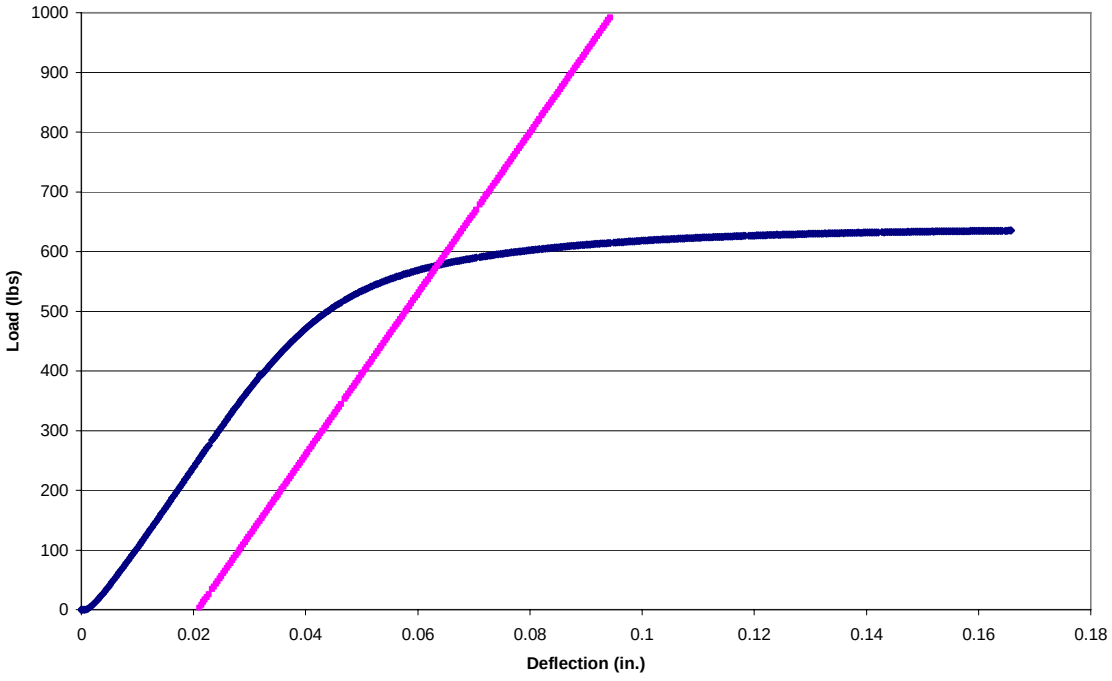

Figure C.11: Load vs. Deflection Curve and 5% Offset Line, E6s1

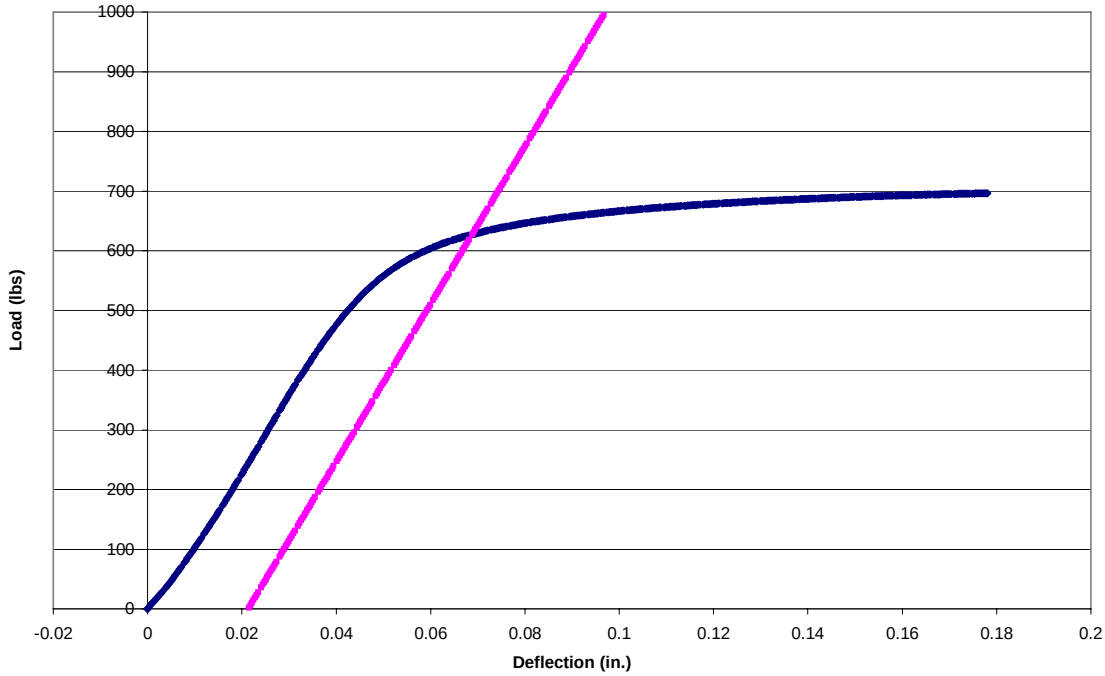

Figure C.12: Load vs. Deflection Curve and 5% Offset Line, E6s2

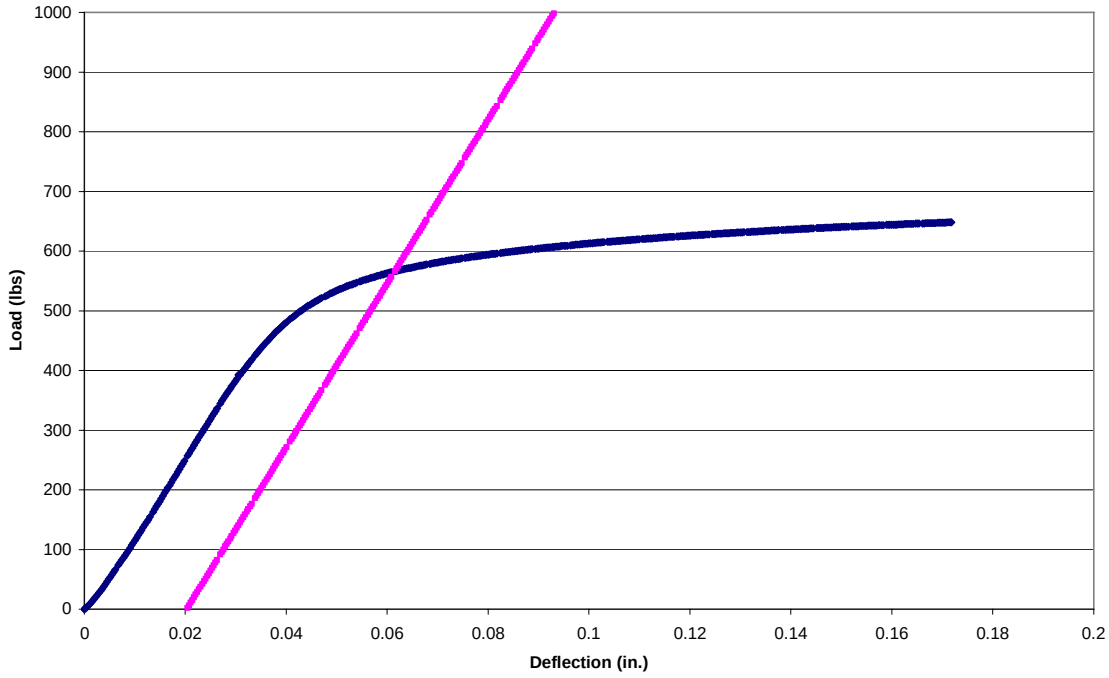

Figure C.13: Load vs. Deflection Curve and 5% Offset Line, E6s3

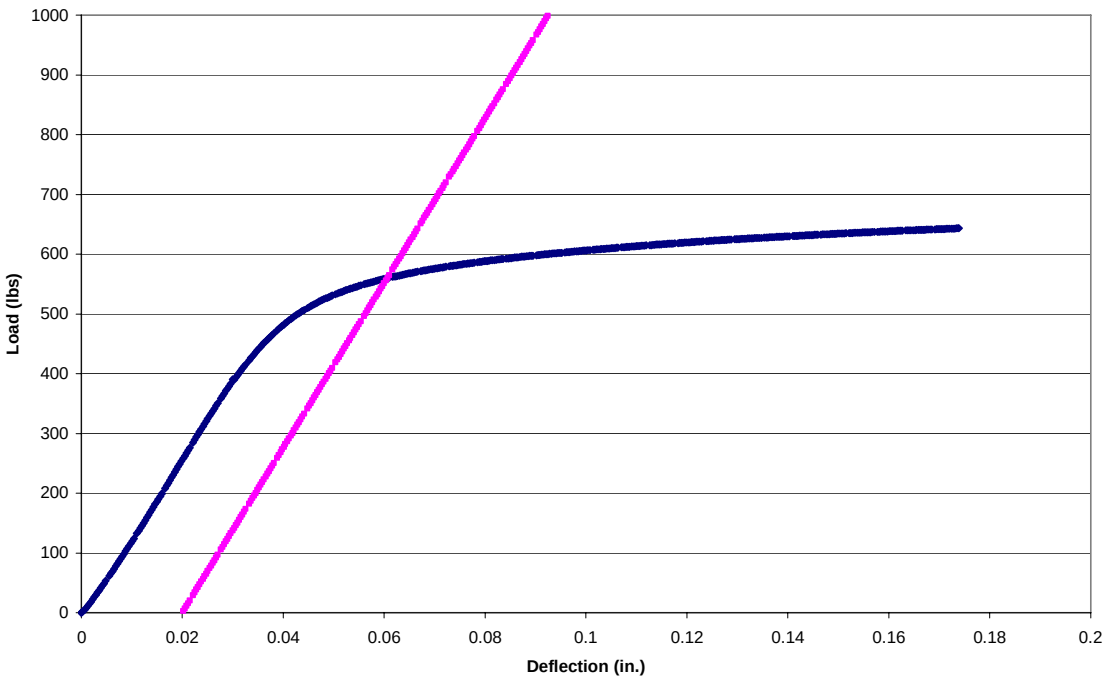

Figure C.14: Load vs. Deflection Curve and 5% Offset Line, E6s4

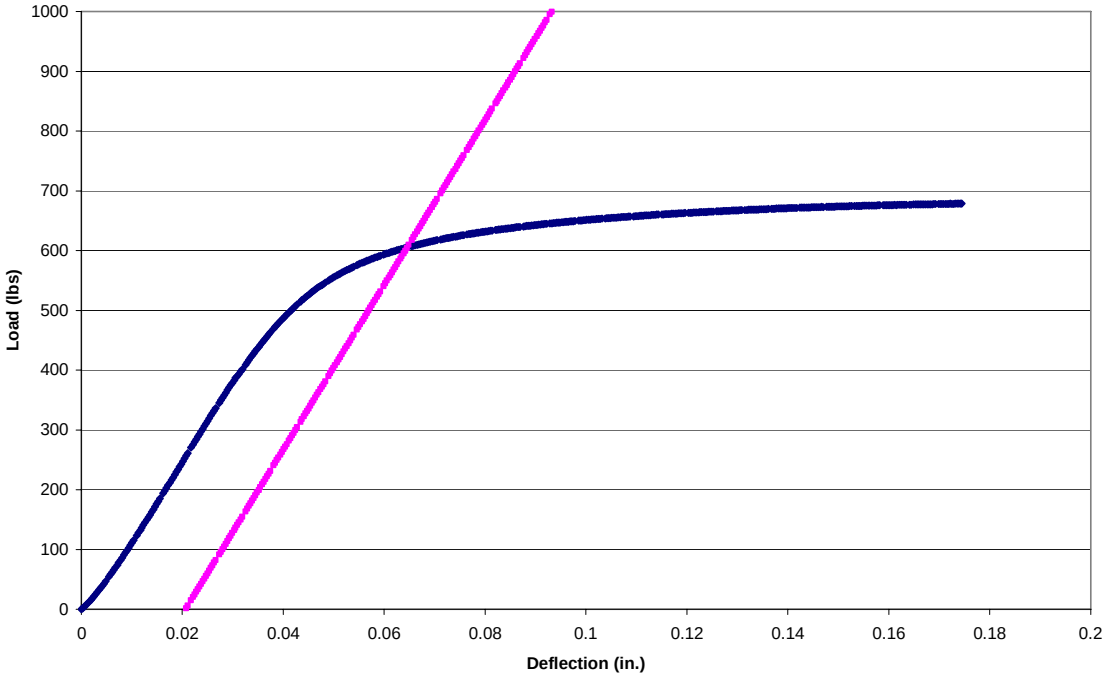

Figure C.15: Load vs. Deflection Curve and 5% Offset Line, E6s5

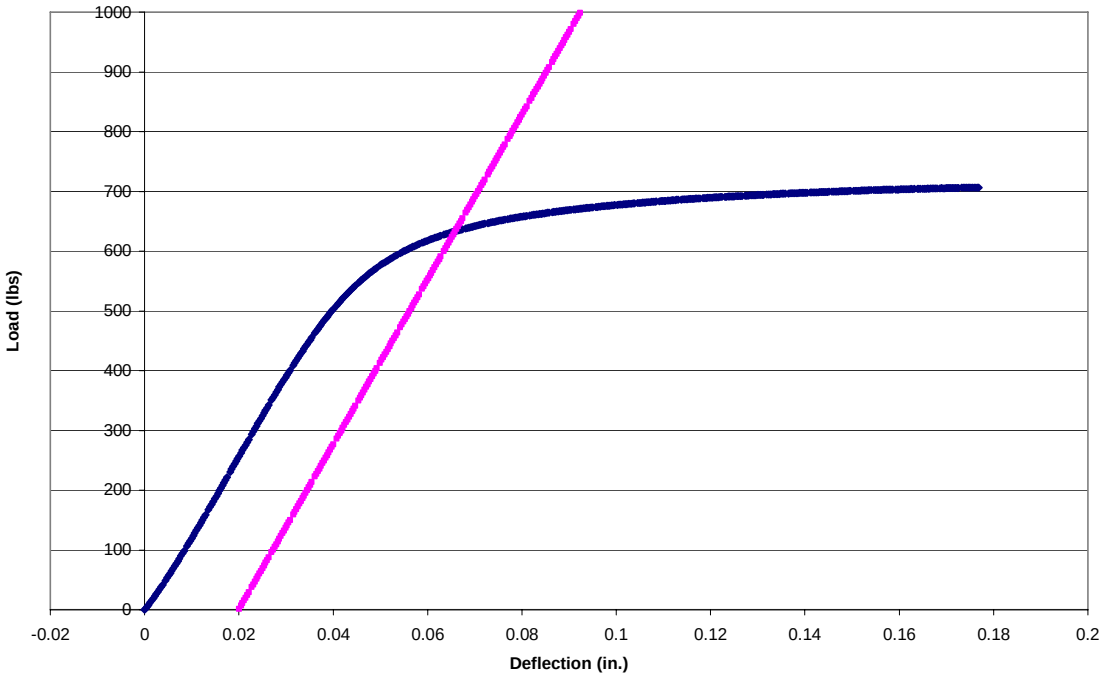

Figure C.16: Load vs. Deflection Curve and 5% Offset Line, E6s6

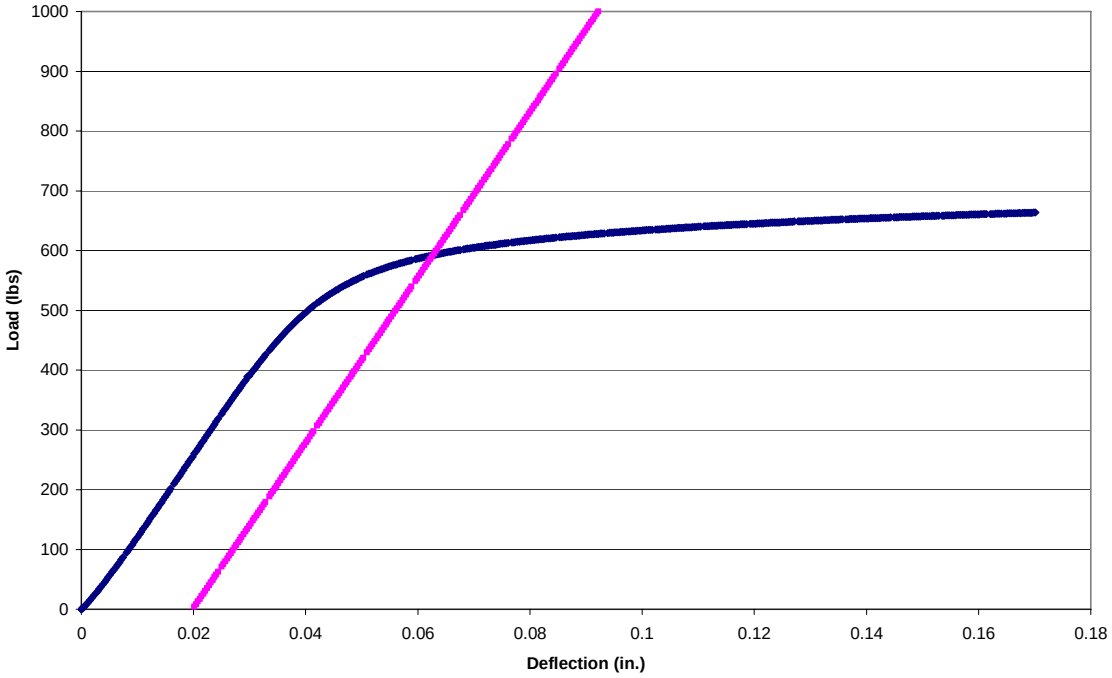

Figure C.17: Load vs. Deflection Curve and 5% Offset Line, E6s7

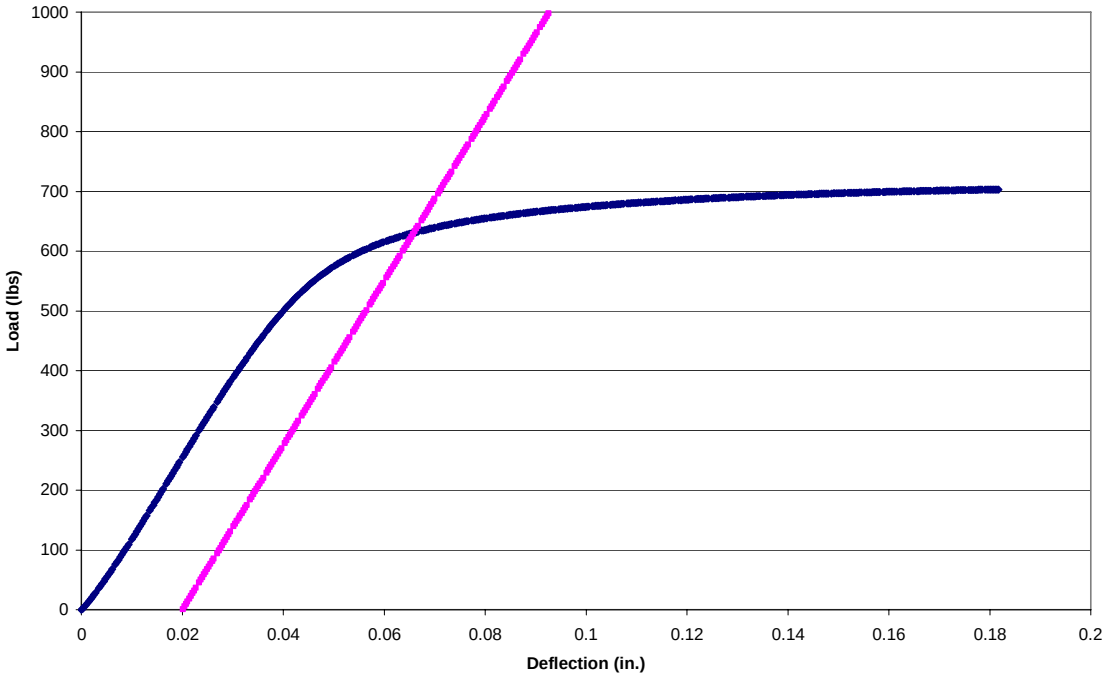

Figure C.18: Load vs. Deflection Curve and 5% Offset Line, E6s8

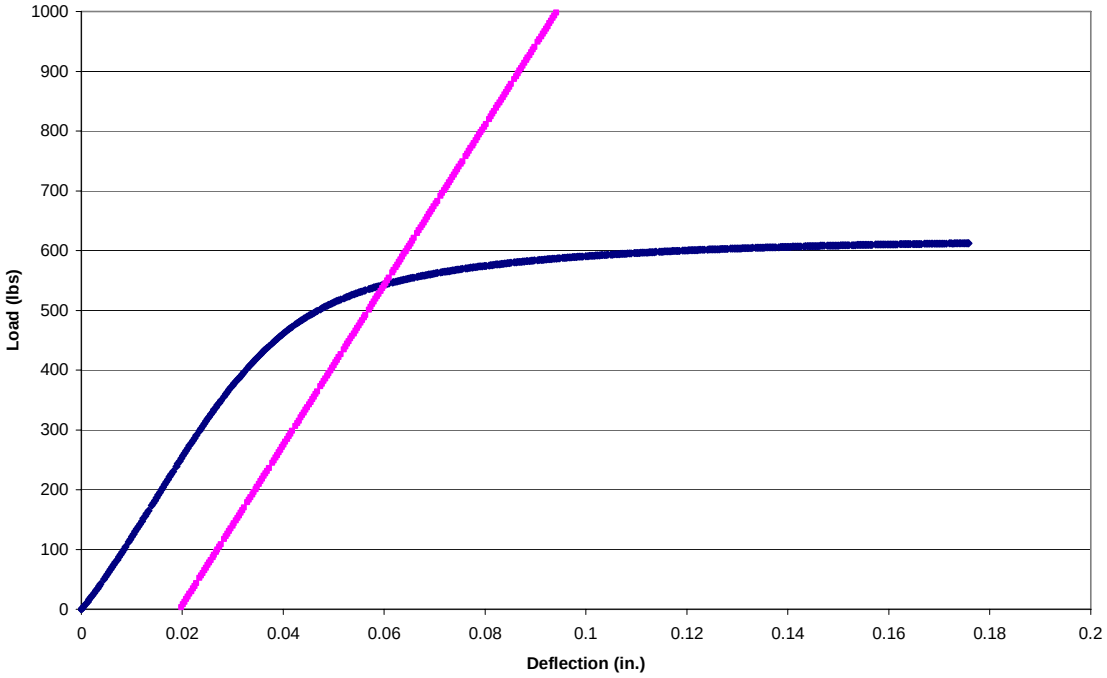

Figure C.19: Load vs. Deflection Curve and 5% Offset Line, E6s9

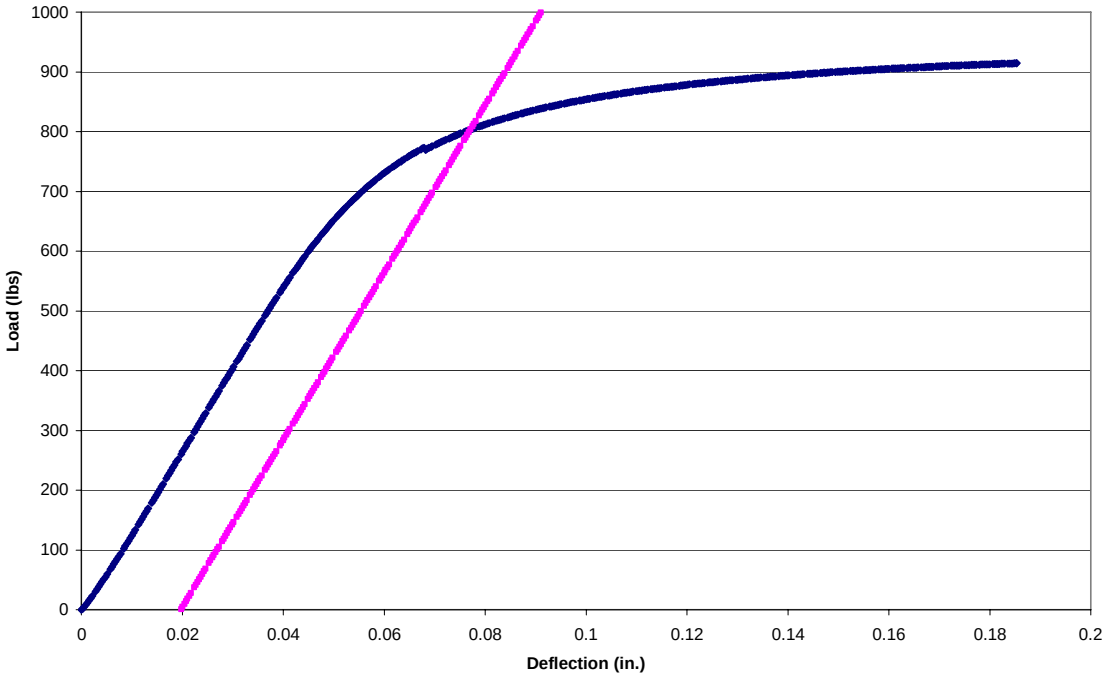

Figure C.20: Load vs. Deflection Curve and 5% Offset Line, E6s10

Table C.3: Test Results for E8s Data Set

$E8s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	610	656
S2	595	640
S3	611	657
S4	610	656
S5	612	658
S6	599	644
S7	649	698
S8	628	675
S9	627	674
S10	600	645
AVG	**614**	**660**
Standard Dev.	**16**	**18**
COV (%)	**2.7**	**2.7**

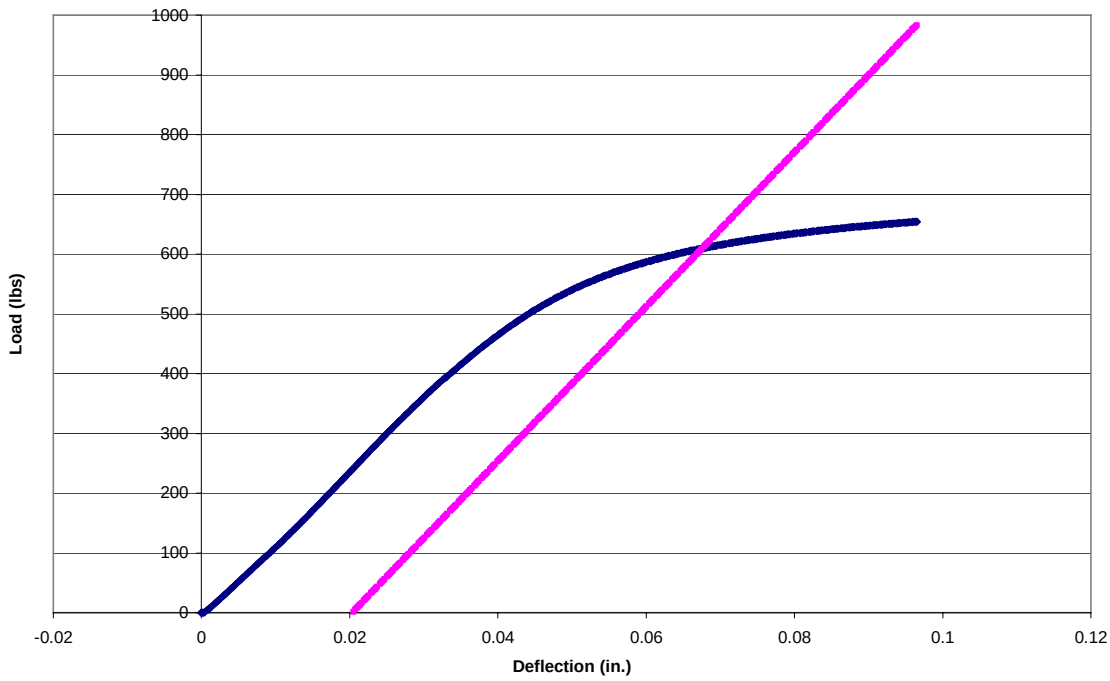

Figure C.21: Load vs. Deflection Curve and 5% Offset Line, E8s1

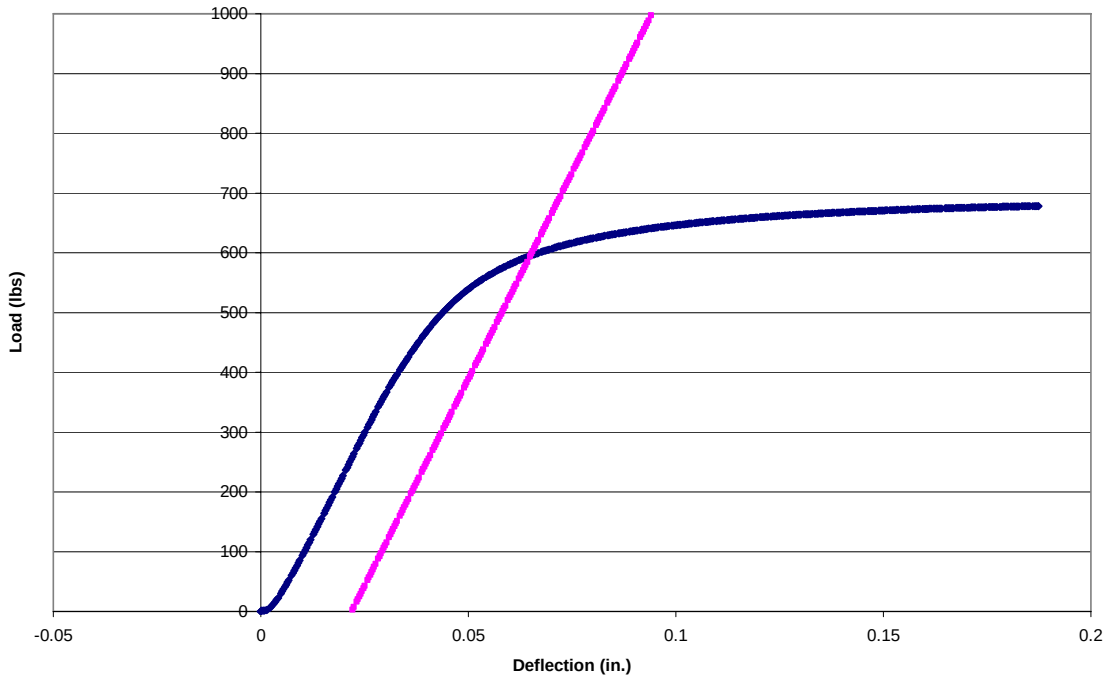

Figure C.22: Load vs. Deflection Curve and 5% Offset Line, E8s2

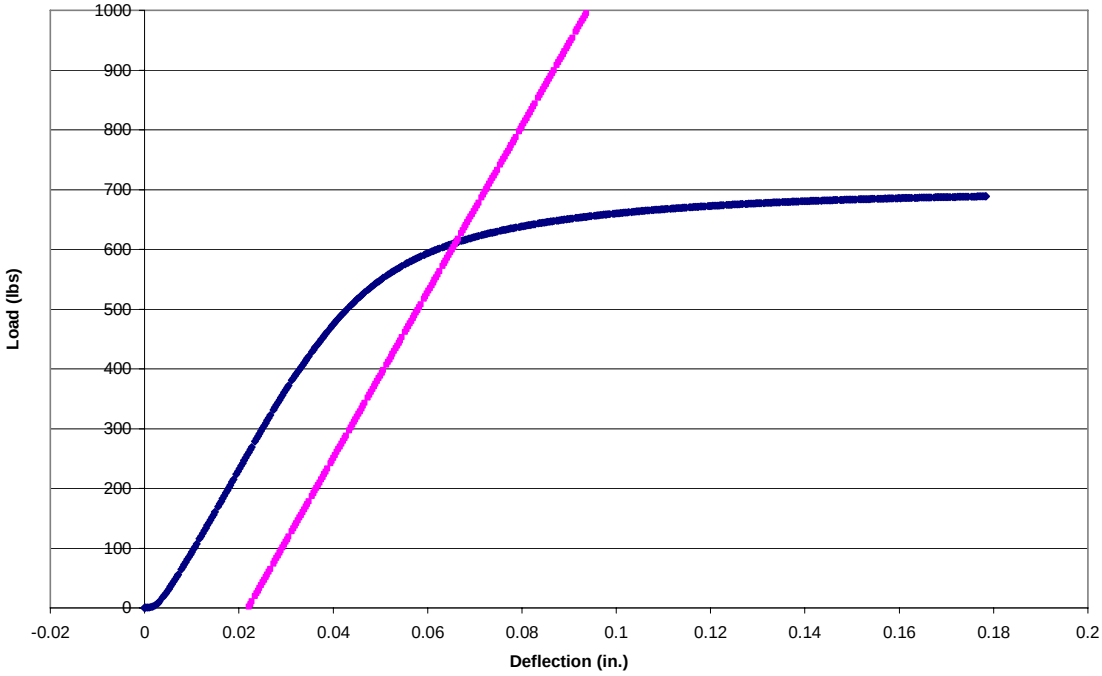

Figure C.23: Load vs. Deflection Curve and 5% Offset Line, E8s3

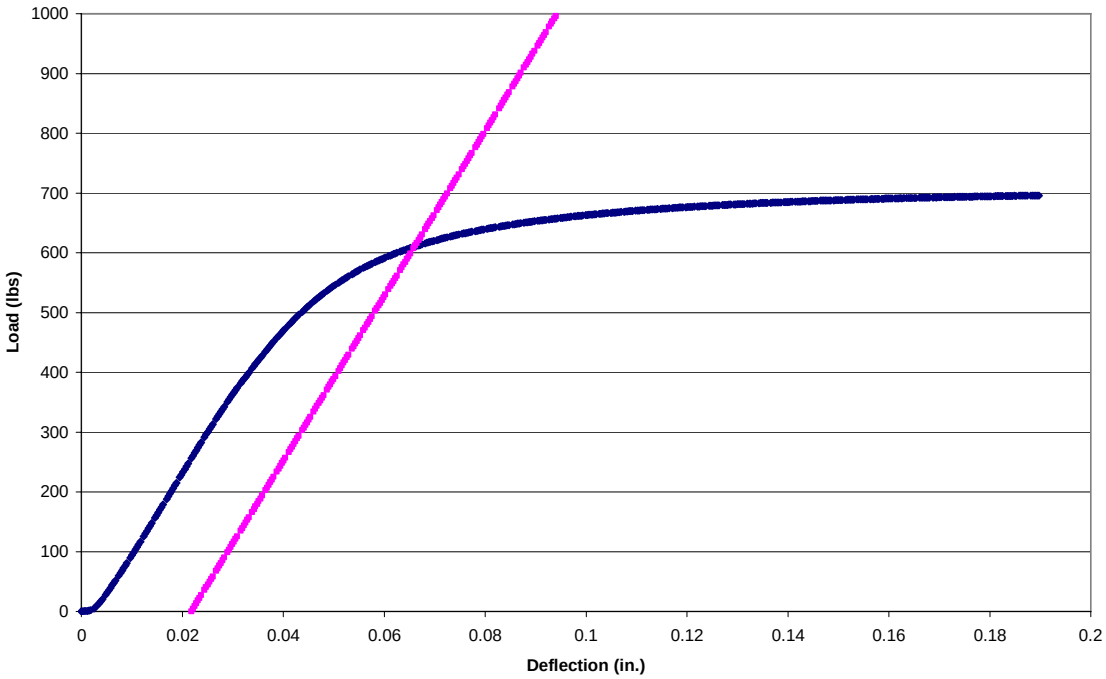

Figure C.24: Load vs. Deflection Curve and 5% Offset Line, E8s4

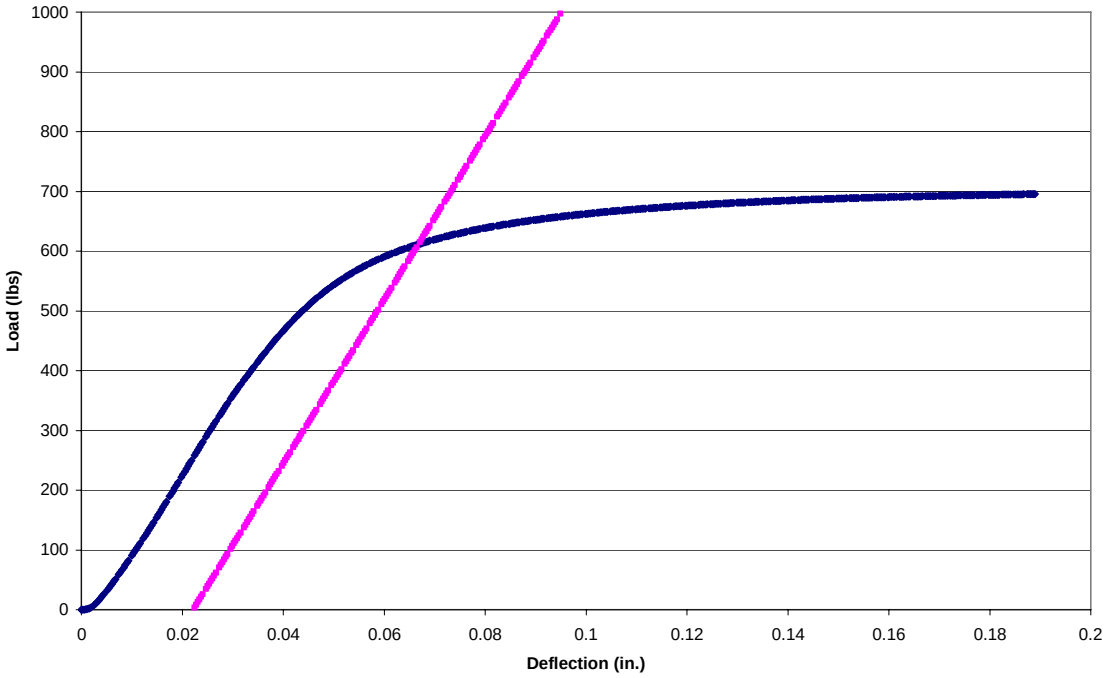

Figure C.25: Load vs. Deflection Curve and 5% Offset Line, E8s5

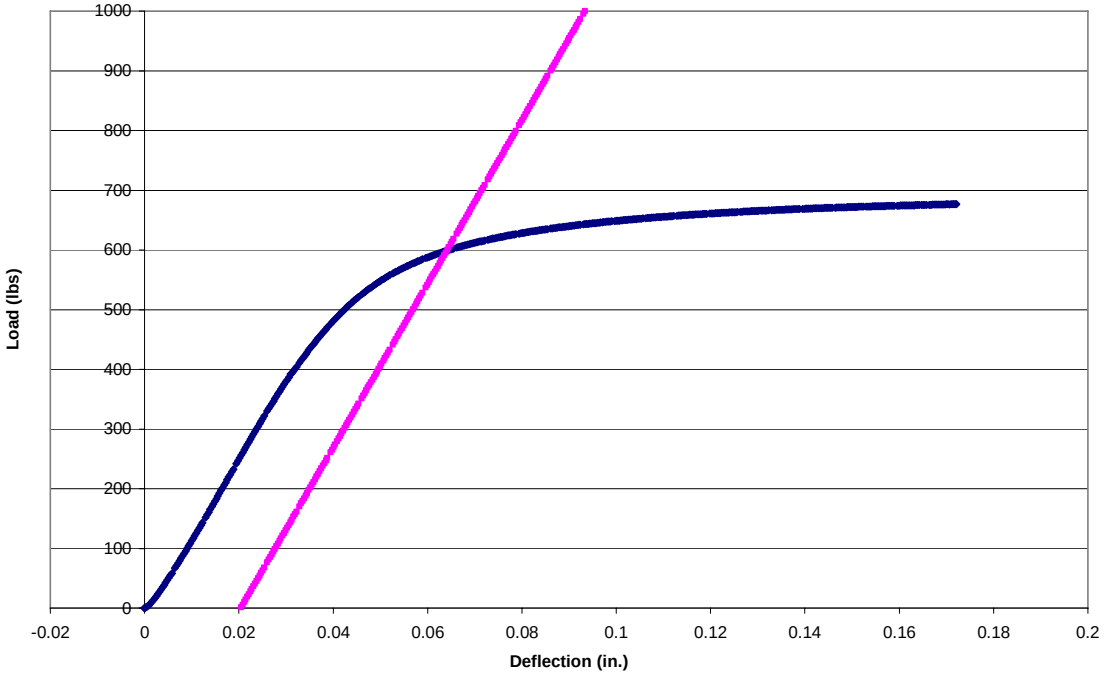

Figure C.26: Load vs. Deflection Curve and 5% Offset Line, E8s6

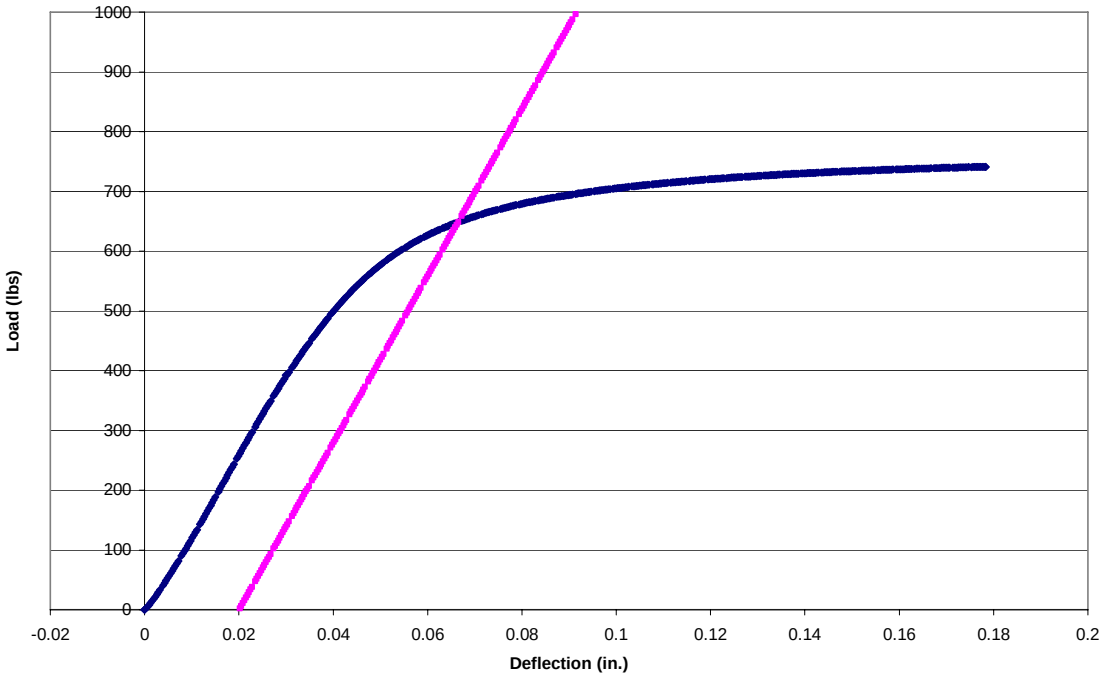

Figure C.27: Load vs. Deflection Curve and 5% Offset Line, E8s7

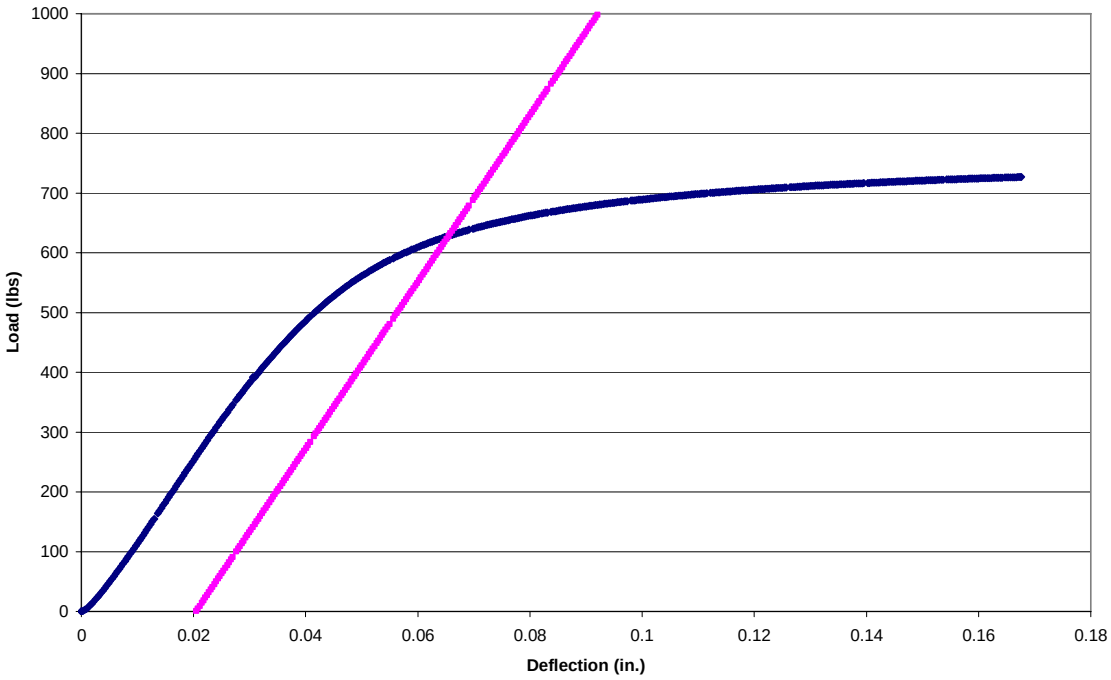

Figure C.28: Load vs. Deflection Curve and 5% Offset Line, E8s8

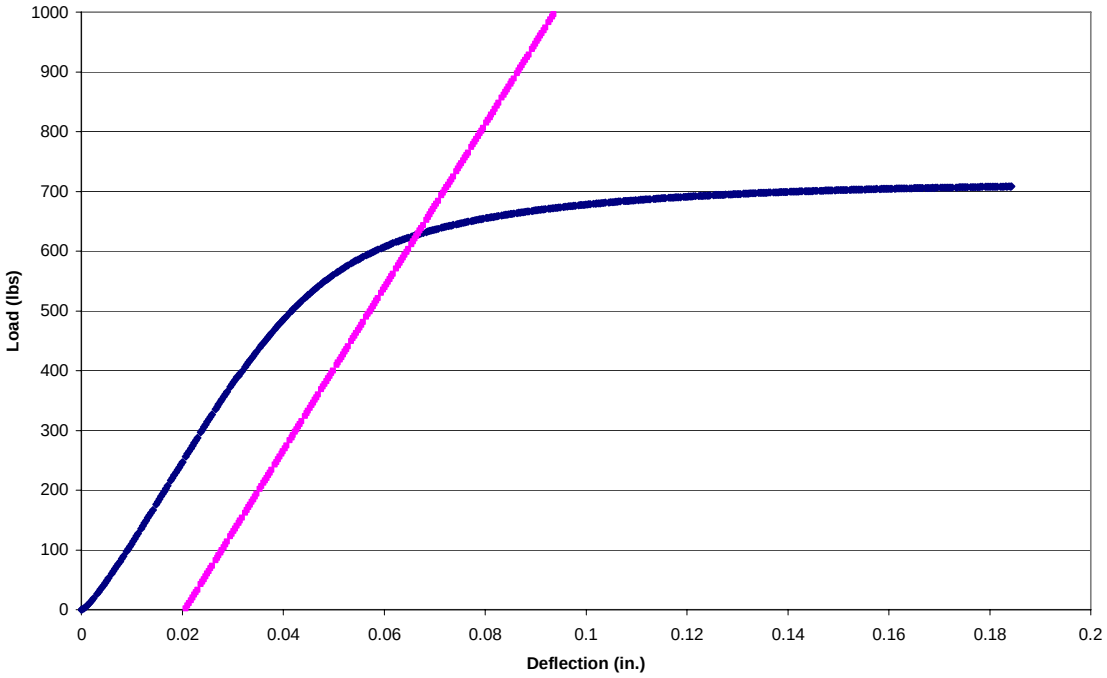

Figure C.29: Load vs. Deflection Curve and 5% Offset Line, E8s9

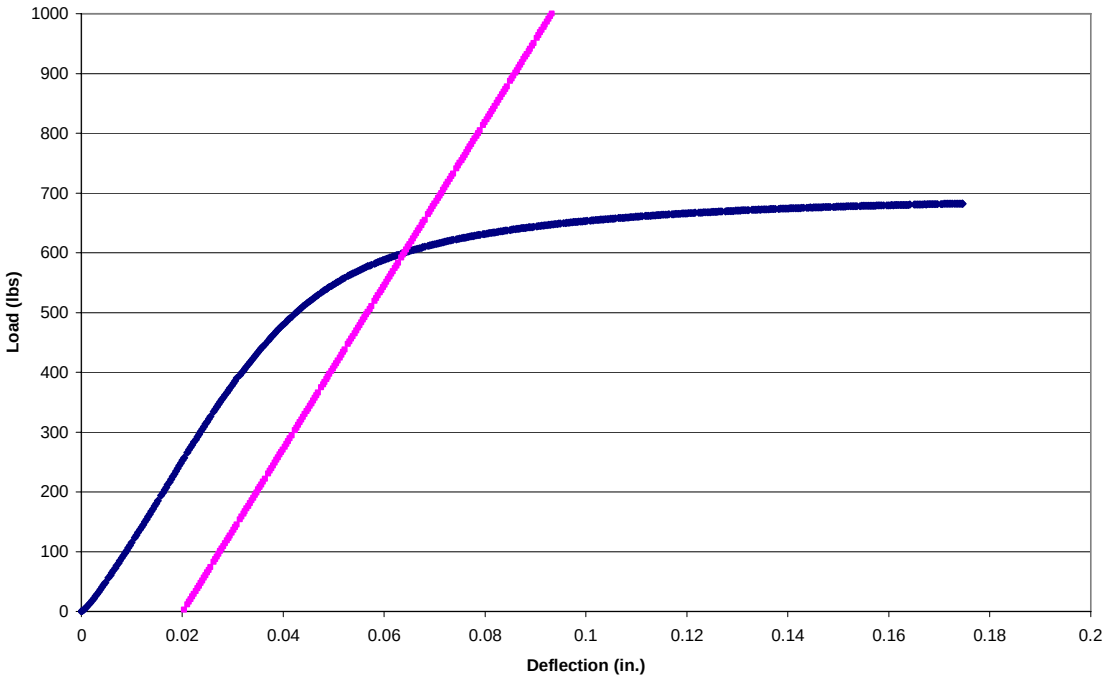

Figure C.30: Load vs. Deflection Curve and 5% Offset Line, E8s10

Table C.4: Test Results for H4s Data Set

$H4s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	3580	2014
S2	3540	1991
S3	3620	2036
S4	3620	2036
S5	3600	2025
S6	3530	1986
S7	3550	1997
S8	3630	2042
S9	3610	2031
S10	3640	2048
AVG	**3592**	**2021**
Standard Dev.	**40**	**22**
COV (%)	**1.1**	**1.1**

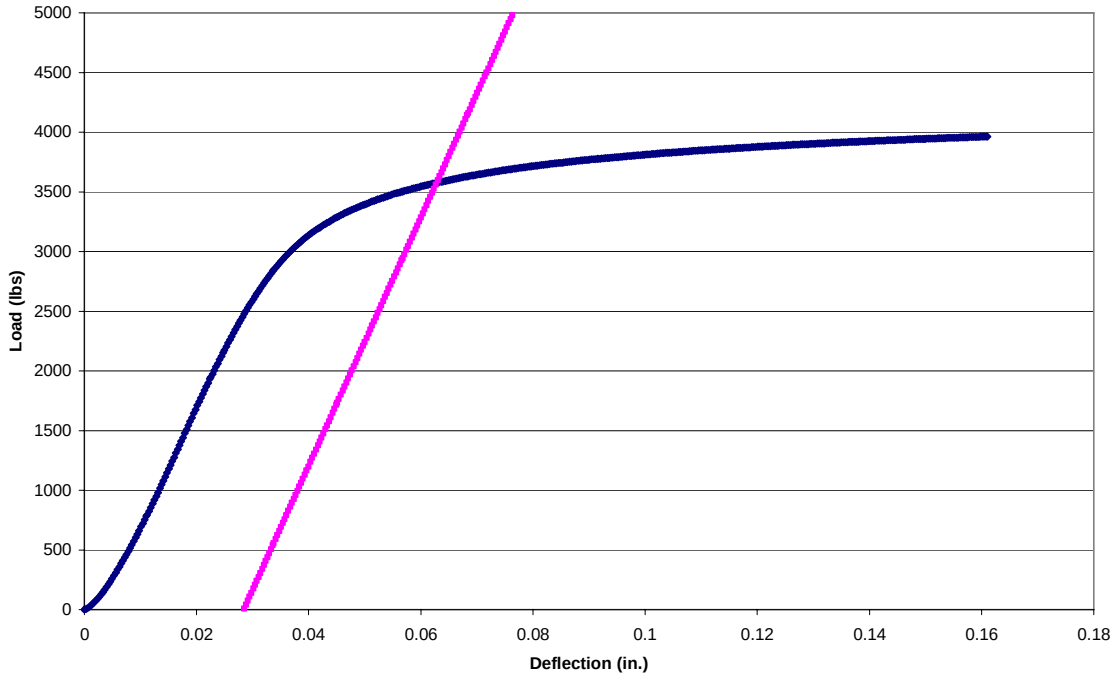

Figure C.31: Load vs. Deflection Curve and 5% Offset Line, H4s1

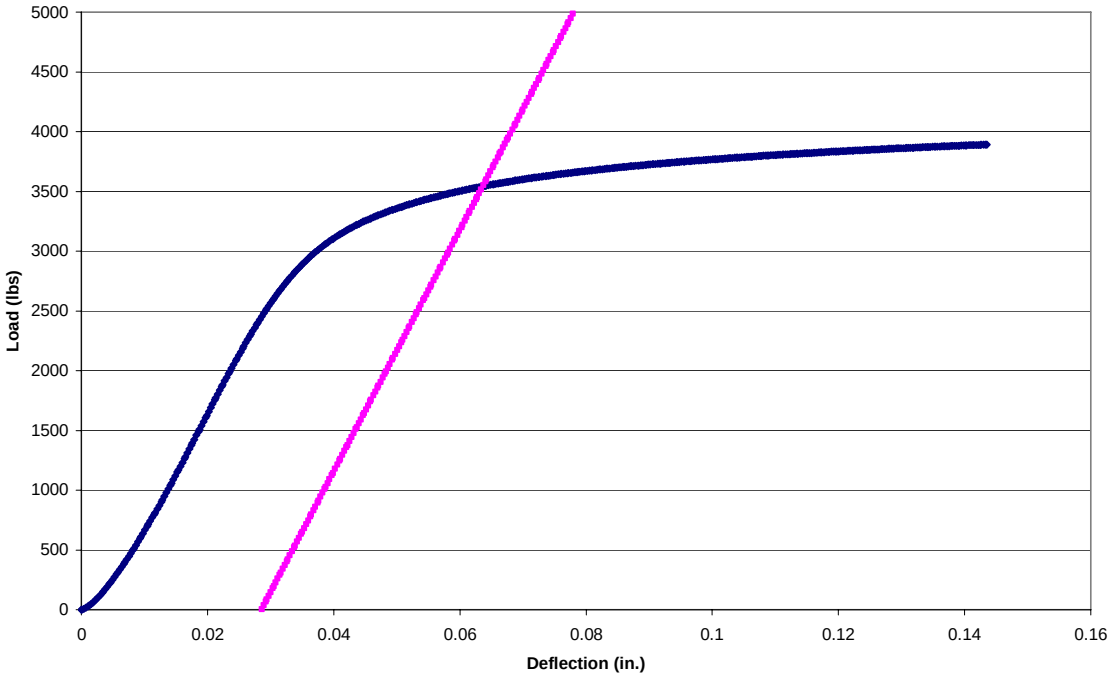

Figure C.32: Load vs. Deflection Curve and 5% Offset Line, H4s2

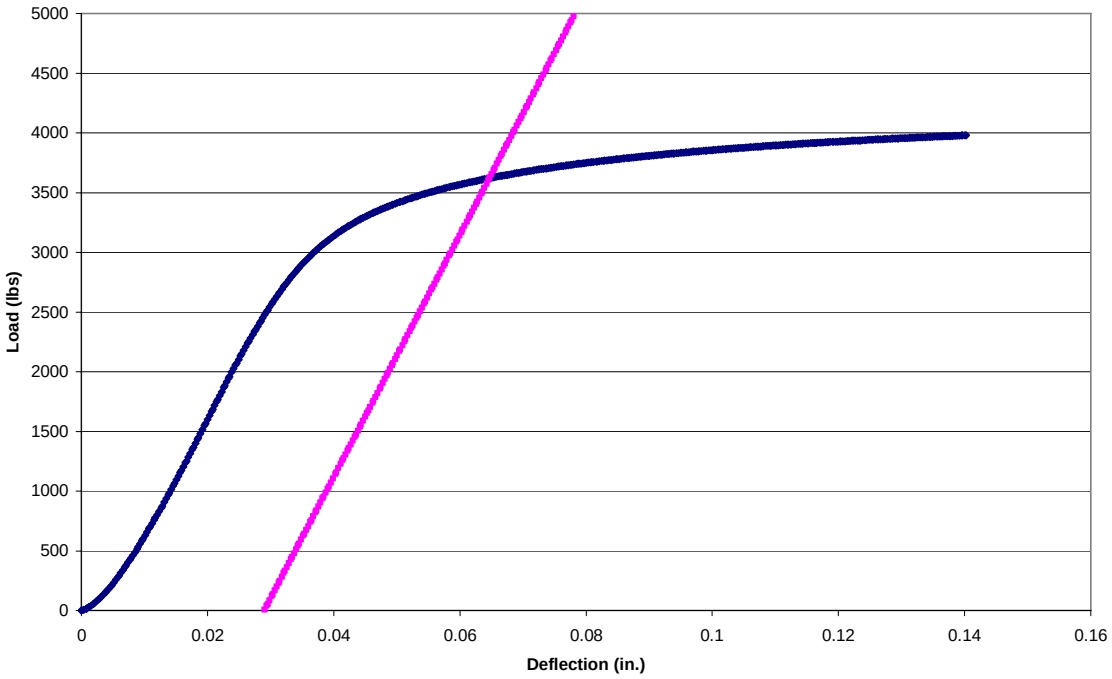

Figure C.33: Load vs. Deflection Curve and 5% Offset Line, H4s3

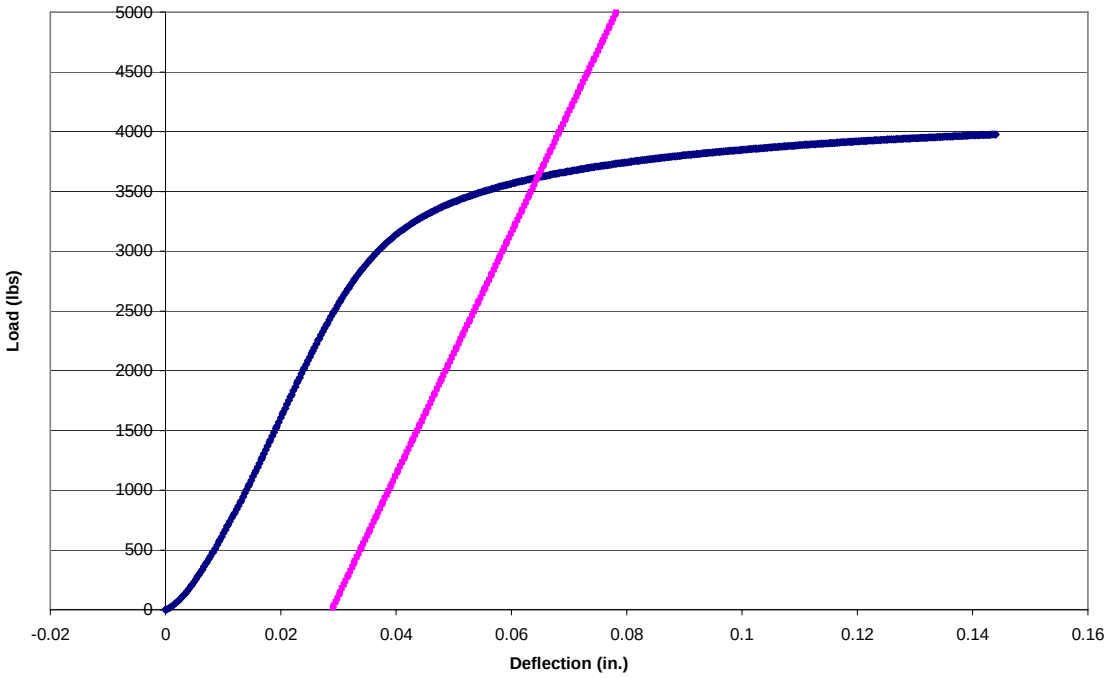

Figure C.34: Load vs. Deflection Curve and 5% Offset Line, H4s4

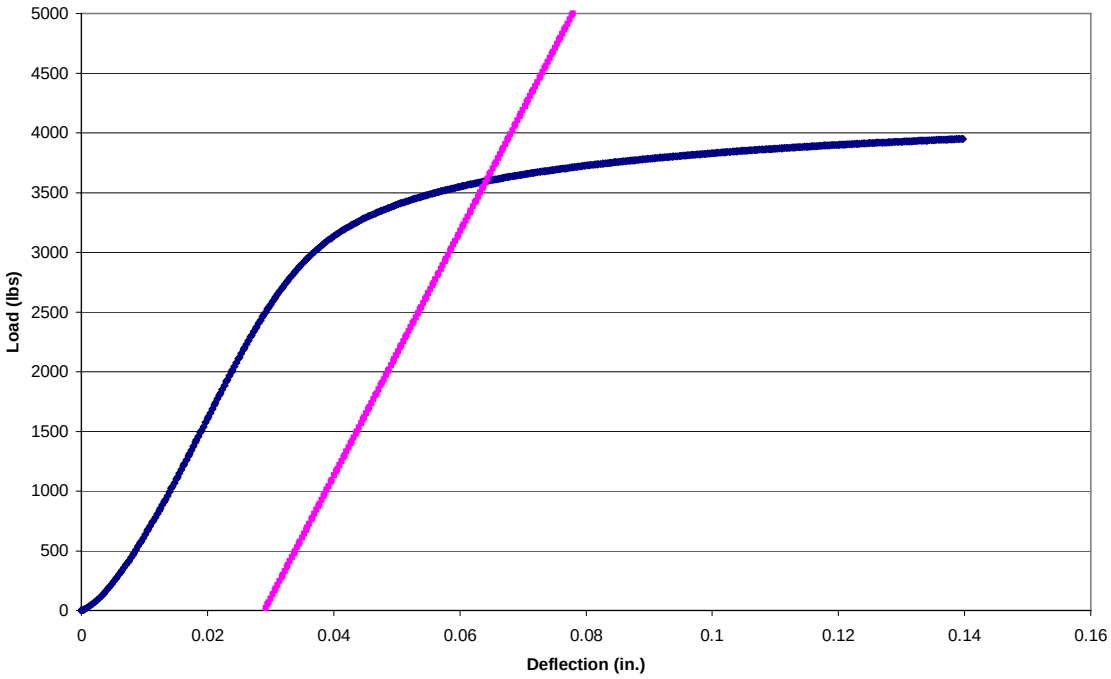

Figure C.35: Load vs. Deflection Curve and 5% Offset Line, H4s5

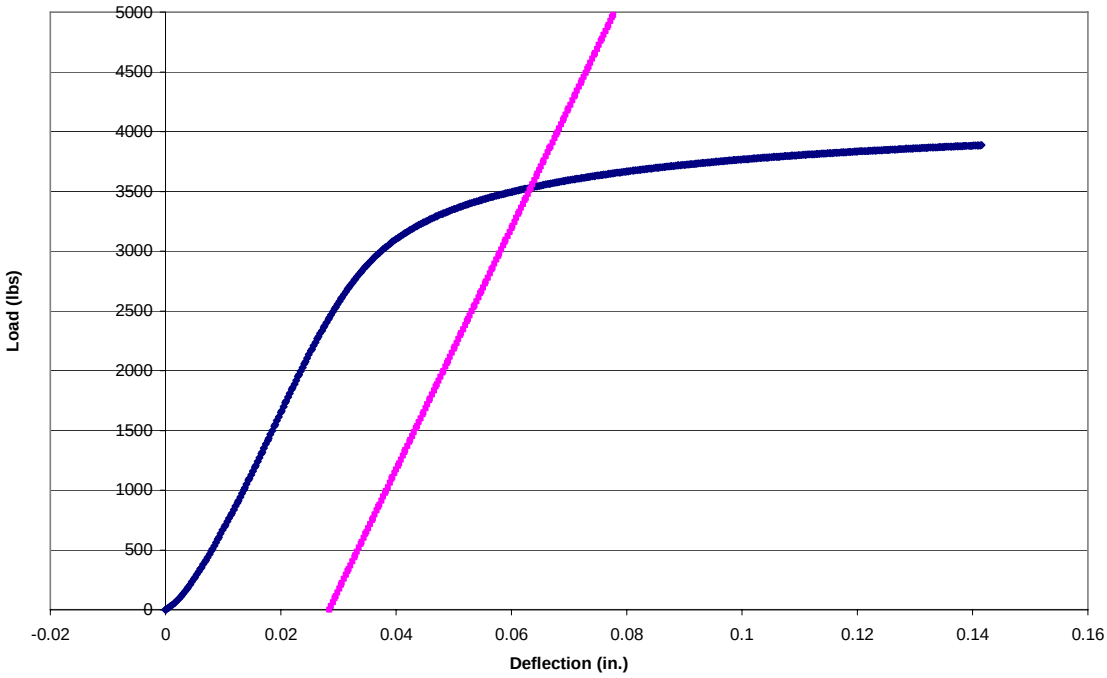

Figure C.36: Load vs. Deflection Curve and 5% Offset Line, H4s6

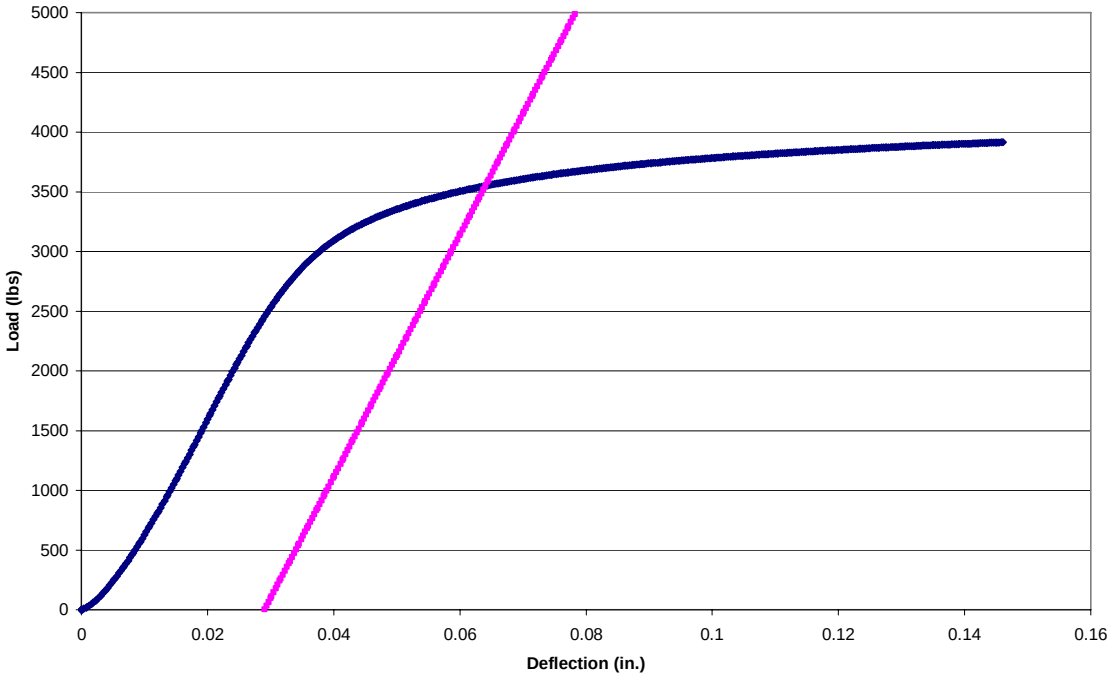

Figure C.37: Load vs. Deflection Curve and 5% Offset Line, H4s7

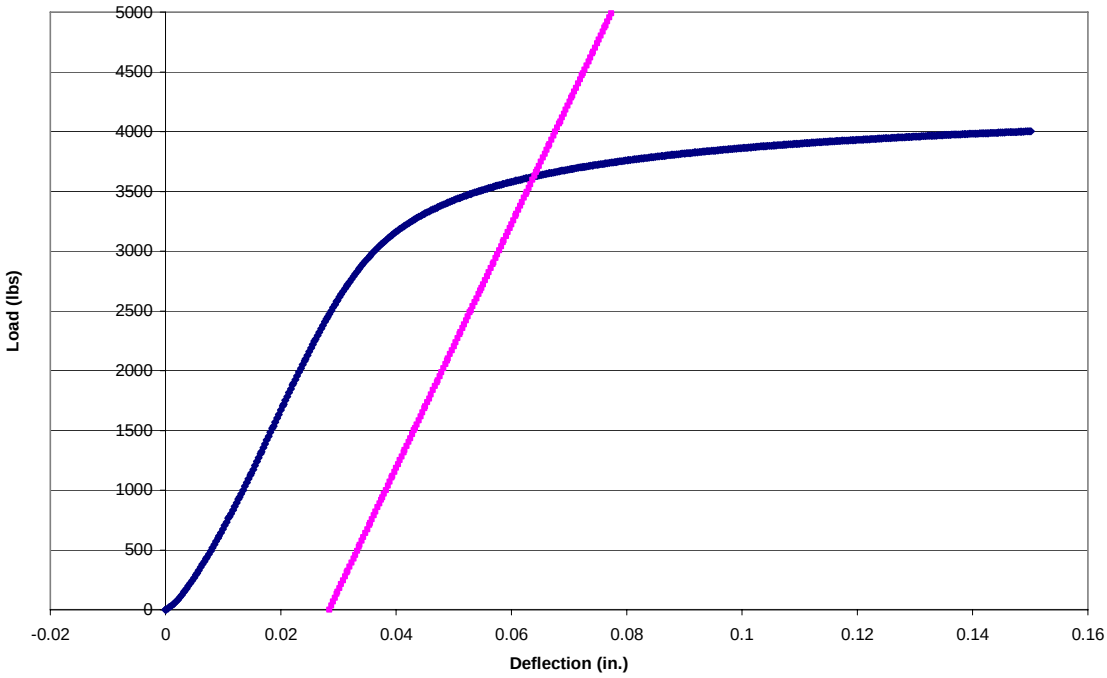

Figure C.38: Load vs. Deflection Curve and 5% Offset Line, H4s8

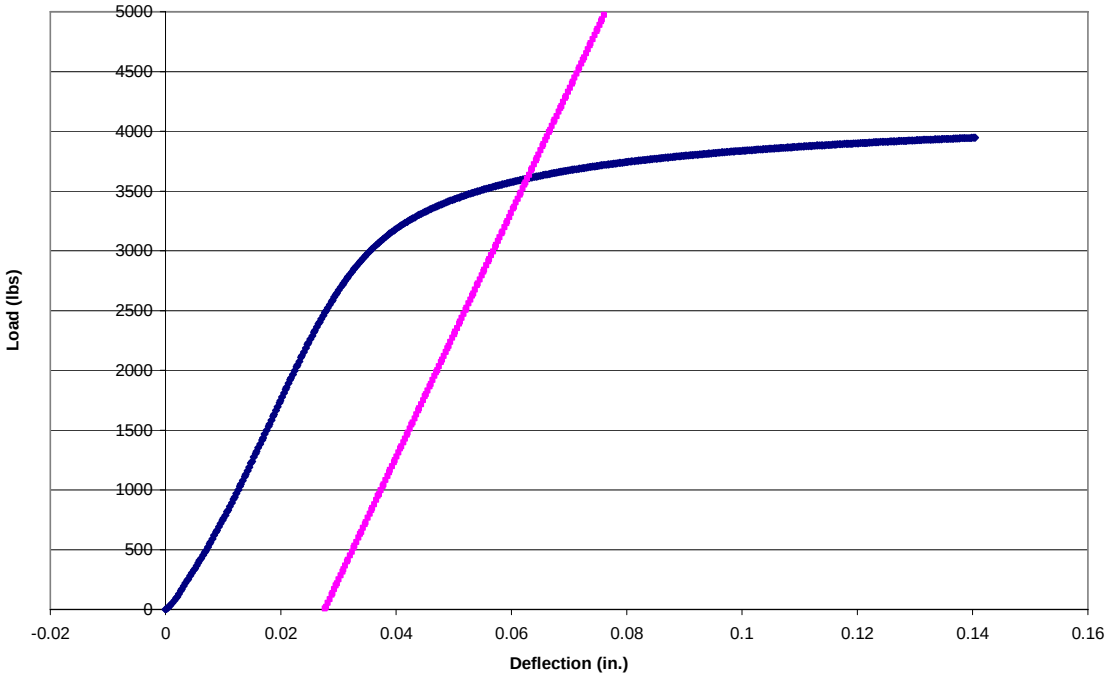

Figure C.39: Load vs. Deflection Curve and 5% Offset Line, H4s9

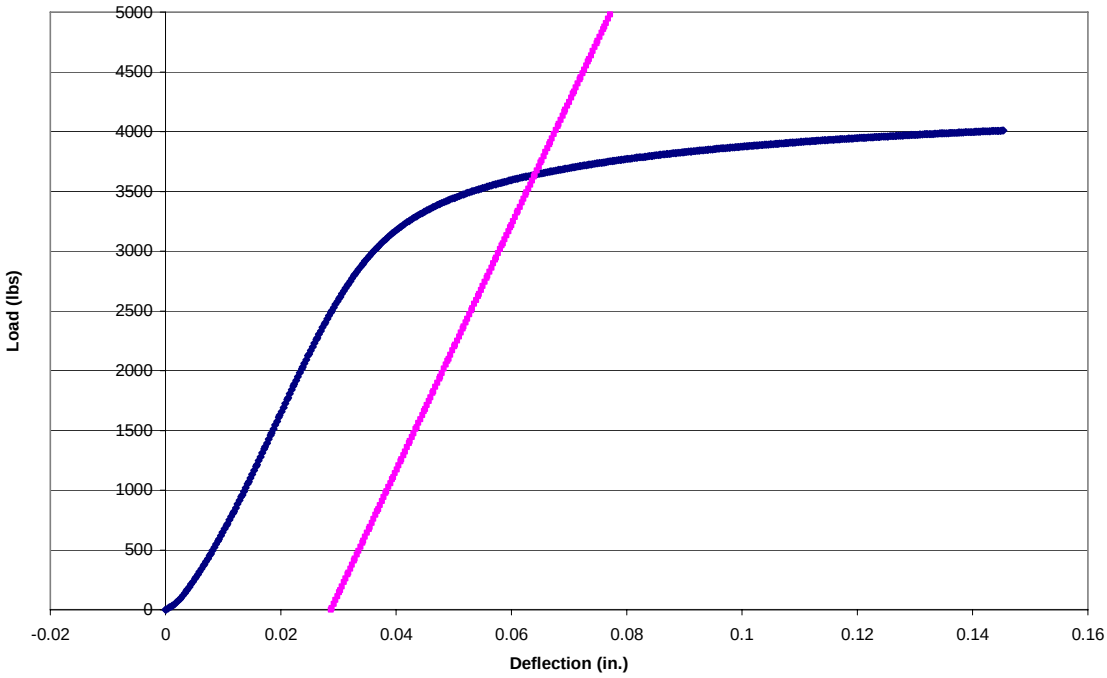

Figure C.40: Load vs. Deflection Curve and 5% Offset Line, H4s10

Table C.5: Test Results for H6s Data Set

$H6s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	1670	1670
S2	1890	1890
S3	1600	1600
S4	1750	1750
S5	1680	1680
S6	1710	1710
S7	1700	1700
S8	1740	1740
S9	1730	1730
S10	1890	1890
AVG	**1736**	**1736**
Standard Dev.	**92**	**92**
COV (%)	**5.3**	**5.3**

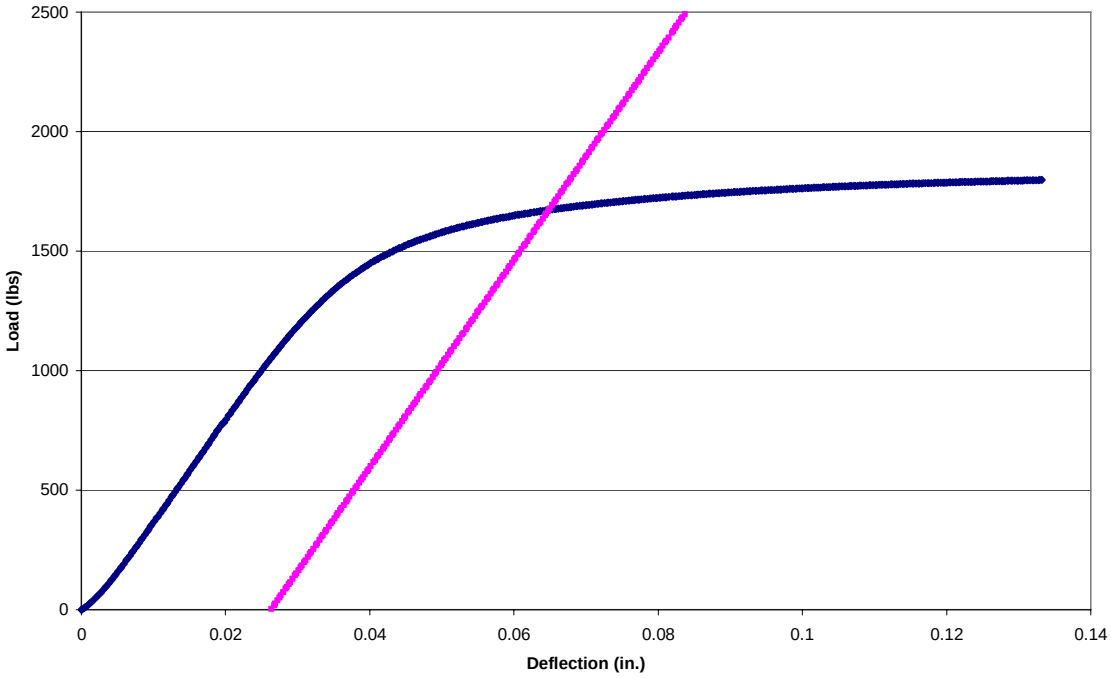

Figure C.41: Load vs. Deflection Curve and 5% Offset Line, H6s1

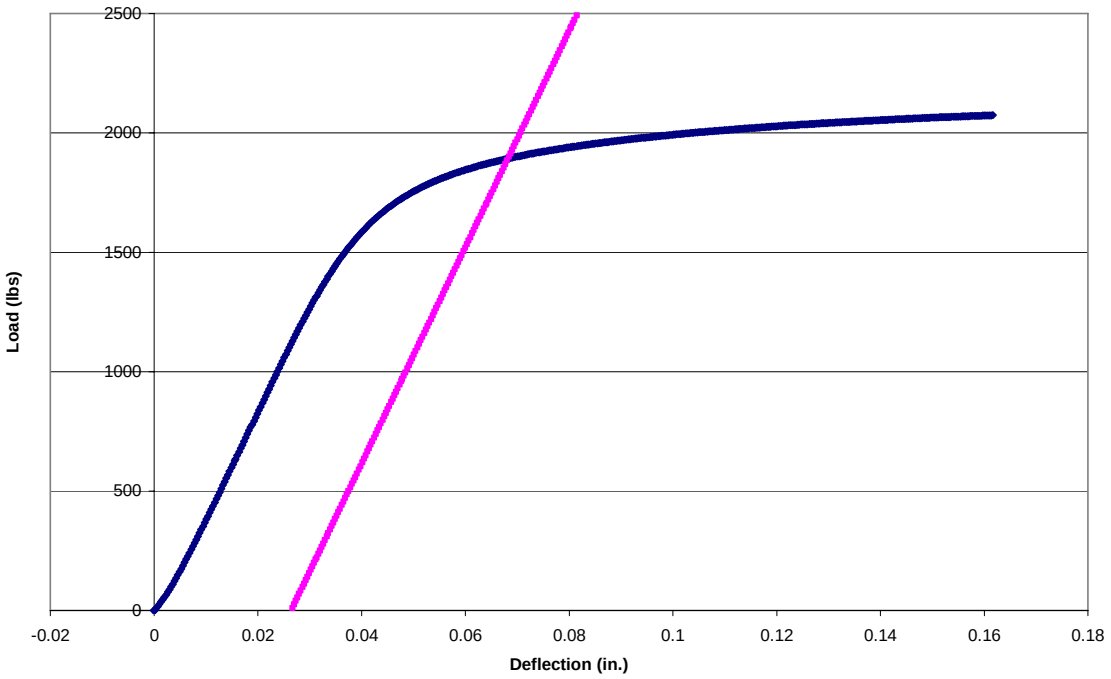

Figure C.42: Load vs. Deflection Curve and 5% Offset Line, H6s2

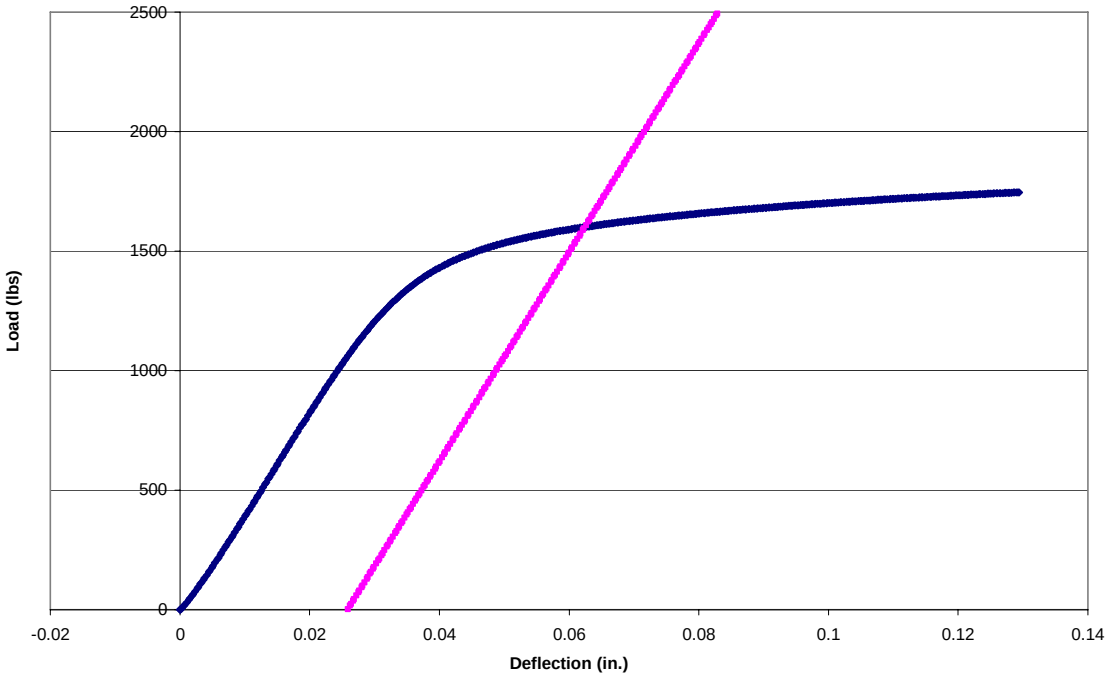

Figure C.43: Load vs. Deflection Curve and 5% Offset Line, H6s3

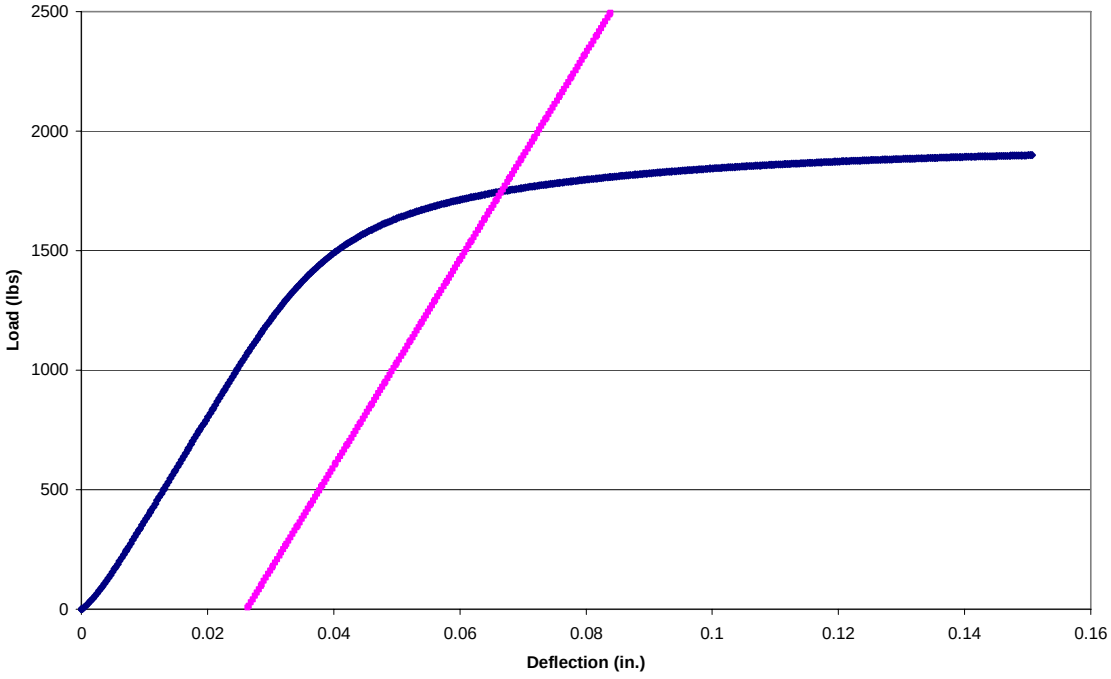

Figure C.44: Load vs. Deflection Curve and 5% Offset Line, H6s4

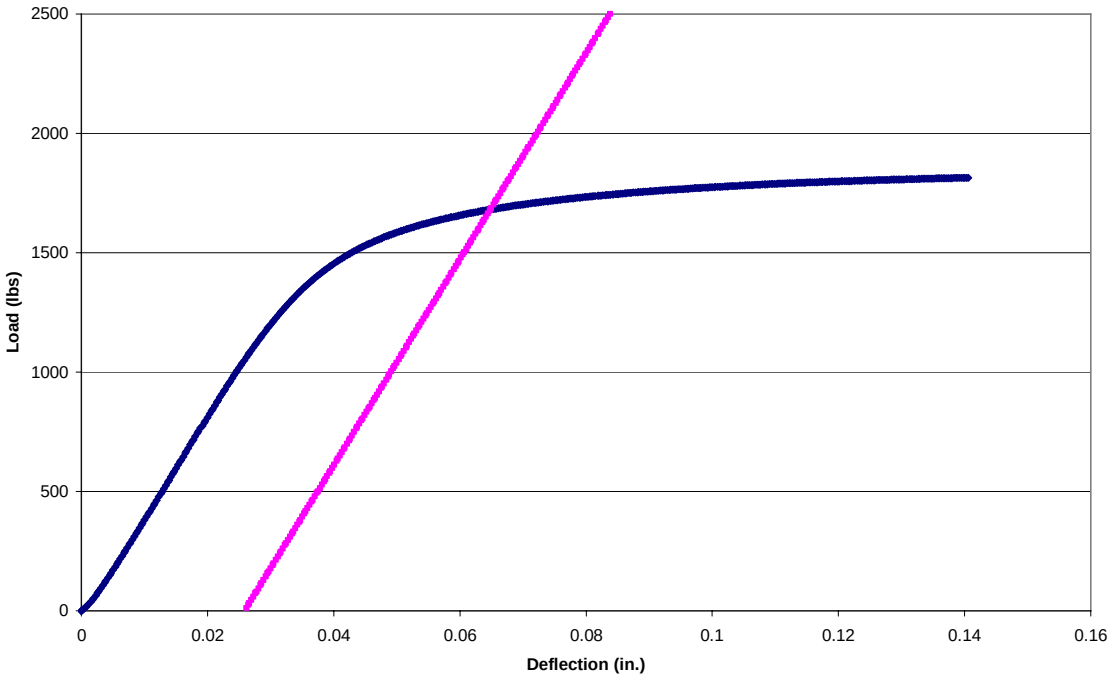

Figure C.45: Load vs. Deflection Curve and 5% Offset Line, H6s5

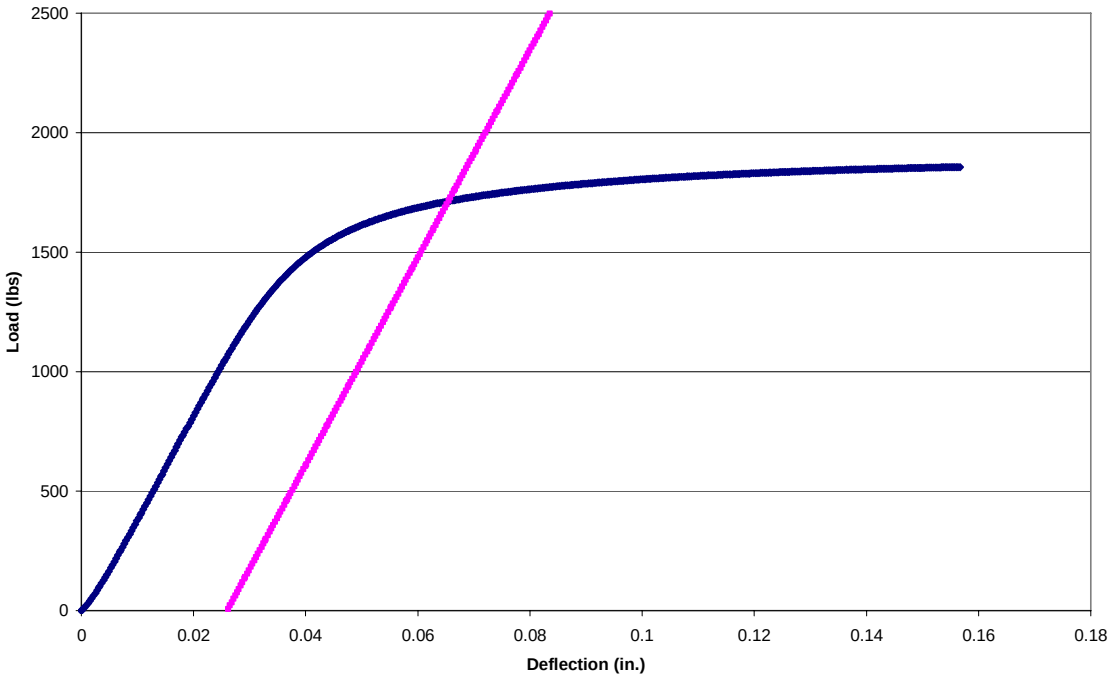

Figure C.46: Load vs. Deflection Curve and 5% Offset Line, H6s6

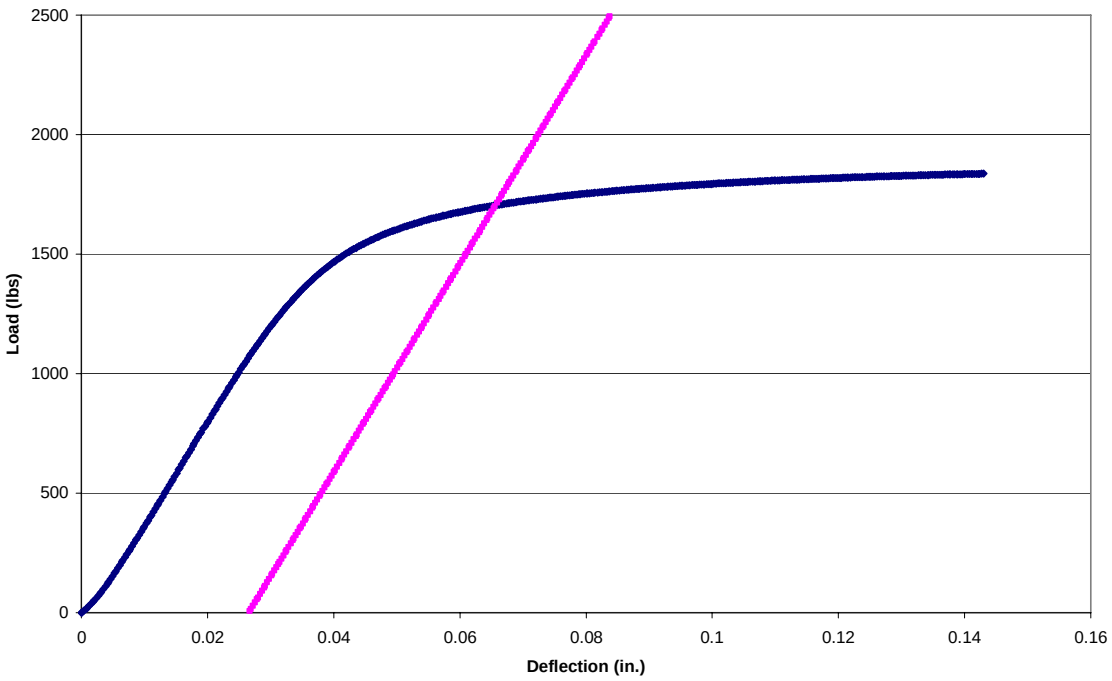

Figure C.47: Load vs. Deflection Curve and 5% Offset Line, H6s7

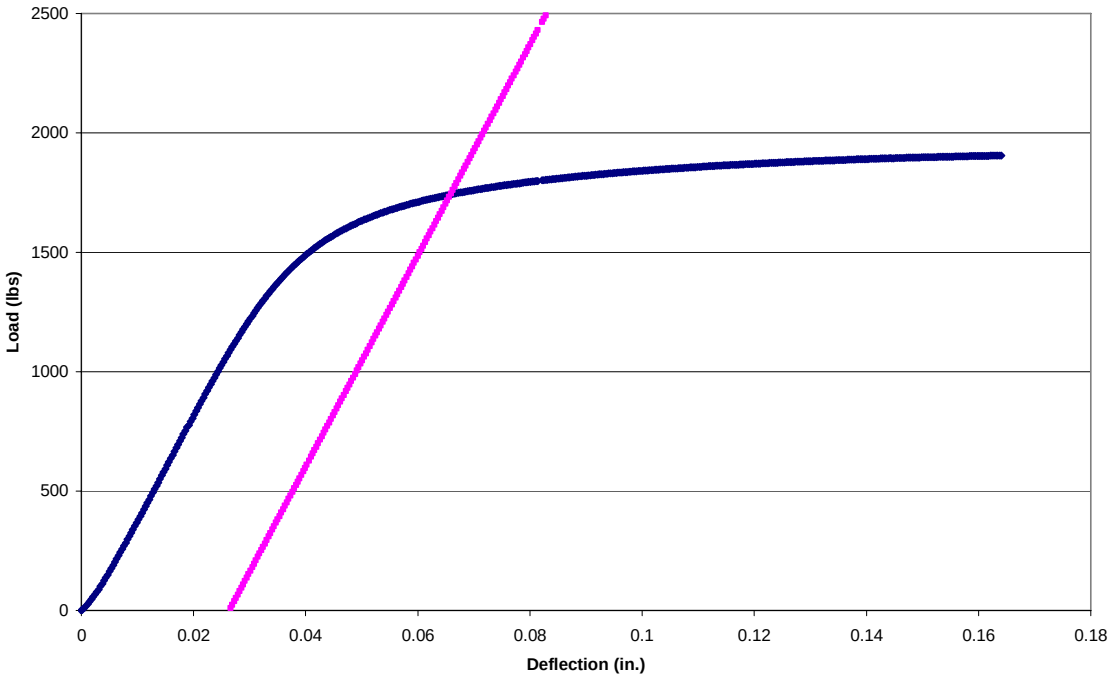

Figure C.48: Load vs. Deflection Curve and 5% Offset Line, H6s8

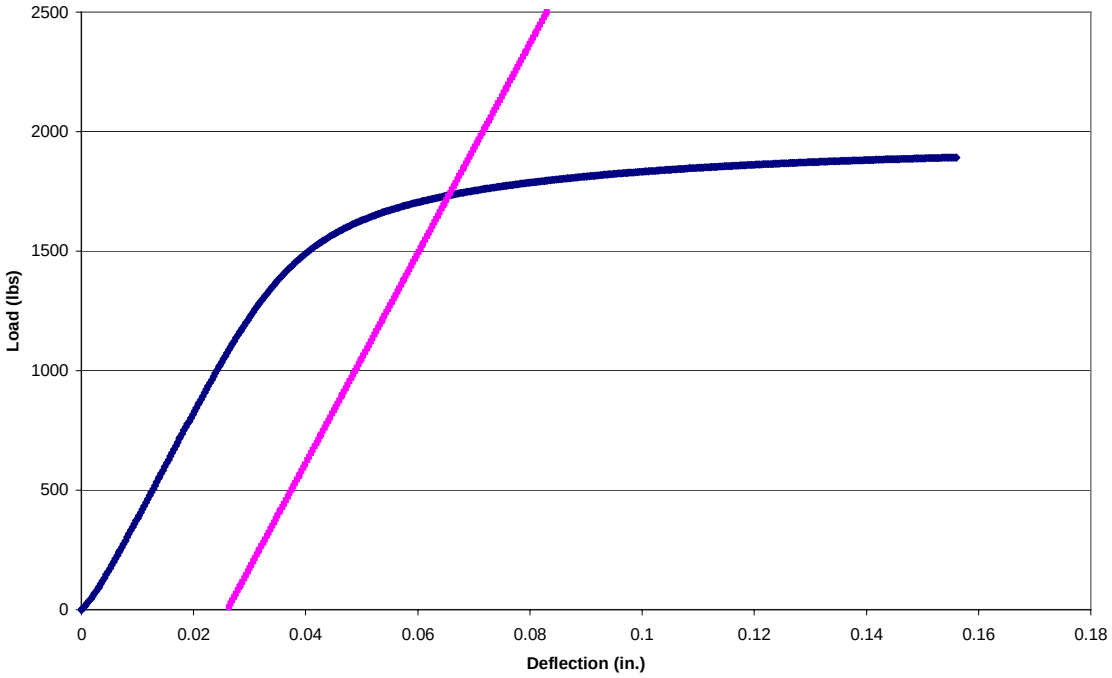

Figure C.49: Load vs. Deflection Curve and 5% Offset Line, H6s9

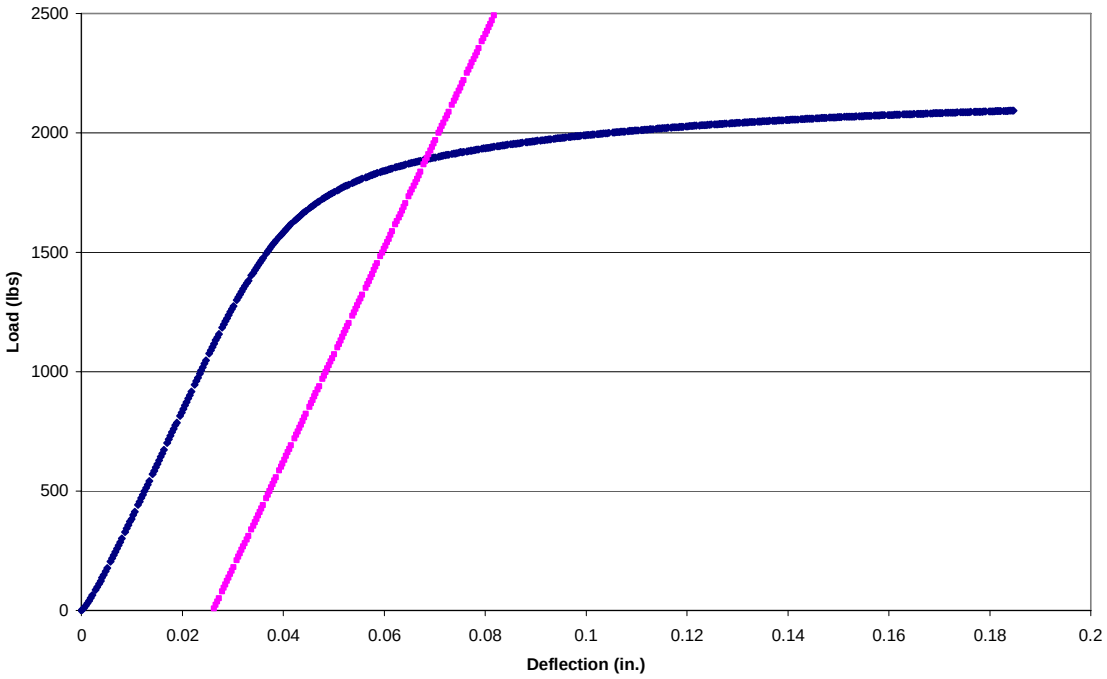

Figure C.50: Load vs. Deflection Curve and 5% Offset Line, H6s10

Table C.6: Test Results for H8s Data Set

$H8s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	946	1372
S2	899	1304
S3	935	1356
S4	923	1338
S5	1024	1485
S6	840	1218
S7	901	1306
S8	966	1401
S9	961	1393
S10	943	1367
AVG	**934**	**1354**
Standard Dev.	**49**	**71**
COV (%)	**5.2**	**5.2**

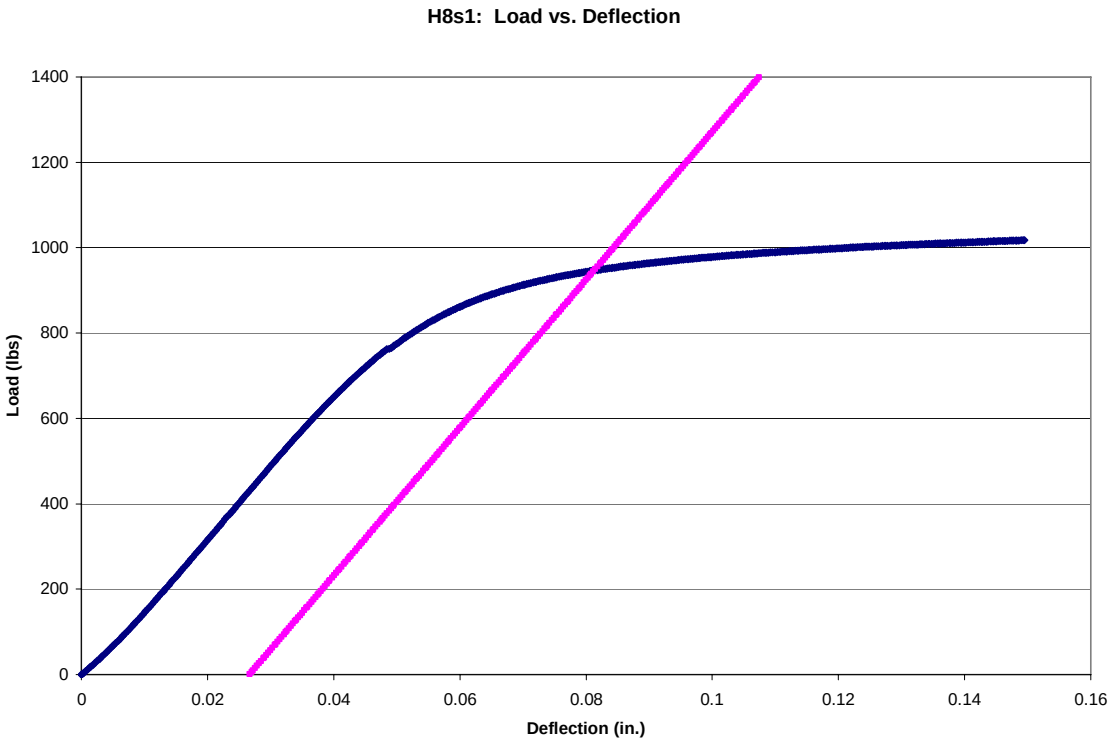

Figure C.51: Load vs. Deflection Curve and 5% Offset Line, H8s1

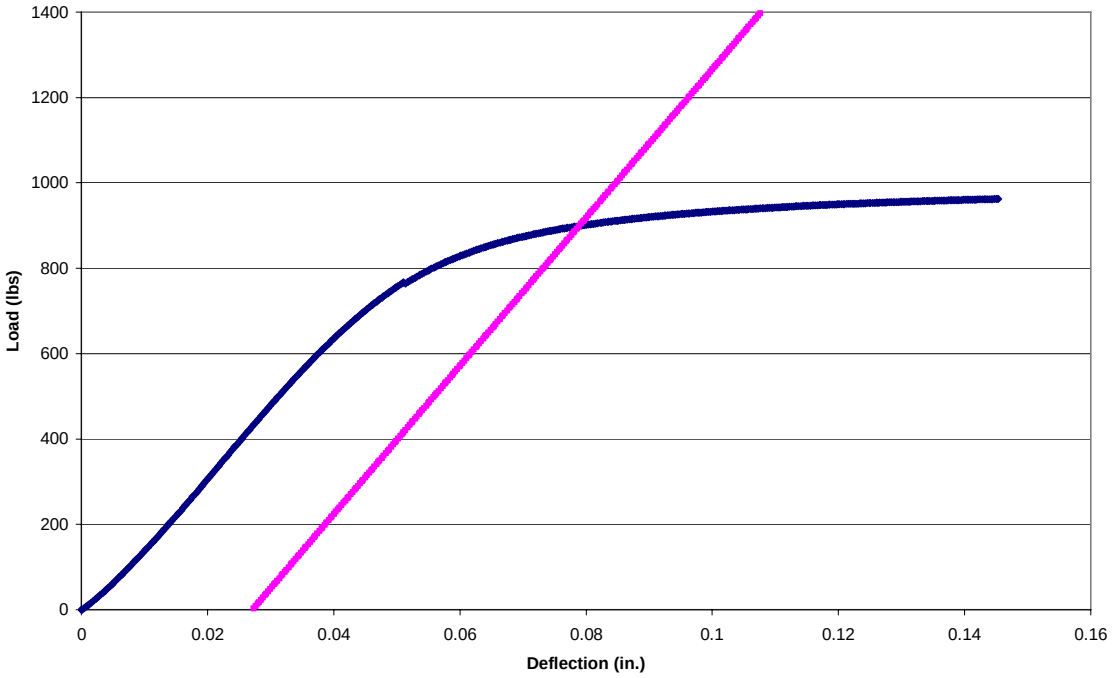

Figure C.52: Load vs. Deflection Curve and 5% Offset Line, H8s2

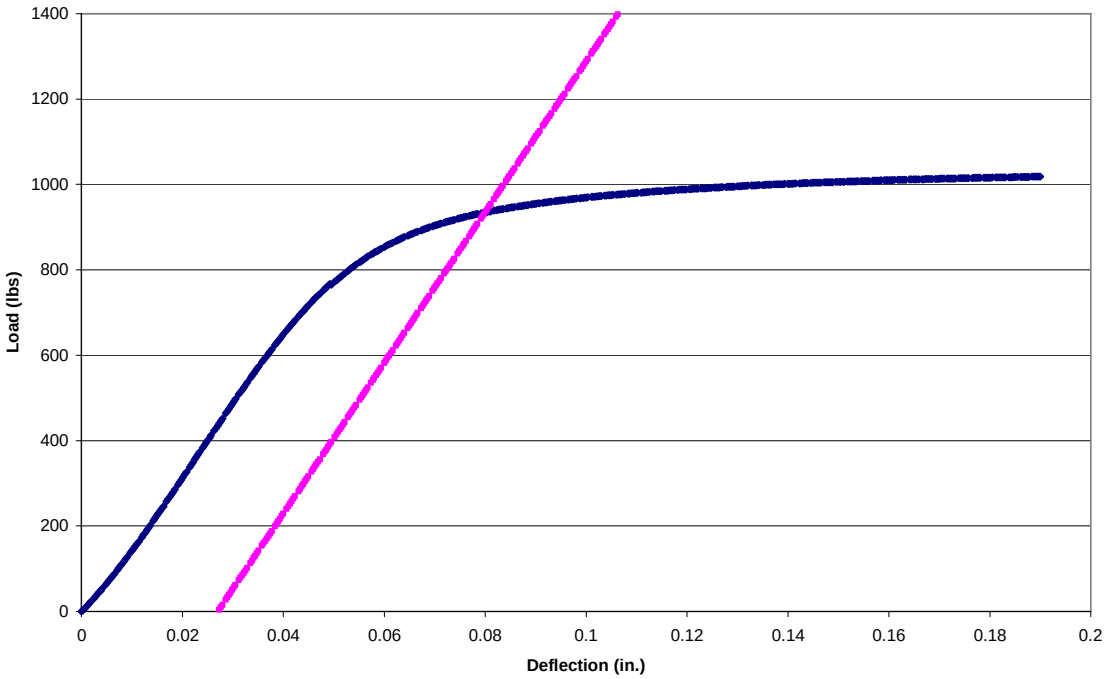

Figure C.53: Load vs. Deflection Curve and 5% Offset Line, H8s3

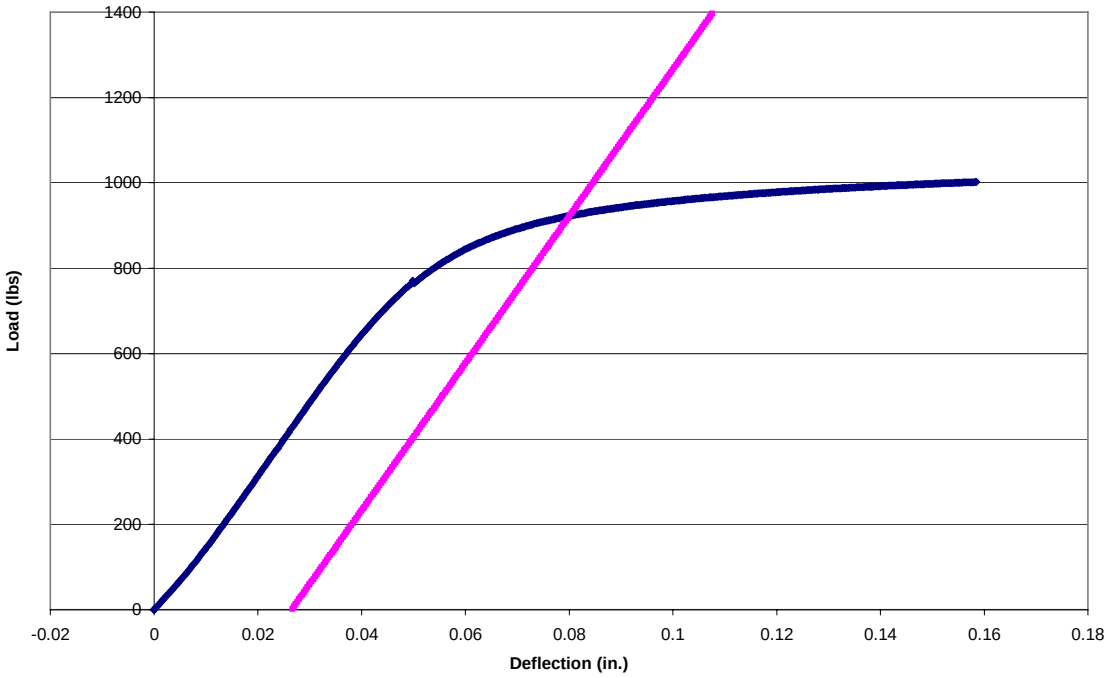

Figure C.54: Load vs. Deflection Curve and 5% Offset Line, H8s4

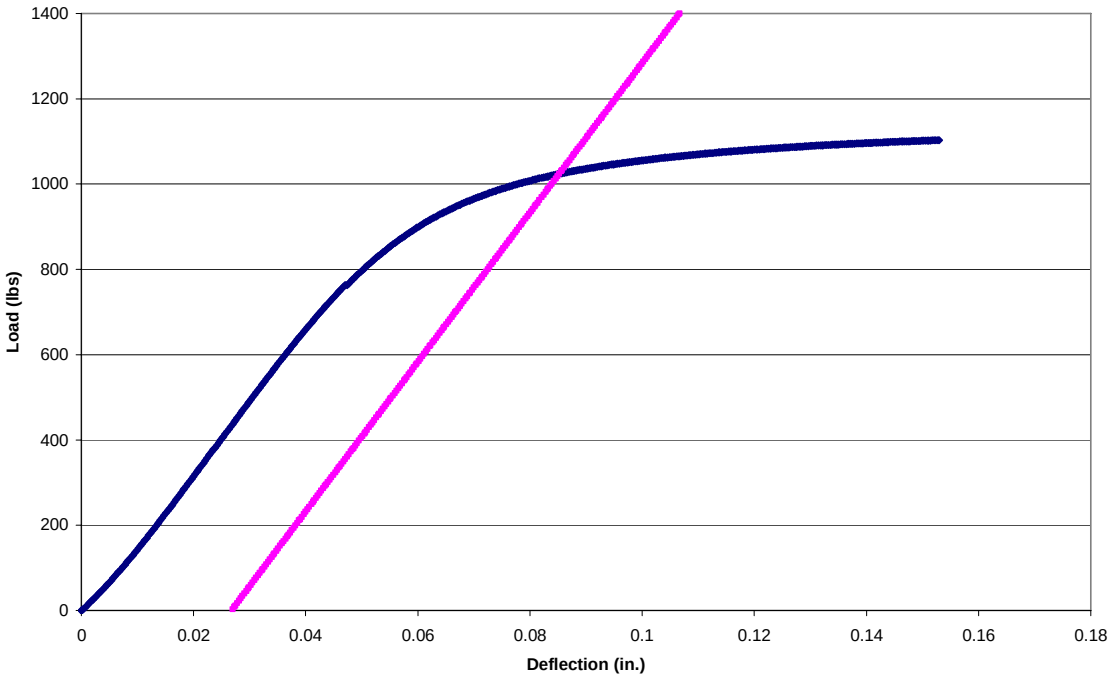

Figure C.55: Load vs. Deflection Curve and 5% Offset Line, H8s5

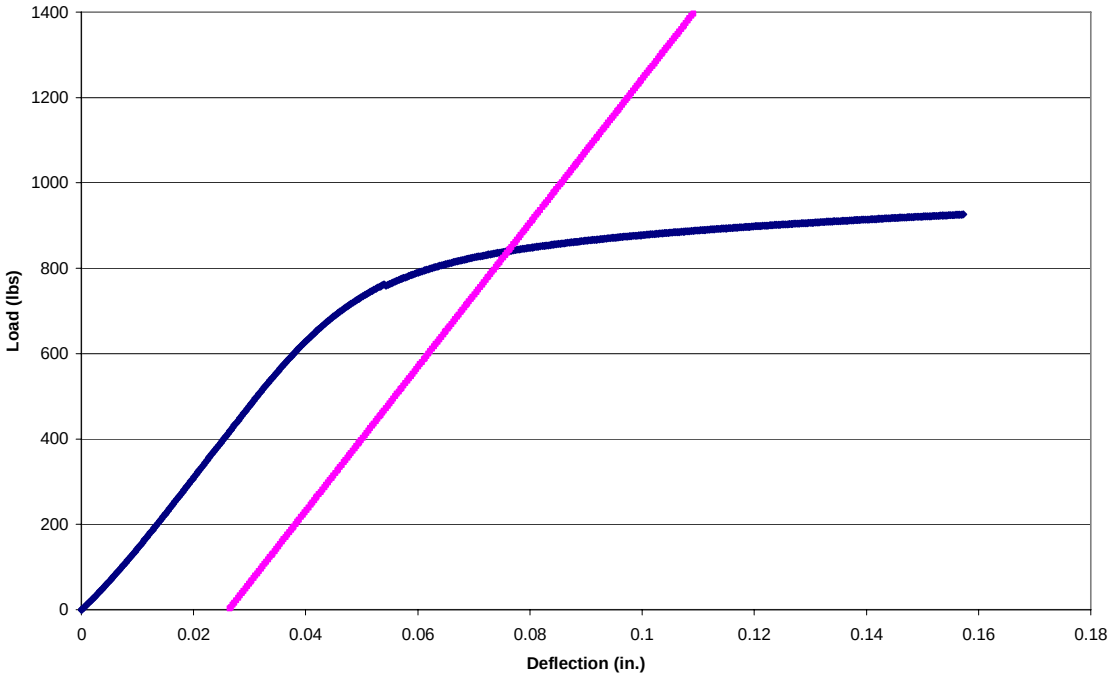

Figure C.56: Load vs. Deflection Curve and 5% Offset Line, H8s6

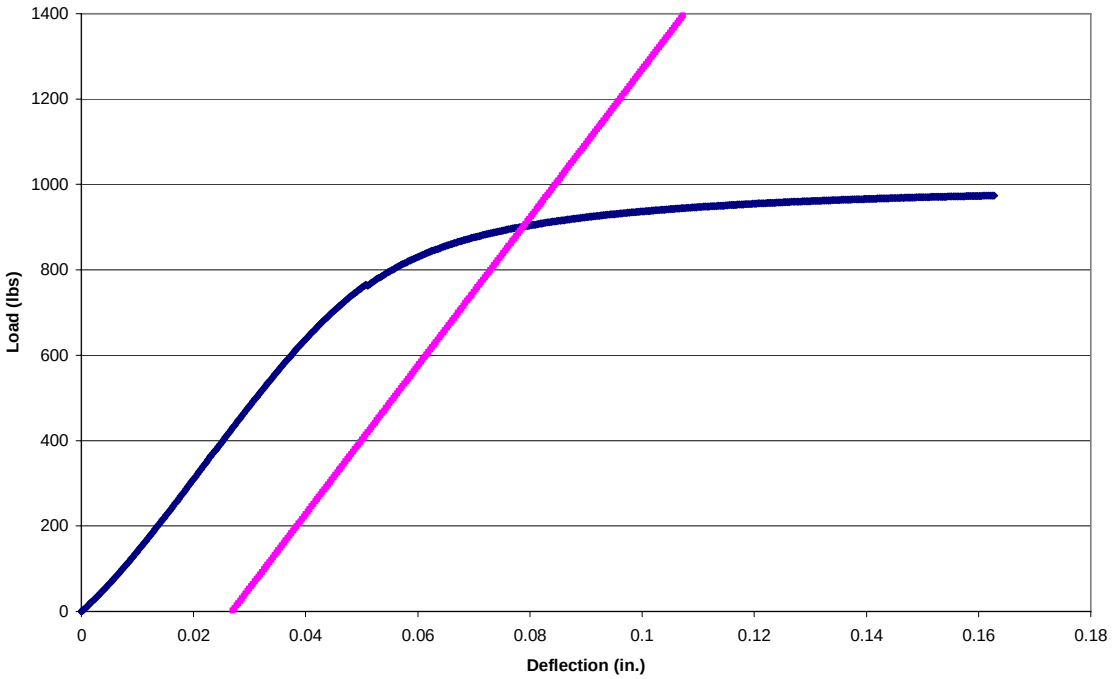

Figure C.57: Load vs. Deflection Curve and 5% Offset Line, H8s7

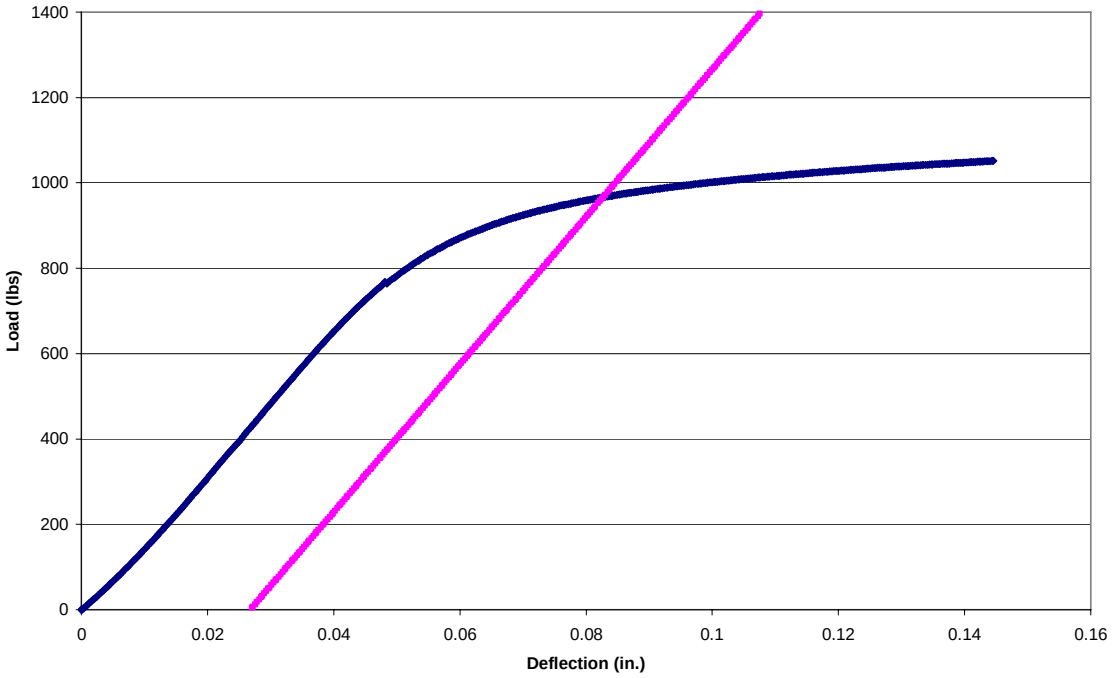

Figure C.58: Load vs. Deflection Curve and 5% Offset Line, H8s8

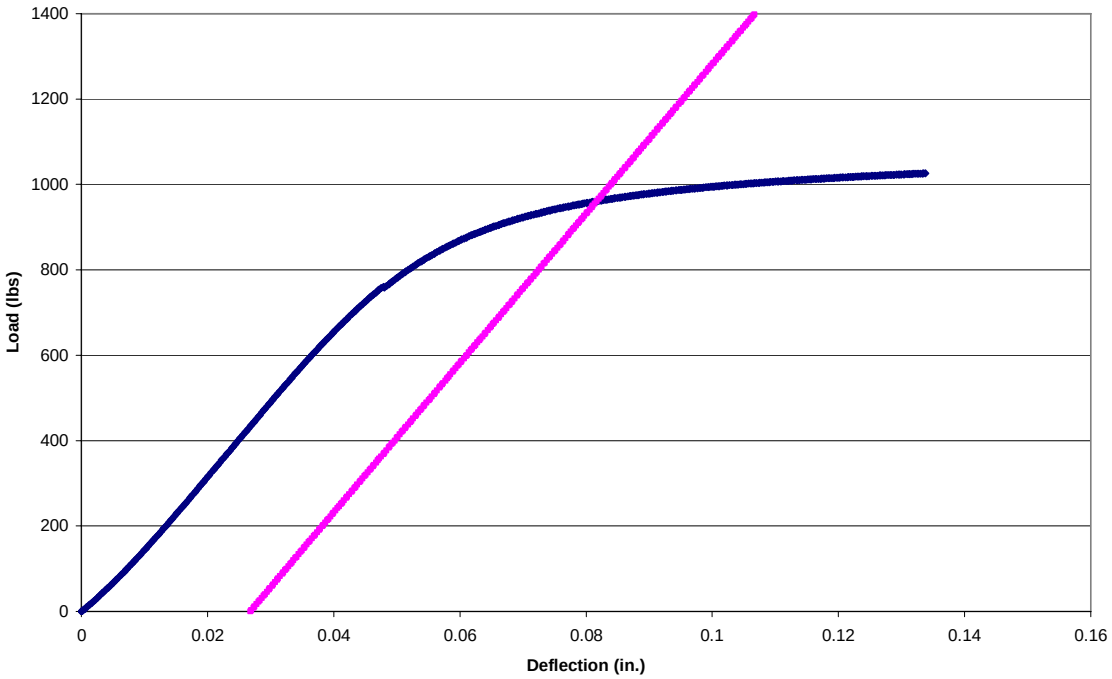

Figure C.59: Load vs. Deflection Curve and 5% Offset Line, H8s9

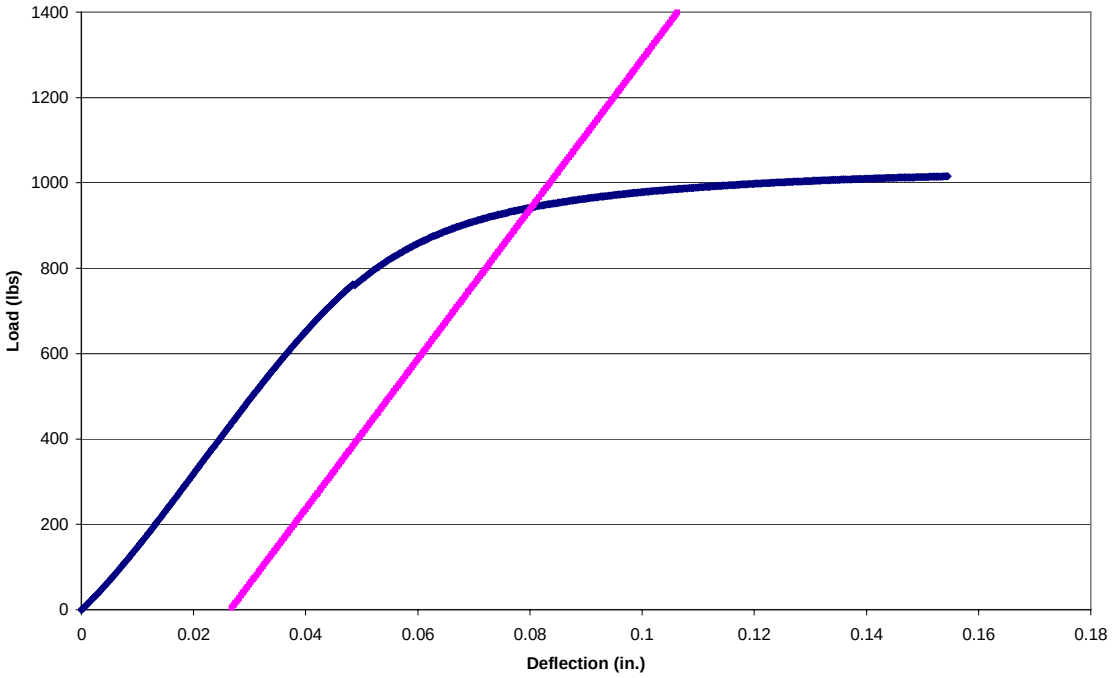

Figure C.60: Load vs. Deflection Curve and 5% Offset Line, H8s10

Table C.7: Test Results for F6s Data Set

$F6s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	8170	7149
S2	8060	7053
S3	7860	6878
S4	7800	6825
S5	7110	6221
S6	7530	6589
S7	8210	7184
S8	7870	6886
S9	7870	6886
S10	7650	6694
AVG	**7813**	**6836**
Standard Dev.	**326**	**285**
COV (%)	**4.2**	**4.2**

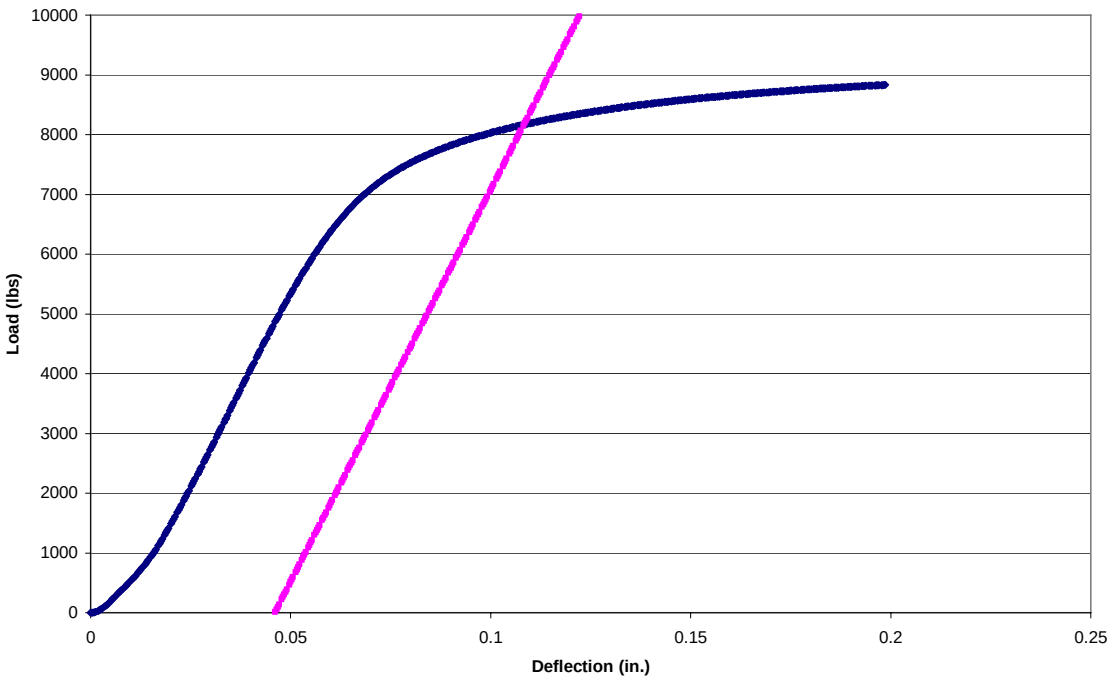

Figure C.61: Load vs. Deflection Curve and 5% Offset Line, F6s1

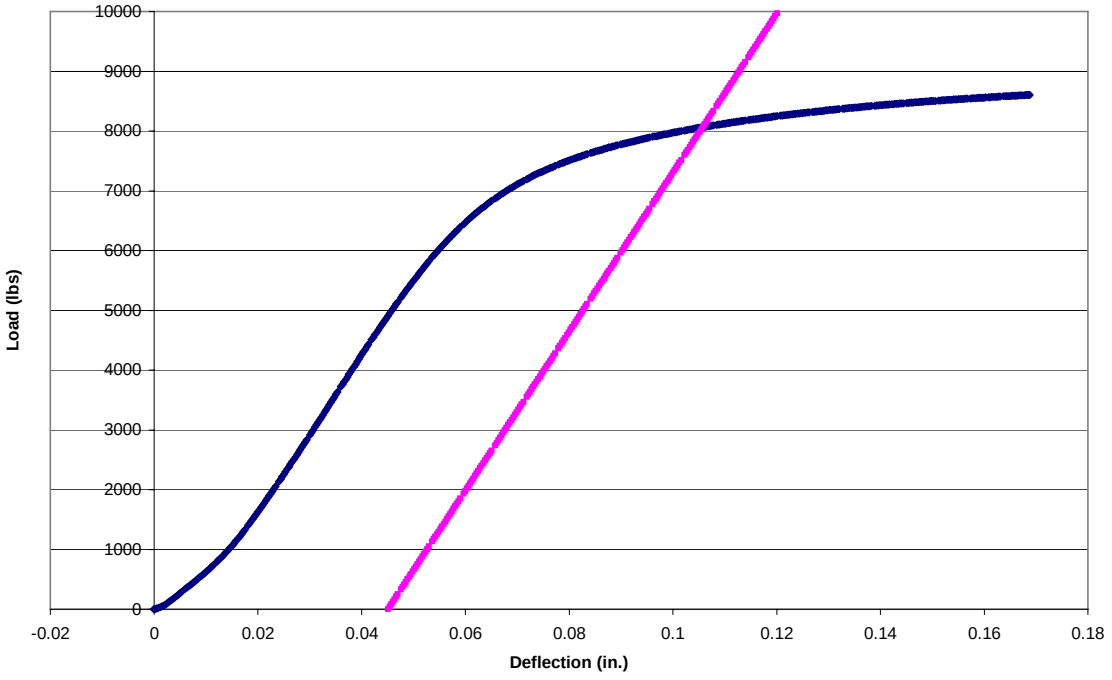

Figure C.62: Load vs. Deflection Curve and 5% Offset Line, F6s2

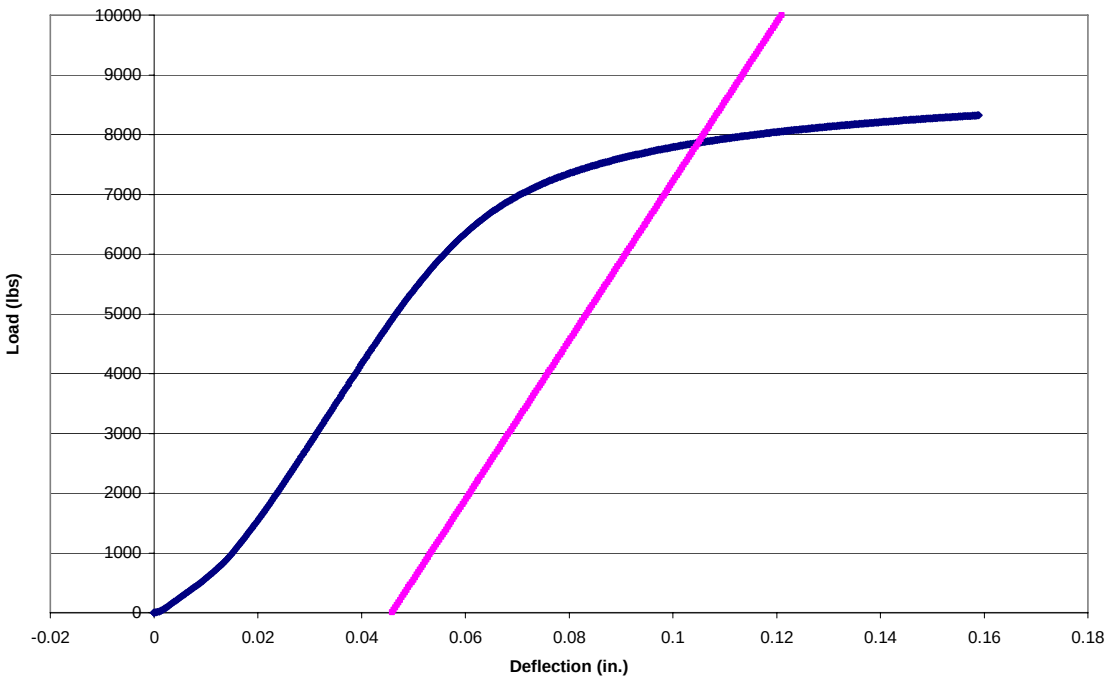

Figure C.63: Load vs. Deflection Curve and 5% Offset Line, F6s3

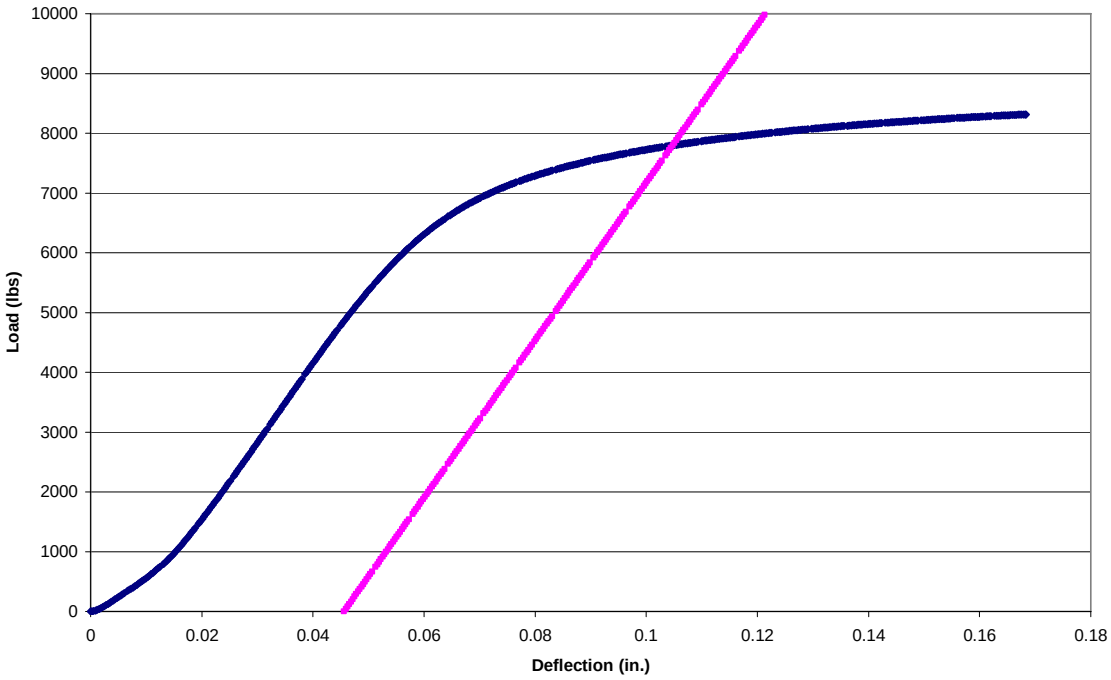

Figure C.64: Load vs. Deflection Curve and 5% Offset Line, F6s4

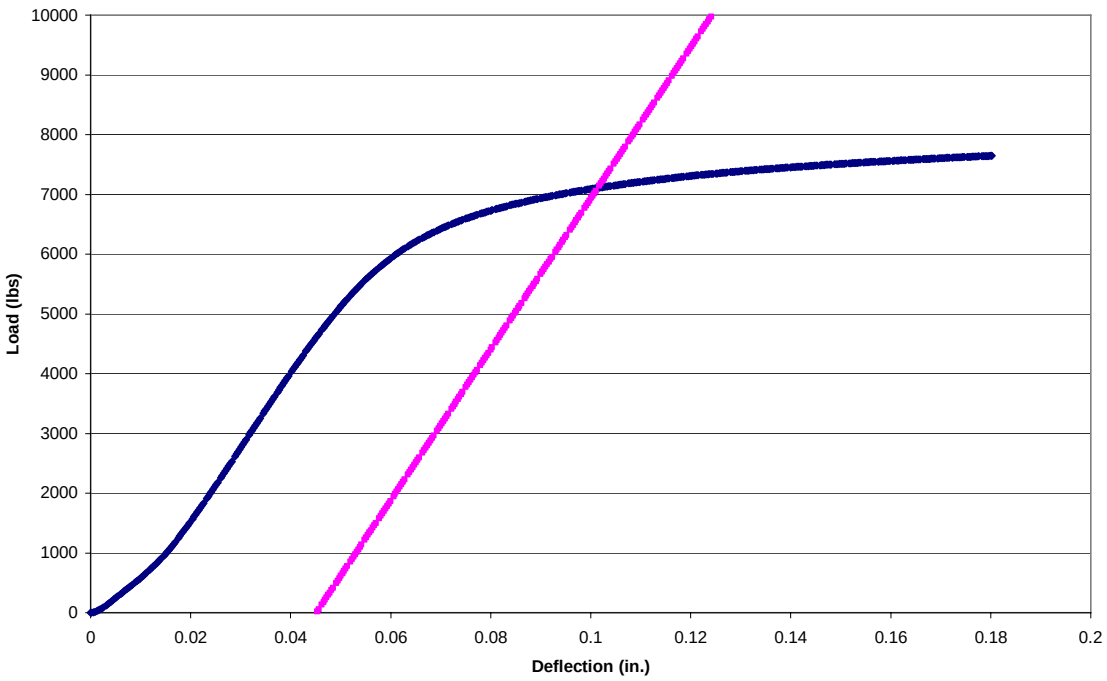

Figure C.65: Load vs. Deflection Curve and 5% Offset Line, F6s5

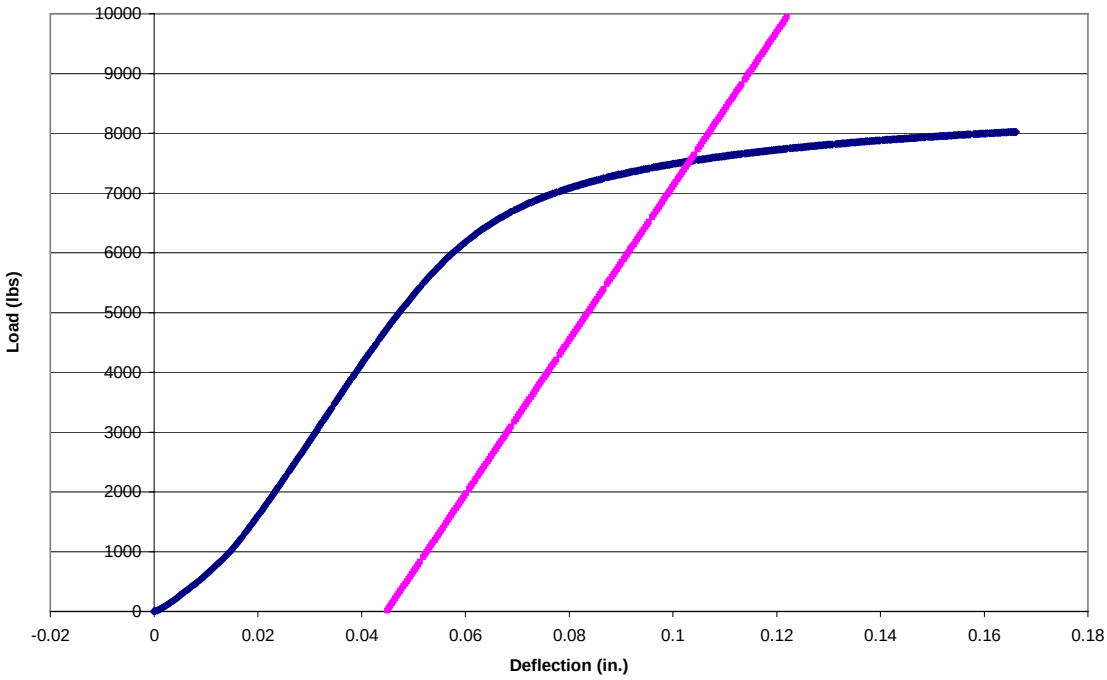

Figure C.66: Load vs. Deflection Curve and 5% Offset Line, F6s6

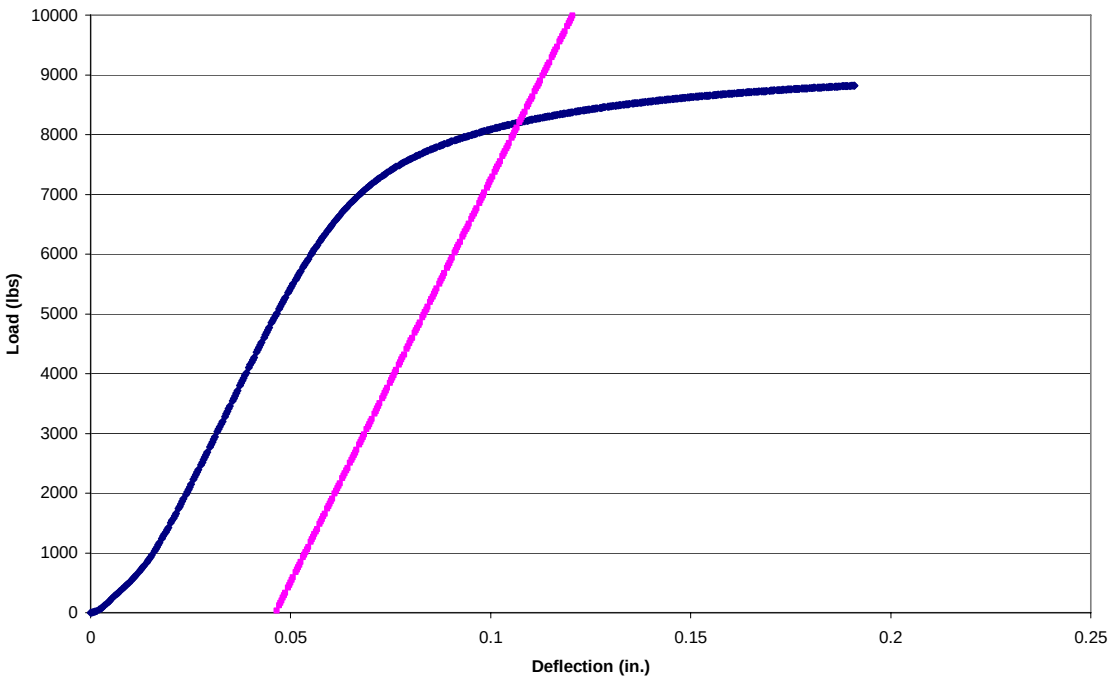

Figure C.67: Load vs. Deflection Curve and 5% Offset Line, F6s7

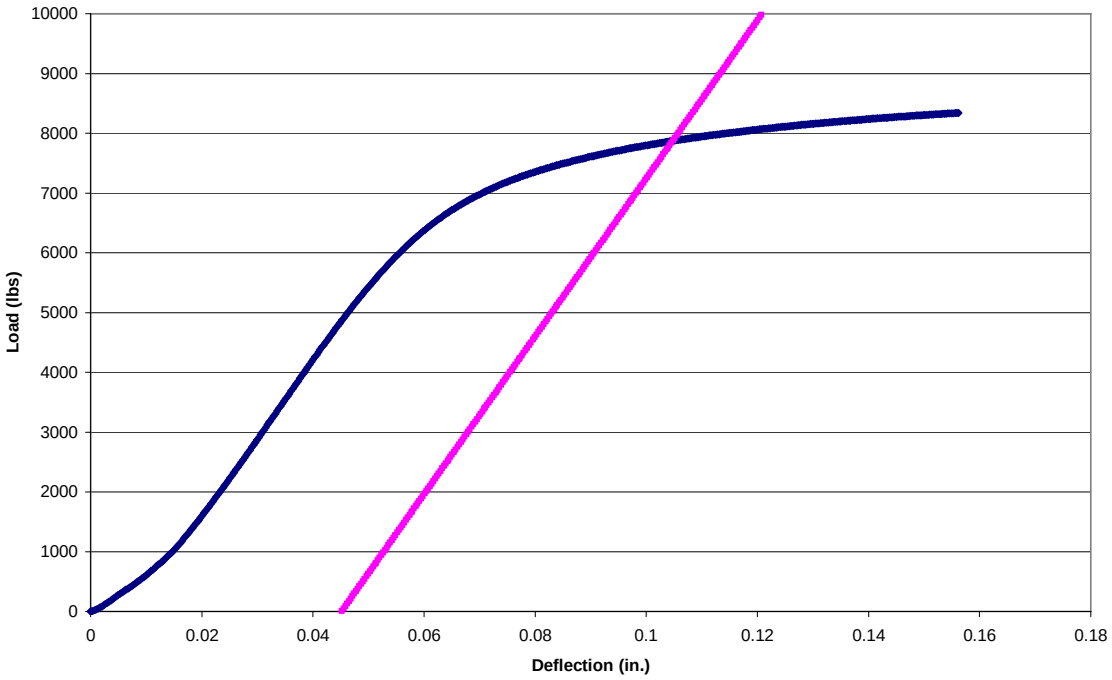

Figure C.68: Load vs. Deflection Curve and 5% Offset Line, F6s8

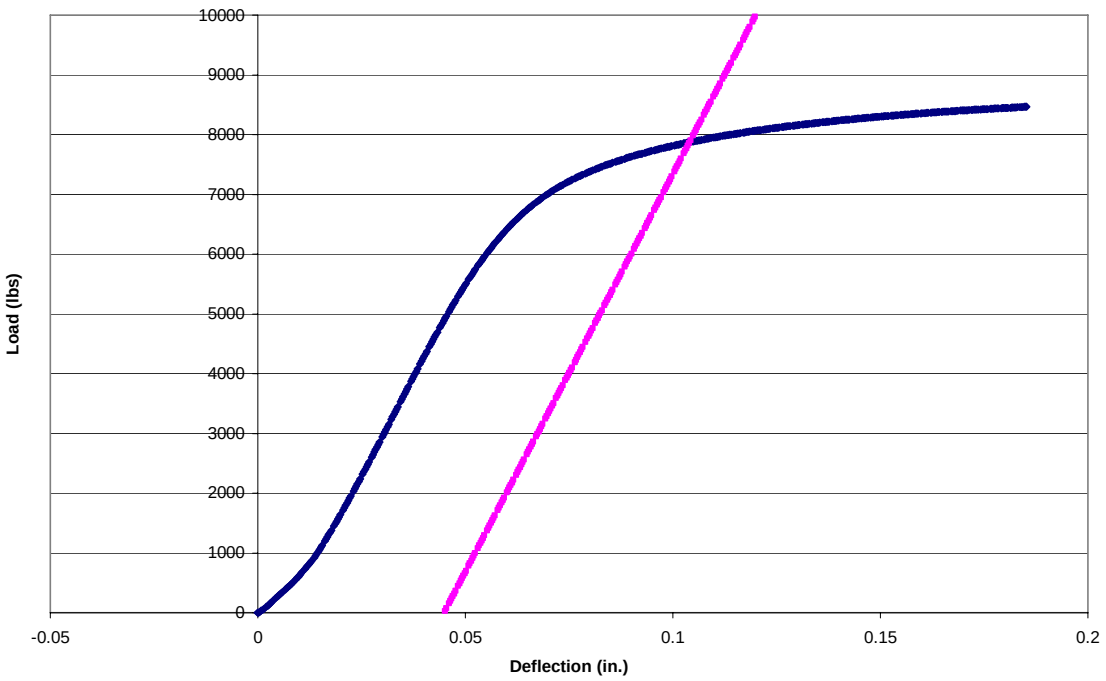

Figure C.69: Load vs. Deflection Curve and 5% Offset Line, F6s9

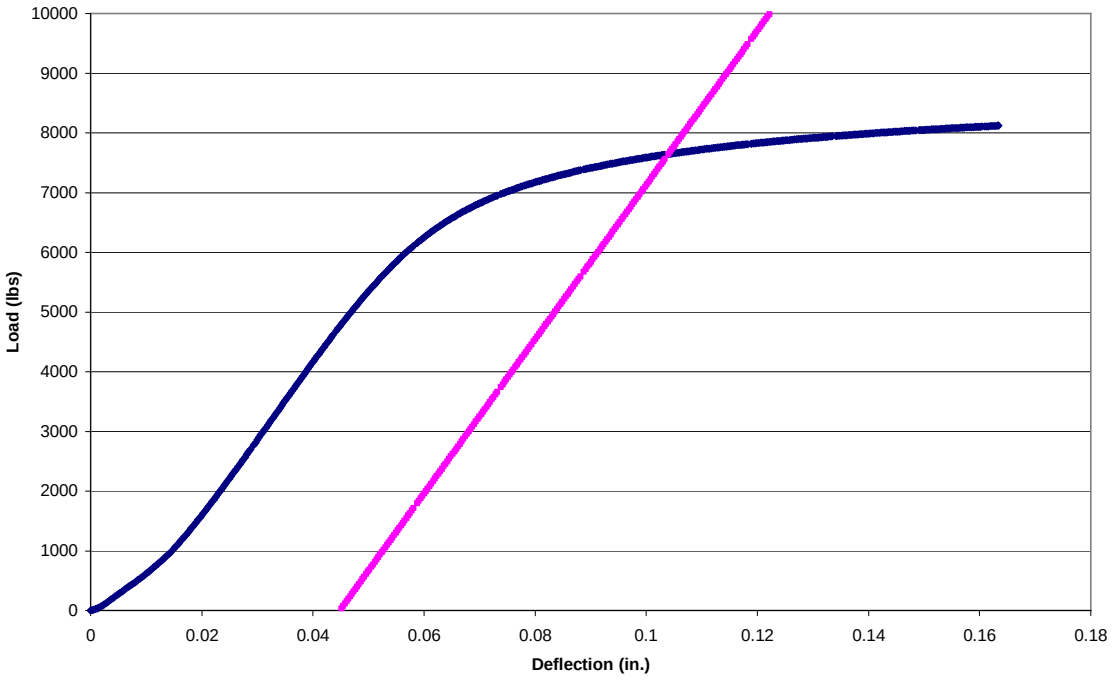

Figure C.70: Load vs. Deflection Curve and 5% Offset Line, F6s10

Table C.8: Test Results for F8s Data Set

$F8s_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
S1	3570	4463
S2	3530	4413
S3	3570	4463
S4	3590	4488
S5	3640	4550
S6	3760	4700
S7	3570	4463
S8	3650	4563
S9	3540	4425
S10	3540	4425
AVG	**3596**	**4495**
Standard Dev.	**70**	**88**
COV (%)	**2.0**	**2.0**

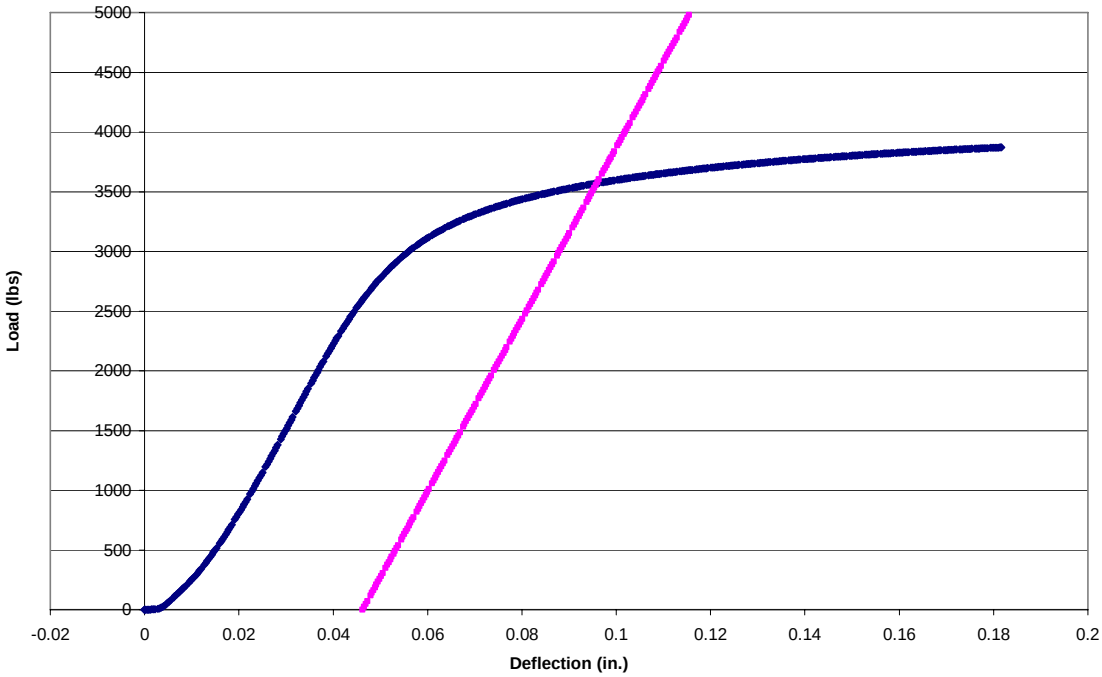

Figure C.71: Load vs. Deflection Curve and 5% Offset Line, F8s1

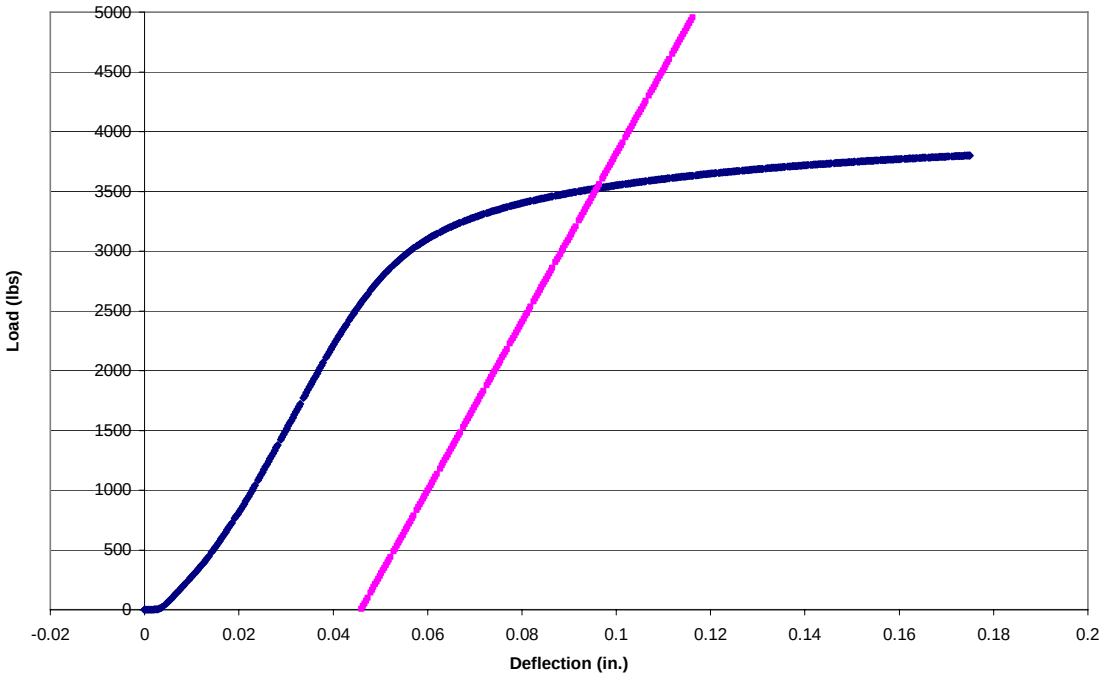

Figure C.72: Load vs. Deflection Curve and 5% Offset Line, F8s2

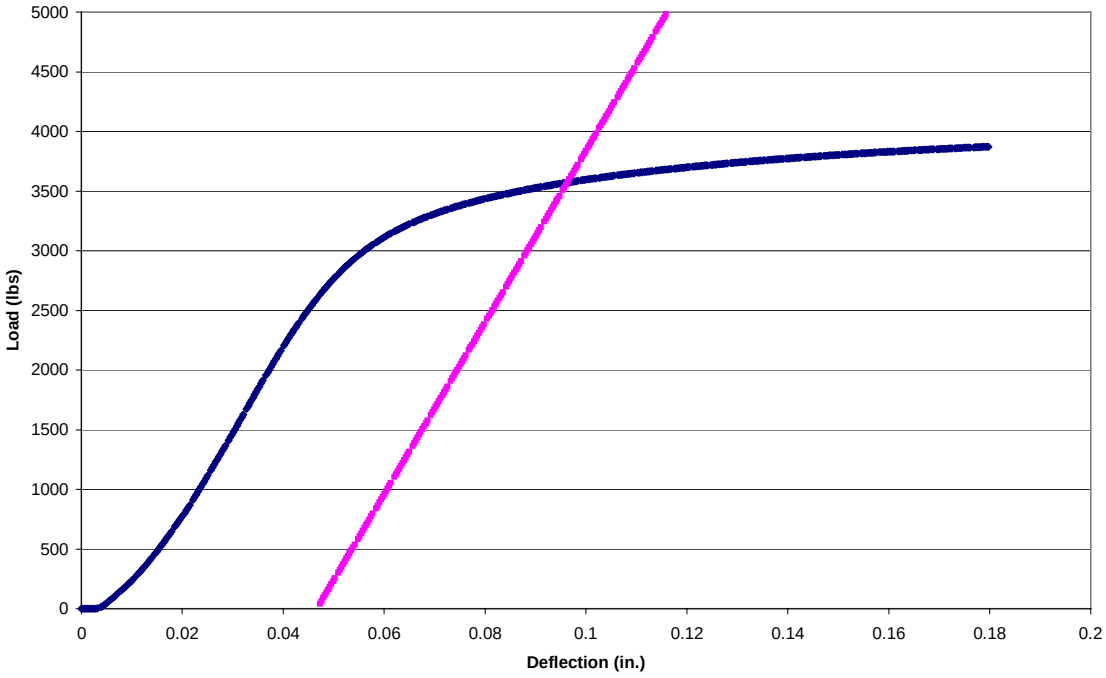

Figure C.73: Load vs. Deflection Curve and 5% Offset Line, F8s3

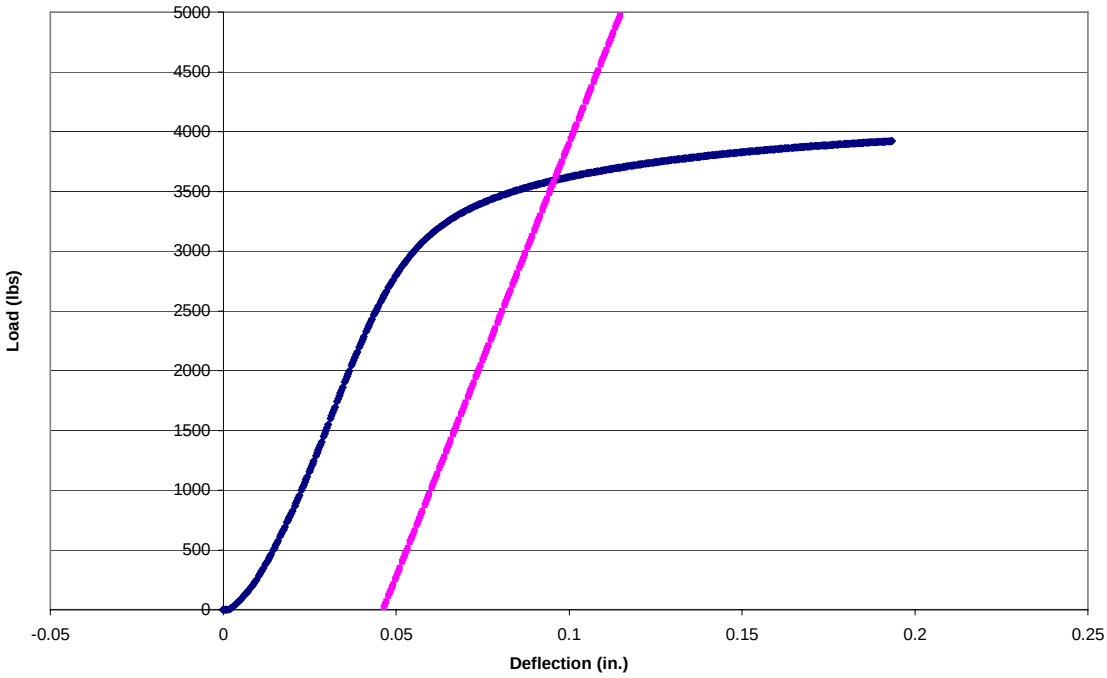

Figure C.74: Load vs. Deflection Curve and 5% Offset Line, F8s4

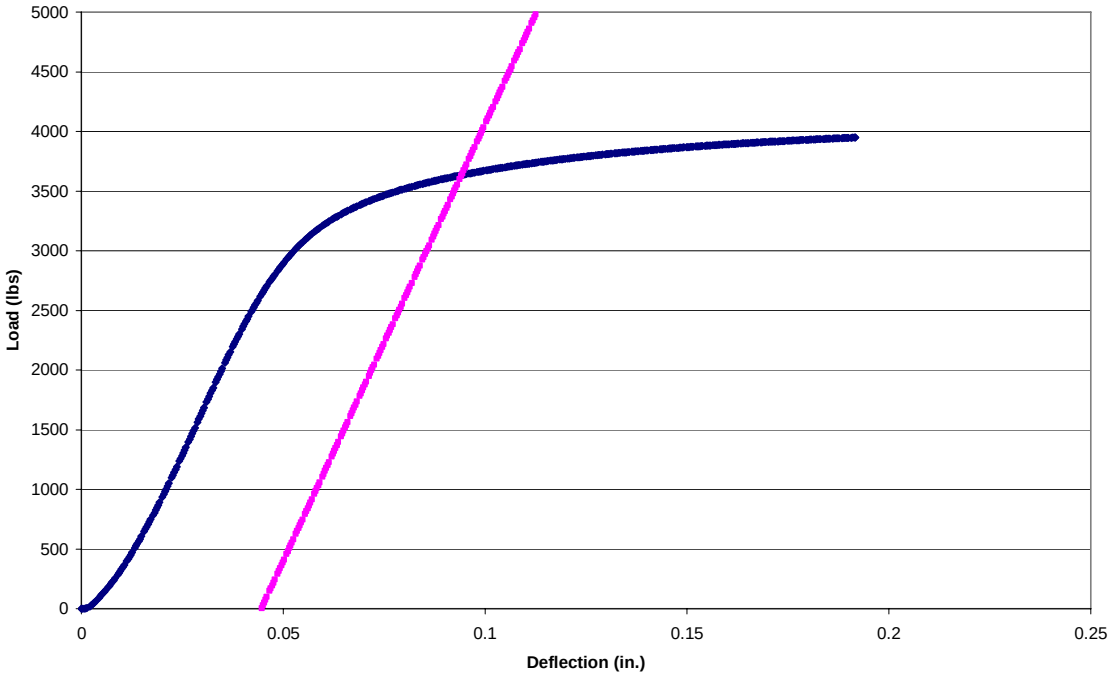

Figure C.75: Load vs. Deflection Curve and 5% Offset Line, F8s5

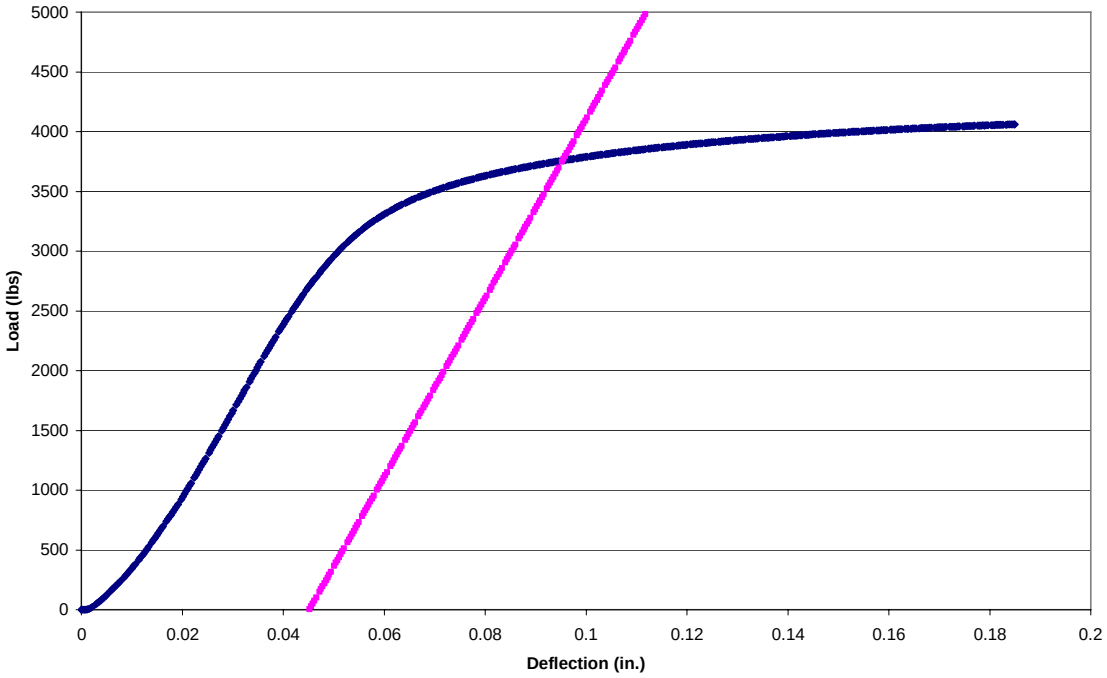

Figure C.76: Load vs. Deflection Curve and 5% Offset Line, F8s6

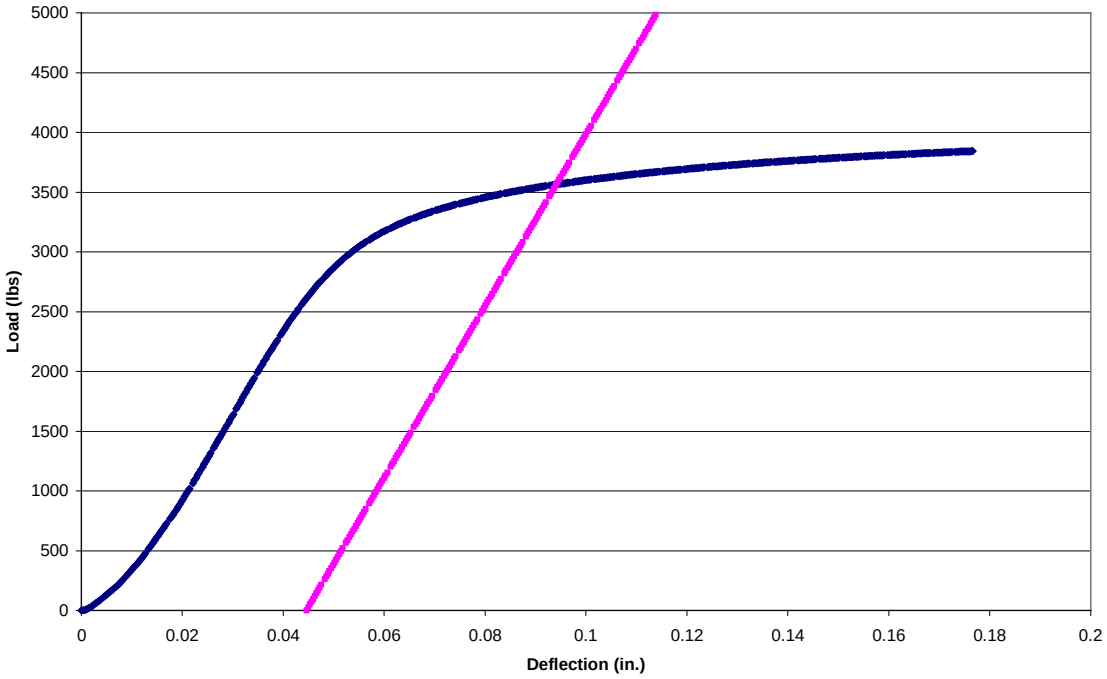

Figure C.77: Load vs. Deflection Curve and 5% Offset Line, F8s7

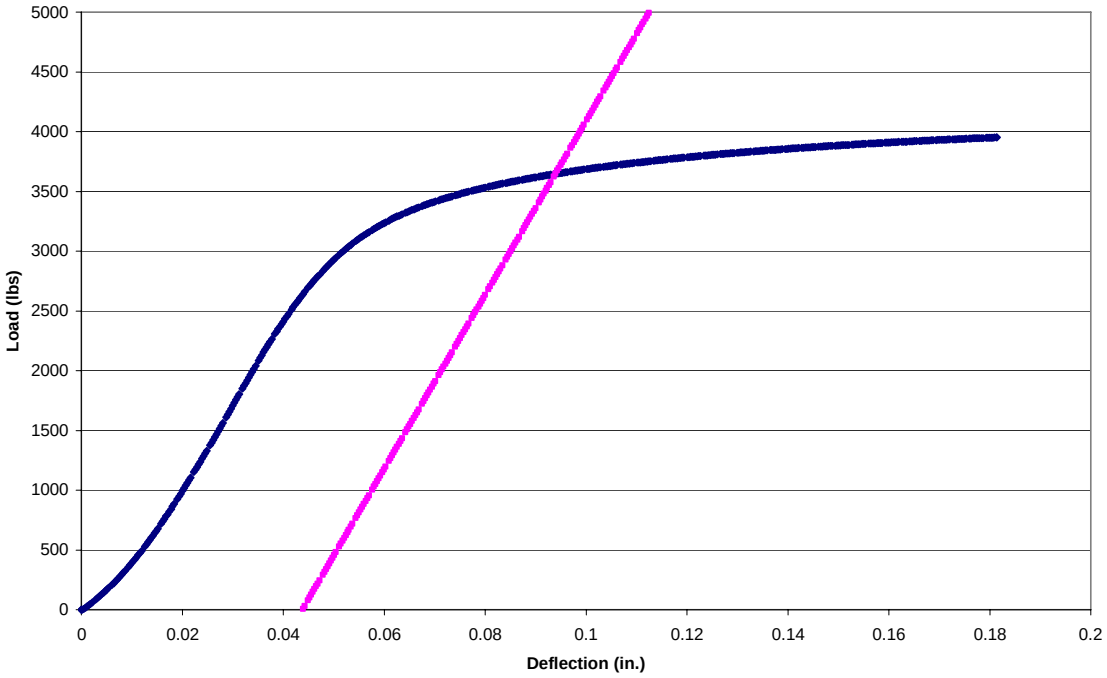

Figure C.78: Load vs. Deflection Curve and 5% Offset Line, F8s8

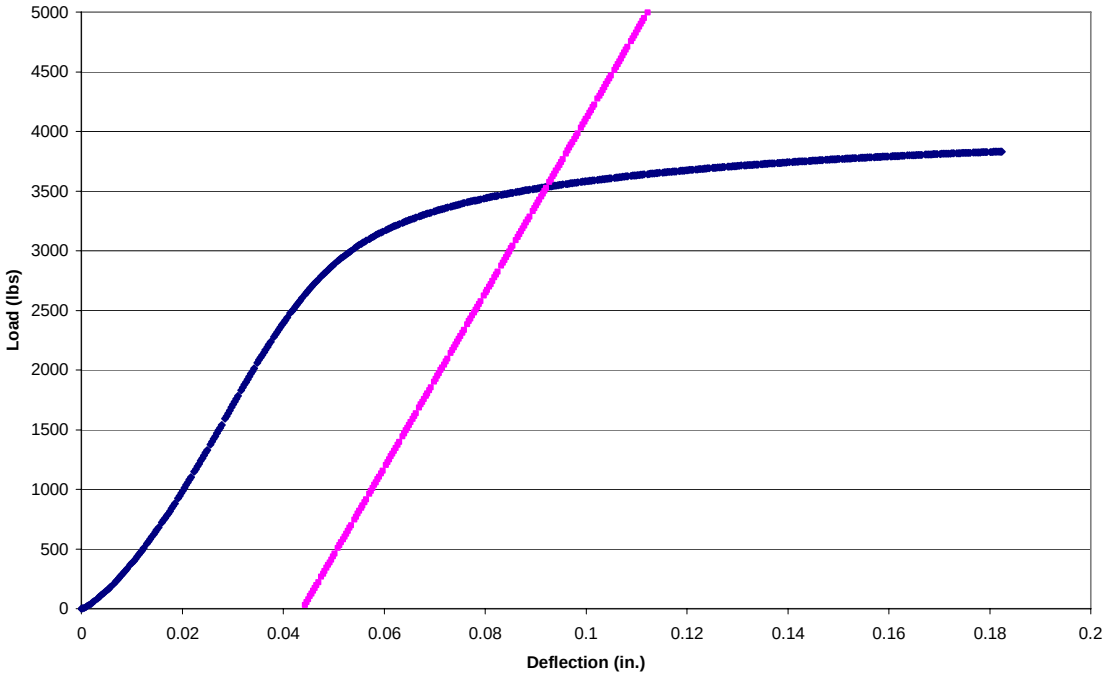

Figure C.79: Load vs. Deflection Curve and 5% Offset Line, F8s9

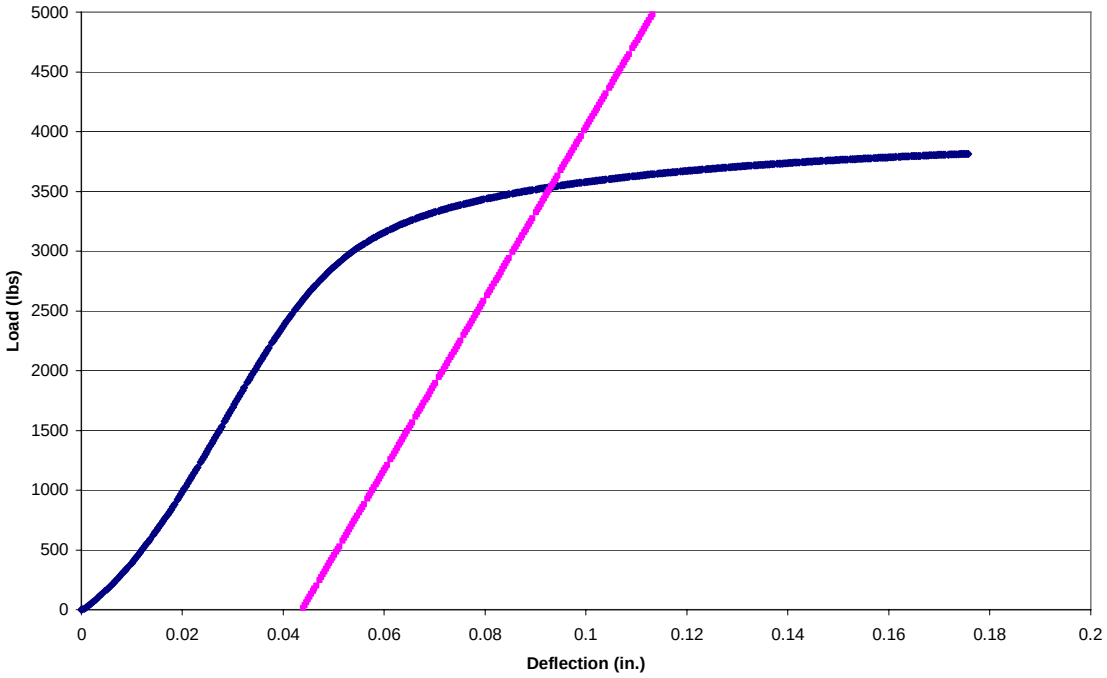

Figure C.80: Load vs. Deflection Curve and 5% Offset Line, F8s10

C.3: Cantilever Bending Tests

Below are the results of the cantilever bending tests. The test data for each of the nine data sets are summarized in Tables B.9-B.17. Following each of these tables are the load-deflection curves and 5% offset lines for each bolt specimen in that given set. See section 4.4.4 for the resulting values of bolt bending yield strength (F_{yb}).

Table C.9: Test Results for E4c Data Set

$E4c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	252	504
C2	260	520
C3	248	496
C4	244	488
C5	252	504
C6	263	526
C7	262	524
C8	259	518
C9	268	536
C10	260	520
AVG	**257**	**514**
Standard Dev.	**7**	**15**
COV (%)	**2.9**	**2.9**

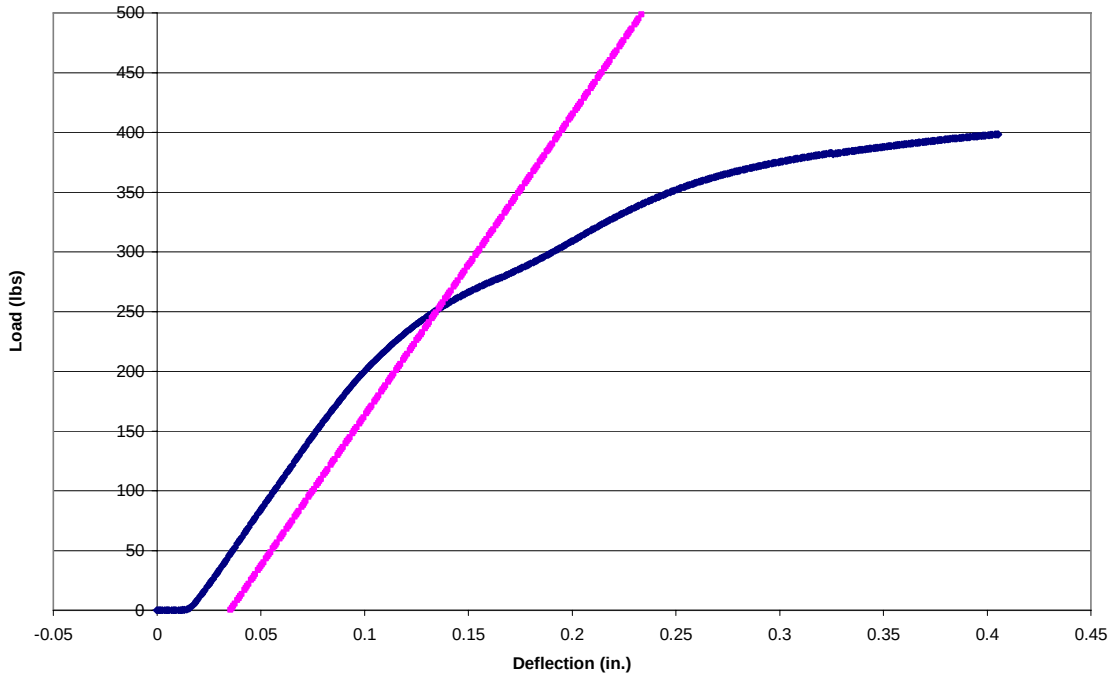

Figure C.81: Load vs. Deflection Curve and 5% Offset Line, E4c1

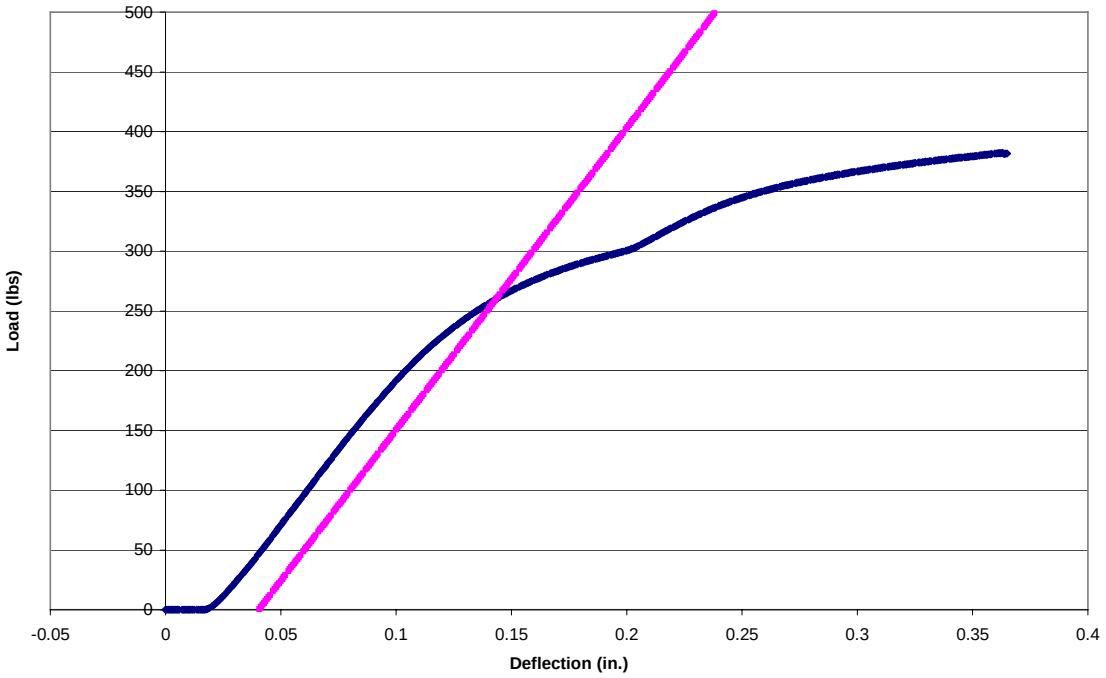

Figure C.82: Load vs. Deflection Curve and 5% Offset Line, E4c2

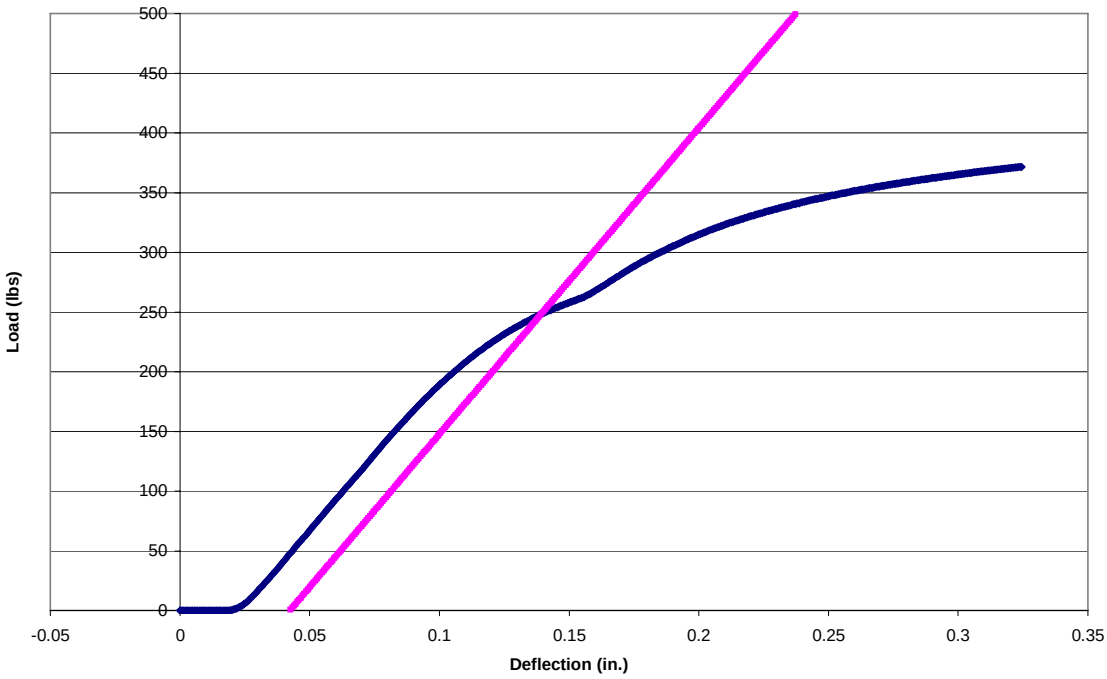

Figure C.83: Load vs. Deflection Curve and 5% Offset Line, E4c3

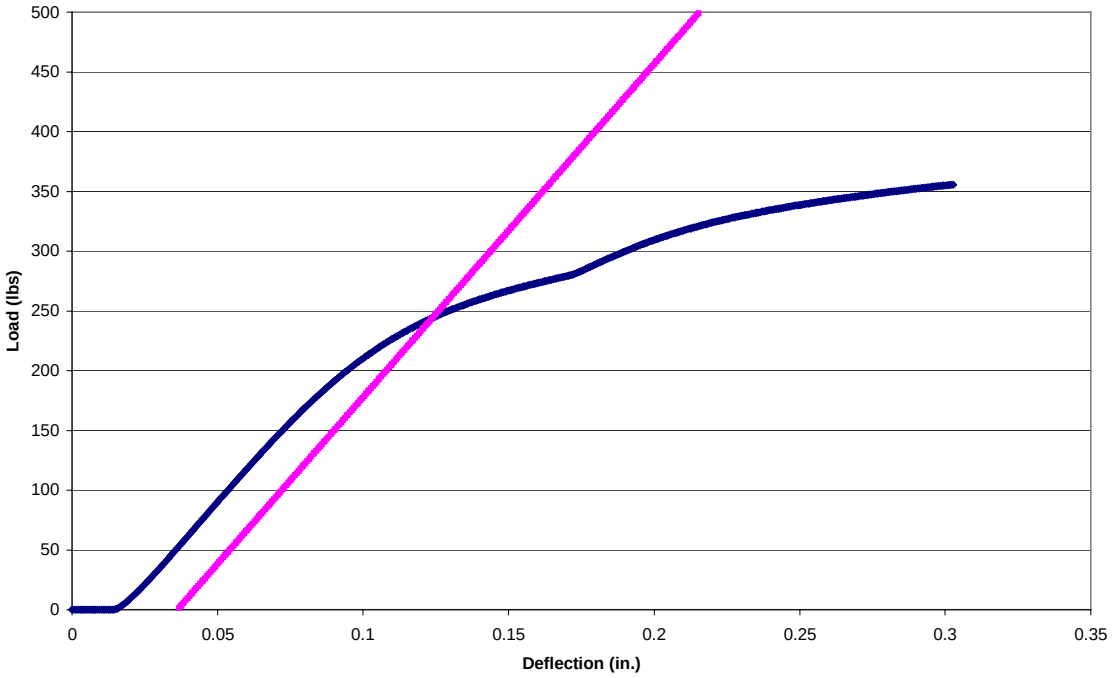

Figure C.84: Load vs. Deflection Curve and 5% Offset Line, E4c4

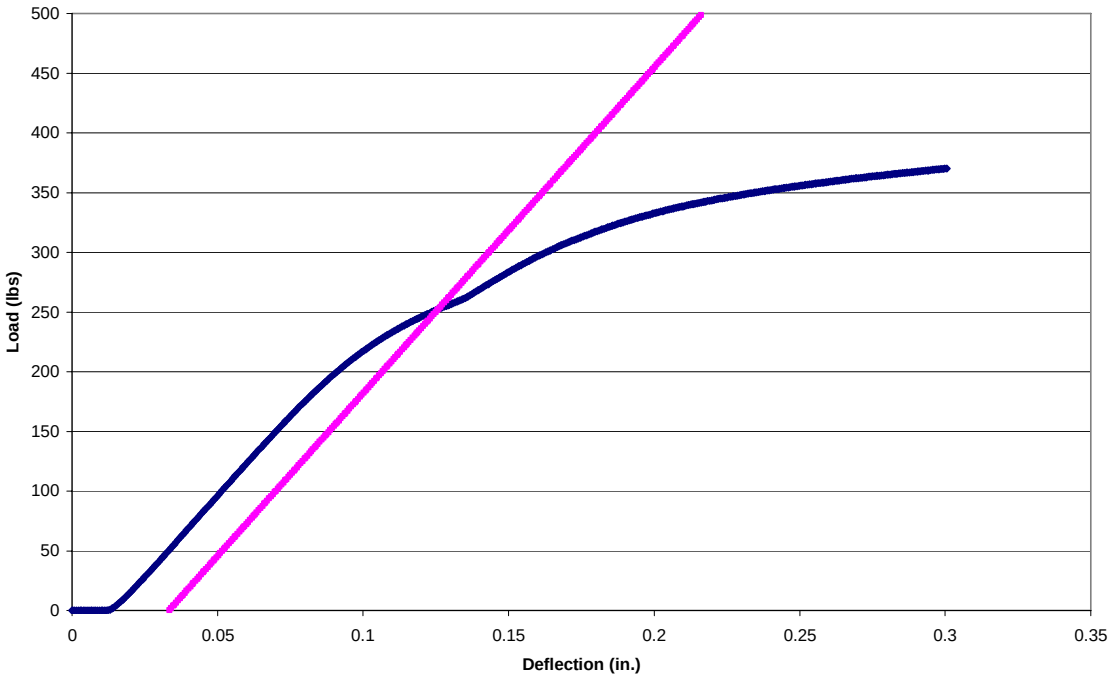

Figure C.85: Load vs. Deflection Curve and 5% Offset Line, E4c5

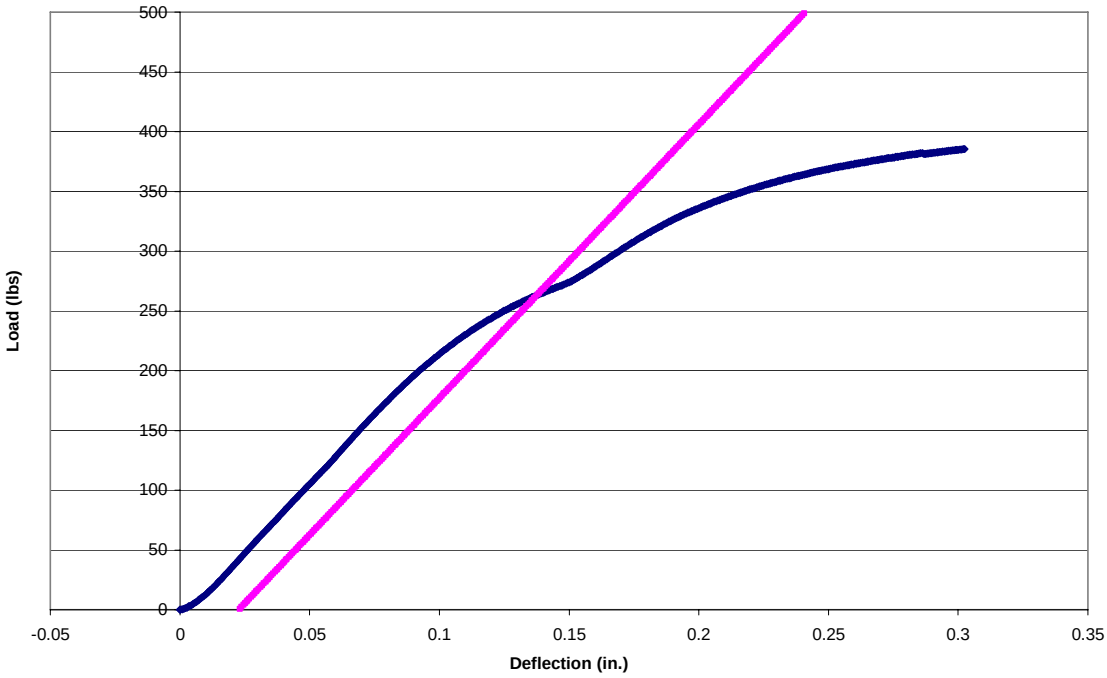

Figure C.86: Load vs. Deflection Curve and 5% Offset Line, E4c6

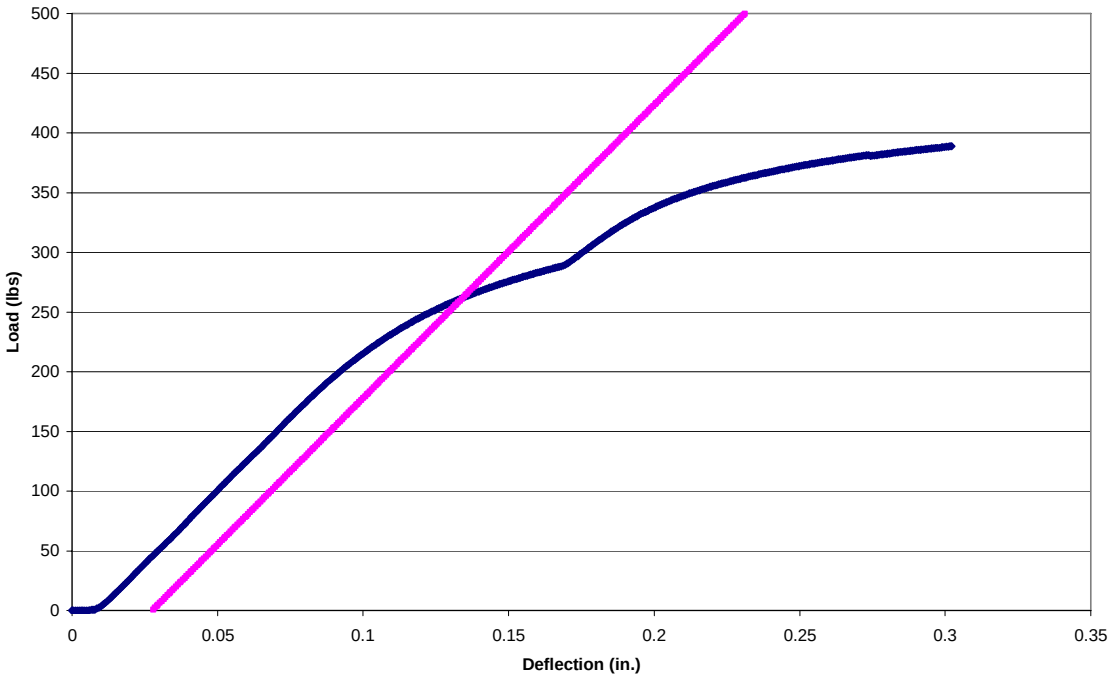

Figure C.87: Load vs. Deflection Curve and 5% Offset Line, E4c7

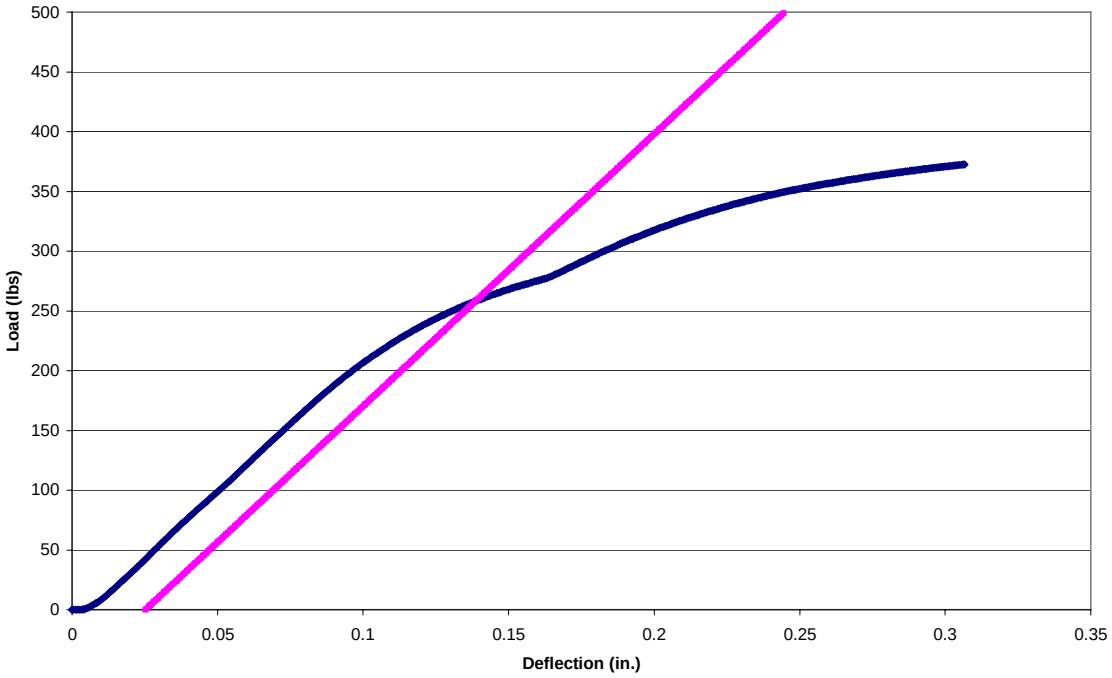

Figure C.88: Load vs. Deflection Curve and 5% Offset Line, E4c8

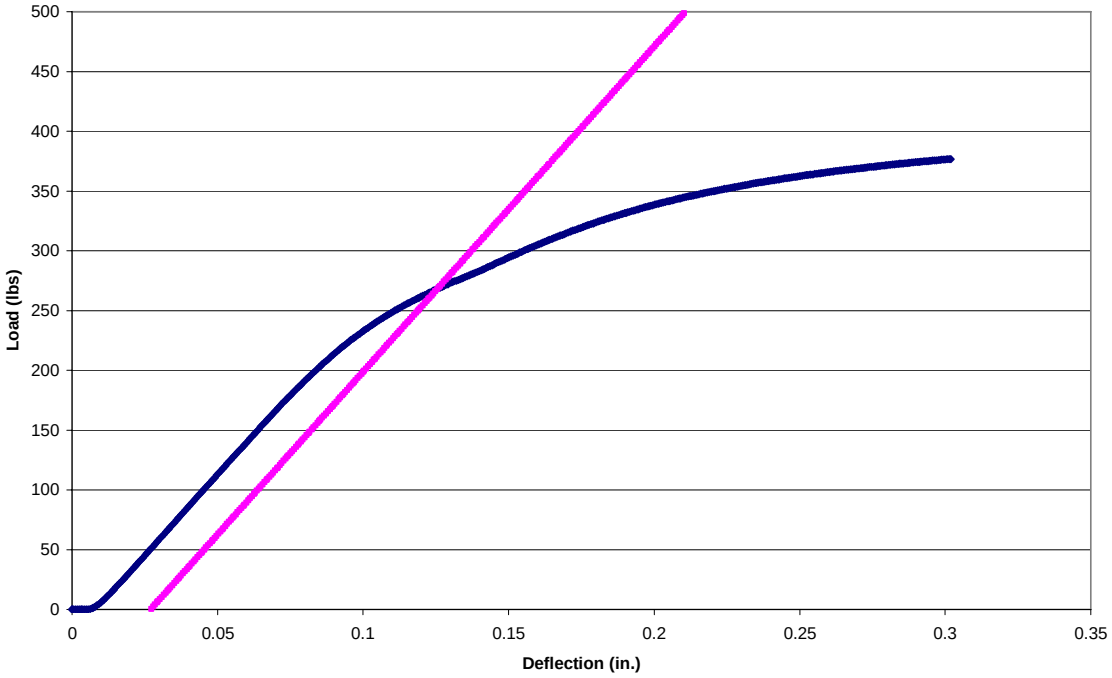

Figure C.89: Load vs. Deflection Curve and 5% Offset Line, E4c9

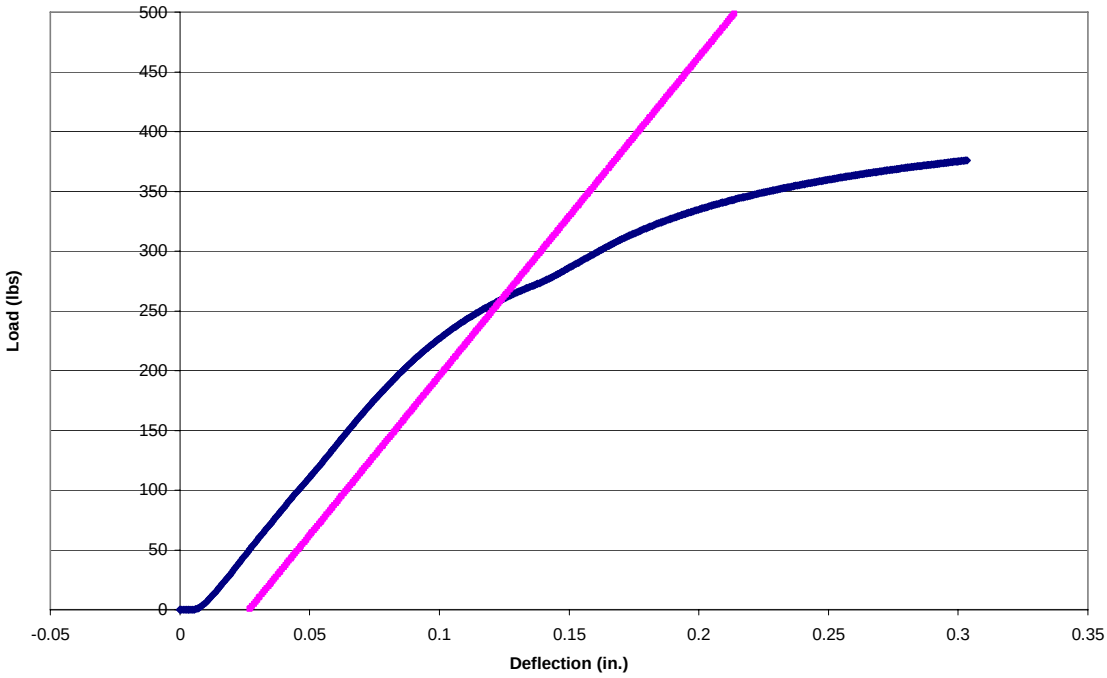

Figure C.90: Load vs. Deflection Curve and 5% Offset Line, E4c10

Table C.10: Test Results for E6c Data Set

$E6c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	211	739
C2	152	532
C3	171	599
C4	151	529
C5	152	532
C6	169	592
C7	153	536
C8	164	574
C9	156	546
C10	161	564
AVG	**164**	**574**
Standard Dev.	**18**	**63**
COV (%)	**11.0**	**11.0**

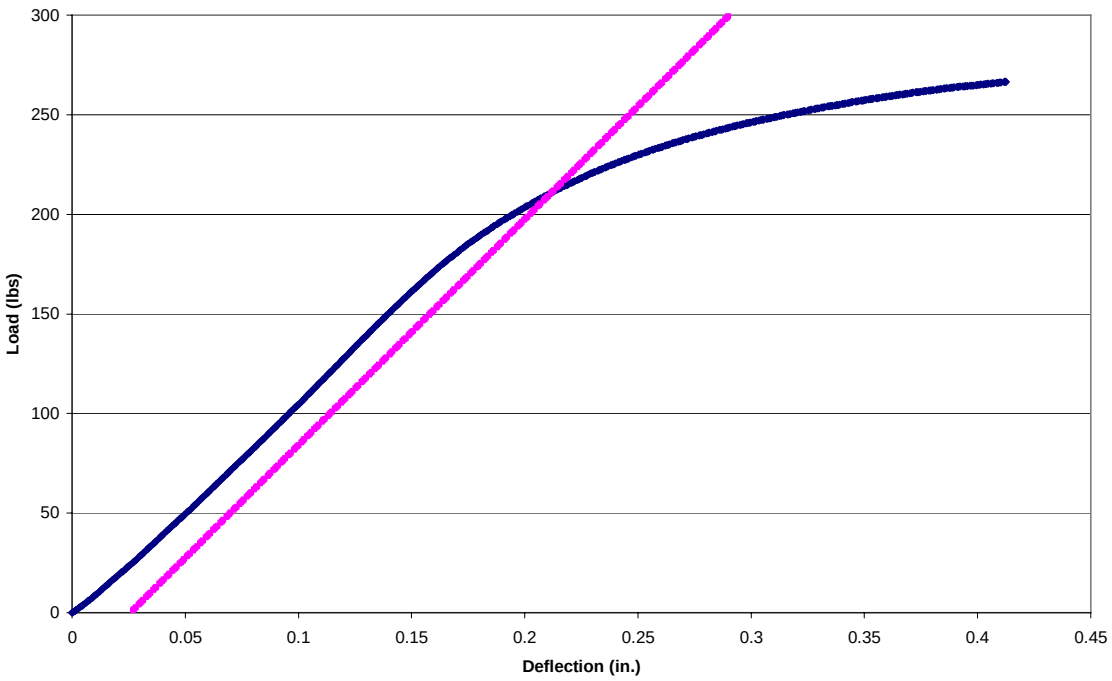

Figure C.91: Load vs. Deflection Curve and 5% Offset Line, E6c1

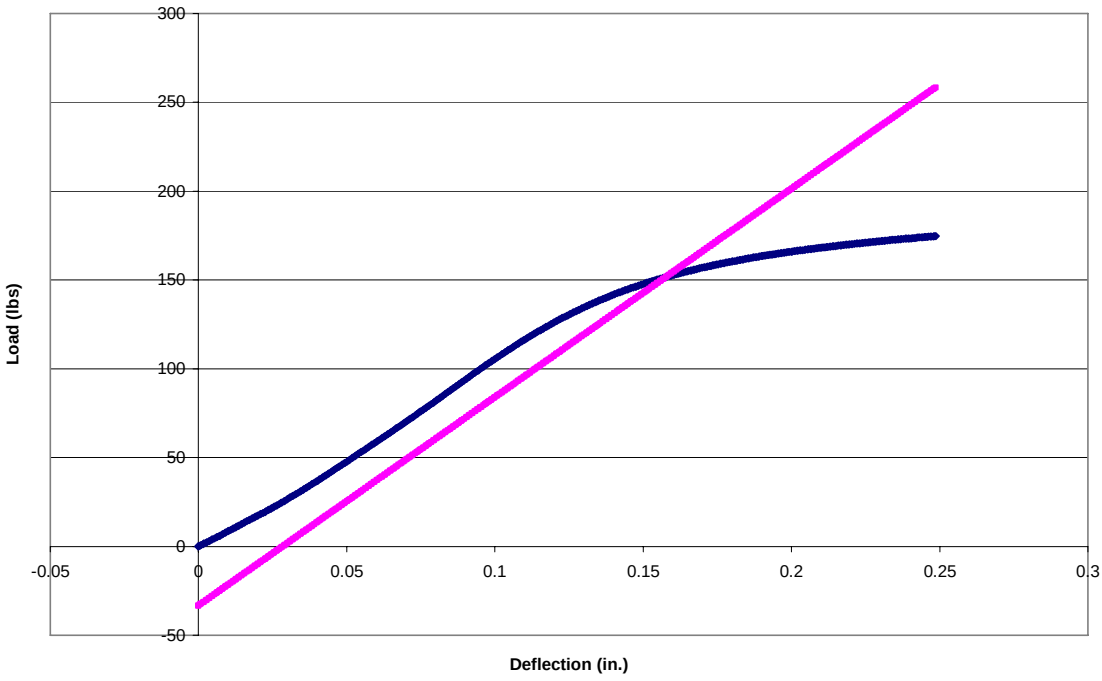

Figure C.92: Load vs. Deflection Curve and 5% Offset Line, E6c2

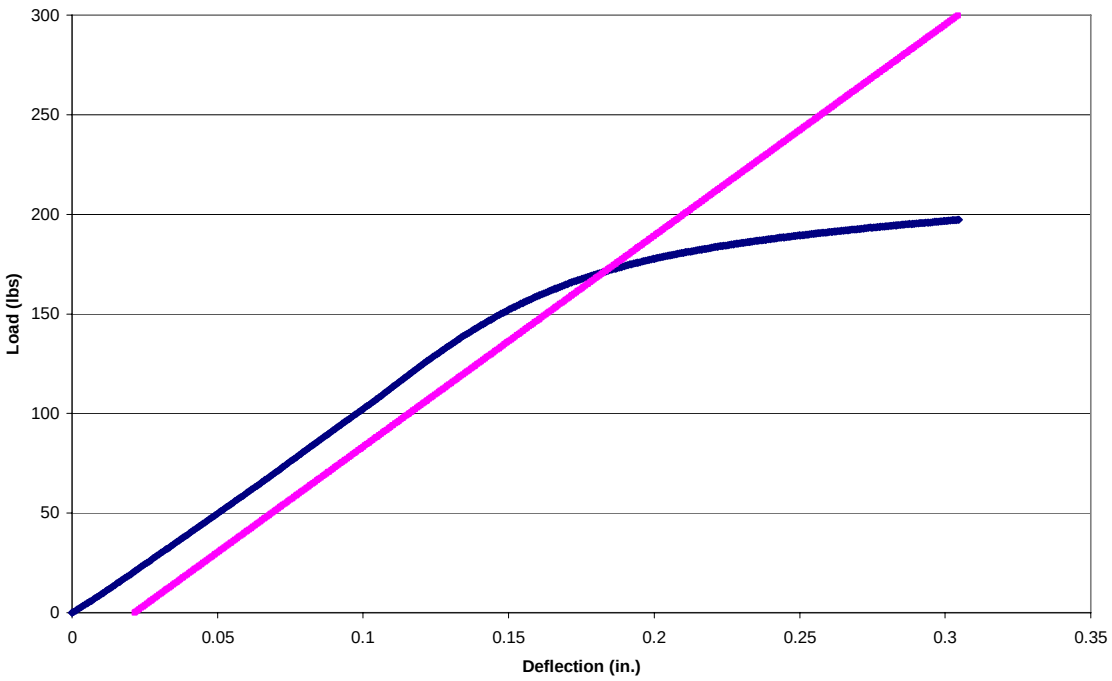

Figure C.93: Load vs. Deflection Curve and 5% Offset Line, E6c3

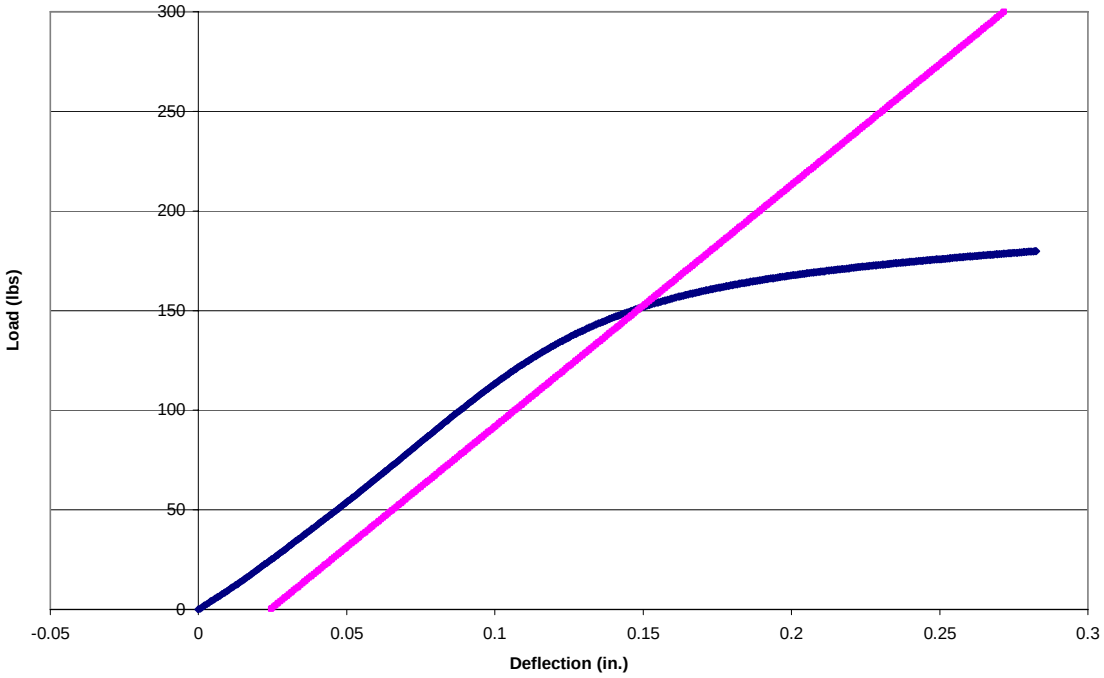

Figure C.94: Load vs. Deflection Curve and 5% Offset Line, E6c4

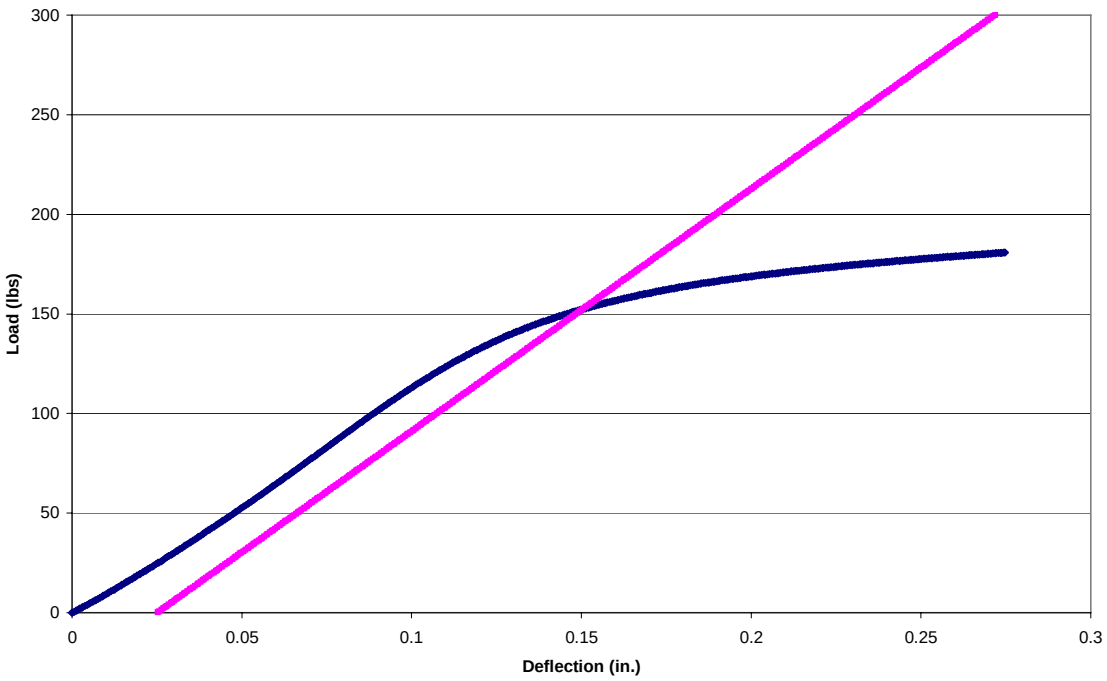

Figure C.95: Load vs. Deflection Curve and 5% Offset Line, E6c5

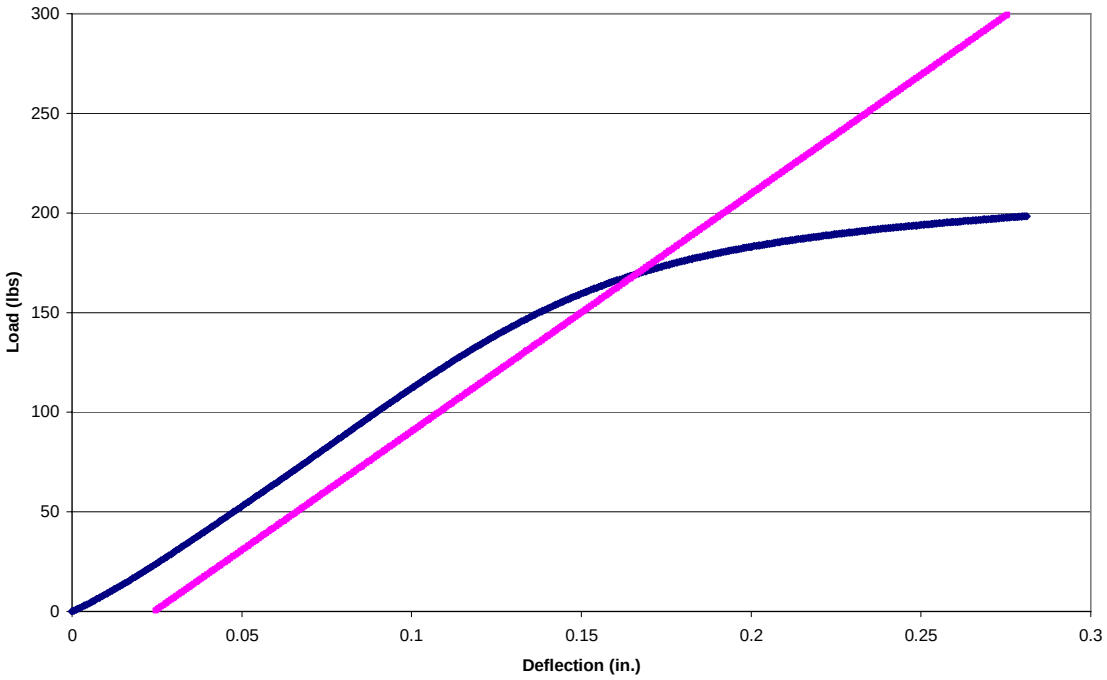

Figure C.96: Load vs. Deflection Curve and 5% Offset Line, E6c6

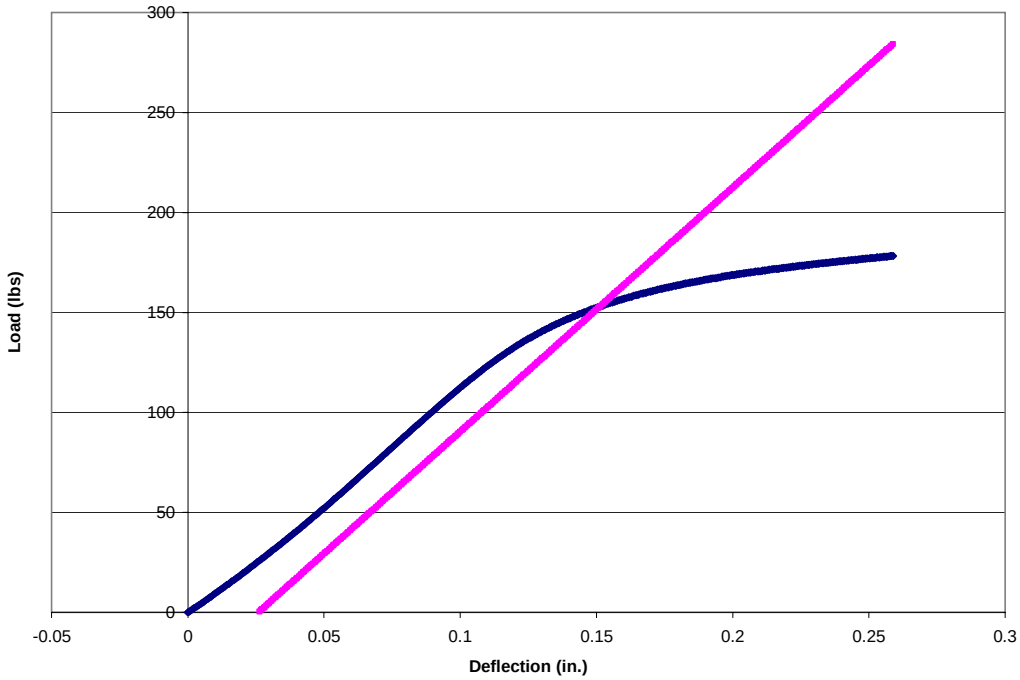

Figure C.97: Load vs. Deflection Curve and 5% Offset Line, E6c7

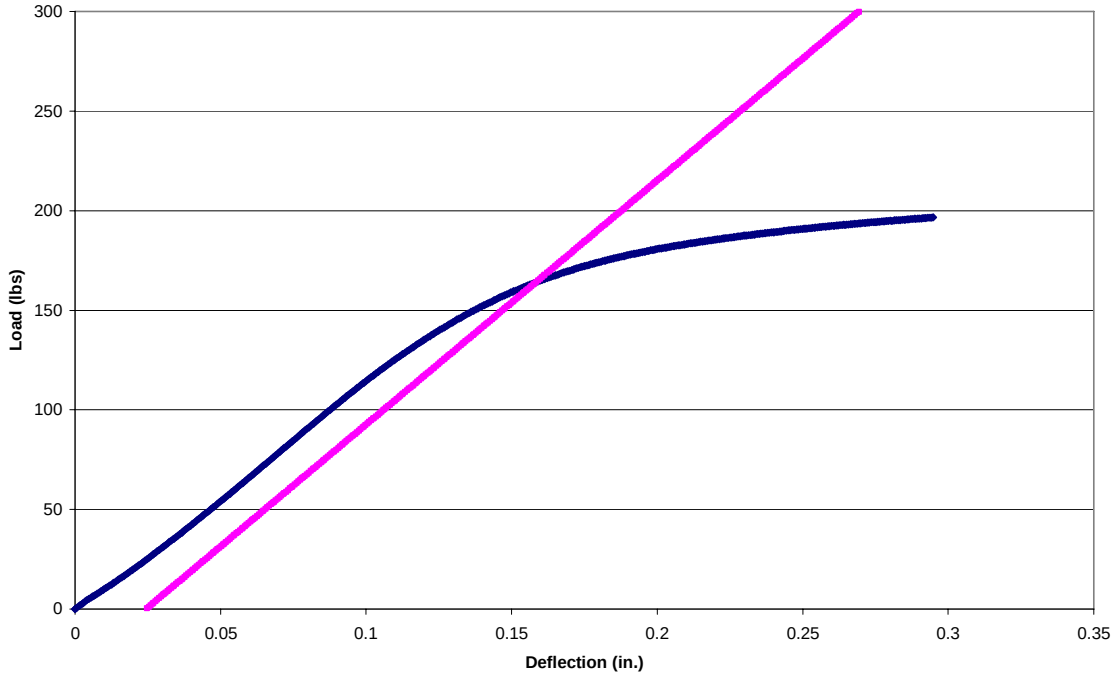

Figure C.98: Load vs. Deflection Curve and 5% Offset Line, E6c8

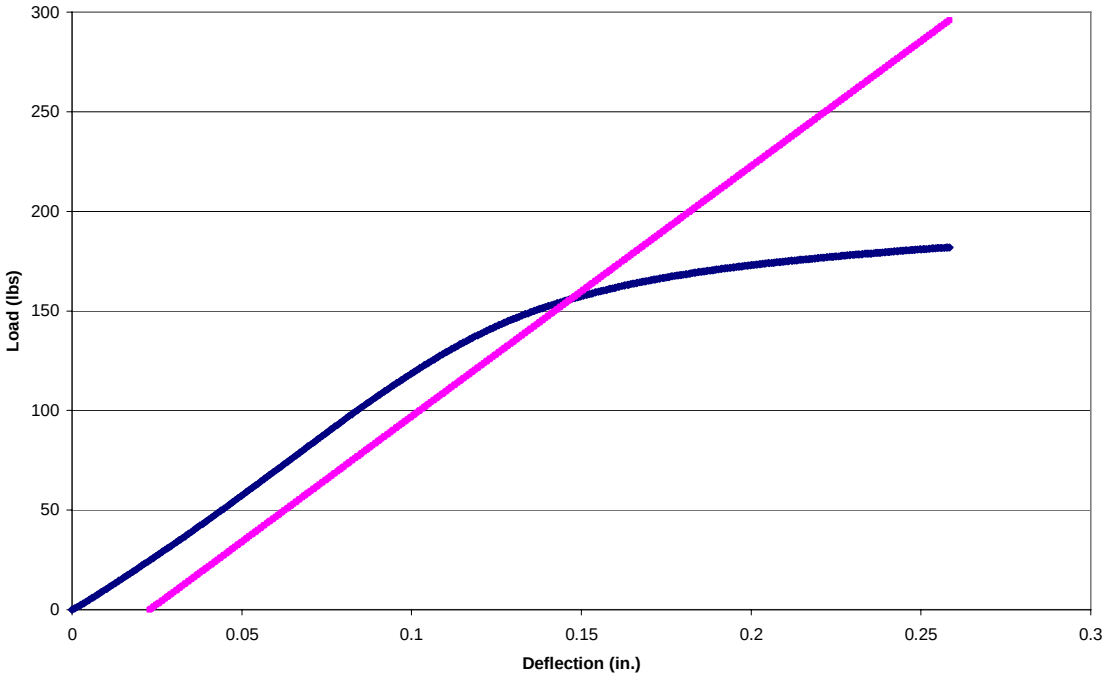

Figure C.99: Load vs. Deflection Curve and 5% Offset Line, E6c9

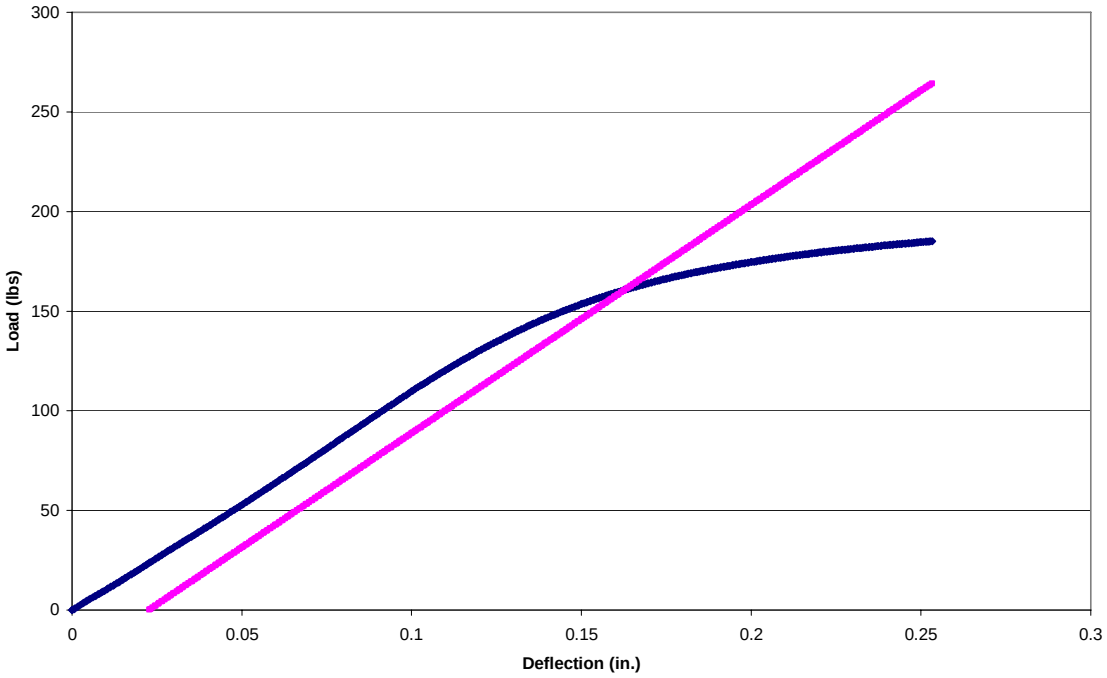

Figure C.100: Load vs. Deflection Curve and 5% Offset Line, E6c10

Table C.11: Test Results for E8c Data Set

$E8c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	97	485
C2	97	485
C3	96	480
C4	96	480
C5	97	485
C6	104	520
C7	93	465
C8	93	465
C9	95	475
C10	96	480
AVG	**96**	**482**
Standard Dev.	**3**	**15**
COV (%)	**3.2**	**3.2**

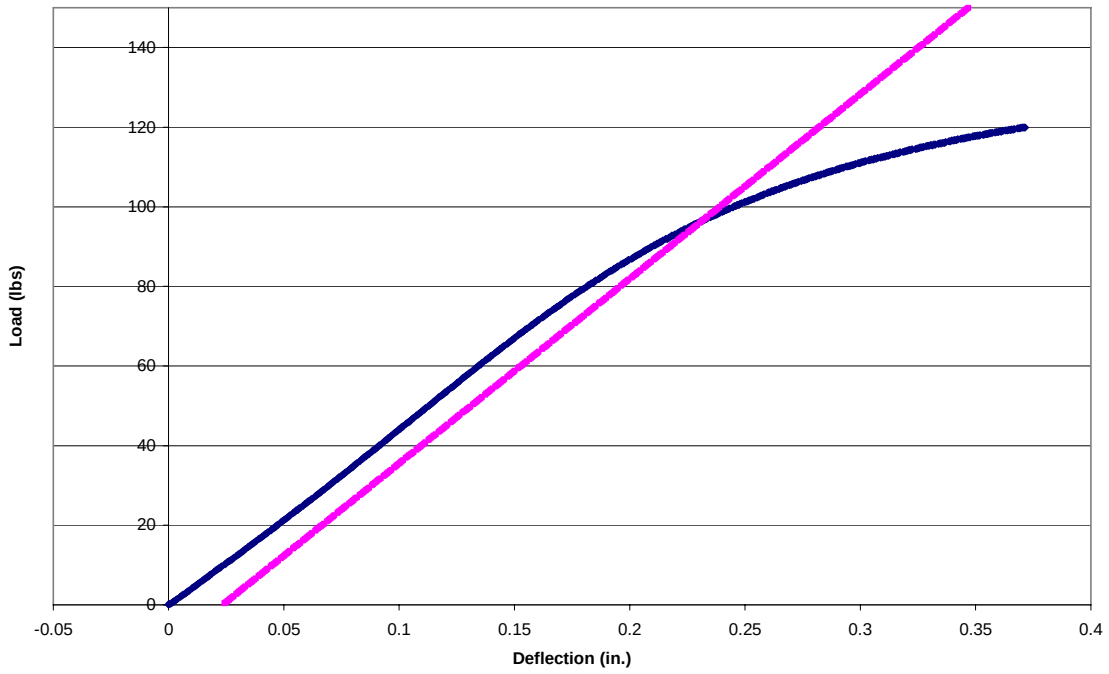

Figure C.101: Load vs. Deflection Curve and 5% Offset Line, E8c1

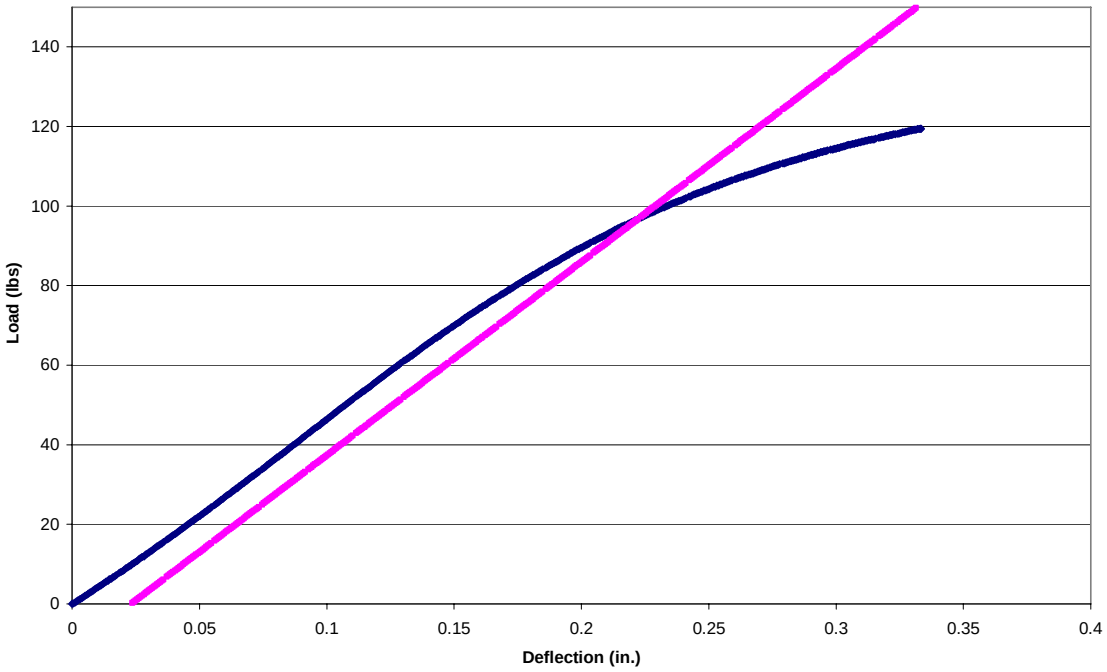

Figure C.102: Load vs. Deflection Curve and 5% Offset Line, E8c2

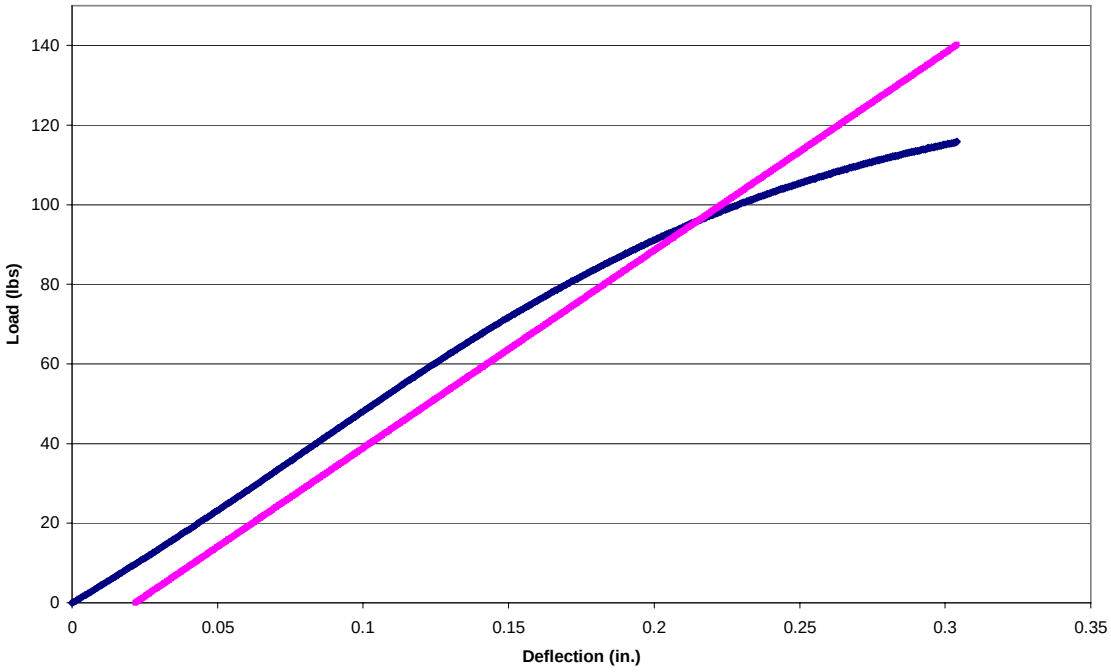

Figure C.103: Load vs. Deflection Curve and 5% Offset Line, E8c3

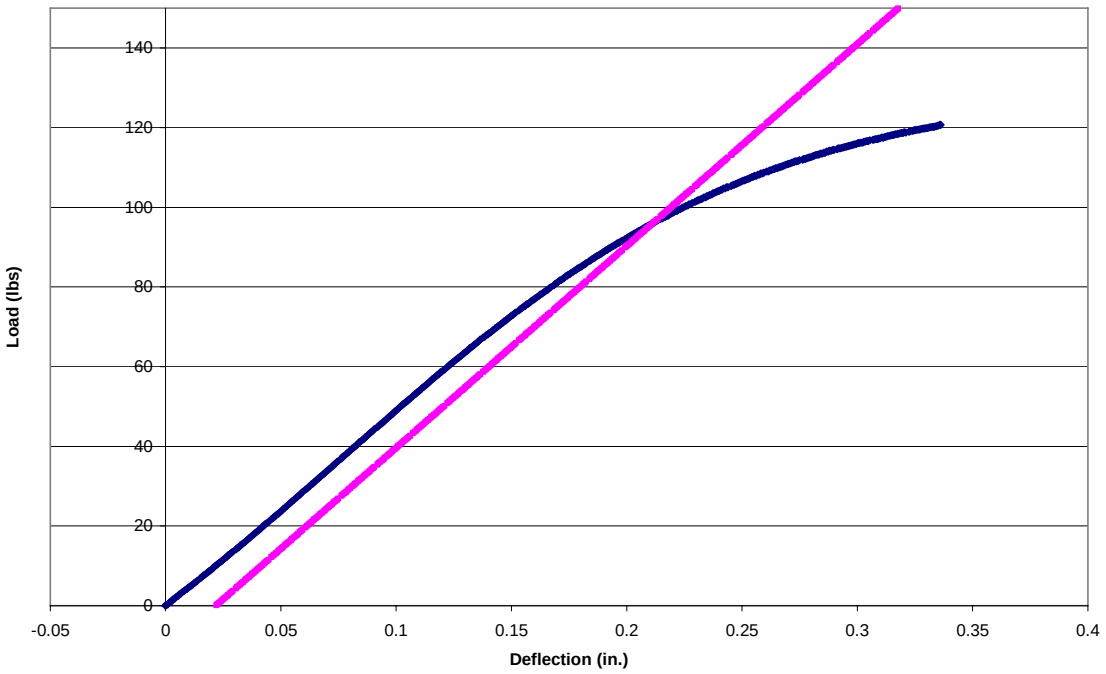

Figure C.104: Load vs. Deflection Curve and 5% Offset Line, E8c4

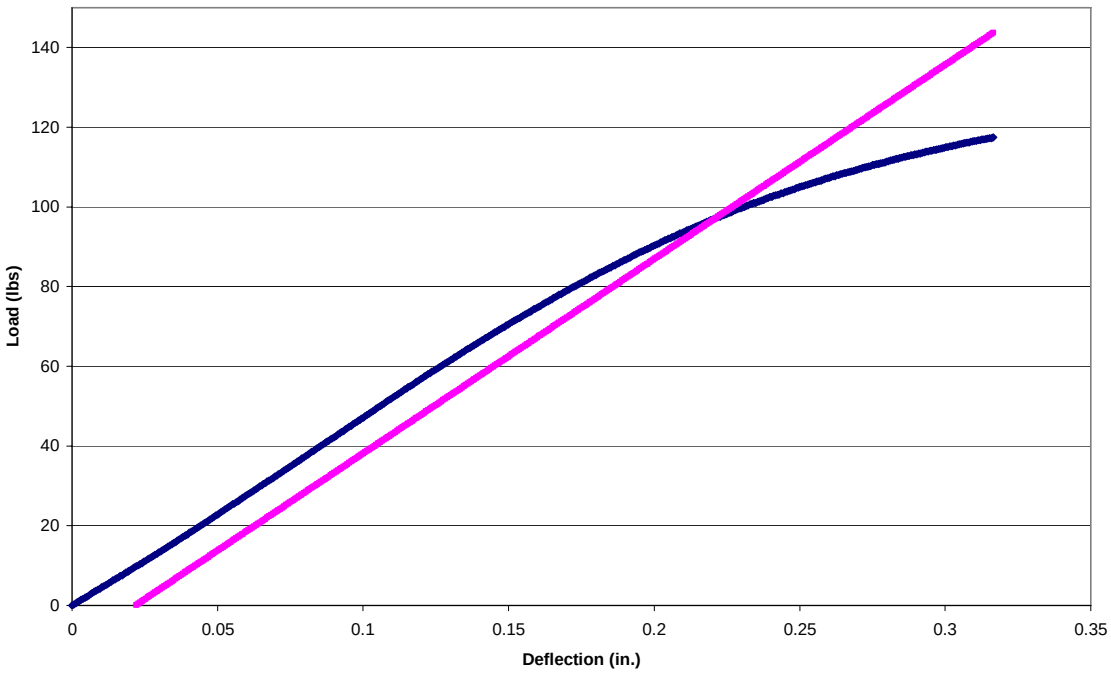

Figure C.105: Load vs. Deflection Curve and 5% Offset Line, E8c5

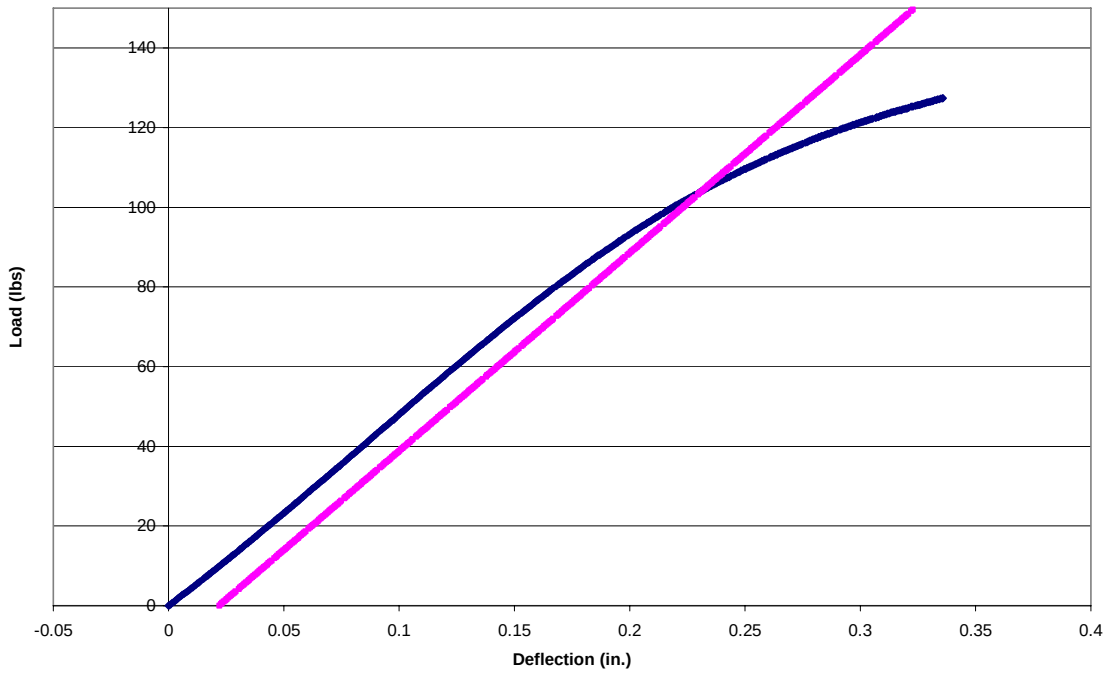

Figure C.106: Load vs. Deflection Curve and 5% Offset Line, E8c6

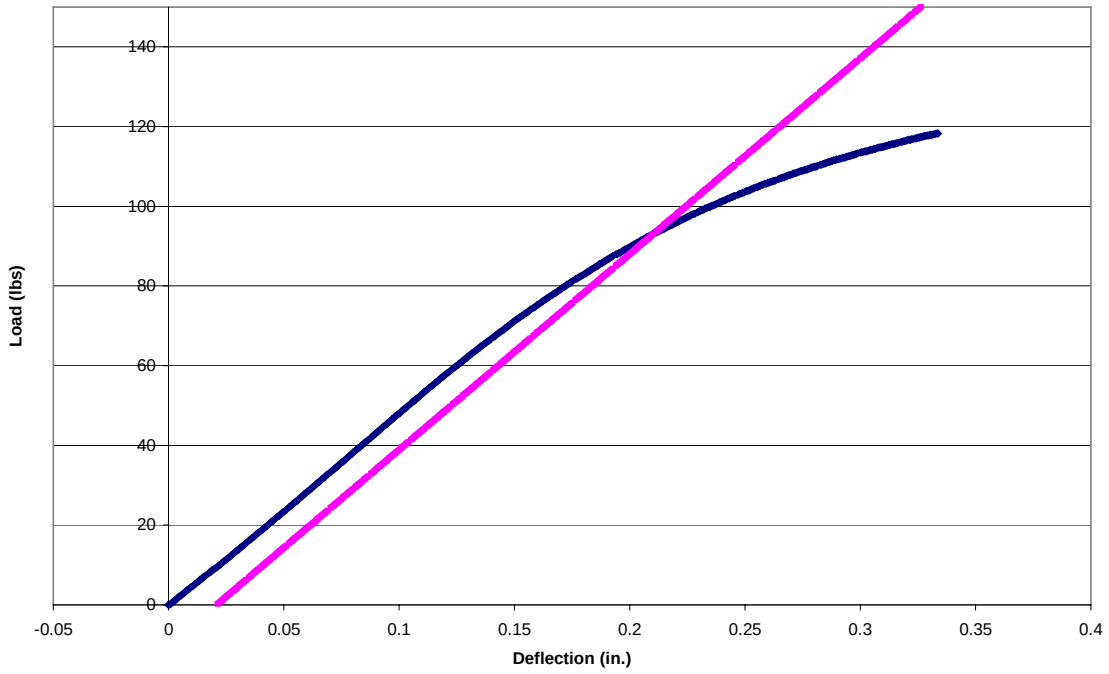

Figure C.107: Load vs. Deflection Curve and 5% Offset Line, E8c7

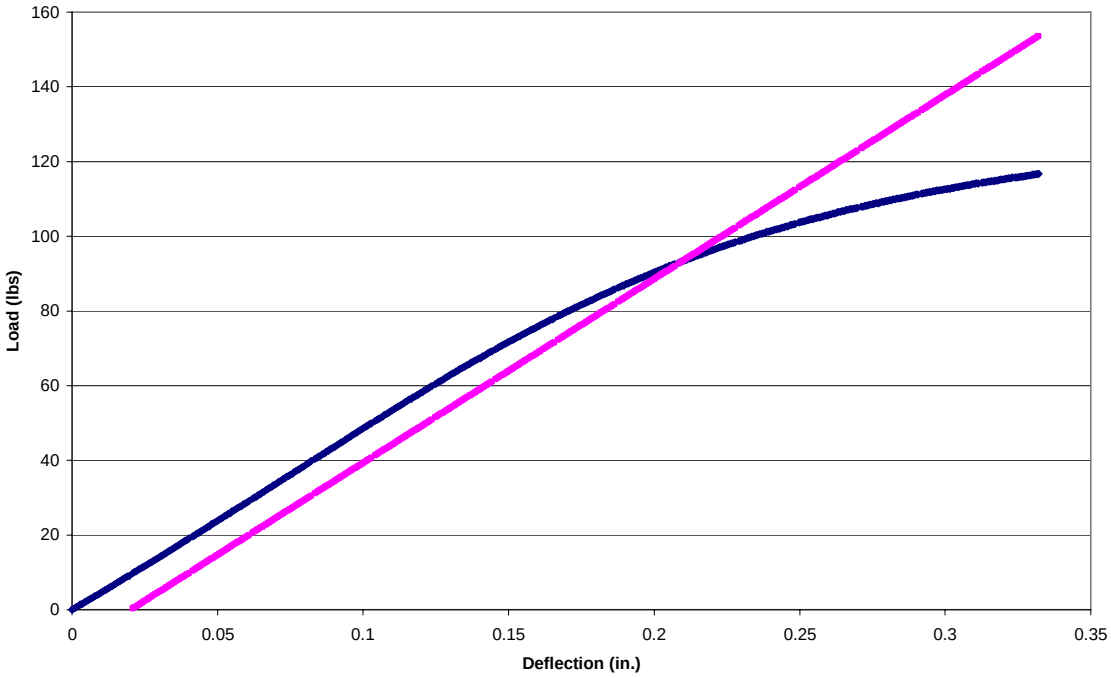

Figure C.108: Load vs. Deflection Curve and 5% Offset Line, E8c8

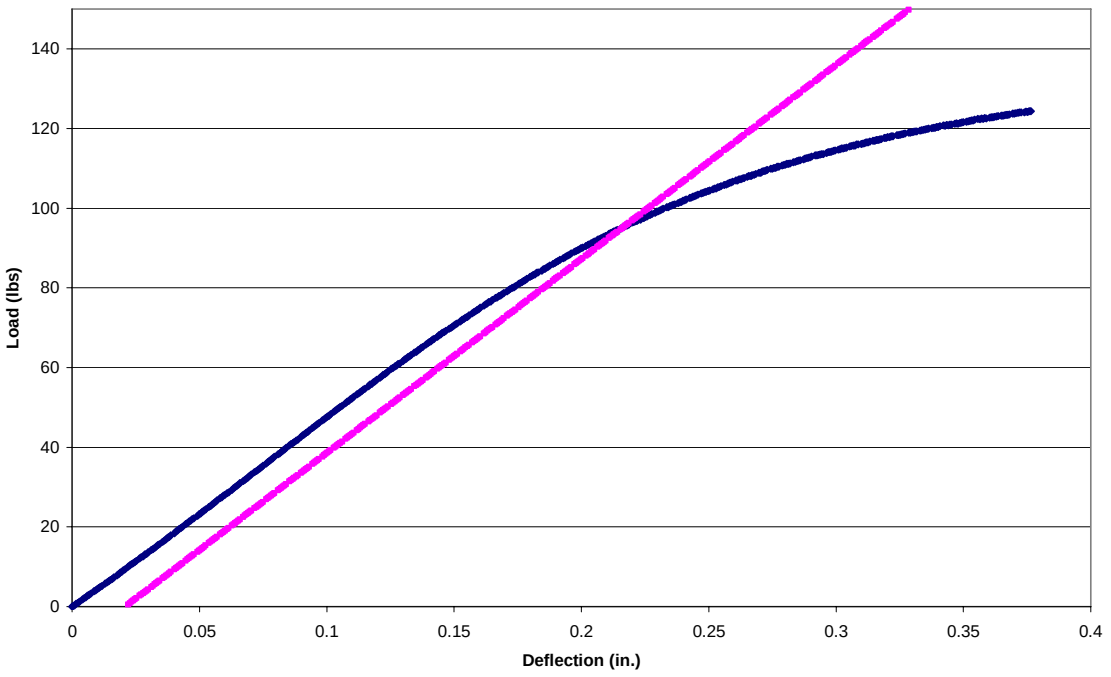

Figure C.109: Load vs. Deflection Curve and 5% Offset Line, E8c9

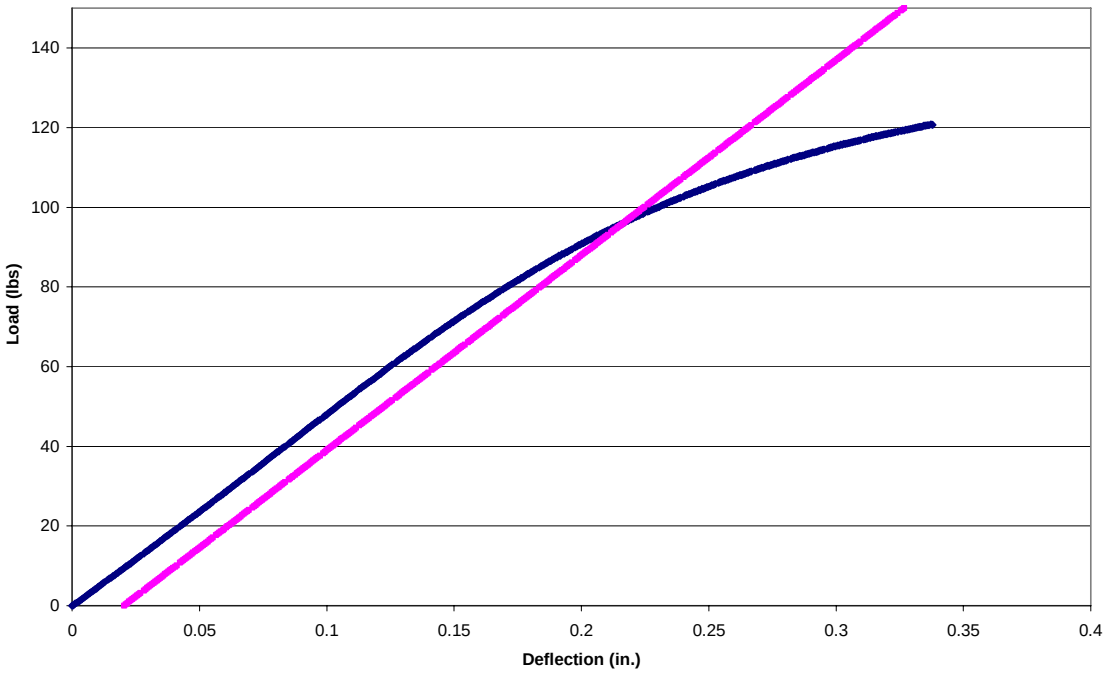

Figure C.110: Load vs. Deflection Curve and 5% Offset Line, E8c10

Table C.12: Test Results for H4c Data Set

$H4c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	858	1716
C2	978	1956
C3	847	1694
C4	987	1974
C5	825	1650
C6	935	1870
C7	983	1966
C8	942	1884
C9	950	1900
C10	903	1806
AVG	**921**	**1842**
Standard Dev.	**60**	**119**
COV (%)	**6.5**	**6.5**

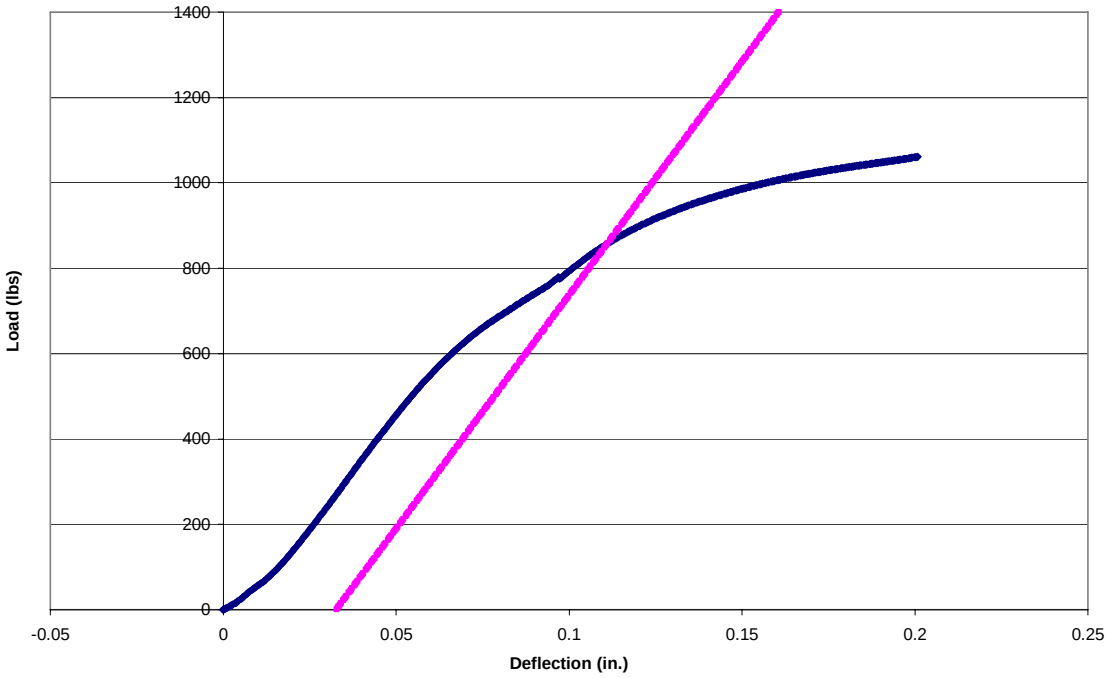

Figure C.111: Load vs. Deflection Curve and 5% Offset Line, H4c1

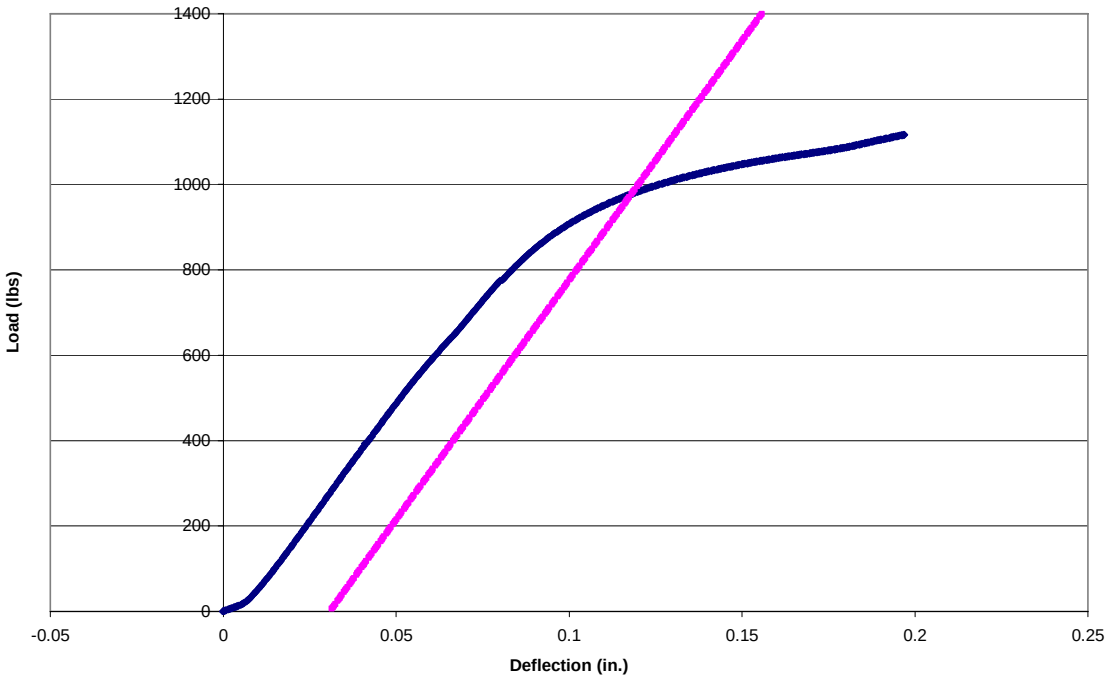

Figure C.112: Load vs. Deflection Curve and 5% Offset Line, H4c2

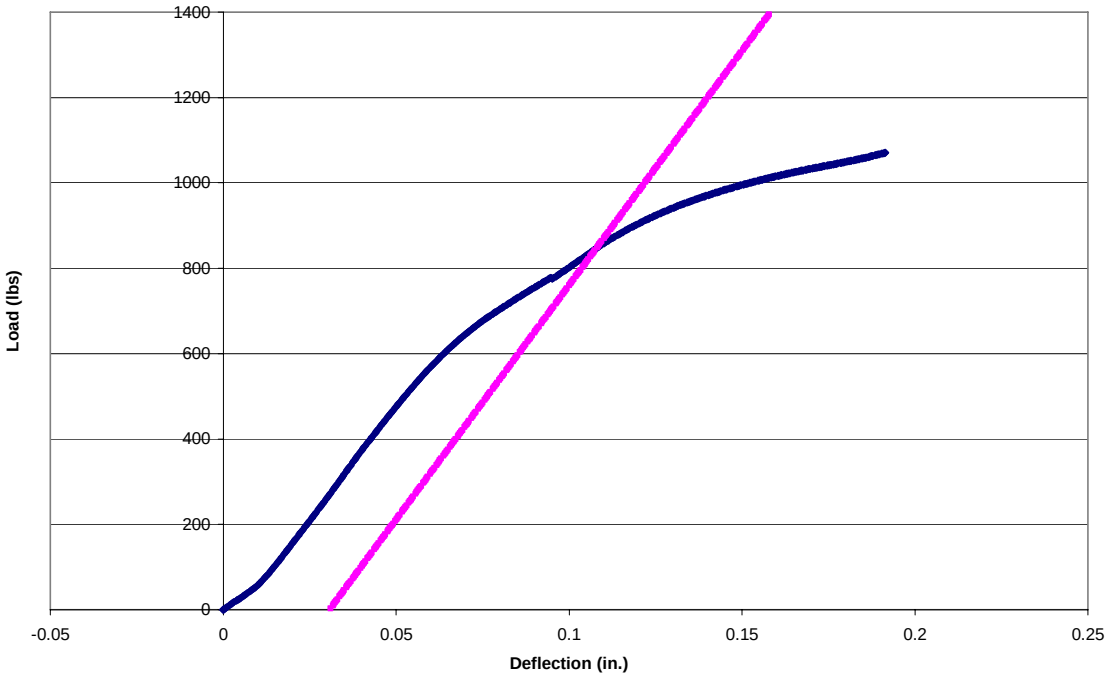

Figure C.113: Load vs. Deflection Curve and 5% Offset Line, H4c3

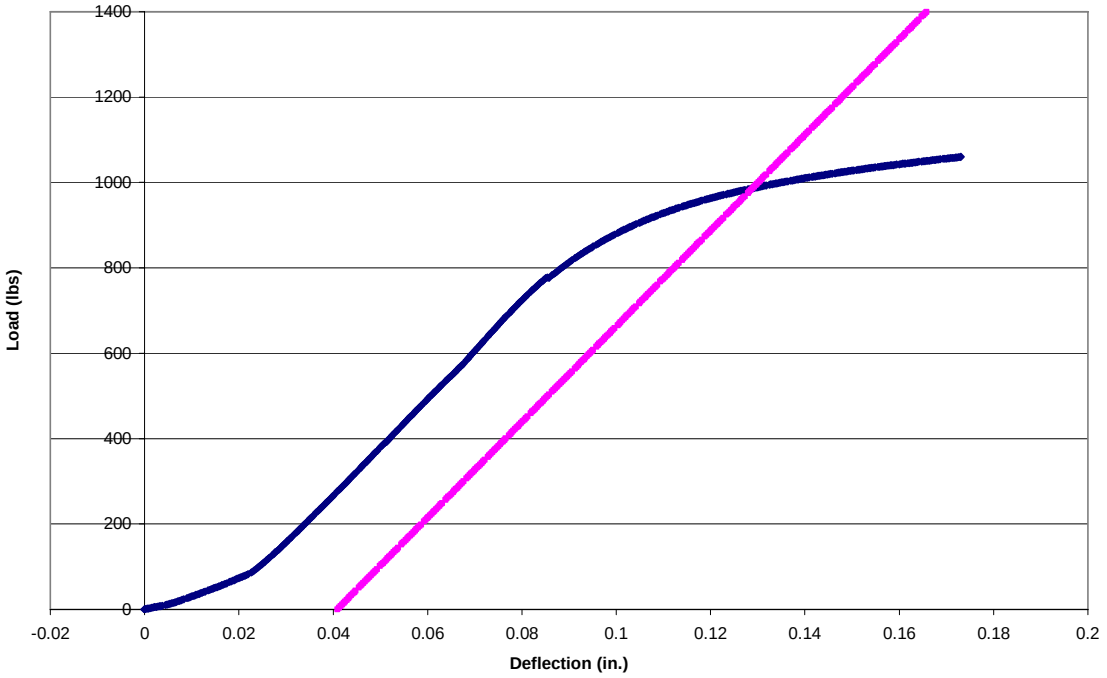

Figure C.114: Load vs. Deflection Curve and 5% Offset Line, H4c4

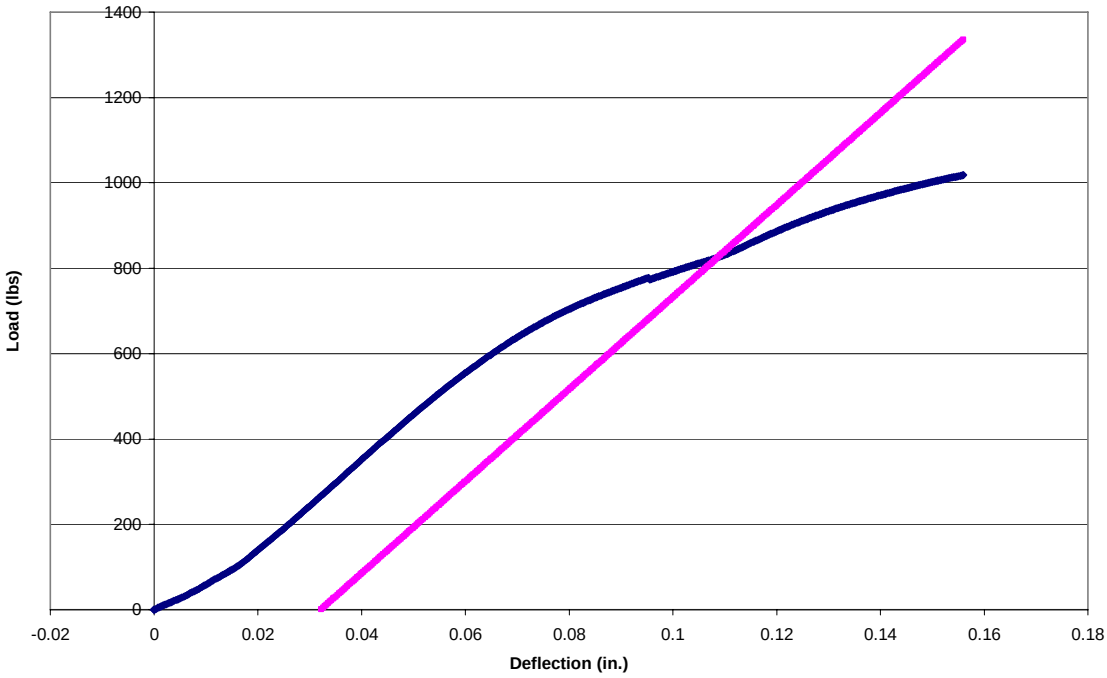

Figure C.115: Load vs. Deflection Curve and 5% Offset Line, H4c5

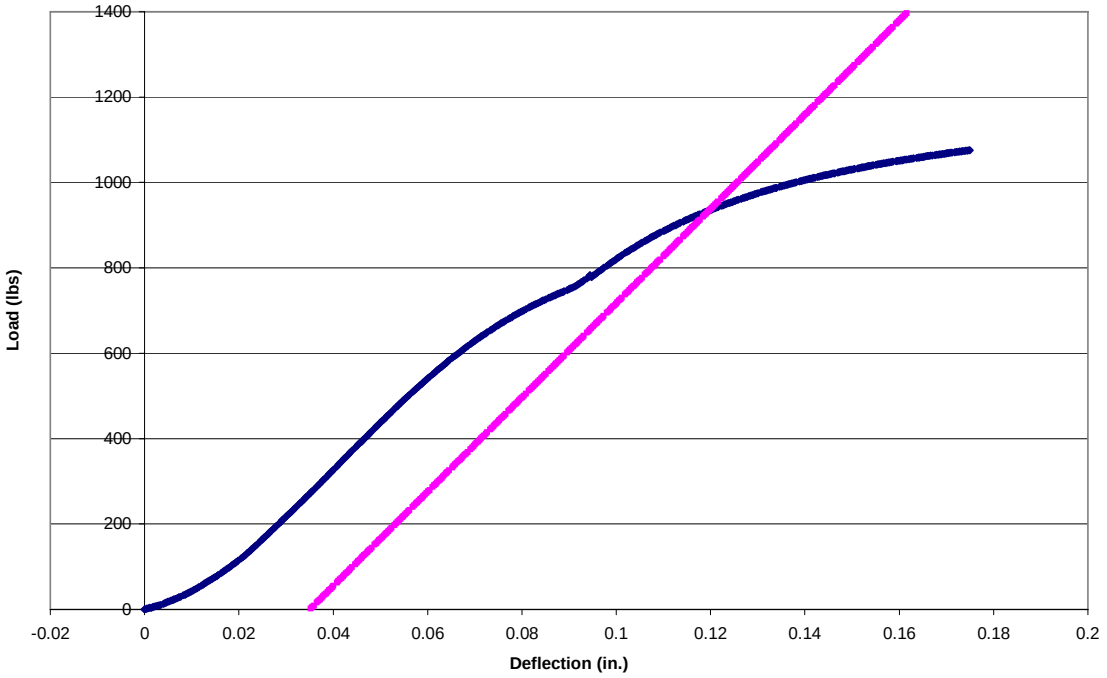

Figure C.116: Load vs. Deflection Curve and 5% Offset Line, H4c6

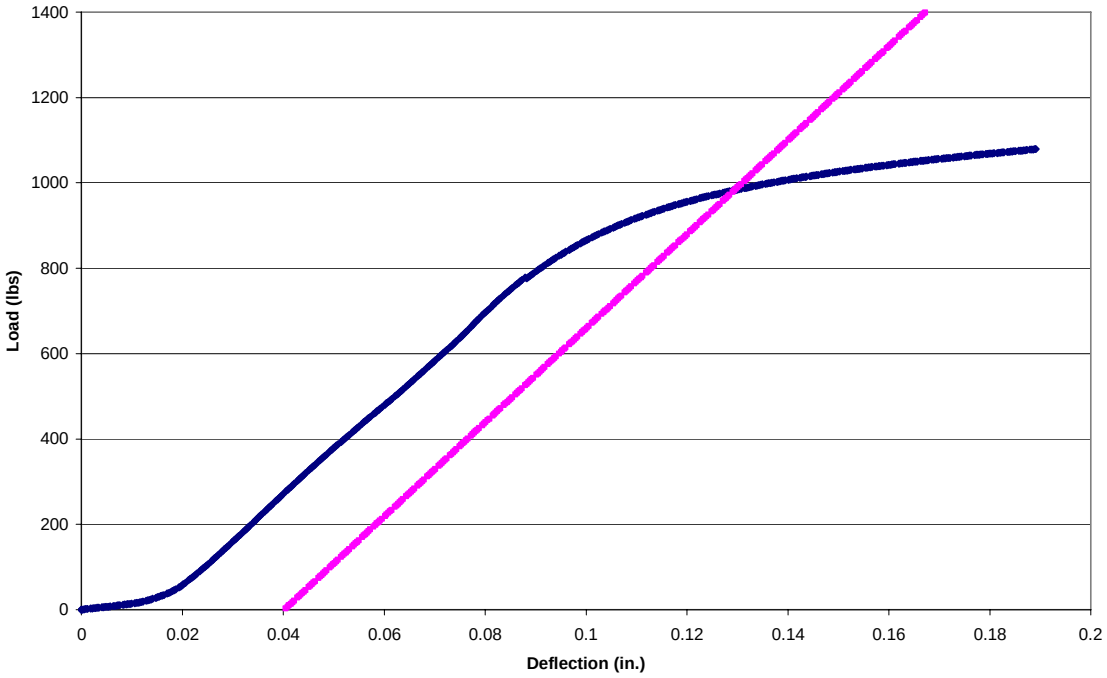

Figure C.117: Load vs. Deflection Curve and 5% Offset Line, H4c7

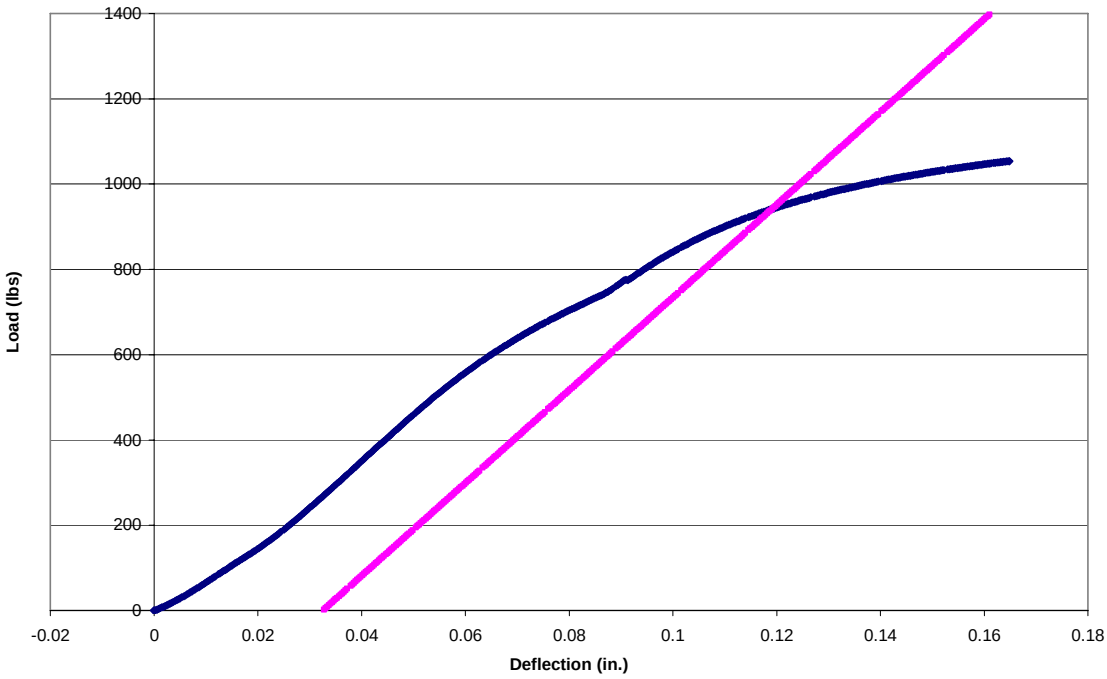

Figure C.118: Load vs. Deflection Curve and 5% Offset Line, H4c8

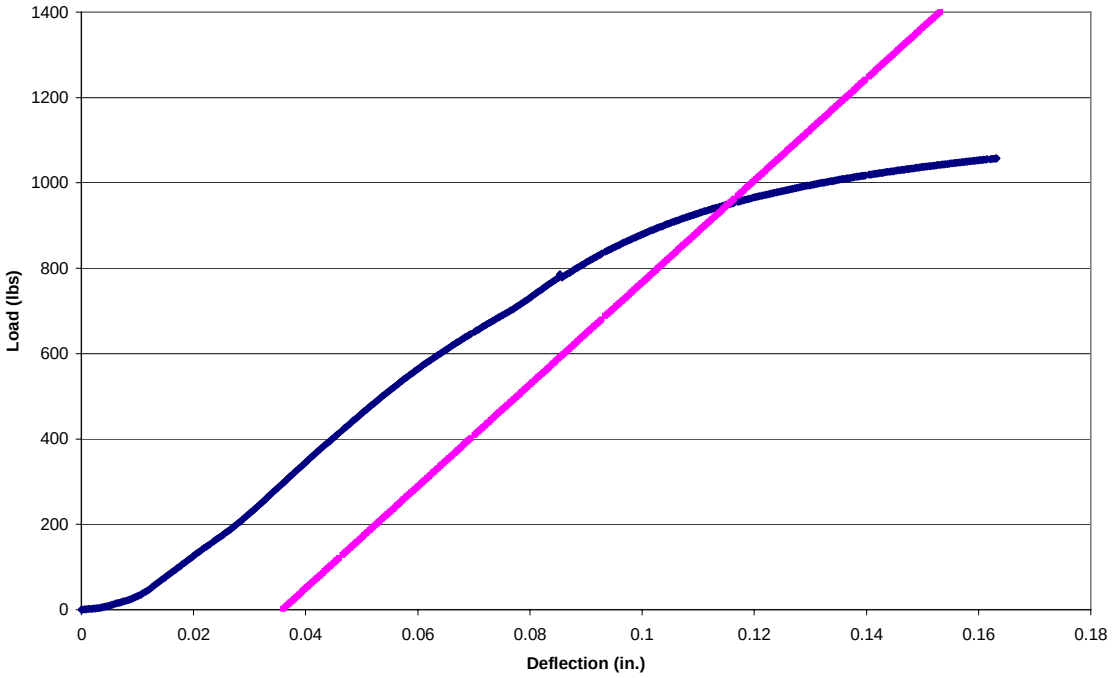

Figure C.119: Load vs. Deflection Curve and 5% Offset Line, H4c9

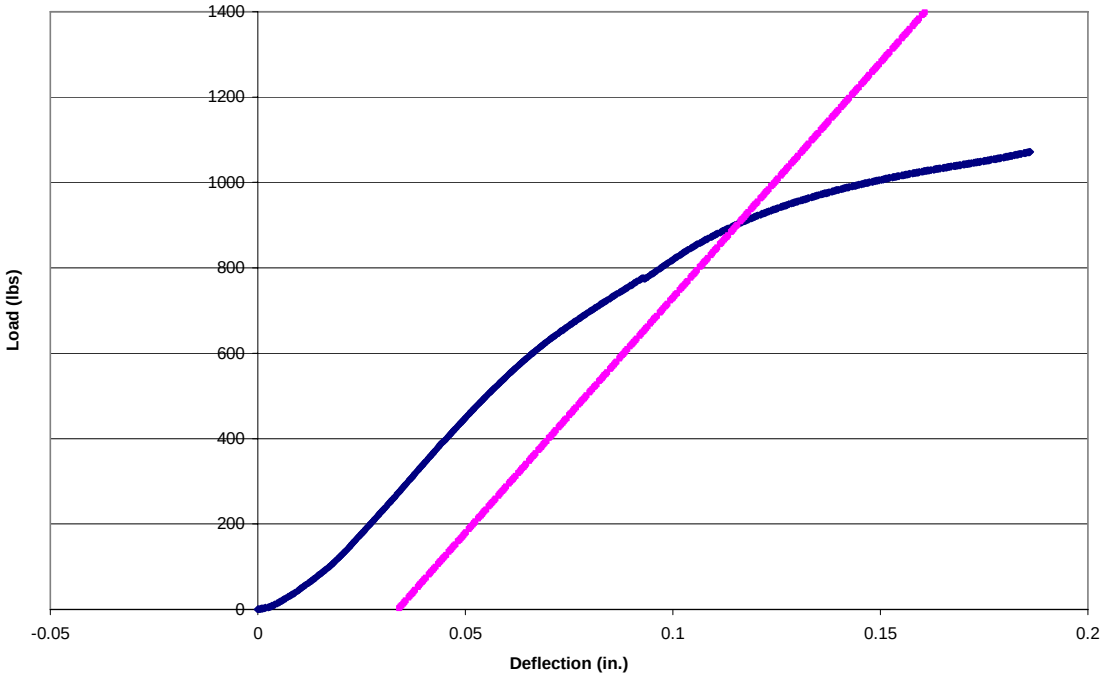

Figure C.120: Load vs. Deflection Curve and 5% Offset Line, H4c10

Table C.13: Test Results for H6c Data Set

$H6c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	412	1442
C2	439	1537
C3	432	1512
C4	417	1460
C5	409	1432
C6	426	1491
C7	435	1523
C8	413	1446
C9	415	1453
C10	410	1435
AVG	**421**	**1473**
Standard Dev.	**11**	**39**
COV (%)	**2.7**	**2.7**

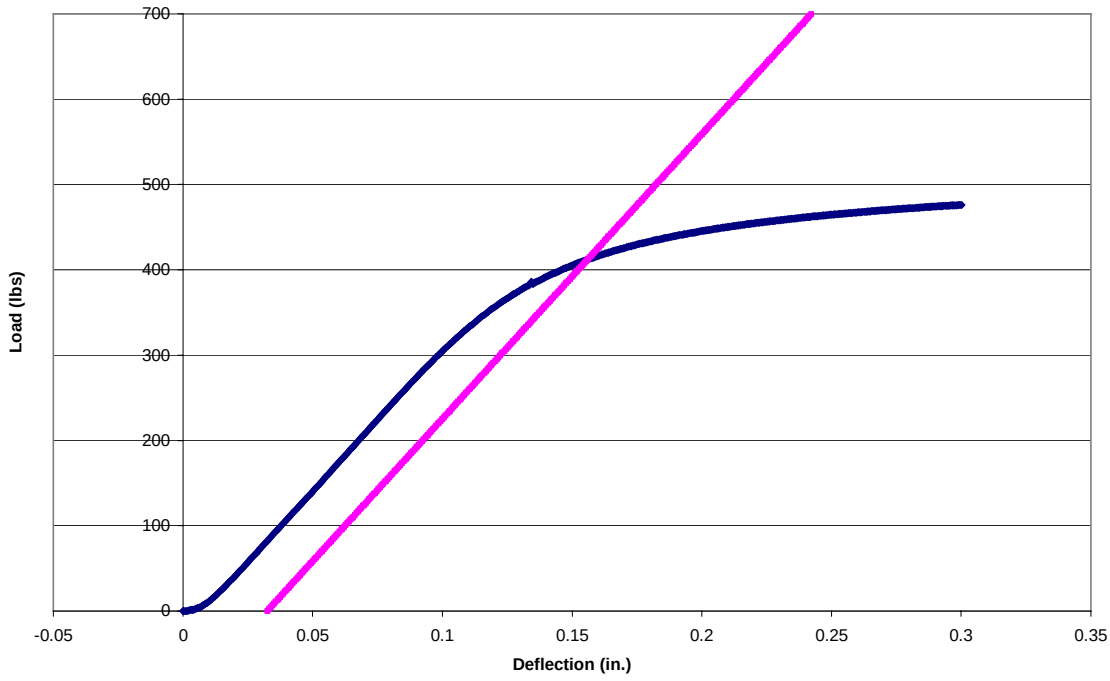

Figure C.121: Load vs. Deflection Curve and 5% Offset Line, H6c1

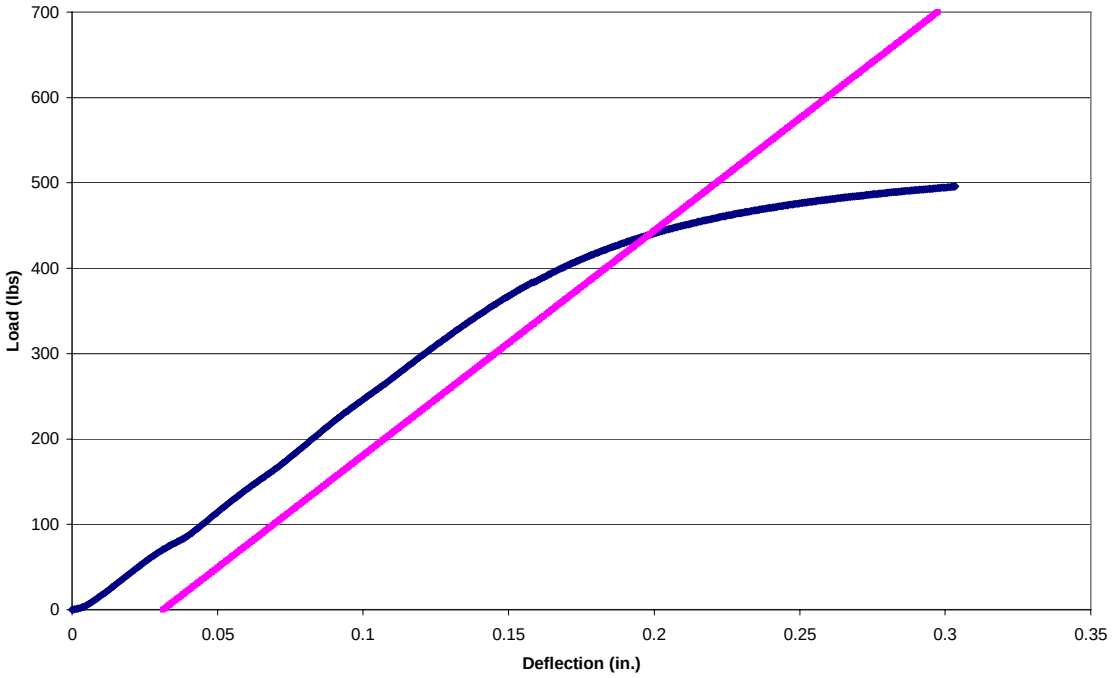

Figure C.122: Load vs. Deflection Curve and 5% Offset Line, H6c2

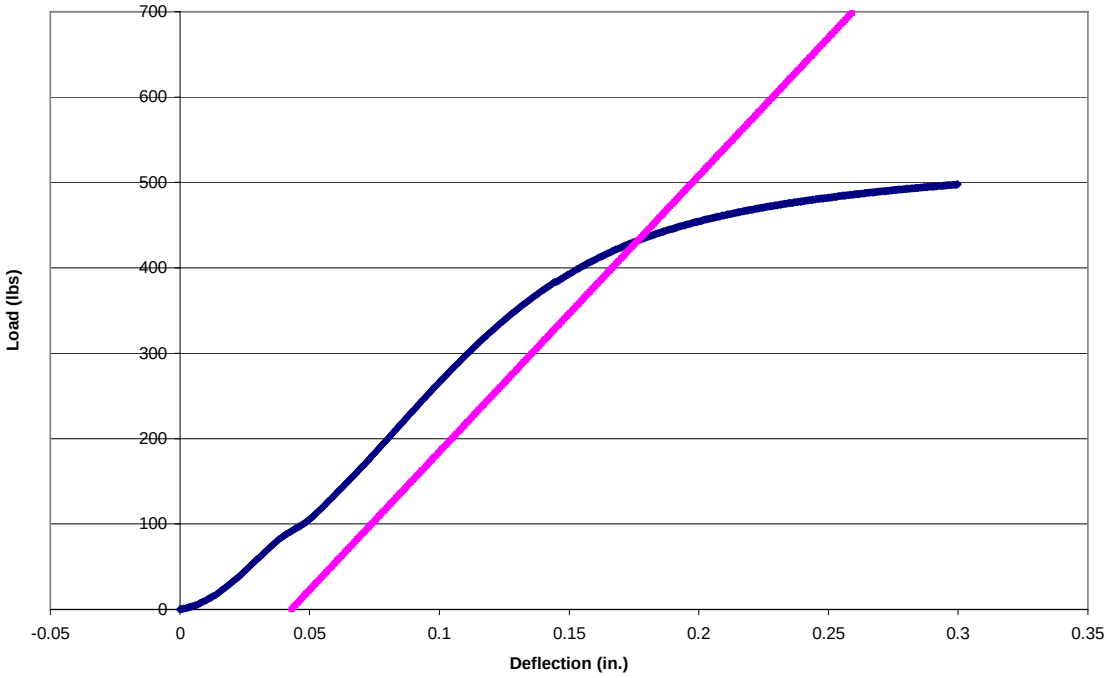

Figure C.123: Load vs. Deflection Curve and 5% Offset Line, H6c3

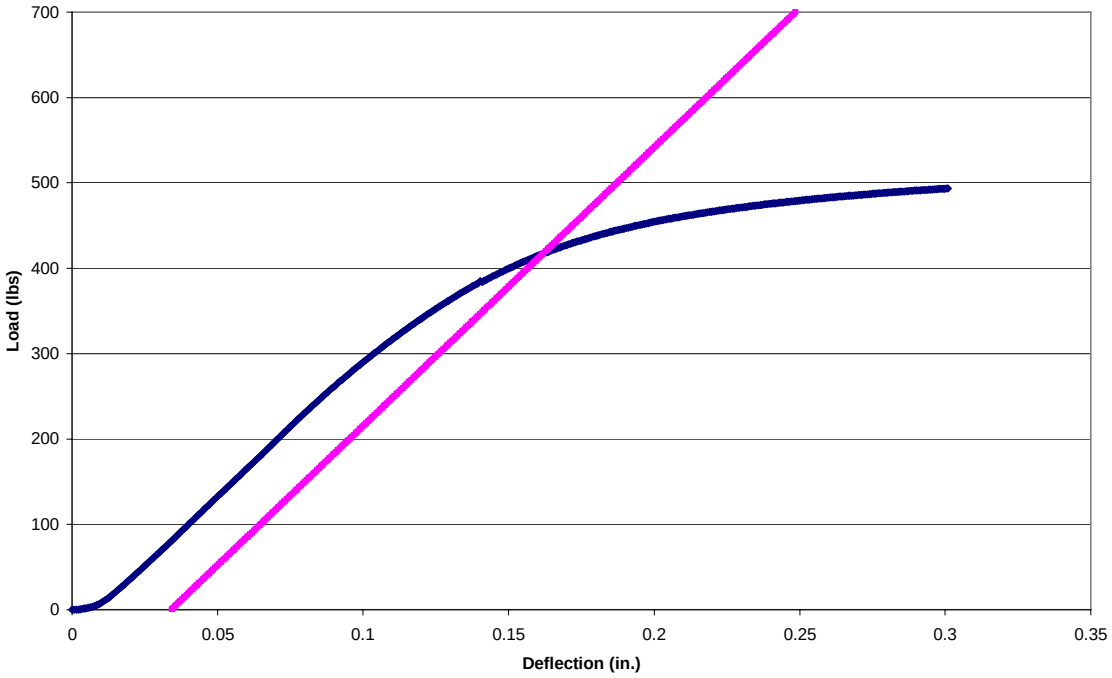

Figure C.124: Load vs. Deflection Curve and 5% Offset Line, H6c4

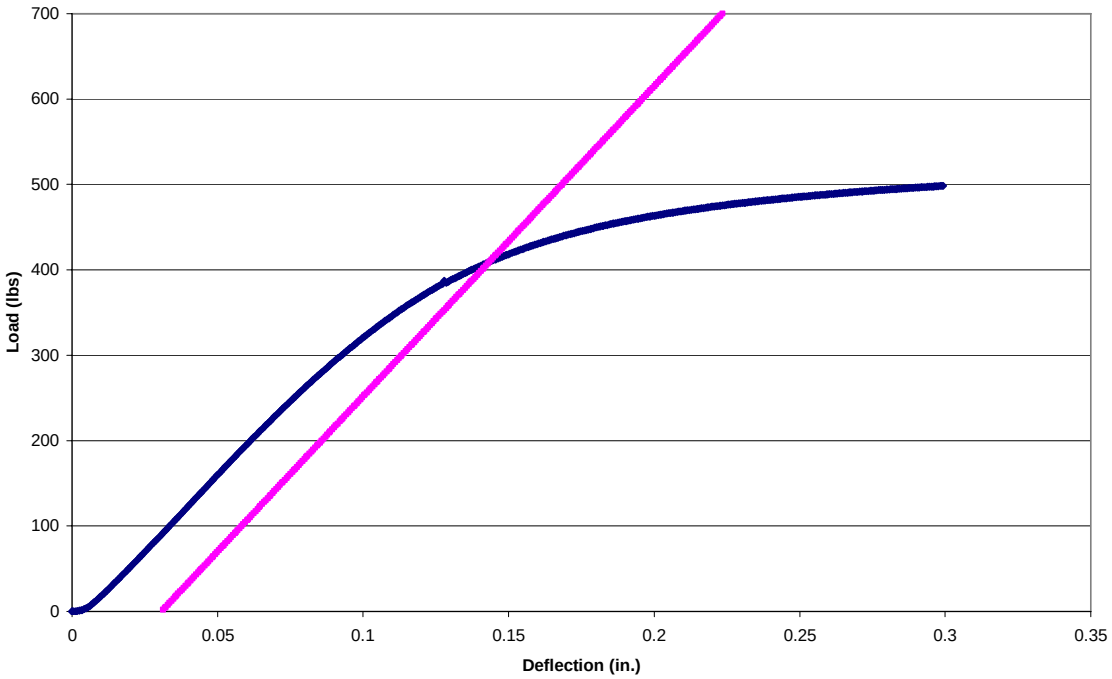

Figure C.125: Load vs. Deflection Curve and 5% Offset Line, H6c5

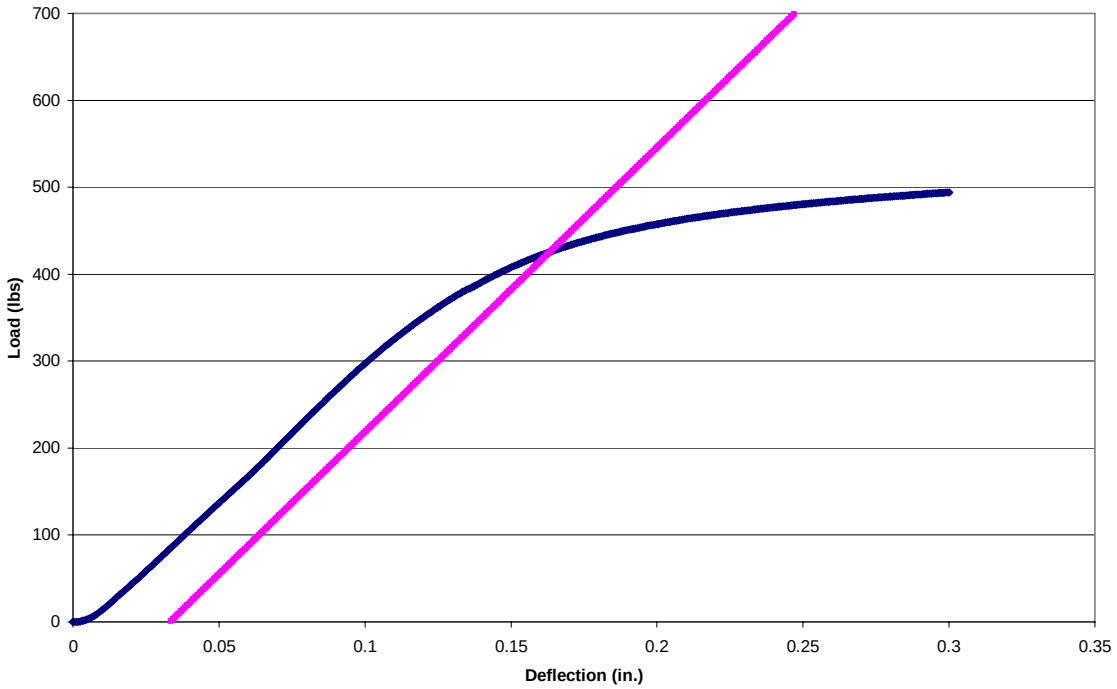

Figure C.126: Load vs. Deflection Curve and 5% Offset Line, H6c6

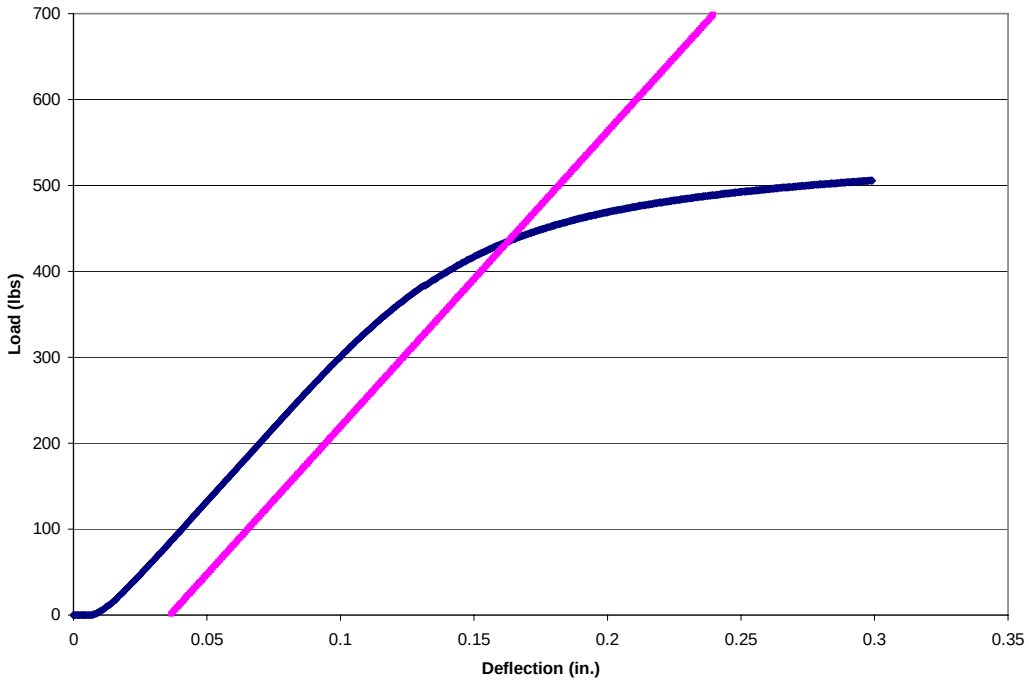

Figure C.127: Load vs. Deflection Curve and 5% Offset Line, H6c7

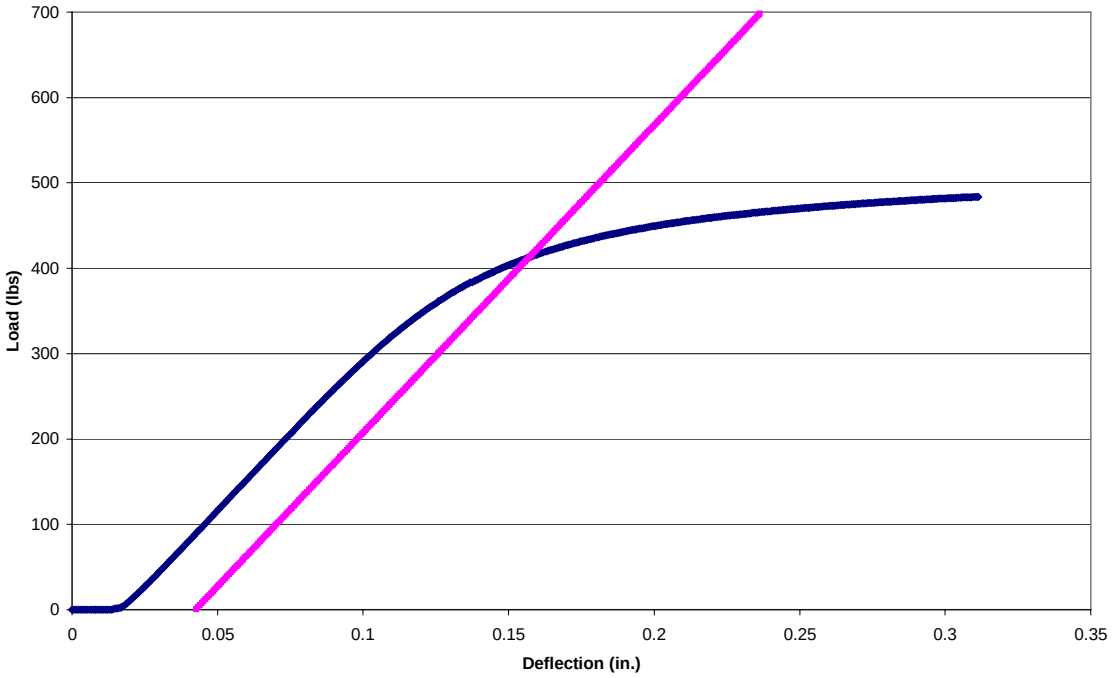

Figure C.128: Load vs. Deflection Curve and 5% Offset Line, H6c8

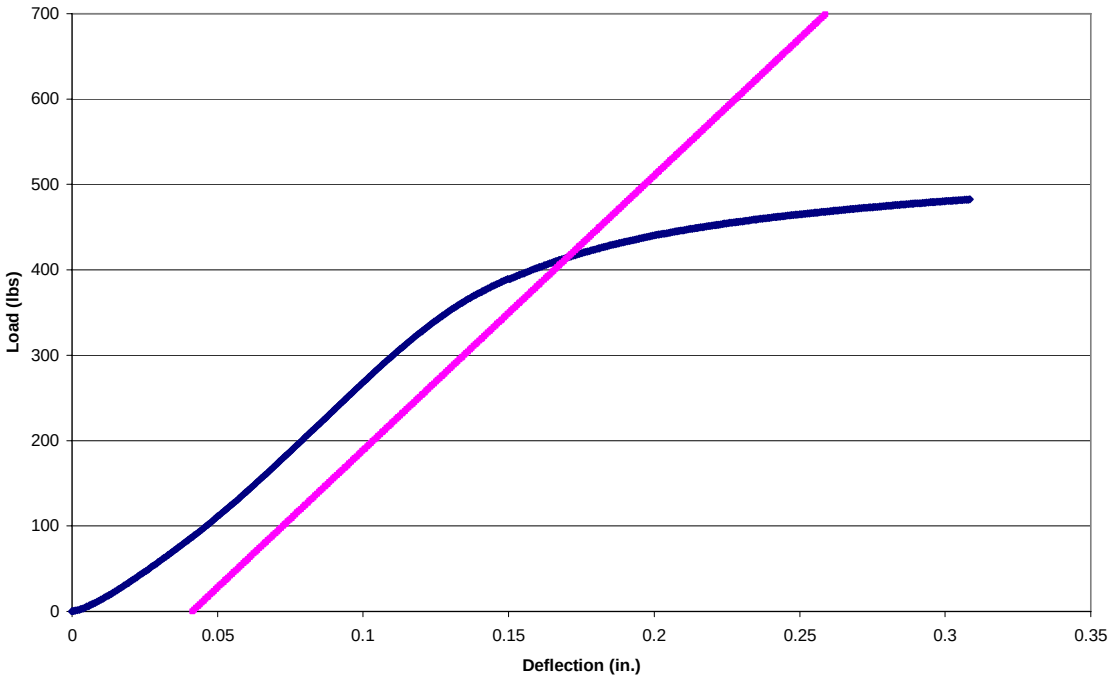

Figure C.129: Load vs. Deflection Curve and 5% Offset Line, H6c9

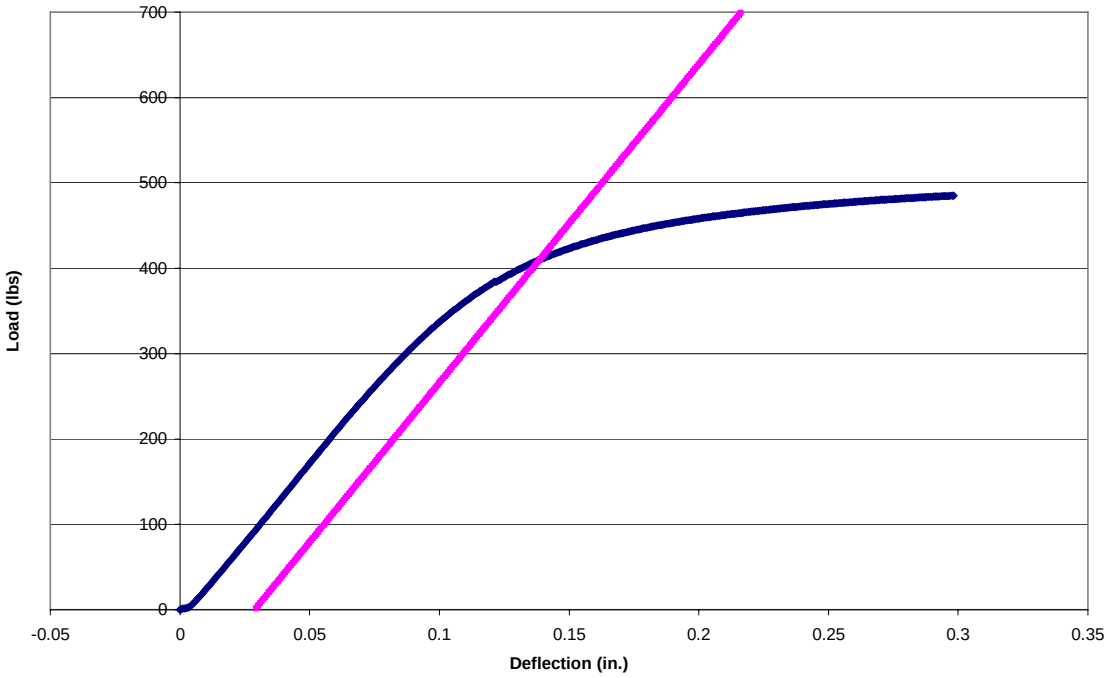

Figure C.130: Load vs. Deflection Curve and 5% Offset Line, H6c10

Table C.14: Test Results for H8c Data Set

$H8c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	170	850
C2	257	1285
C3	228	1140
C4	220	1100
C5	223	1115
C6	230	1150
C7	224	1120
C8	255	1275
C9	224	1120
C10	236	1180
AVG	**227**	**1134**
Standard Dev.	**24**	**119**
COV (%)	**10.5**	**10.5**

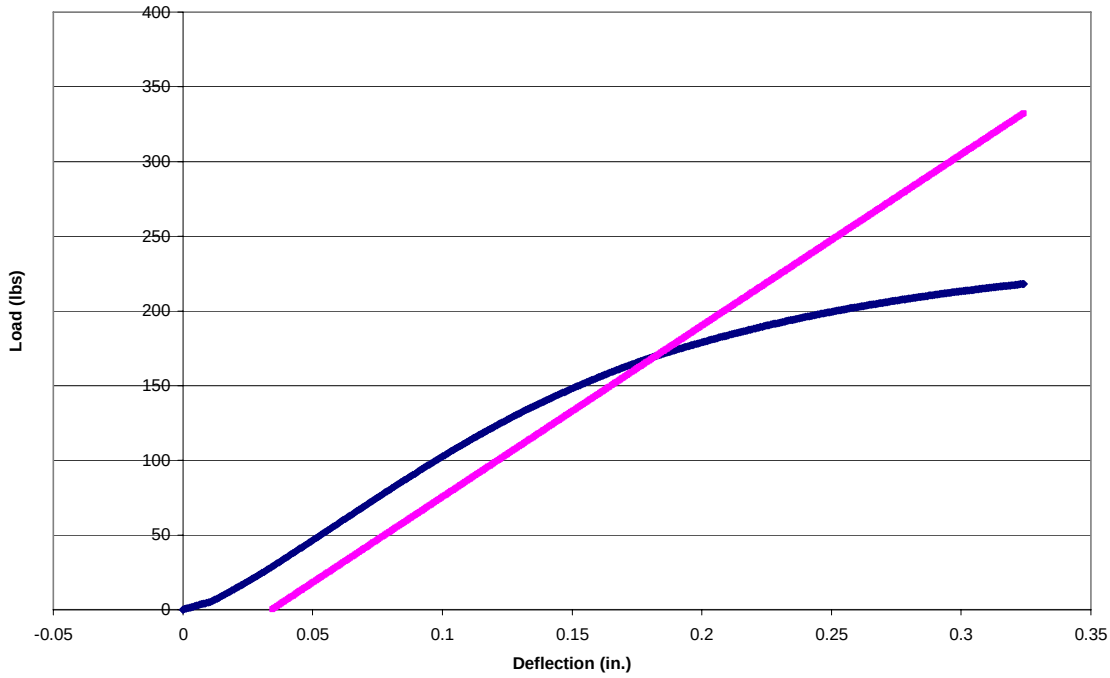

Figure C.131: Load vs. Deflection Curve and 5% Offset Line, H8c1

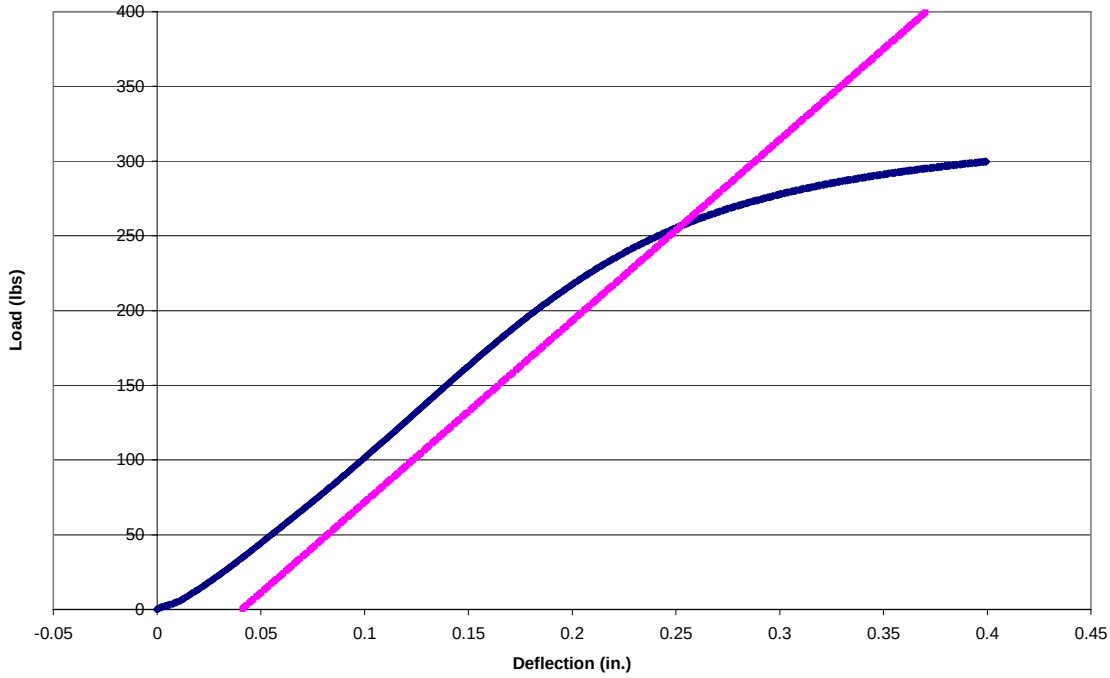

Figure C.132: Load vs. Deflection Curve and 5% Offset Line, H8c2

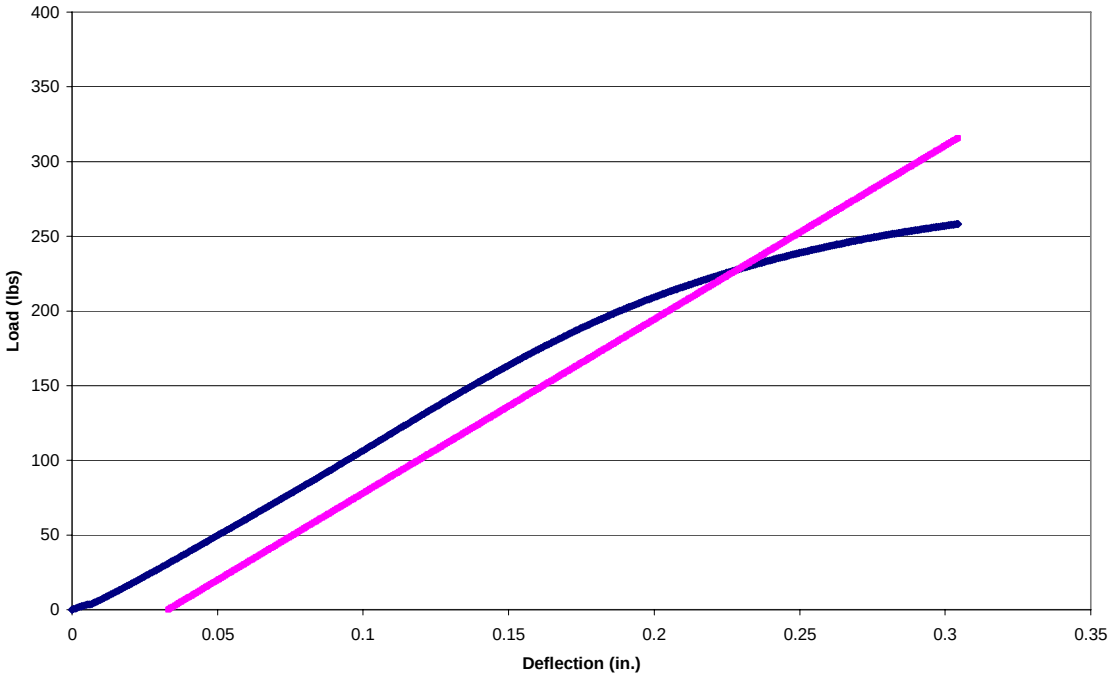

Figure C.133: Load vs. Deflection Curve and 5% Offset Line, H8c3

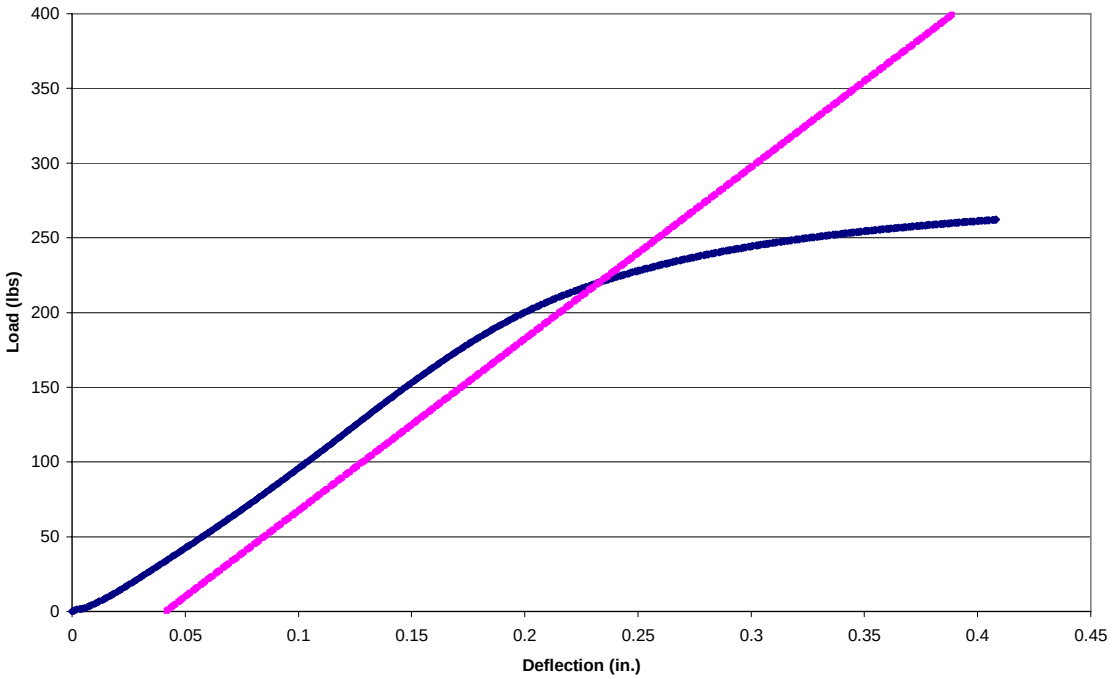

Figure C.134: Load vs. Deflection Curve and 5% Offset Line, H8c4

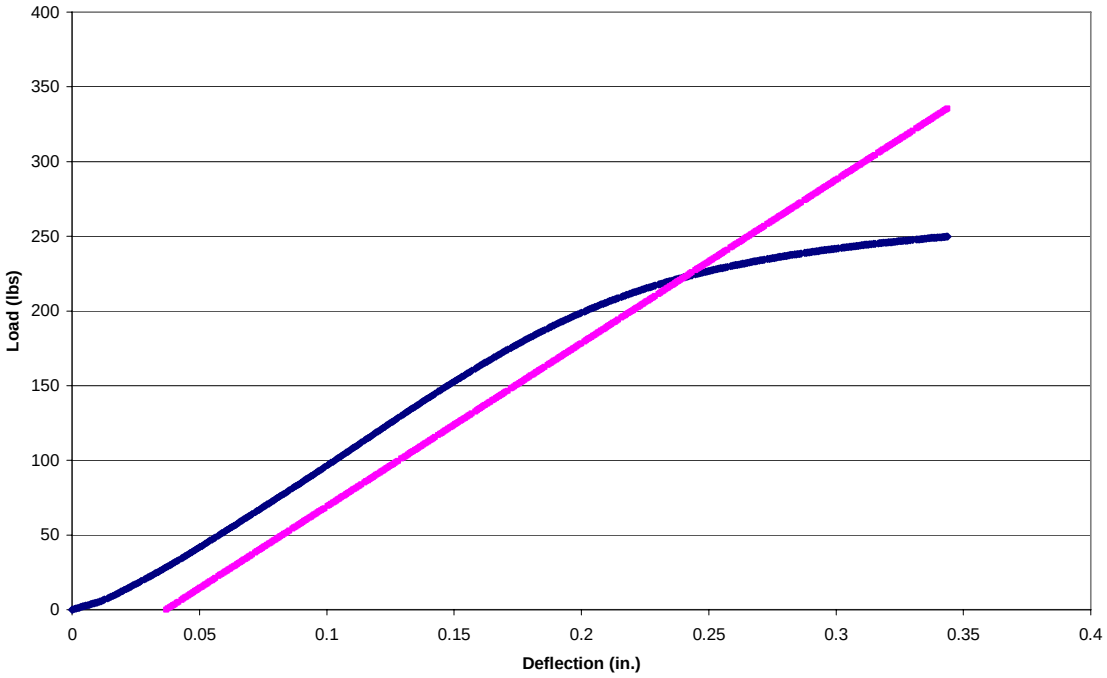

Figure C.135: Load vs. Deflection Curve and 5% Offset Line, H8c5

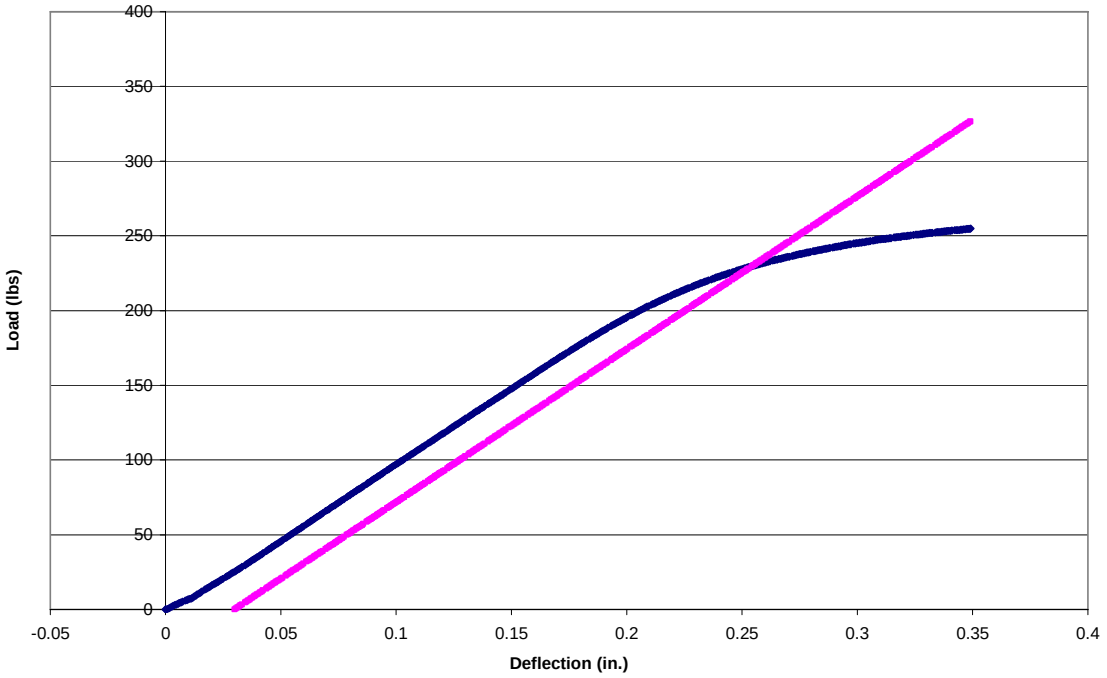

Figure C.136: Load vs. Deflection Curve and 5% Offset Line, H8c6

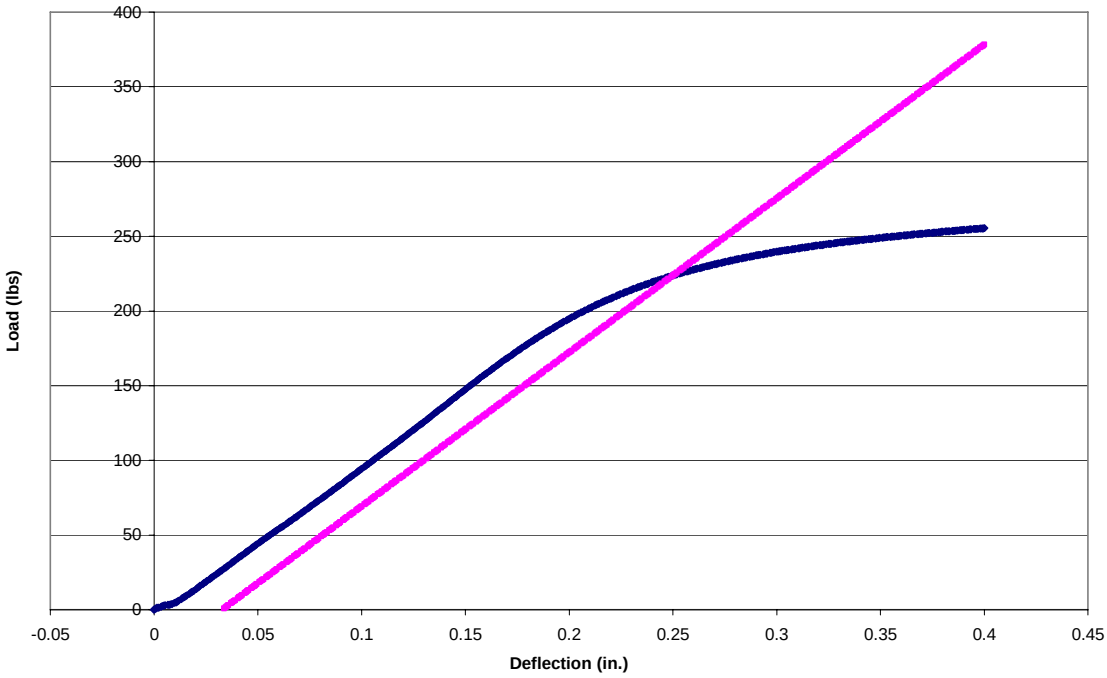

Figure C.137: Load vs. Deflection Curve and 5% Offset Line, H8c7

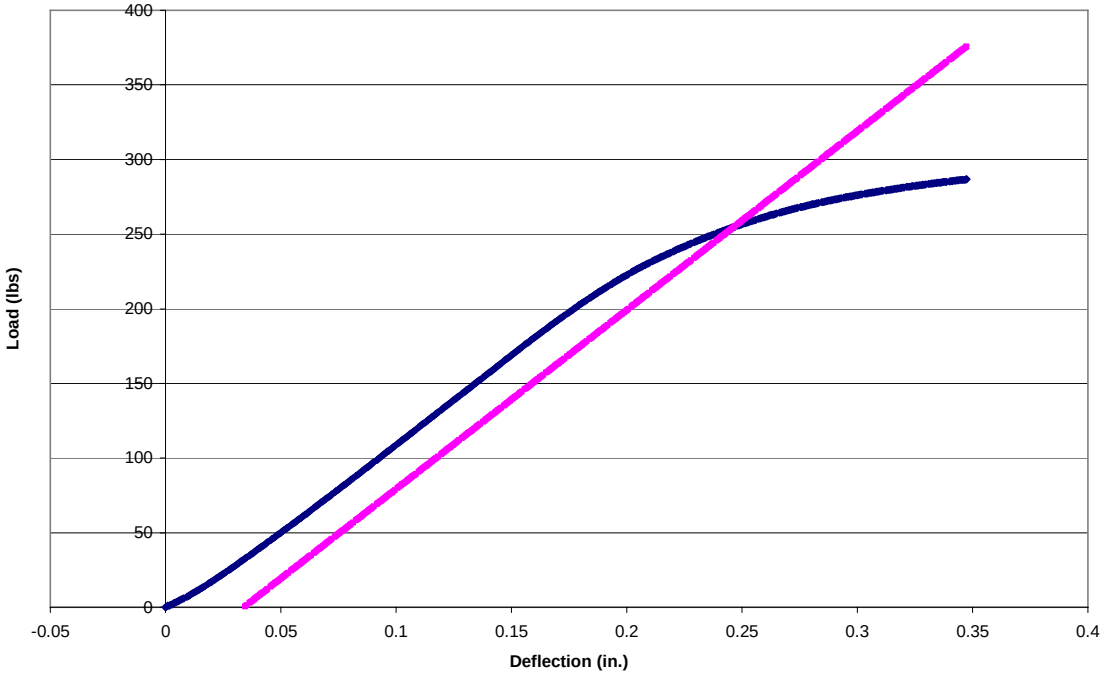

Figure C.138: Load vs. Deflection Curve and 5% Offset Line, H8c8

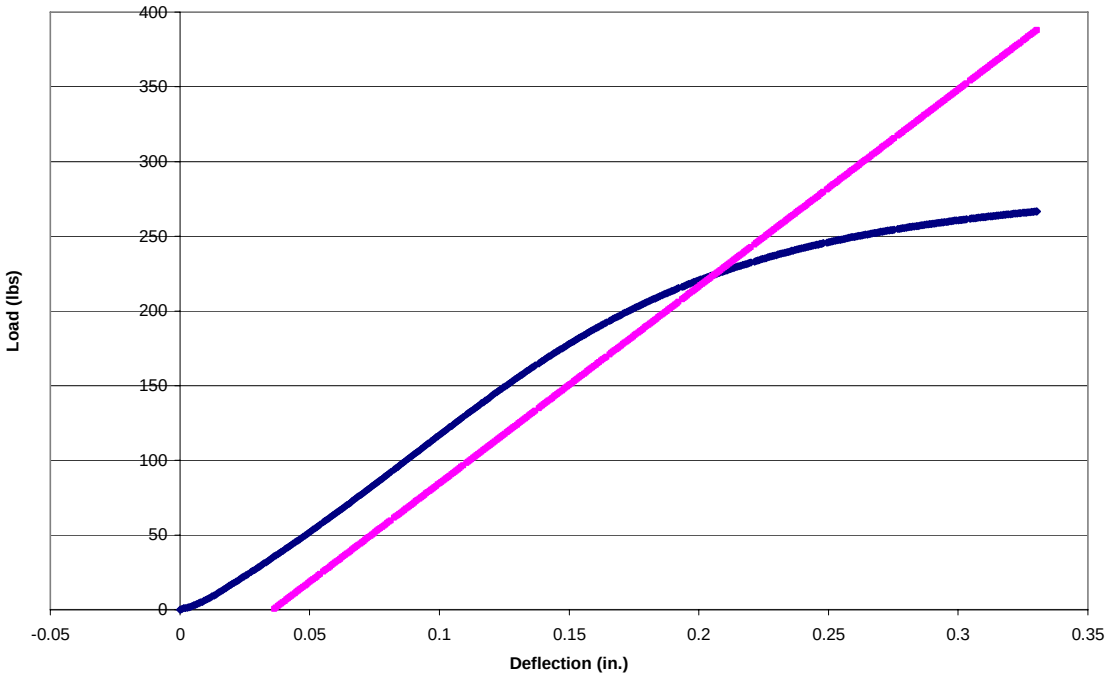

Figure C.139: Load vs. Deflection Curve and 5% Offset Line, H8c9

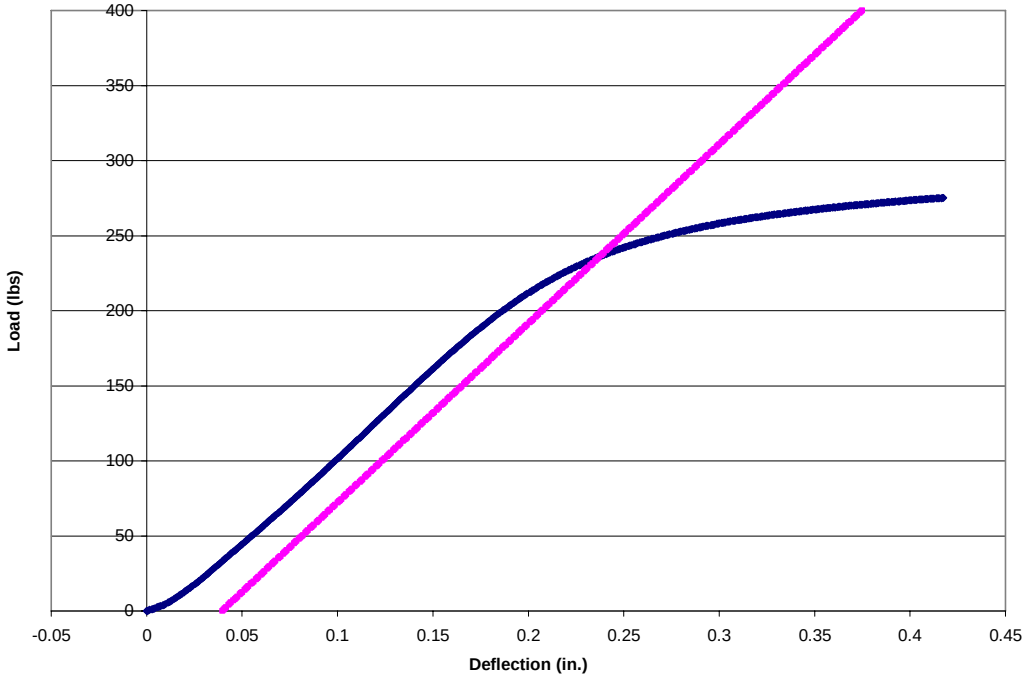

Figure C.140: Load vs. Deflection Curve and 5% Offset Line, H8c10

Table C.15: Test Results for F4c Data Set

$F4c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	5250	6563
C2	5320	6650
C3	5250	6563
C4	5050	6313
C5	5210	6513
C6	4430	5538
C7	4860	6075
C8	5080	6350
C9	4800	6000
C10	4990	6238
AVG	**5024**	**6280**
Standard Dev.	**271**	**338**
COV (%)	**5.4**	**5.4**

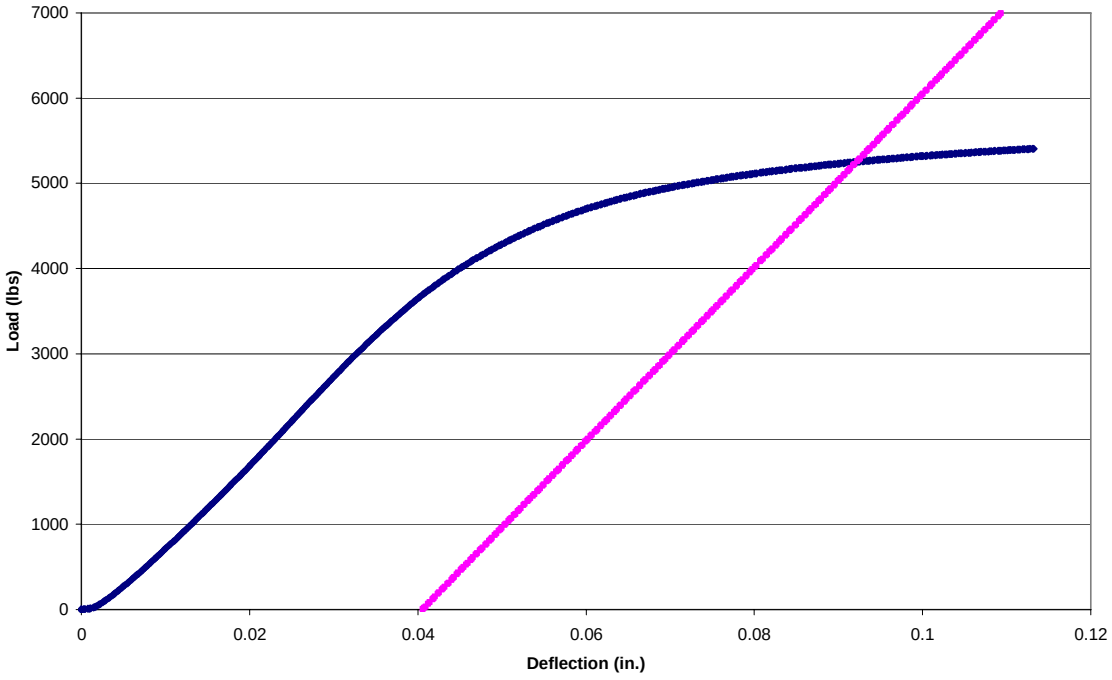

Figure C.141: Load vs. Deflection Curve and 5% Offset Line, F4c1

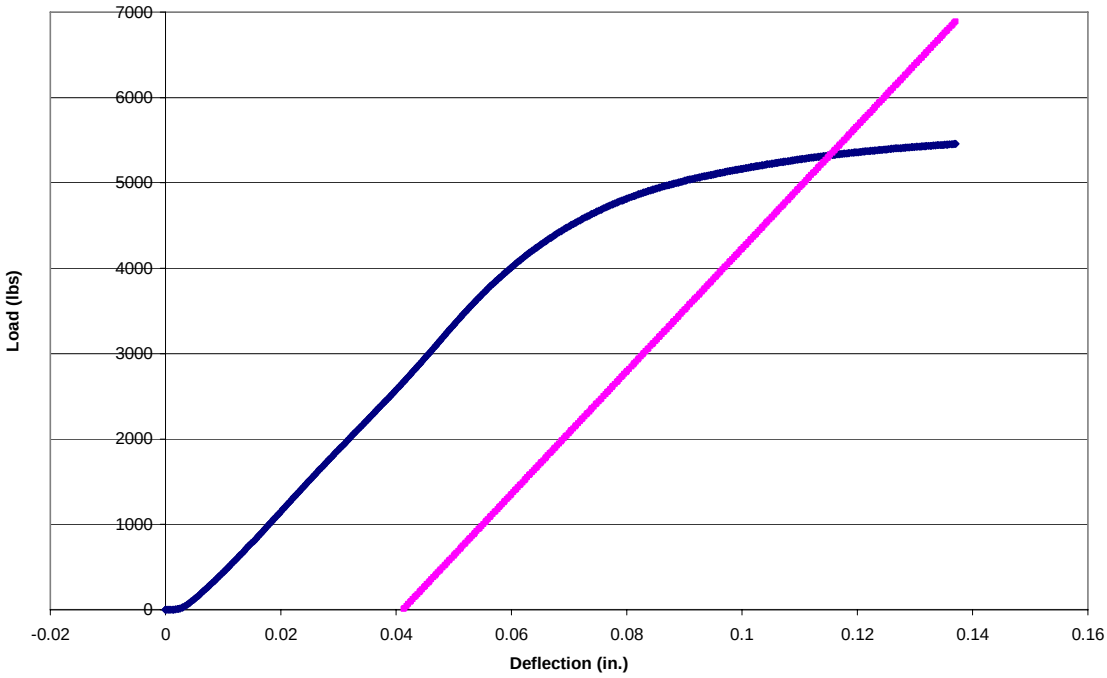

Figure C.142: Load vs. Deflection Curve and 5% Offset Line, F4c2

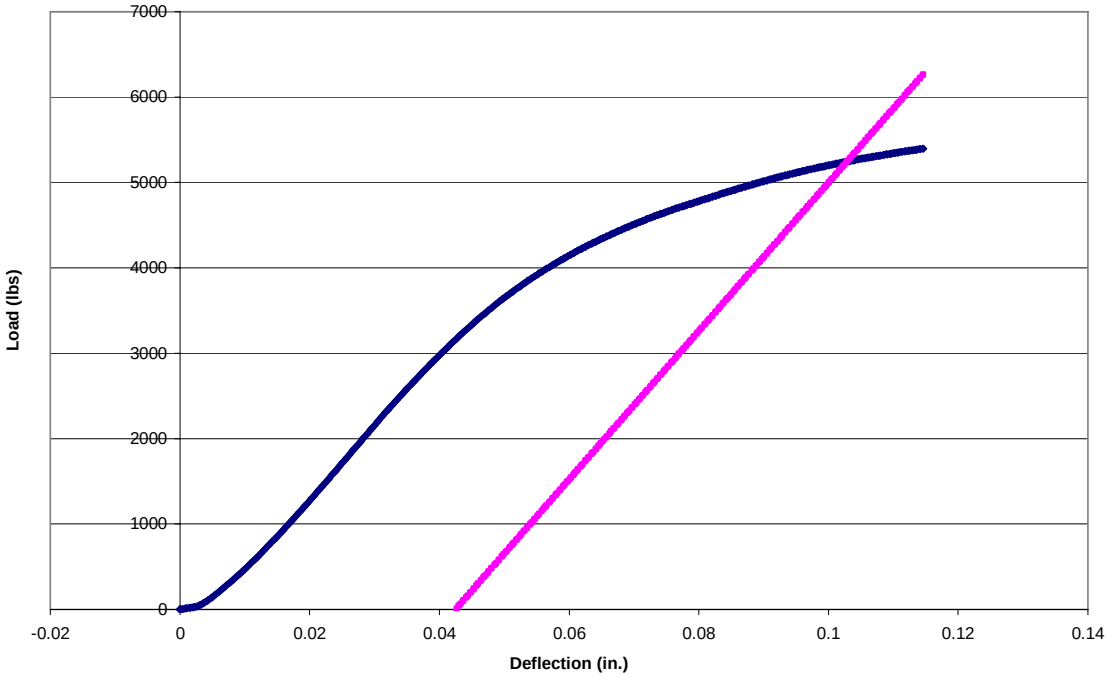

Figure C.143: Load vs. Deflection Curve and 5% Offset Line, F4c3

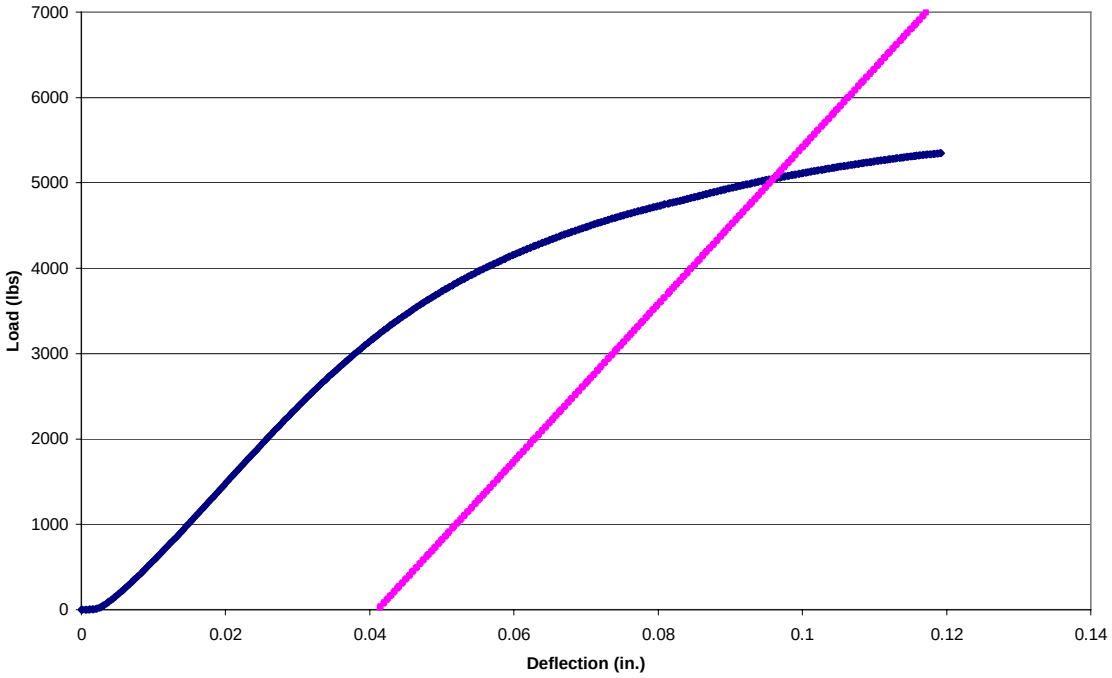

Figure C.144: Load vs. Deflection Curve and 5% Offset Line, F4c4

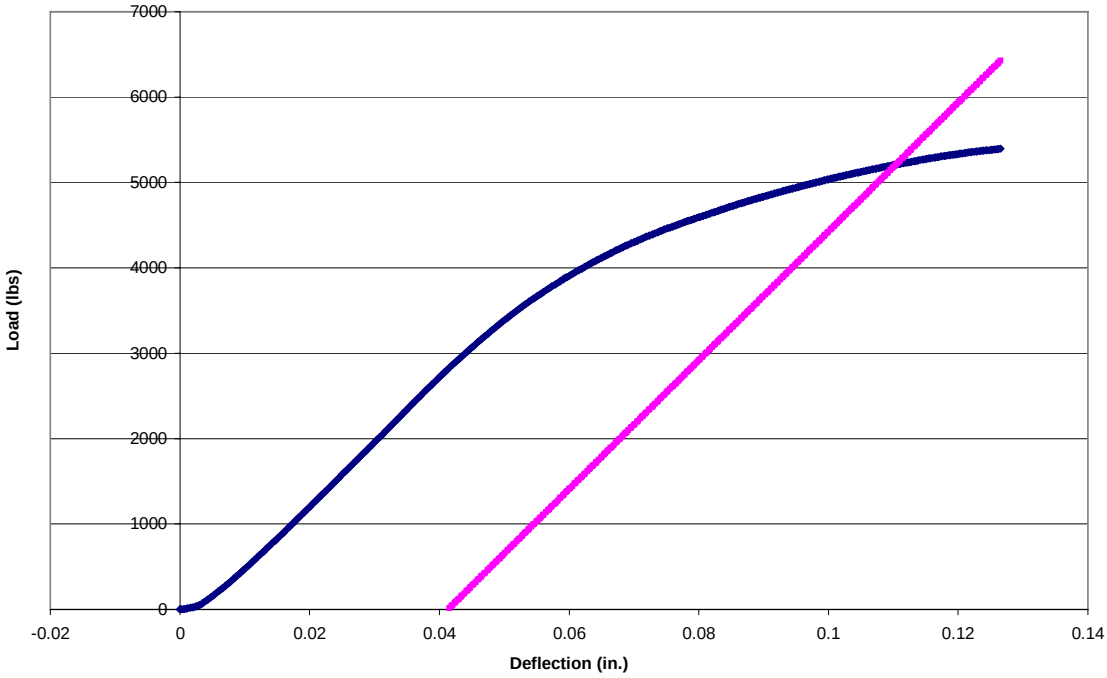

Figure C.145: Load vs. Deflection Curve and 5% Offset Line, F4c5

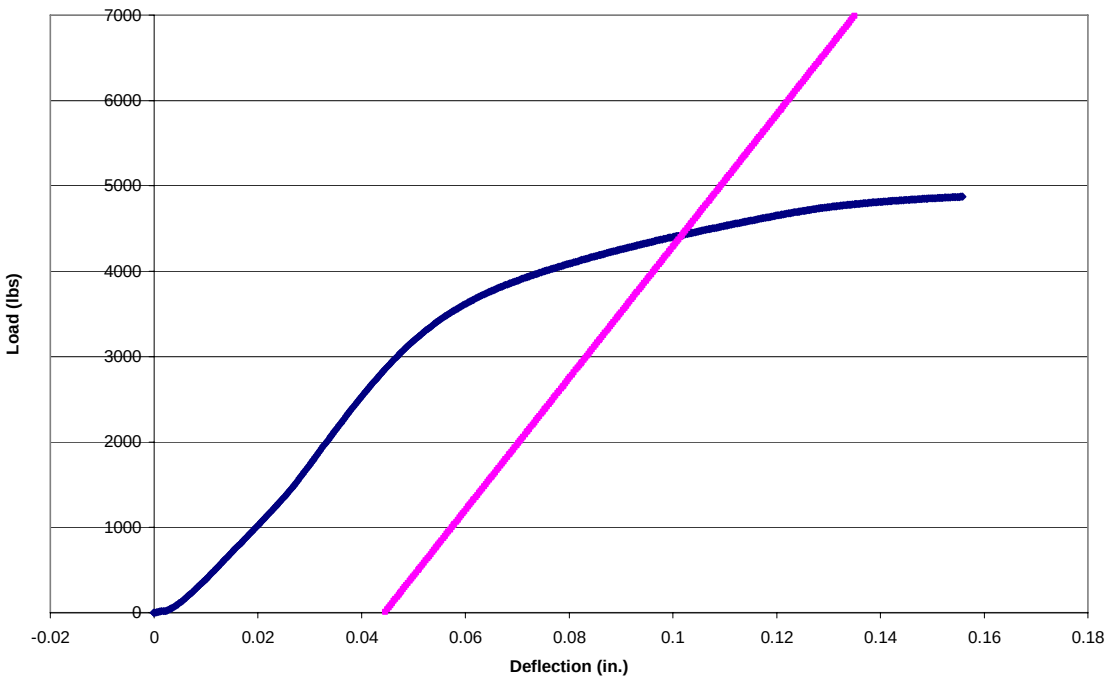

Figure C.146: Load vs. Deflection Curve and 5% Offset Line, F4c6

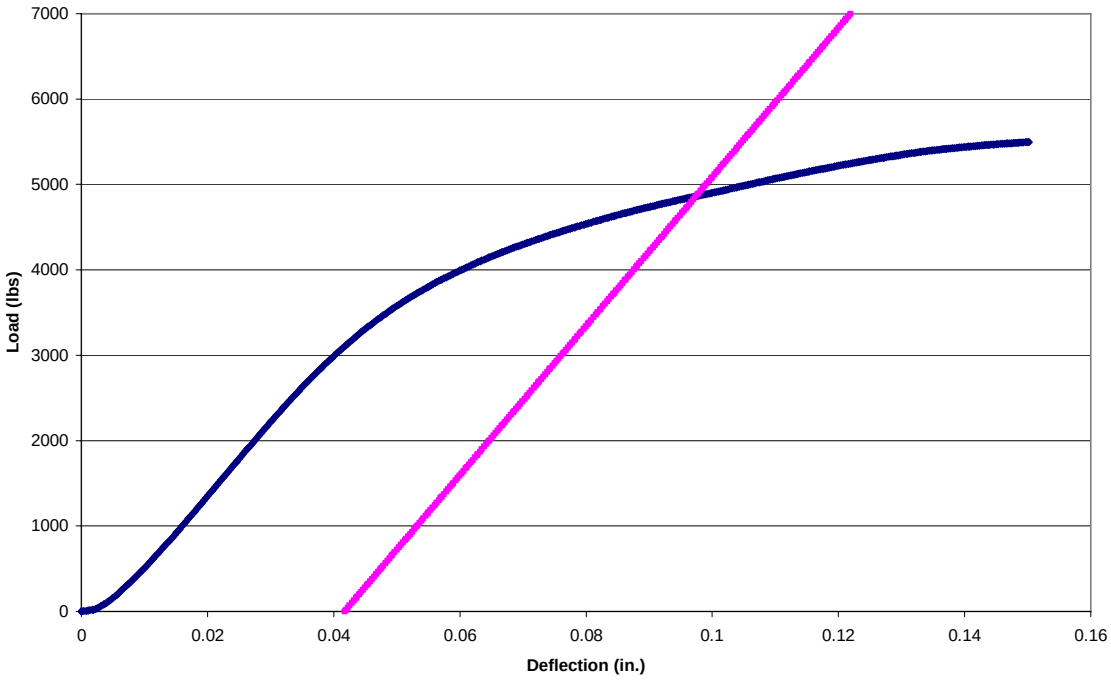

Figure C.147: Load vs. Deflection Curve and 5% Offset Line, F4c7

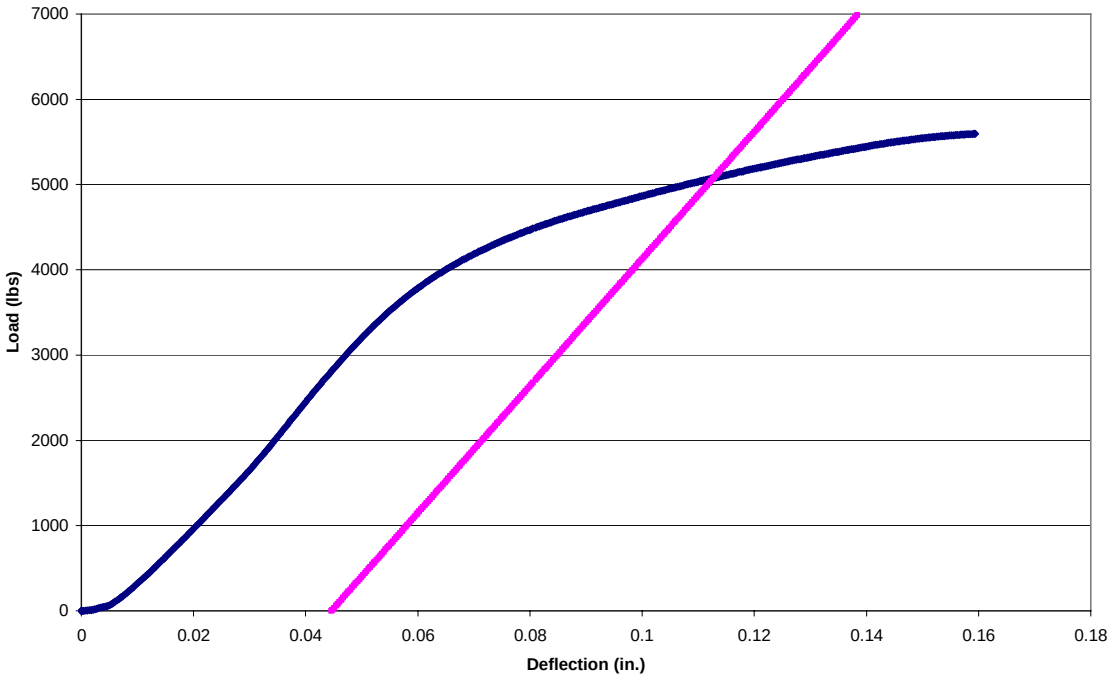

Figure C.148: Load vs. Deflection Curve and 5% Offset Line, F4c8

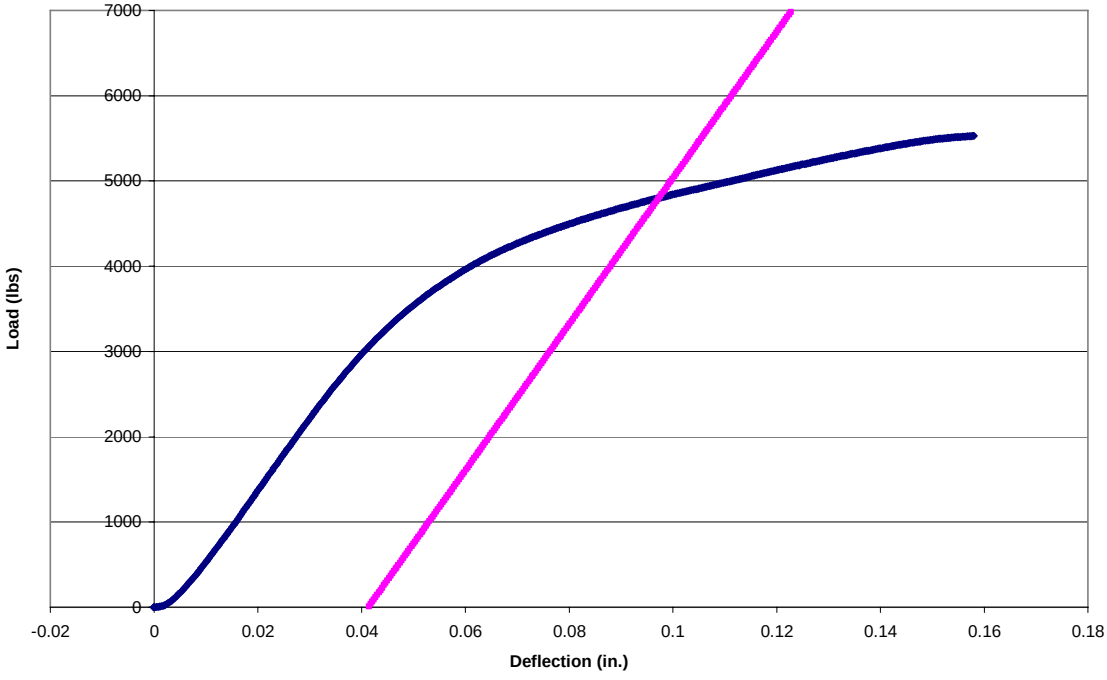

Figure C.149: Load vs. Deflection Curve and 5% Offset Line, F4c9

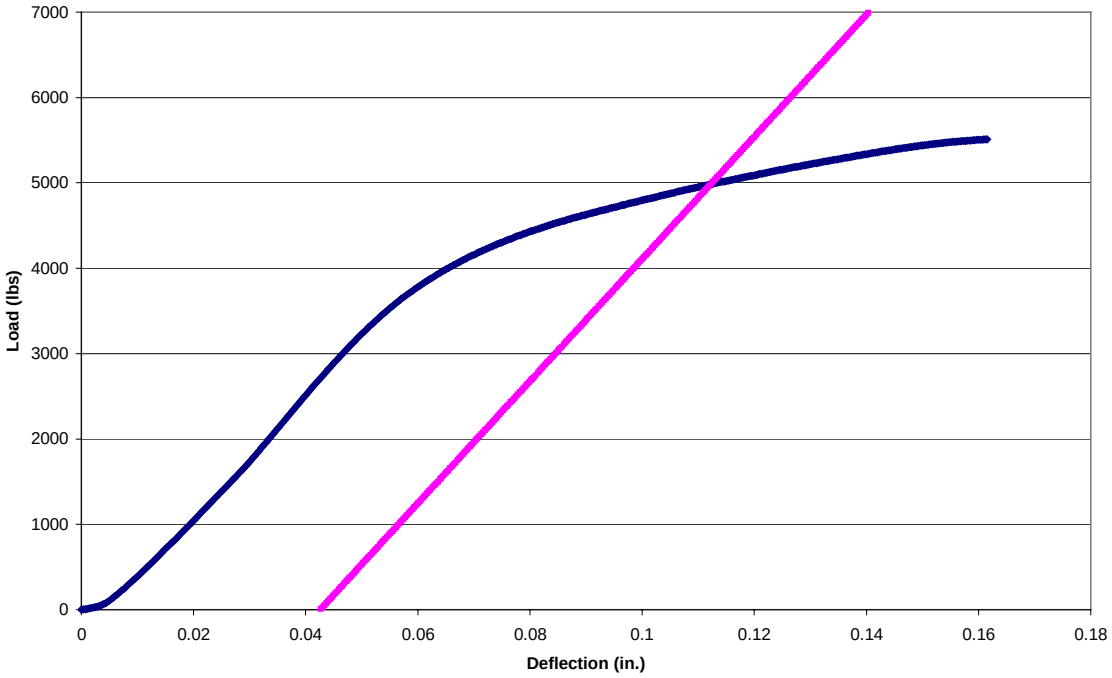

Figure C.150: Load vs. Deflection Curve and 5% Offset Line, F4c10

Table C.16: Test Results for F6c Data Set

$F6c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	1840	5520
C2	1960	5880
C3	1980	5940
C4	1990	5970
C5	1940	5820
C6	1810	5430
C7	1960	5880
C8	1960	5880
C9	1830	5490
C10	1720	5160
AVG	**1899**	**5697**
Standard Dev.	**92**	**275**
COV (%)	**4.8**	**4.8**

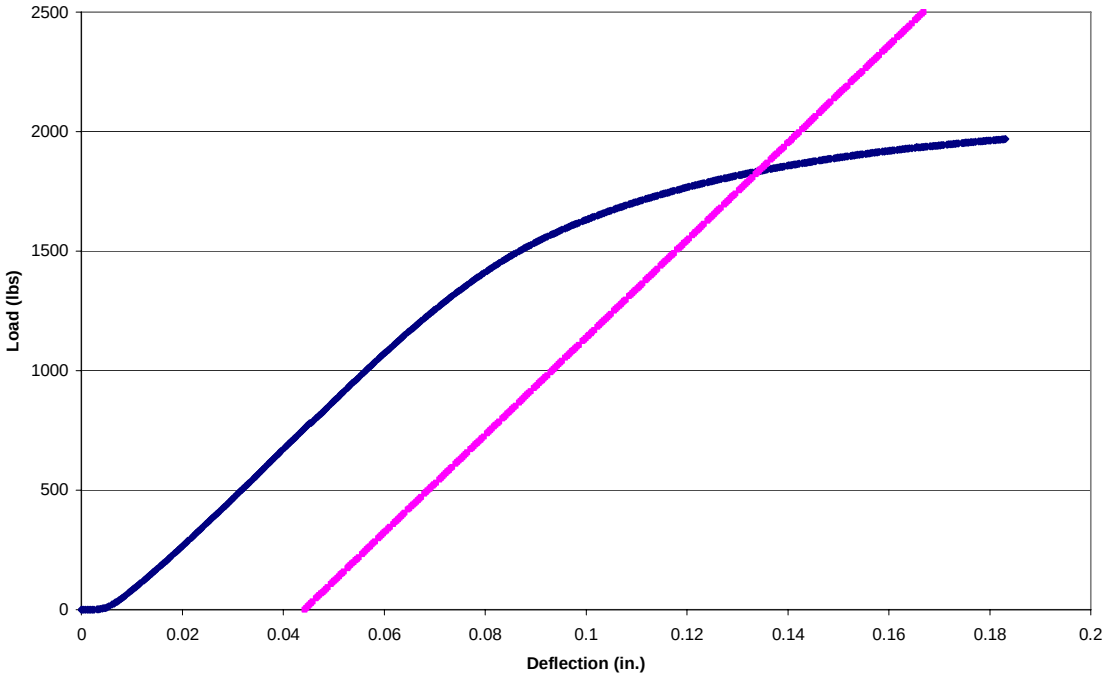

Figure C.151: Load vs. Deflection Curve and 5% Offset Line, F6c1

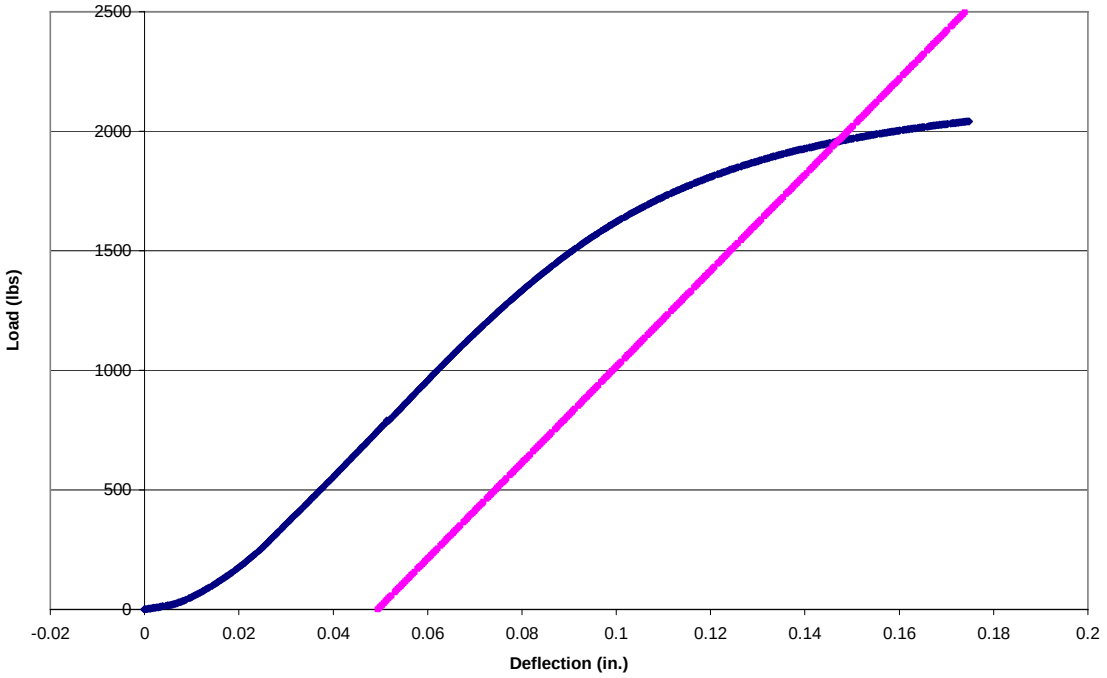

Figure C.152: Load vs. Deflection Curve and 5% Offset Line, F6c2

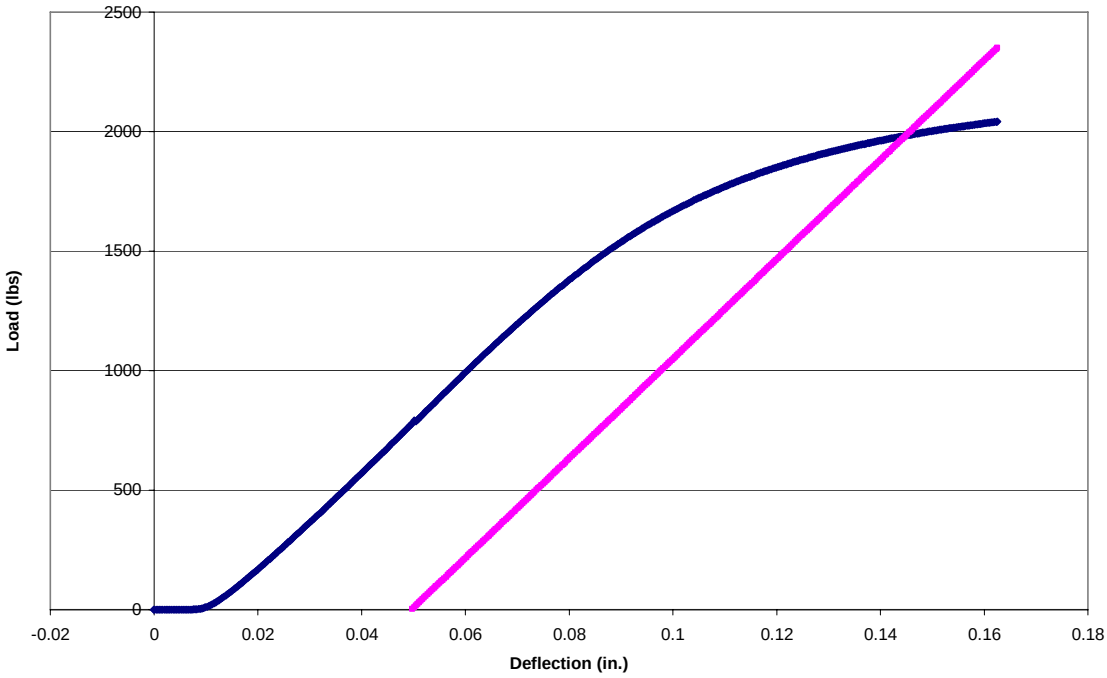

Figure C.153: Load vs. Deflection Curve and 5% Offset Line, F6c3

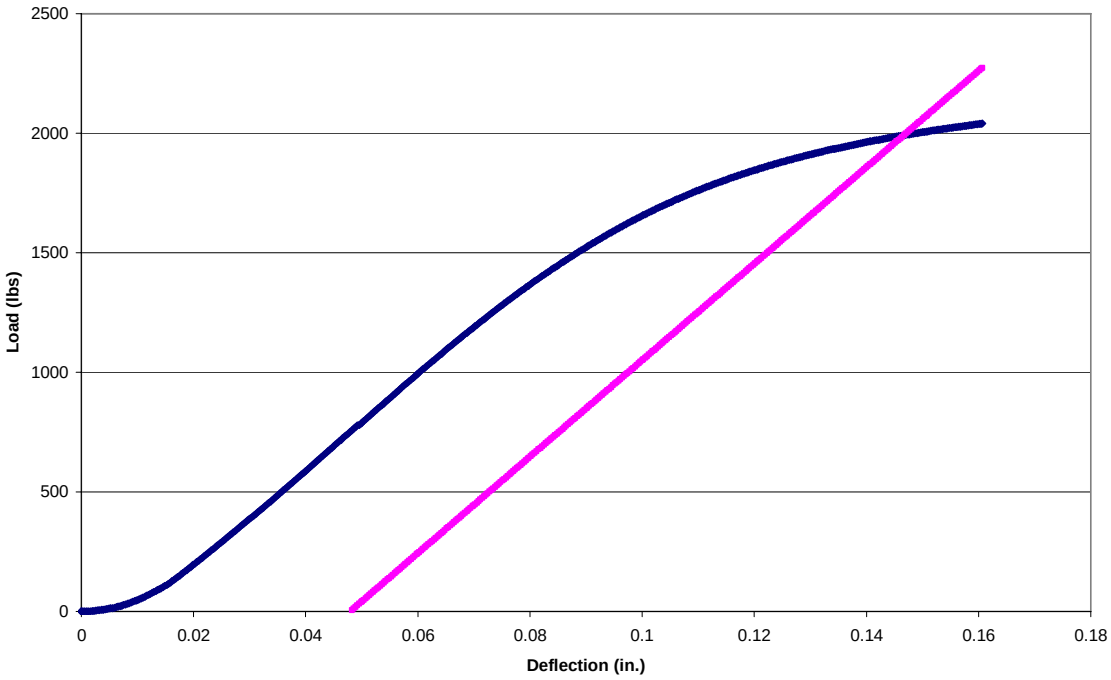

Figure C.154: Load vs. Deflection Curve and 5% Offset Line, F6c4

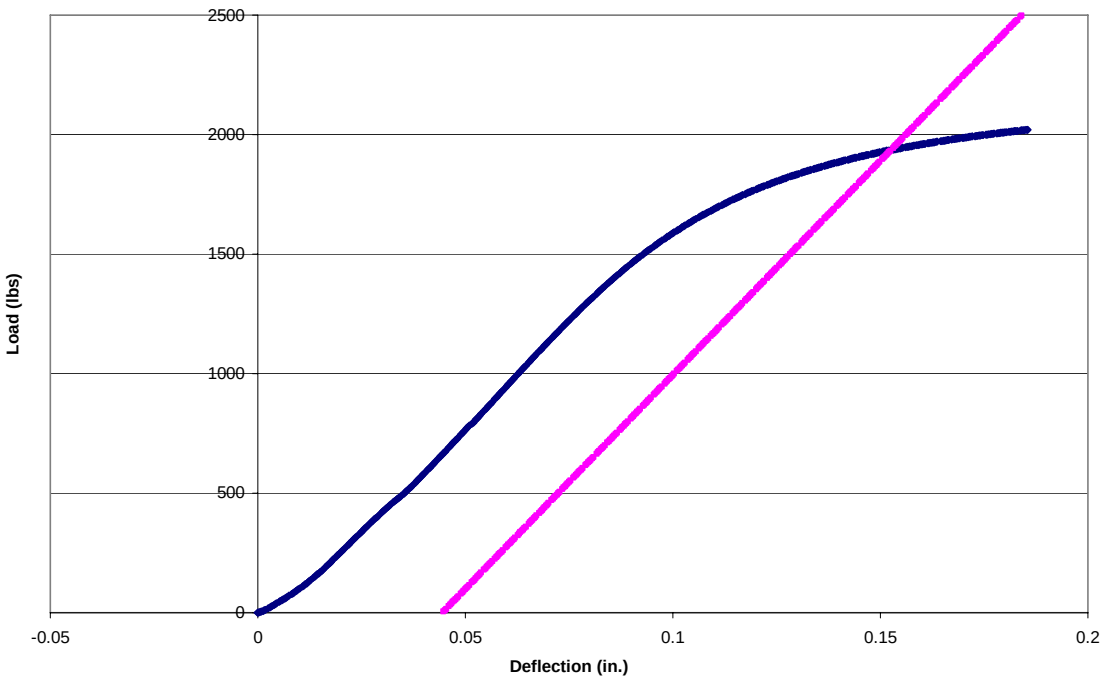

Figure C.155: Load vs. Deflection Curve and 5% Offset Line, F6c5

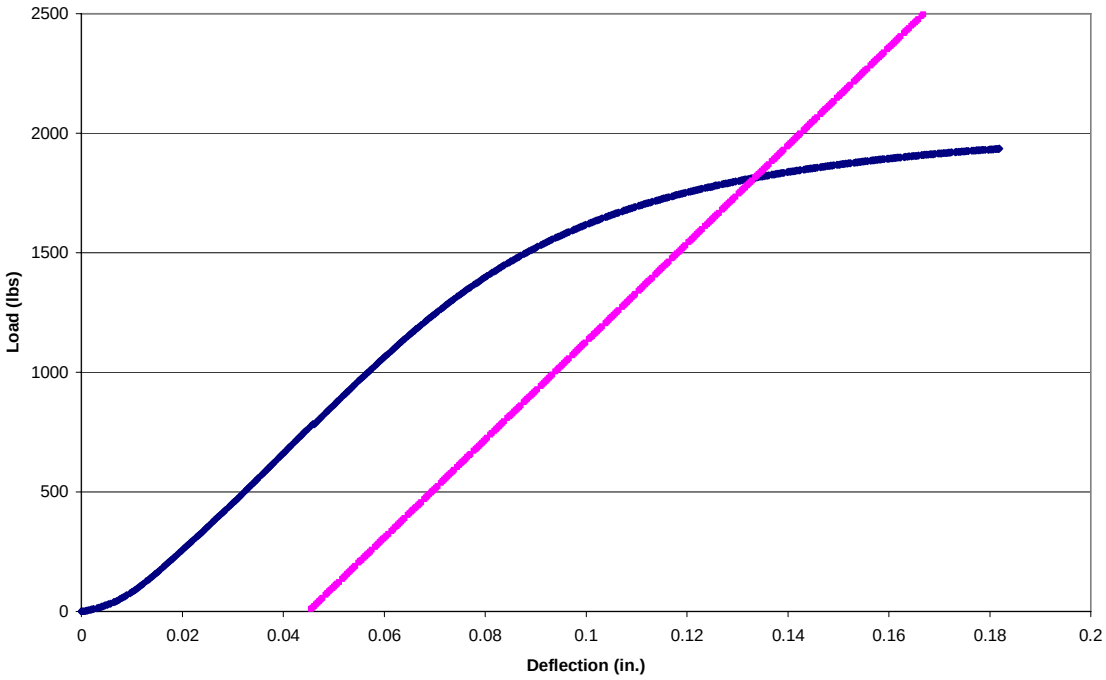

Figure C.156: Load vs. Deflection Curve and 5% Offset Line, F6c6

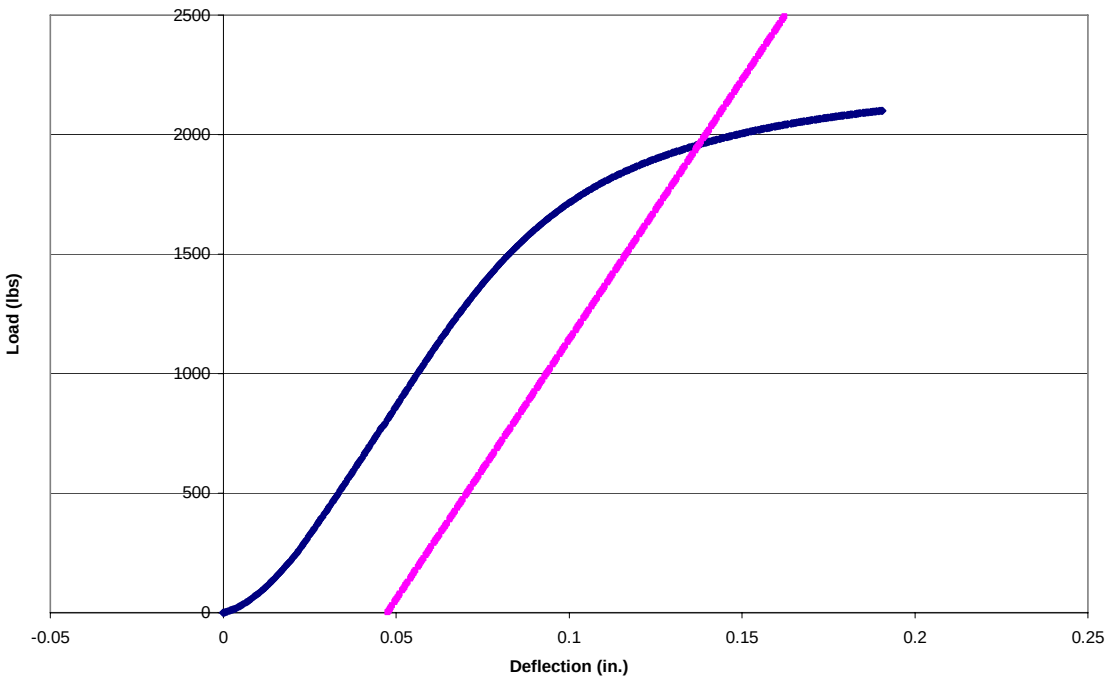

Figure C.157: Load vs. Deflection Curve and 5% Offset Line, F6c7

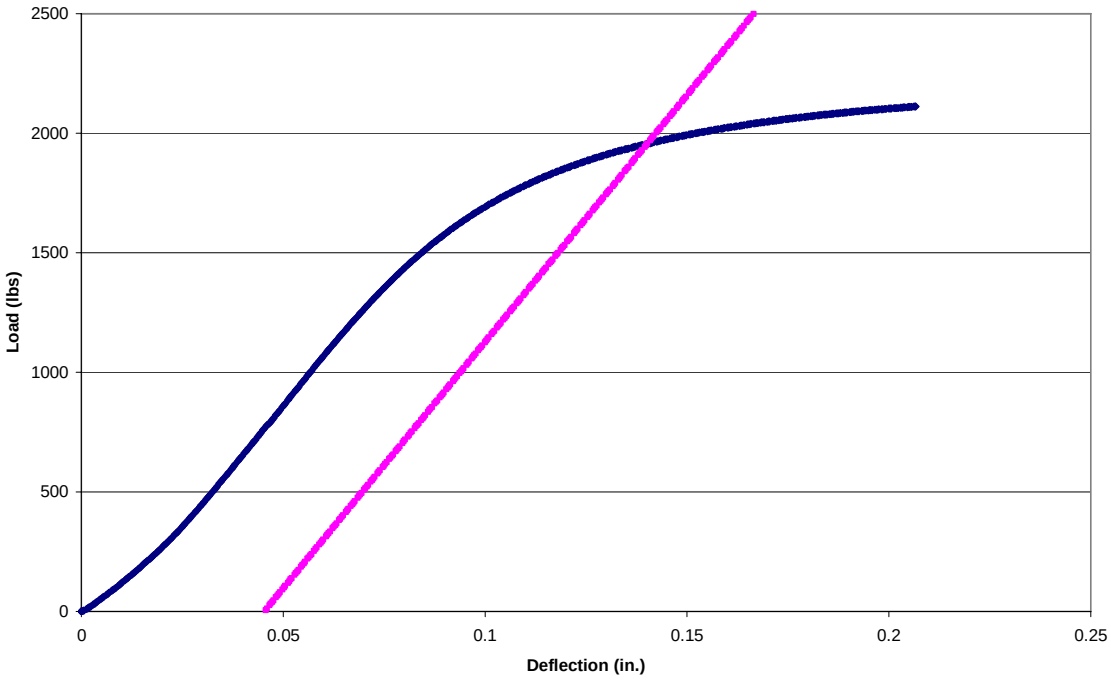

Figure C.158: Load vs. Deflection Curve and 5% Offset Line, F6c8

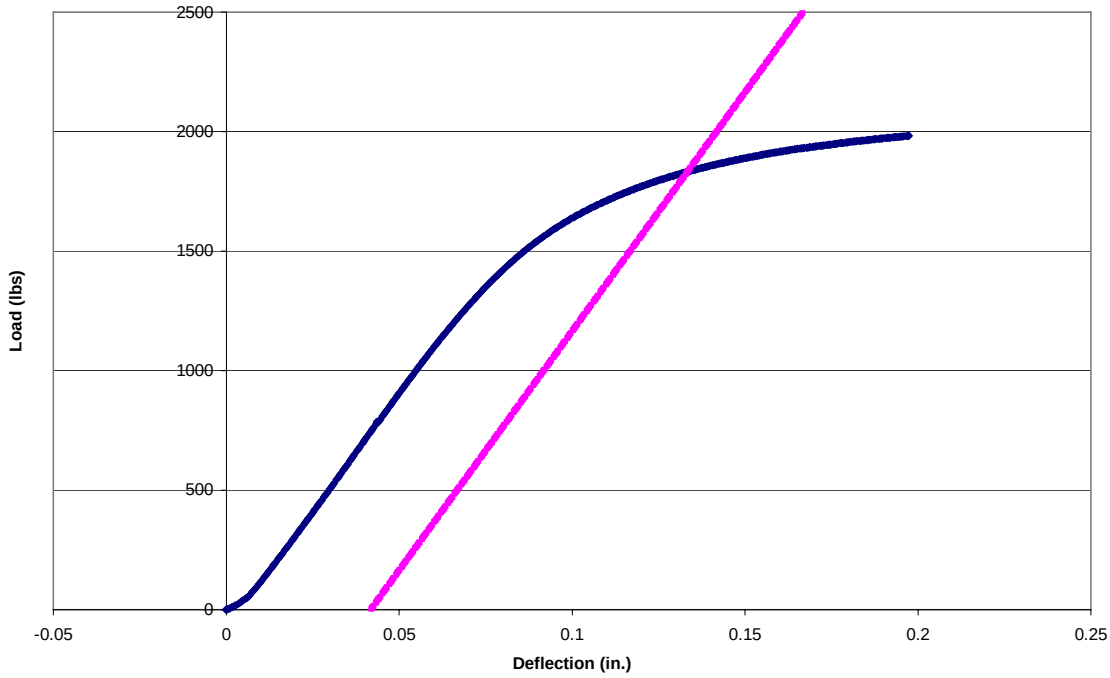

Figure C.159: Load vs. Deflection Curve and 5% Offset Line, F6c9

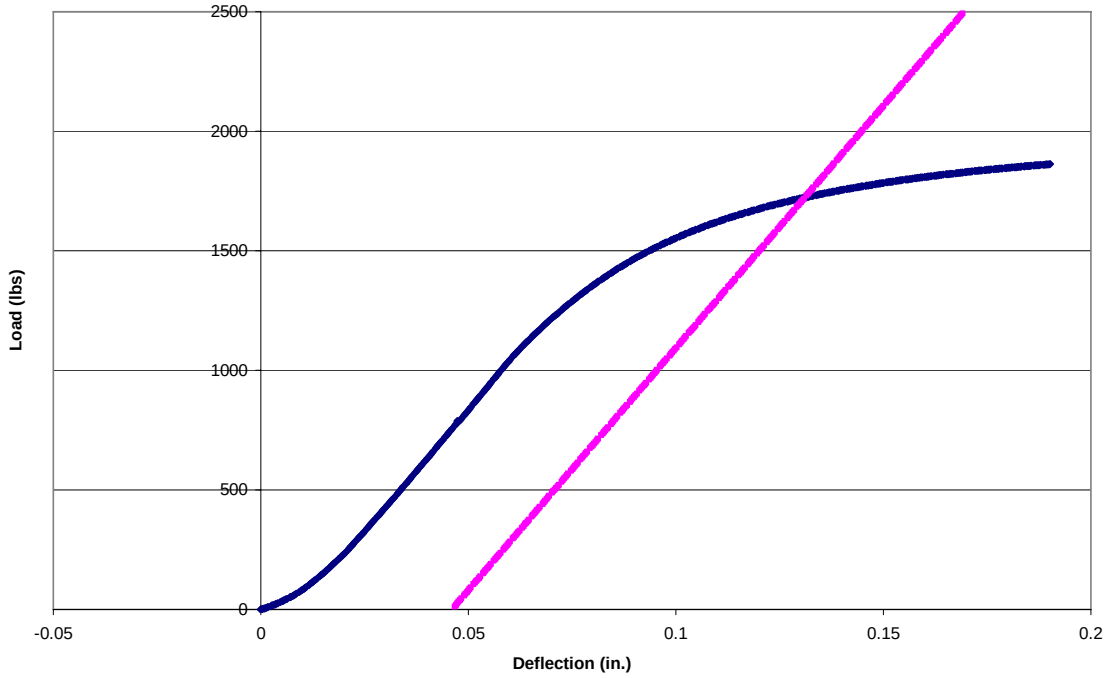

Figure C.160: Load vs. Deflection Curve and 5% Offset Line, F6c10

Table C.17: Test Results for F8c Data Set

$F8c_n$	5% offset yield load (lbs)	Yield Moment (lbs*in.)
C1	934	3736
C2	929	3716
C3	934	3736
C4	964	3856
C5	959	3836
C6	947	3788
C7	960	3840
C8	944	3776
C9	949	3796
C10	982	3928
AVG	**950**	**3801**
Standard Dev.	**16**	**65**
COV (%)	**1.7**	**1.7**

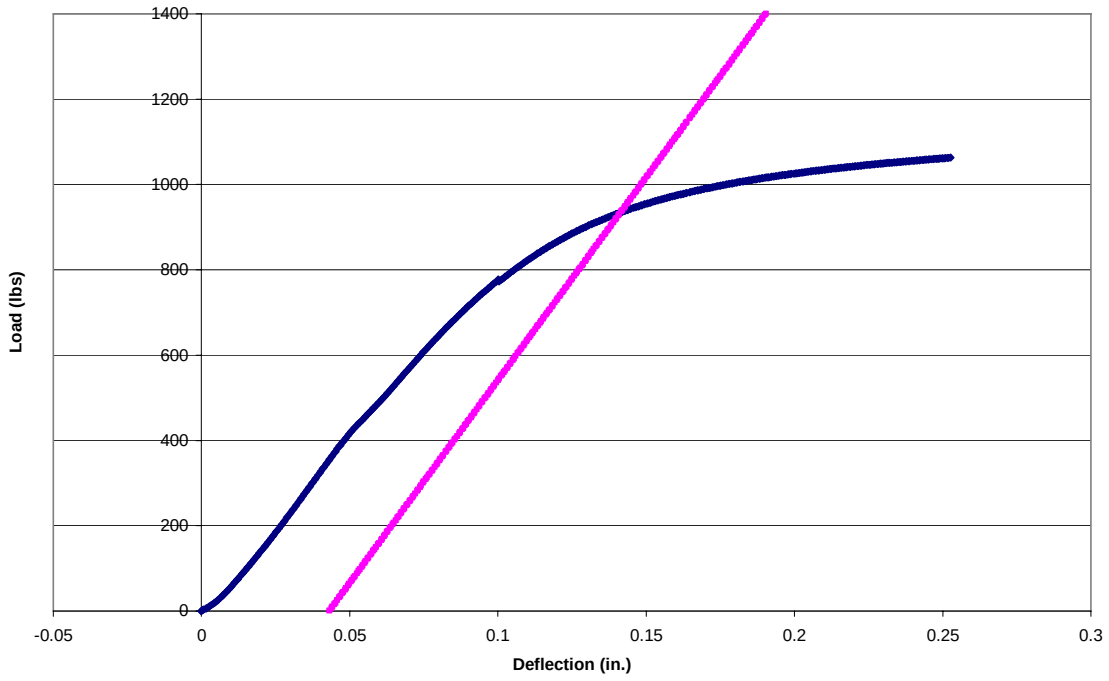

Figure C.161: Load vs. Deflection Curve and 5% Offset Line, F8c1

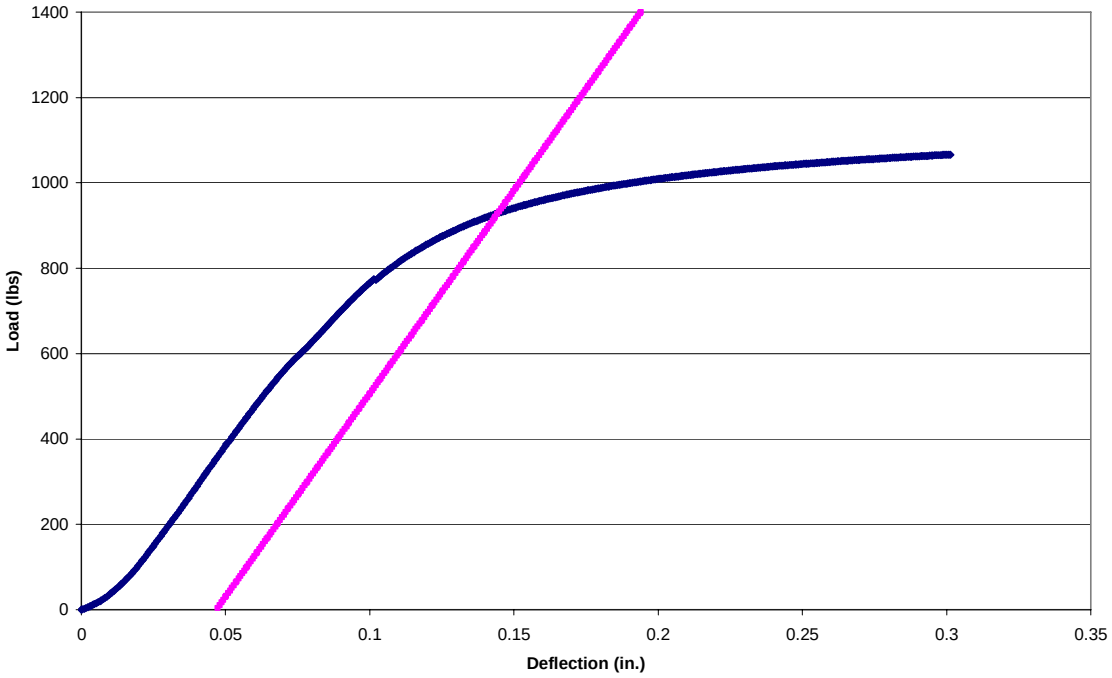

Figure C.162: Load vs. Deflection Curve and 5% Offset Line, F8c2

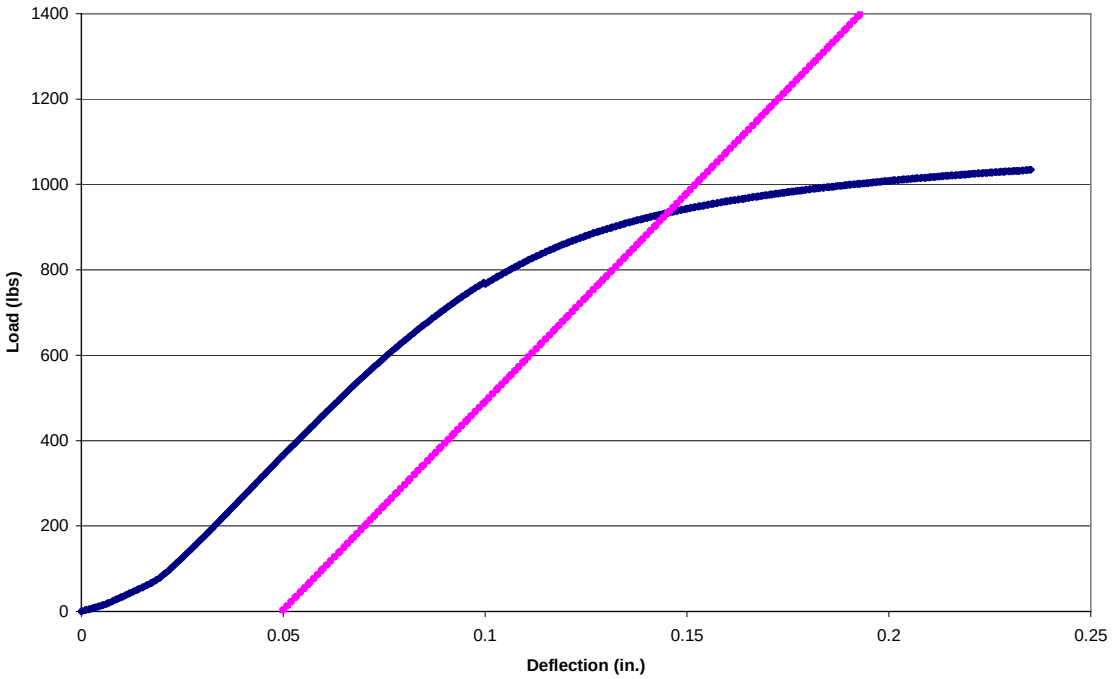

Figure C.163: Load vs. Deflection Curve and 5% Offset Line, F8c3

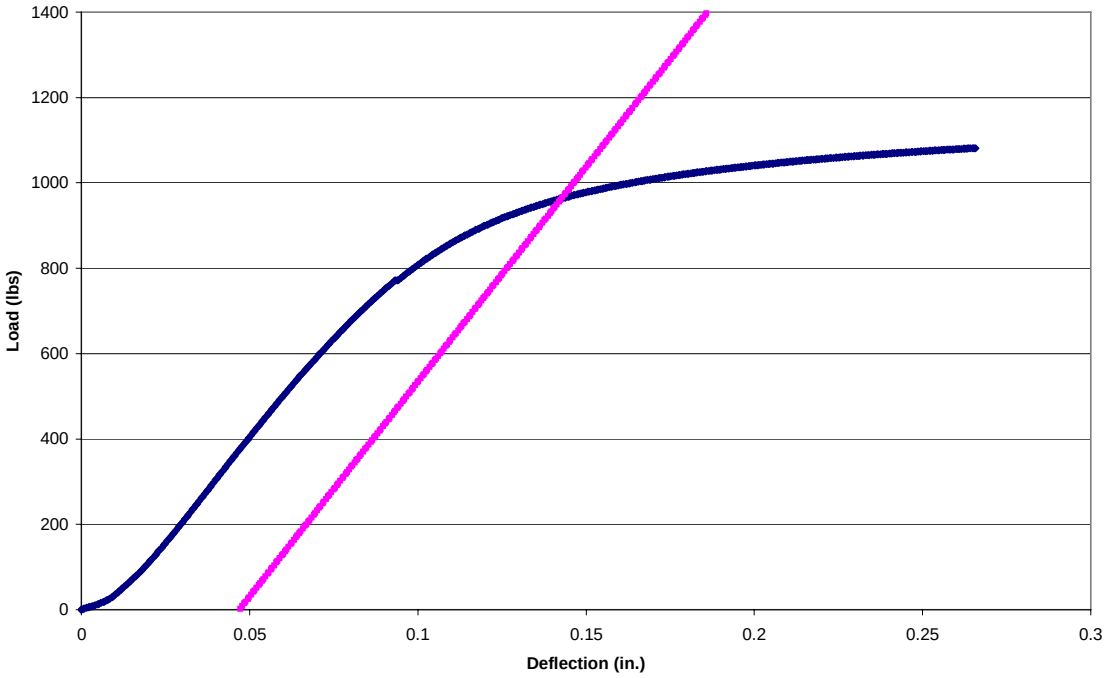

Figure C.164: Load vs. Deflection Curve and 5% Offset Line, F8c4

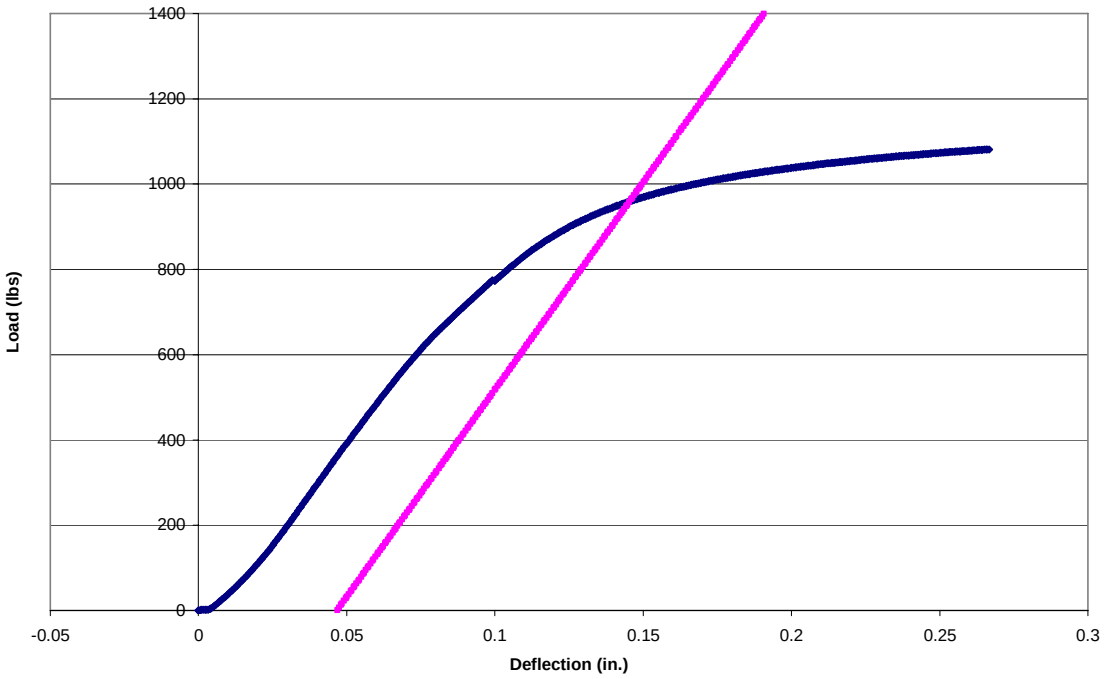

Figure C.165: Load vs. Deflection Curve and 5% Offset Line, F8c5

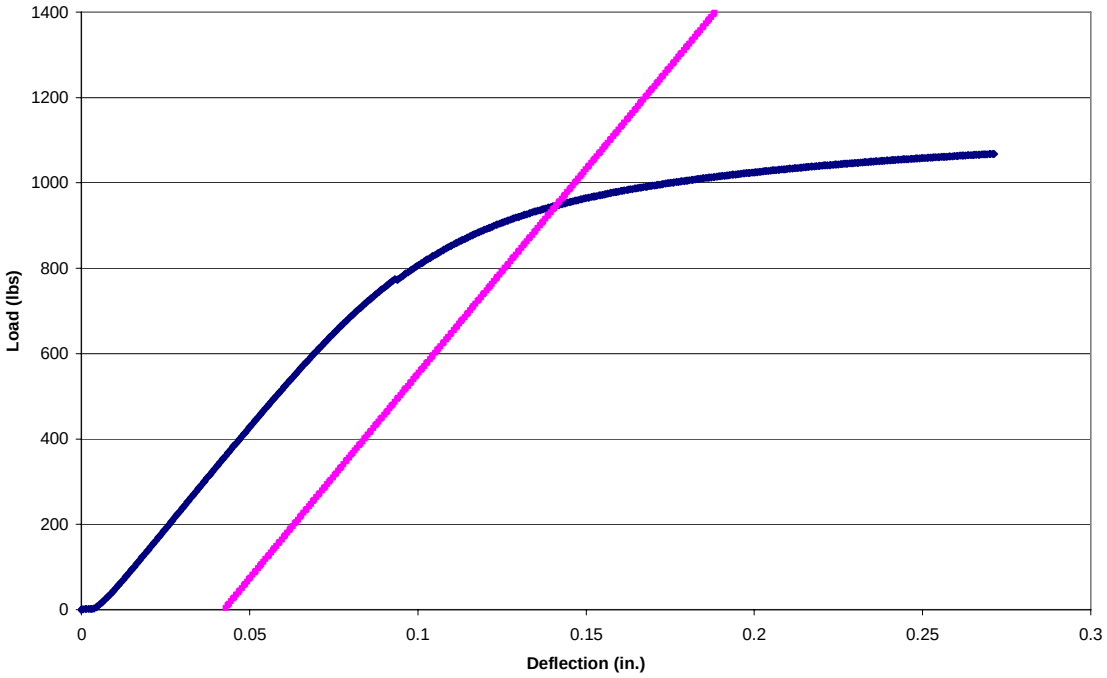

Figure C.166: Load vs. Deflection Curve and 5% Offset Line, F8c6

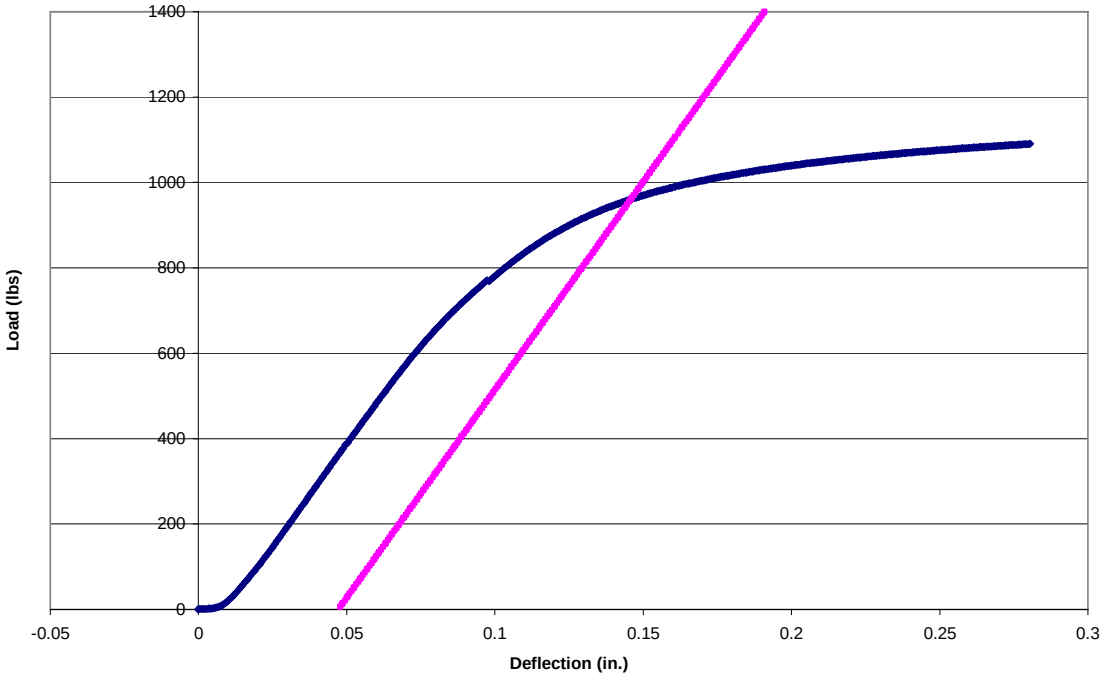

Figure C.167: Load vs. Deflection Curve and 5% Offset Line, F8c7

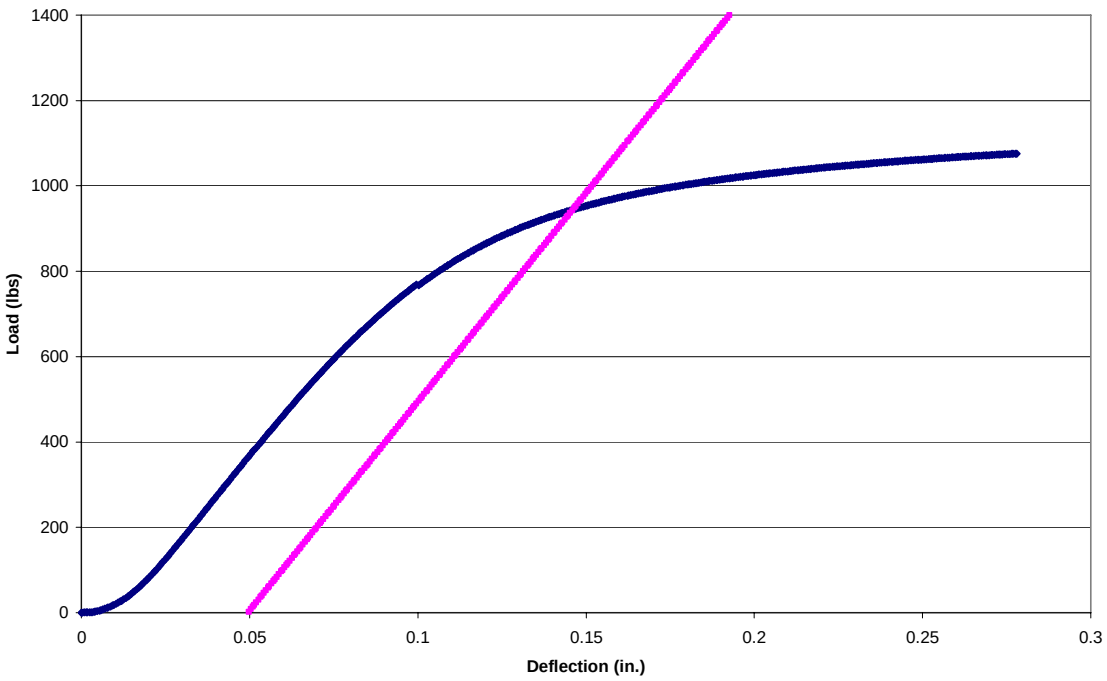

Figure C.168: Load vs. Deflection Curve and 5% Offset Line, F8c8

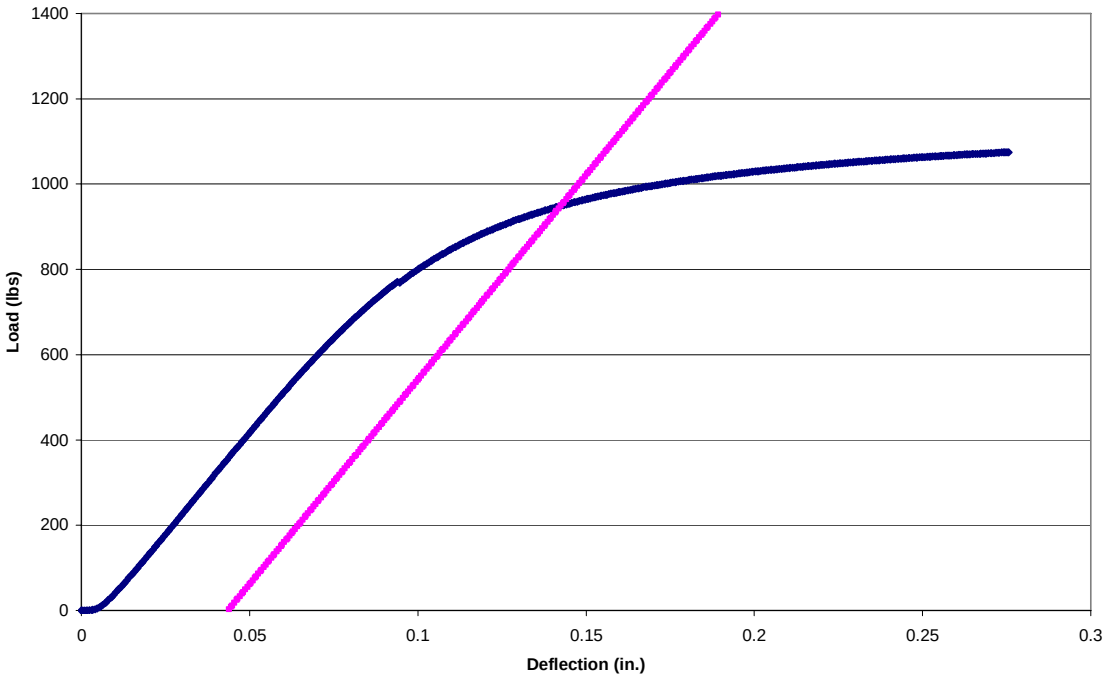

Figure C.169: Load vs. Deflection Curve and 5% Offset Line, F8c9

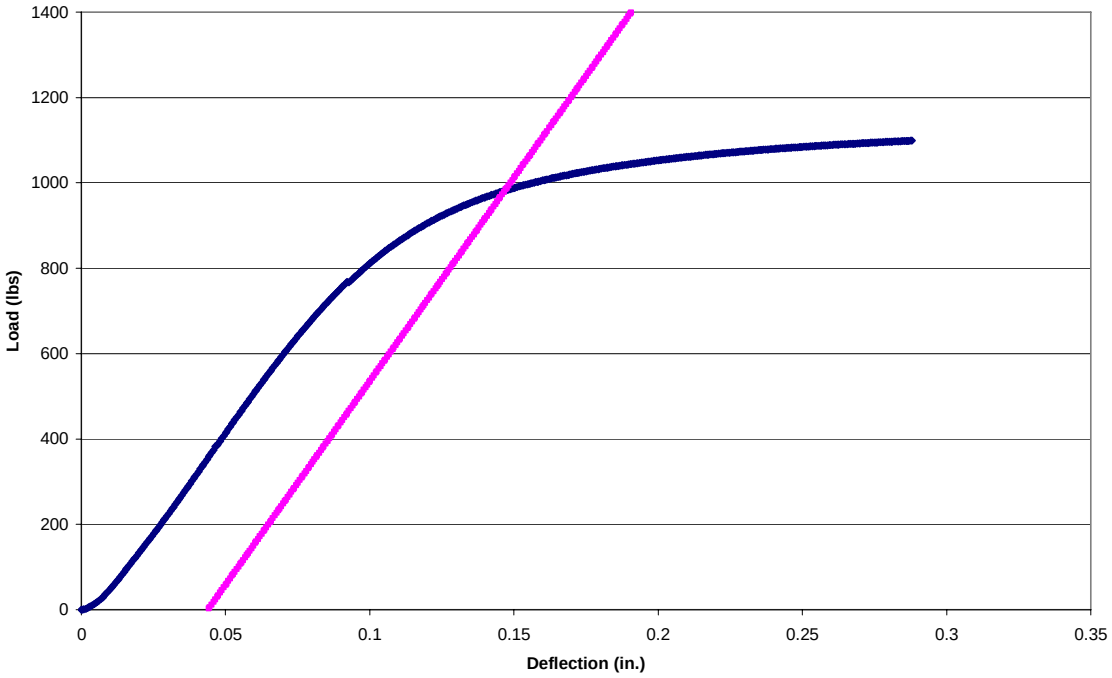

Figure C.170: Load vs. Deflection Curve and 5% Offset Line, F8c10