research report

Cold-Formed Steel Top Load Bearing Tracks

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American Iron and Steel Institute

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PREFACE

This report was developed by the NAHB Research Center for the Steel Framing Alliance. The objective of this project was to develop and test top load-bearing tracks to provide alternatives to the in-line framing requirement in the AISI *Standard for Cold-Formed Steel Framing – General Provisions*. This project involved a series of 21 full-scale tests to evaluate the capacity of 3 different top load bearing track assemblies that are common for light-frame construction with maximum framing member spacing of 24-inch (610 mm) on center.

Upon completion of the project, the SFA Research Team reviewed the report and offers the following cautionary notes to the reader:

- Table 1 shows nominal dimensions for the members tested, but implies they are actual dimensions. Actual dimensions, including the corner radii, are needed for proper analysis of the results.
- Table 2 shows nominal material properties for the members tested, but implies they are actual material properties. The steel material properties are given in an appendix, but actual wood material properties do not seem to have been verified.
- The test setup, as shown in Figure 5, is problematic because the setup is indeterminate. Thus, one cannot analytically evaluate the performance or extrapolate the tested performance.
- There is no apparent connection of the wood top plate to the steel top track in the Track with 2x4 Wood Top Plate assembly. The method of attachment would likely have a dramatic influence on the behavior.
- In the evaluation of the factor of safety for the "hybrid" Track with 2x4 Wood Top Plate assembly, it would be important to define whether the capacity was limited by a wood or steel failure. If the capacity was ultimately limited by failure of the wood, the validity of the calculated resistance factor is questionable.
- On page 13, Mm is given for bending and compression; however, there were no compression tests. Also, since the failure mode was identified as bending and web crippling for the long leg track, Mm should be given for bending and web crippling.
- In the data analysis, m is given as 1, but m = n-1, were n is the number of tests. Since there were 3 tests, m should be equal to 2.
- Tables 4 and 6 use the term "Factored Capacity". According to the AISI Specification the correct term is "Design Strength". It should be noted that these design strength values must be adjusted for the thickness and yield stress. Table 4 is really not needed, since Tables 5 and 6 provide the adjusted values.
- On page 16 in the design example to develop values for the prescriptive tables, the test results for a two-span beam are extrapolated to a multiple-span condition. Some discussion would be appropriate to validate the extension of this data to conditions other than what was tested, including simple-span and multiple-spans.
- It would be helpful to provide a comparison of the tested versus computed deflections. This may help to understand the indeterminate test setup.

Research Team
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Cold-formed steel Top Load Bearing Tracks

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INTRODUCTION

Cold-formed steel framing has seen some market growth in the housing market most probably due to its similarity to wood stick framing and competitive material costs. However, in different regions of the U.S., the installed cost of steel framing may not be less than that of wood. The construction of stick-built steel framed homes is currently inflexible because in-line framing is strictly required [1]. The in-line framing requirement can be an obstacle for builders who want to maximize the efficiency of using steel without having the added cost of an engineered design. For example, builders who want to space their steel studs at 24 inches (610 mm) on center with floor joists spaced at 16 inches (400 mm) on center must have an engineered design for a load distribution member between the floor and the wall to properly transfer the loads. In wood-framed homes, load distribution members can be easily constructed with two 2x4 wood top plates without the need for an approved or engineered design.

The purpose of this report is to investigate the feasibility of using three different configurations of steel top load-bearing track assemblies to provide builders and framers with the flexibility in their construction methods. The investigation is limited to testing of top track assemblies that are common for light-frame construction with maximum framing member spacing of 24-inch (610 mm) on center.

LITERATURE REVIEW

Very little testing of load-bearing steel tracks was found. The Australians have developed several shapes for top track load distribution members [2]. Two Australian profiles that are relevant to residential construction are shown in Figure 1.

Figure 1 – Australian Load-Bearing Top Track Configurations

Mitek Holdings, Inc. also tested and patented a top load-bearing top track configuration as shown in Figure 2 [3].

Figure 2 – Mitek's Load Bearing Top Track Configuration

EXPERIMENTAL APPROACH

Test Specimens

Three different configurations (refer to Figure 3) of the load-bearing top tracks were assembled using construction materials and methods appropriate for light-frame construction of cold-formed steel (Figure 4). All steel materials used in the tests conform to the dimensional and material requirements of Tables 1 and 2. Tensile and yield strength were verified by tensile tests in accordance with ASTM A370 [4]. Base steel thicknesses were also established and measured in accordance with ASTM A90 [5]. Mechanical properties were based on coupons cut from the center of the web of a sample of the test specimens.

A total of 21 assemblies were constructed and tested, three for each assembly identified in Table 1.

Table 1 – Top Load-Bearing Track Assembly

Assembly	Track Designation	Track Web Depth (in.)	Track Flange Width (in.)	Track Flange Width (in.)	Track Thickness (in.)	Wood Top Plate	Comments
Deep Leg Track	350T200-33	3.50	2.00	2.00	0.033	None	Track flanges were fastened to studs with No. 8 screw
	350T200-43	3.50	2.00	2.00	0.043	None	
	350T200-54	3.50	2.00	2.00	0.054	None	
Wood Top Plate	350T150-33	3.50	1.50	1.50	0.033	2x4	2x4 wood plate nailed to top track below with nails at 12 in. on center
J-Tracks	350T150-33	3.50	1.50	4.00	0.033	None	Track flanges were fastened to studs with No. 8 screw
	350T150-43	3.50	1.50	4.00	0.043	None	
	350T150-54	3.50	1.50	4.00	0.054	None	

For SI: 1 inch = 25.4 mm

Table 2 – Material Properties

Material Property	Value[1] (psi)	
Steel Yield Strength	33,000	
2x4 SPF Wood Members, S-Dry, Stud Grade	Bending, F_b	675
	Shear Parallel to Grain, F_v	70
	Tension Parallel to Grain, F_t	350
	Modulus of Elasticity, E	1,200,000
Metal Screws	No. 8 self-drilling, self tapping truss head screws	
Nails	0.120 inches x 3 inches full round head pneumatic nail	

For SI: 1 inc = 25.4 mm, 1 psi = 0.0703 kg/cm^2.

[1] Wood properties are taken from the 1997 NDS Supplement [6].

Cold-Formed Steel Top Load Bearing Tracks

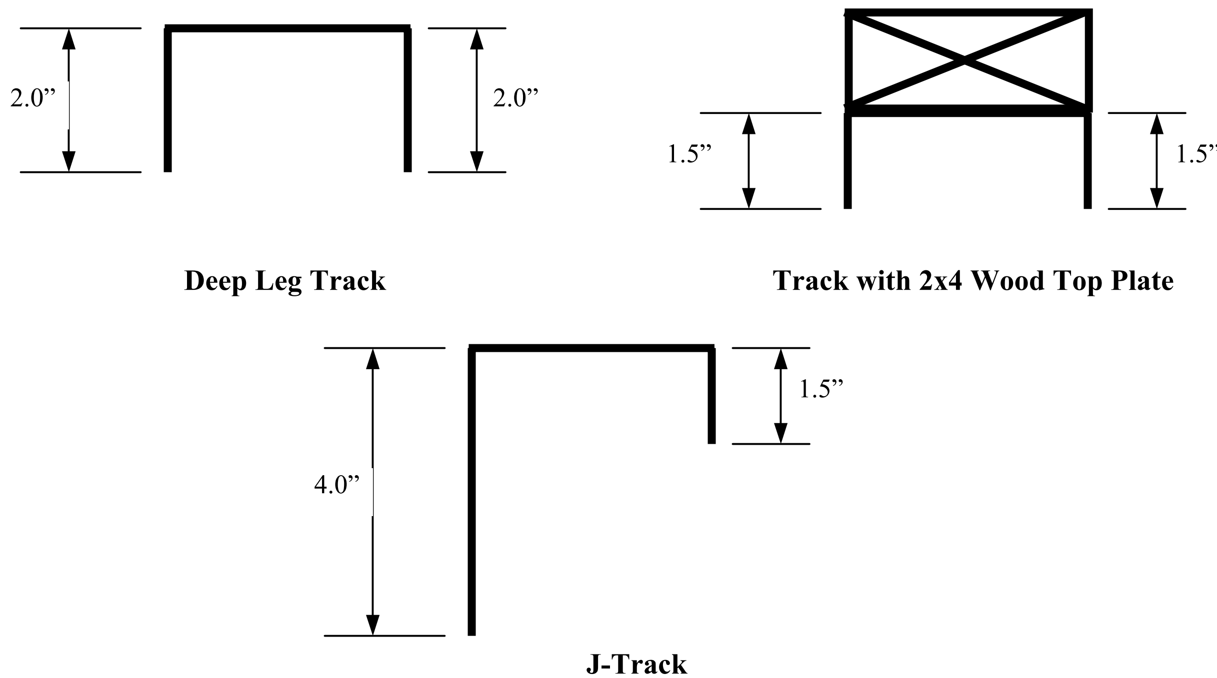


Figure 3 – Load-Bearing Track Configurations

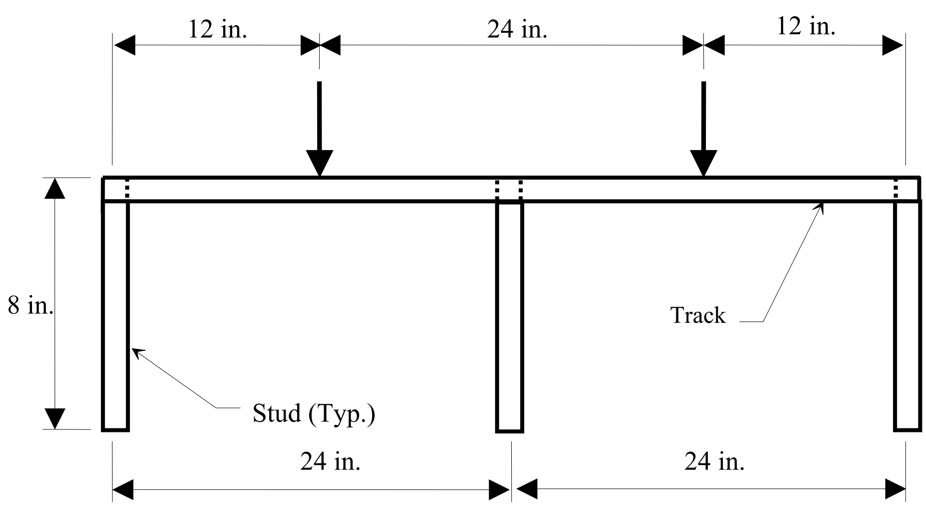


Figure 4 – Top Track Test Assembly

Test Apparatus

Each top track detail was tested in a two span configuration with loads applied at mid-span of each span. Figure 5 depicts a typical test setup. Bearing plates (1.5 inch wide) were used to apply the mid-span load in the bending tests.

The track assemblies were tested using a 200,000 lb (890 kN) universal testing machine (UTM, Southwark-Emery Model 78075), a Satek Epsilon Series 2 inch deflectometer, and a Newvision II Data Acquisition System. The load is applied at a load rate of 1/20 inch per minute until each assembly failed. Failure constitutes failure of the track material (buckling or bearing), failure of the nails or screws (shear or pull out), or failure of the wood plate (where wood is used). Deflections at the load points were recorded during the full range of loads using linear variable differential transformers (LVDTs).

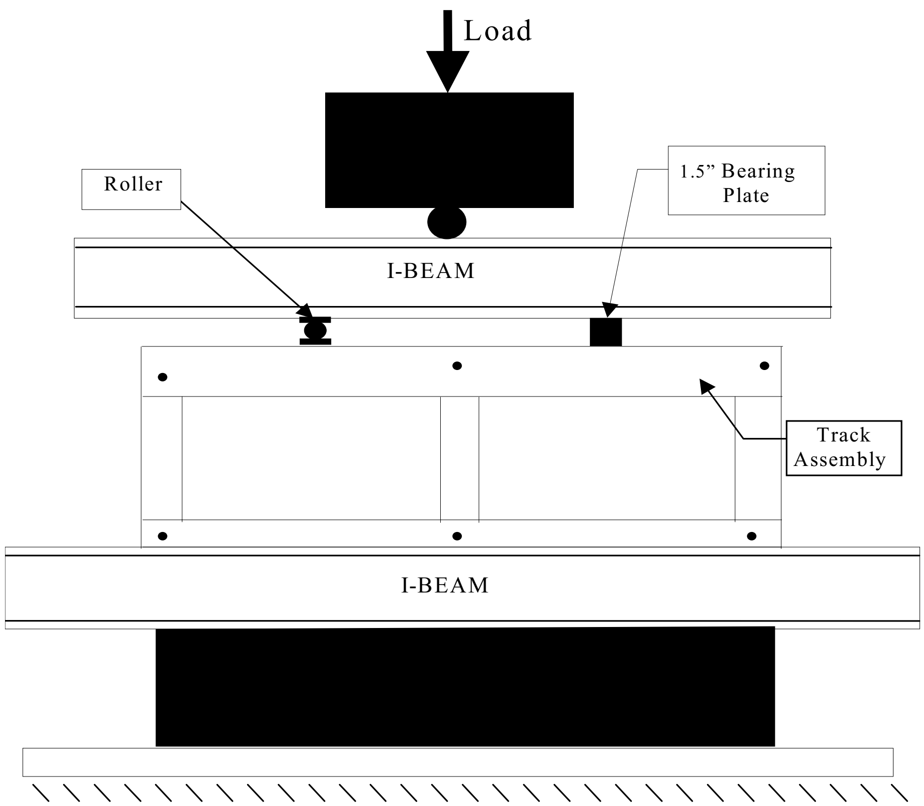


Figure 5 – Load-Bearing Top Track Test Apparatus

RESULTS

The results of the tests are summarized in Table 3. Load-deflection plots of all tests are included in Appendix A. The steel physical properties are included in Appendix B.

Table 3 – Load-Bearing Top Track Test Results

Test No.	Top Track Assembly	Top Track Designation	Web Depth (in.)	Flange Width (in.)	Wood Top Plate	Ultimate Load (lb)	Deflection at Ultimate Load (in.)
1	Deep Leg Track	350T200-33	3.50	2.00	None	1,144	0.451
2		350T200-33	3.50	2.00	None	1,246	0.450
3		350T200-33	3.50	2.00	None	1,202	0.570
		Avg. Load = 1,197 lb.		**Std. Dev. = 51 lb.**		**COV = 0.0427**	
4		350T200-43	3.50	2.00	None	2,216	0.557
5		350T200-43	3.50	2.00	None	2,379	0.681
6		350T200-43	3.50	2.00	None	2,444	0.693
		Avg. Load = 2,346 lb.		**Std. Dev. = 117 lb.**		**COV = 0.0501**	
7		350T200-54	3.50	2.00	None	3,888	0.500
8		350T200-54	3.50	2.00	None	3,940	0.790
9		350T200-54	3.50	2.00	None	3,918	0.577
		Avg. Load = 3,915 lb.		**Std. Dev. = 26 lb.**		**COV = 0.0067**	
10	Track with 2x4 Wood Top Plate	350T150-33	3.50	1.50	2x4	8,592	1.021
11		350T150-33	3.50	1.50	2x4	8,688	1.037
12		350T150-33	3.50	1.50	2x4	9,104	1.068
		Avg. Load = 8,795 lb.		**Std. Dev. = 272 lb.**		**COV = 0.0309**	
13	J-Tracks	350T150-33	3.50	1.5/4.0	None	2,234	0.568
14		350T150-33	3.50	1.5/4.0	None	2,209	0.382
15		350T150-33	3.50	1.5/4.0	None	2,212	0.431
		Avg. Load = 2,218 lb.		**Std. Dev. = 14 lb.**		**COV = 0.0062**	
16		350T150-43	3.50	1.5/4.0	None	2,981	0.554
17		350T150-43	3.50	1.5/4.0	None	2,803	0.435
18		350T150-43	3.50	1.5/4.0	None	2,995	0.538
		Avg. Load = 2,927 lb.		**Std. Dev. = 107 lb.**		**COV = 0.0367**	
19		350T150-54	3.50	1.5/4.0	None	2,764	0.637
20		350T150-54	3.50	1.5/4.0	None	2,790	0.779
21		350T150-54	3.50	1.5/4.0	None	2,832	0.761
		Avg. Load = 2,796 lb.		**Std. Dev. = 34 lb.**		**COV = 0.0122**	

For SI: 1 inch = 25.4 mm, 1 lb. = 4.448 N

FAILURE MODE

Deep Leg Track

All of deep leg track samples ultimately failed in combined bending and web crippling. The steel tracks in all tested specimens were not severely deformed at ultimate loads except at the “hinge” location created by local buckling at the load bearing point. Each steel track started to show signs of local buckling of the flanges at load bearing points at approximately 65 percent of the ultimate load. The track flanges continued to buckle and bulge at locations of load bearing points as the load was increased. Refer to Figure 6 for test configuration and failure mode.

Top Track with 2x4 Wood Plate

All samples with a top track and a 2x4 wood plate ultimately failed in flexure (bending). The steel tracks in all tested specimens were not severely deformed at ultimate loads. Each steel track started to bend at approximately 55 percent of the ultimate load. No signs of local buckling or web crippling were observed, as was the case for the deep leg tracks at the 55 to 75 percent level of the ultimate loads. The tracks continued to bend and buckle in the inelastic range as the load was increased up to the failure load. The ultimate load at which each specimen failed was significantly higher than that achieved with the deep leg tracks. Refer to Figure 7 for tested configuration and failure mode.

J-Tracks

All J-track samples ultimately failed in combined web crippling and bending. The steel tracks in all tested specimens were not severely deformed at ultimate loads except at the “hinge” location created by local buckling at the load bearing points. The stiffer portion of the J-track (side with longer flange) appeared to be attracting more load than the other side due to the nonsymmetrical shape. The nonsymmetrical shape created a concentrated load at the tip of the longer flange end of the J-track resulting in lower load sharing between the flanges and hence lower than expected loads. This phenomenon did not appear to be a problem in lighter tracks (33 and 43 mil sections)(0.84 and 1.09 mm) but became apparent in the heavier 54-mil (1.37 mm) sections. An additional test was conducted with the top load beam free to rotate (out of plane rotation) resulting in lower loads as expected given that bearing forces were free to distribute to the less rigid flange of the J-track. The test configuration used in this study (not allowing out-of-plane rotation of the top beam) is believed to accurately simulate the intended as-built conditions. Refer to Figure 8 for test configuration and failure mode.

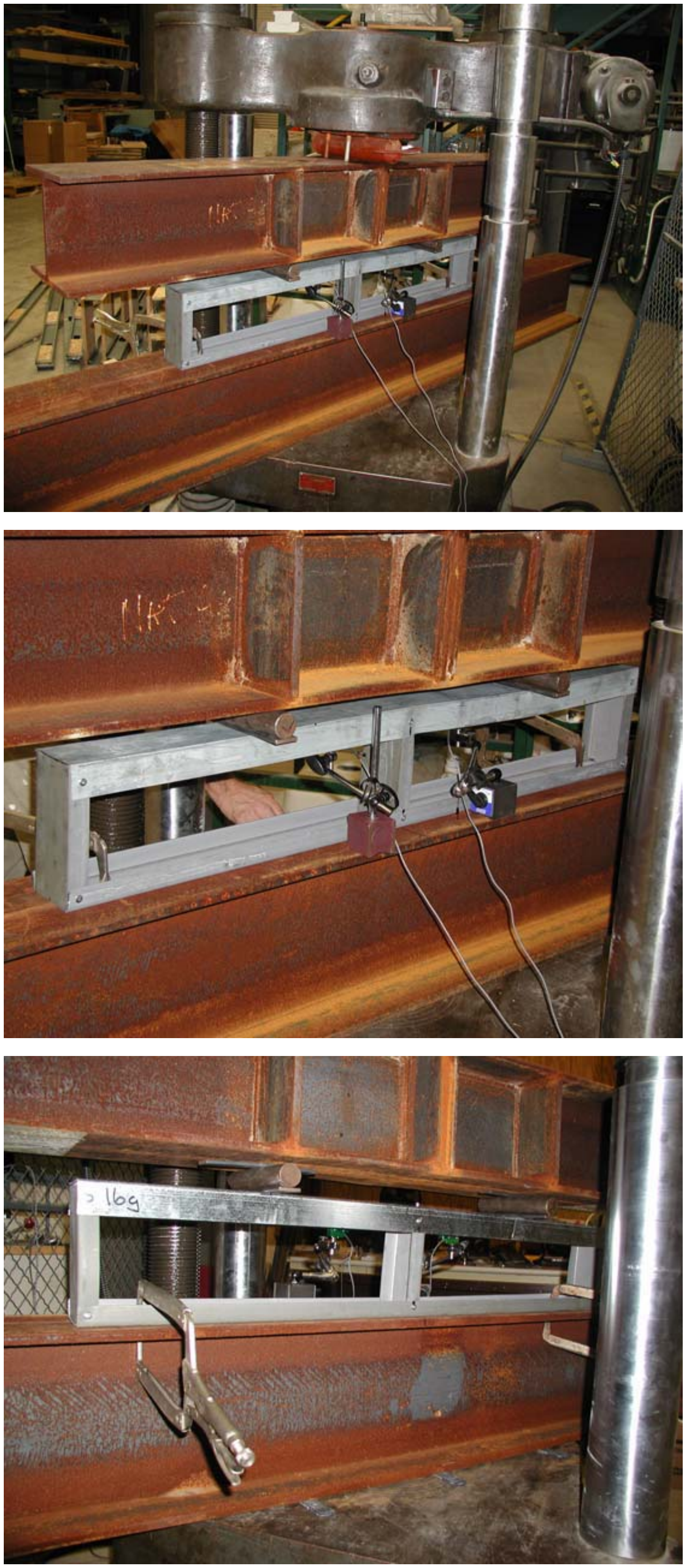


Figure 6 – Deep Leg Track Tests

Figure 6 (cont.) – Deep Leg Track Tests

Figure 7 – Top Track with 2x4 Top Plate Tests

Figure 7 (cont.) – Top Track with 2x4 Top Plate Tests

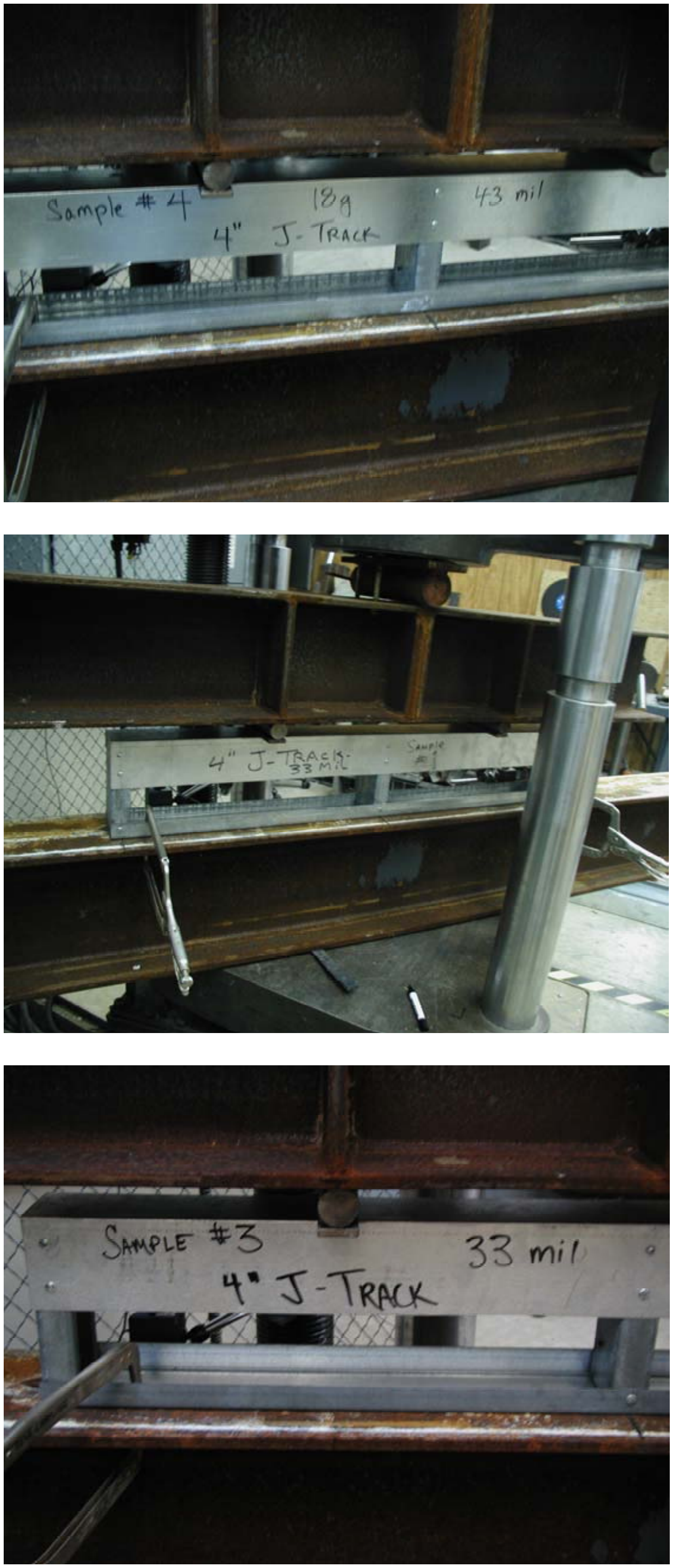


Figure 8 – J-Track Tests

Figure 8 (cont.) – J-Track Tests

Figure 8 (cont.) – J-Track Tests

DISCUSSION

A factor can be applied to the average ultimate capacity for each load-bearing top track assembly shown in Table 3 to estimate the factored (design) capacity. The factor is calculated in accordance with the AISI Design Specification [7] as follows:

The strength of the tested assemblies shall satisfy the following equation:

$$\sum \gamma_i Q_i \le \phi R_n$$

Where: R_n = Average value of the test results.

ϕ = Resistance factor

$\gamma_i Q_i$ Required strength based on the most critical load combination.

ϕ = Resistance factor = $1.5(M_m F_m P_m)e^{-\beta_0 \sqrt{V^2{}_M + V^2{}_F + C_P V_P{}^2 + V^2{}_Q}}$

M_m = Mean value of the material factor = 1.10 (bending or compression)

F_m = Mean value of the fabrication factor = 1.00

P_m = Mean value of the professional factor for the tested component = 1.0

β_0 = Target reliability index = 2.5

V_M = Coefficient of variation of the material factor = 0.10 (bending or compression)

V_F = Coefficient of variation of the fabrication factor = 0.05

C_P = Correction factor = 5.7

V_P = Coefficient of variation of the test results = 5.01% (maximum COV from Table 3)

V_P = 6.5% (for V_p < 6.5%, use 6.5%)

m = Degree of freedom = 1

V_Q = Coefficient of variation of the load effect = 0.21

ϕ = $1.5(1.10x1.00x1.00)e^{-2.5\sqrt{0.10^2+0.05^2+5.7x0.065^2+0.21^2}}$ = 0.7374

ϕ = 0.7374

Therefore, the factored capacity for each track assembly is shown in Table 4 for use with LRFD design provisions and factored LRFD load combinations.

Table 4 – Factored Capacity

Track Assembly	Track Designation	Factored Capacity (lb)
Deep Leg Track	350T200-33	883
	350T200-43	1,723
	350T200-54	2,887
Track with 2x4 Wood Plate	350T200-33	6,485
J-Track	350T150-33	1,636
	350T150-43	2,158
	350T150-54	2,062

For SI: 1 lb. = 4.448 N.

The deep leg track test results showed an increase in capacity as the thickness of the track increased. However, this trend did not apply to the J-track where capacity increased slightly from the 33 to the 43-mil (0.84 to 1.09 mm) thickness but decreased as the track thickness increased to 54 mils (1.37 mm). This finding can be attributed to the nonsymmetrical nature of the J-track. As shown in Figure 9, the 33-mil (0.84 mm) J-track resisted higher load than the 33-mil (0.84 mm) deep leg track, as the non-symmetrical profile of the J-track did not appear to cause unbalanced load distribution between the two flanges. However, as the thickness increased, more load was shifting towards the deeper leg causing higher concentrated bearing loads on the deeper leg and thus resulting in lower overall loads (resistance). The percentage of the load increase from the 33-mil (0.84 mm) to the 43-mil (1.09 mm) was lower for the J-track than that of the deep leg track. As the thickness increased to 54 mils (1.37 mm), the deeper leg of the J-track was much stiffer than the shorter leg thus attracting a higher and more load that caused the track to fail at a lower overall load than the 43 mil (1.09 mm) track.

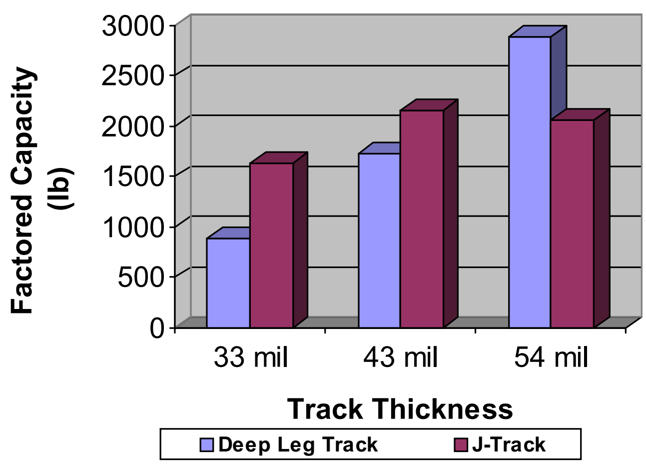


Figure 9 – Deep Leg and J-Track Factored Capacity

NORMALISED TEST RESULTS

The capacity for each track assembly shown in Table 3 is normalized for the tested yield strength and the measured thickness. The results are shown in Table 5. The yield strength factors shown in Table 5 are determined by dividing the minimum yield strength (33 ksi for 33 and 43 mil tracks and 50 ksi for 54 mil tracks) by the measured yield strength. The thickness factors shown in Table 5 are determined by dividing the minimum design thickness by the measured thickness. The normalized capacity is determined by multiplying the ultimate capacity by the yield strength factor and the thickness factor.

Table 6 shows the normalized factored capacity for each track assembly (from Table 4) for use with LRFD design provisions and factored LRFD load combinations. Figure 10 compares the normalized factored capacities of the deep leg track and the J-track.

Table 5 – Normalized Ultimate Capacity

Track Assembly	Track Designation	Ultimate Capacity [1] (lb)	Yield Strength Factor [2]	Thickness Factor [2] (lb)	Normalized Capacity [3] (lb)
Deep Leg Track	350T200-33	1,197	0.9626	0.9740	1,122
	350T200-43	2,346	0.8662	1.0089	2,032
	350T200-54	3,915	1.0242	0.9682	3,791
Track with 2x4 Wood Plate	350T200-33	8,795	0.9661	0.9711	8,251
J-Track	350T150-33	2,218	0.9299	0.9971	2,057
	350T150-43	2,927	0.8553	1.0000	2,503
	350T150-54	2,796	1.0054	0.9700	2,712

For SI: 1 lb. = 4.448 N.
[1] From Table 3.
[2] From Appendix B.
[3] A factor of 1.0 is used for Yield Strength and Thickness factors greater than 1.0.

Table 6 – Normalized Factored Capacity

Track Assembly	Track Designation	Factored Capacity (lb)	Normalized Factored Capacity[1] (lb
Deep Leg Track	350T200-33	883	828
	350T200-43	1,723	1,492
	350T200-54	2,887	2,795
Track with 2x4 Wood Plate	350T200-33	6,485	6,084
J-Track	350T150-33	1,636	1,517
	350T150-43	2,158	1,846
	350T150-54	2,062	2,000

For SI: 1 lb. = 4.448 N.
[1] A factor of 1.0 is used for Yield Strength and Thickness factors greater than 1.0.

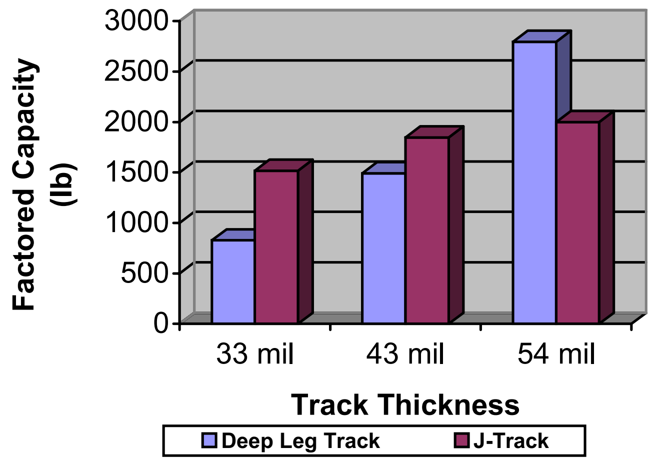


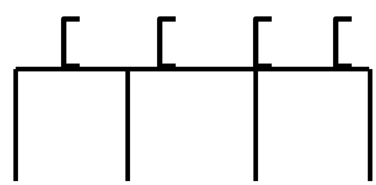
Figure 10 – Deep Leg and J-Track Normalized Factored Capacity

PRESCRIPTIVE TABLES

To investigate the feasibility of using the load-bearing top track assemblies (tested in this report) in single-family dwellings, a simple example is provided as follows:

> Using the applicability limits of the *Prescriptive Method* [1], determine the loads acting on a load-bearing top track for a wall supporting roof and ceiling for a 28-foot (8.5 m) wide building (with 2-foot (610 mm) overhang) with a 30-psf (1.4364 MPa) ground snow load. Roof members are spaced at 16 inches (406 mm) on center, while wall studs are spaced at 24 inch (610 mm) on center. All loads are in accordance with the *Prescriptive Method.*

Load Combinations:



1. $1.4D$
2. $1.2D + 1.6(L_r \text{ or } S) + 0.5L$
3. $1.2D + 0.5(L_r \text{ or } S) + 1.6L$

Loads

Dead Loads:

Ceiling Dead Load =	5(28/2) =	70 plf
Roof Dead Load =	7(32/2) =	<u>112 plf</u>
Total Dead Load	=	182 plf

Live Loads:

Roof Live Load =	16(28 + 4)/2=	256 plf
Roof Snow Load =	0.7(30)(32/2)=	336 plf ← controls

Design load acting on top track = P

1. 1.4(182) = 255 plf
2. 1.2(182) + 1.6(336) = 756 plf ⇐ Controls
3. 1.2(182) + 0.5(336) = 386 plf

For a 16 inch (610 mm) on center spacing, the total load acting on the top track is: $\frac{(756)(16)}{12}$
= 1,008 lb.

Table 6 indicates that a minimum of 350T200-43 deep leg track, or 350T150-33 with 2x4 wood top plate, or 350T150-33 J-track is required to adequately resist the applied loads.

Tables 7 and 8 were developed for use with the *Prescriptive Method* applicability limits. The values in Tables 7 and 8 were derived similar to the example above.

Table 7 – Minimum Thickness (mils) of Load-Bearing Top Track [1]
(Track Under Roof and Ceiling Only)

Building Width (Feet)	Top Track Configuration	Track Designation	Ground Snow Load [2] (psf)			
			20	30	50	70
24	Deep Leg Track	350T200-	43	43	54	54
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	33	33	54	N/A
28	Deep Leg Track	350T200-	43	54	54	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	33	33	N/A	N/A
32	Deep Leg Track	350T200-	43	54	54	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	33	43	N/A	N/A
36	Deep Leg Track	350T200-	54	54	54	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	43	54	N/A	N/A
40	Deep Leg Track	350T200-	54	54	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	43	N/A	N/A	N/A

For SI: 1 mil = 1/1000 inch = 0.0254 mm, 1 psf = 4.88 kg/m^2.

[1] Values are applicable for framing member spacing not greater than 24 inches (610 mm) on center and all *Prescriptive Method* applicability limits. Values also apply to top tracks over center load bearing walls. Maximum roof overhang is 2 feet (610 mm).

[2] N/A indicates top load bearing tracks tested in this report are not adequate for the given loading condition.

Table 8 – Minimum Thickness (mils) of Load-Bearing Top Track [1]
(Track Under One Floor, Roof and Ceiling)

Building Width (Feet)	Top Track Configuration	Track Designation	Ground Snow Load [2] (psf)			
			20	30	50	70
24	Deep Leg Track	350T200-	54	54	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	N/A	N/A	N/A	N/A
28	Deep Leg Track	350T200-	54	N/A	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	N/A	N/A	N/A	N/A
32	Deep Leg Track	350T200-	N/A	N/A	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	N/A	N/A	N/A	N/A
36	Deep Leg Track	350T200-	N/A	N/A	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	N/A	N/A	N/A	N/A
40	Deep Leg Track	350T200-	N/A	N/A	N/A	N/A
	Track w/2x4	350T150-	33	33	33	33
	J-Track	350T150-	N/A	N/A	N/A	N/A

For SI: 1 mil = 1/1000 inch = 0.0254 mm, 1 psf = 4.88 kg/m^2.

[1] Values are applicable for framing member spacing not greater than 24 inches (610 mm) on center and all *Prescriptive Method* applicability limits. Values also apply to top tracks over center load bearing walls. Maximum roof overhang is 2 feet (610 mm).

[2] N/A indicates top load bearing tracks tested in this report are not adequate for the given loading condition.

CONCLUSION

Three configurations of load-bearing top tracks were tested and evaluated in this report. All three configurations can be used as load distribution members for light-frame cold-formed steel structures with 24 inches (610 mm) maximum on-center spacing of framing members. The most widely applicable assembly was the 33 mil (0.84 mm) top track and 2x4 wood top plate combination. The use of load-bearing top tracks eliminates the in-line framing requirement in the *Prescriptive Method* and provides needed flexibility in design and construction. Tables were developed for the "tested" load-bearing top tracks with the *Prescriptive Method* applicability limits and loading conditions.

REFERENCES

[1] AISI *Standard for Cold-Formed Steel Framing-Prescriptive Method for One and Two Family Dwellings.* American Iron and Steel Institute, Washington, DC. June 2002.

[2] Lysaght, John, "*Lysaght Referee, 27th Edition*," Limited Head Office, 50 Young Street, Sydney Australia. April 1985.

[3] Patent Number 5,412,919. United States Patent. Metal Wall Framing. Inventors: Michael A. Pellock and Arturo P. Sordo. Copy Provided by PTCS from the PTO APS Image Data Base on 11/08/1995.

[4] ASTM A370-02 *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*, American Society for Testing and Materials (ASTM), West Conshohocken, PA. 2002.

[5] ASTM A90/A90M-01 *Standard Test Method of Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings*. American Society for Testing and Materials (ASTM), West Conshohocken, PA. 2001.

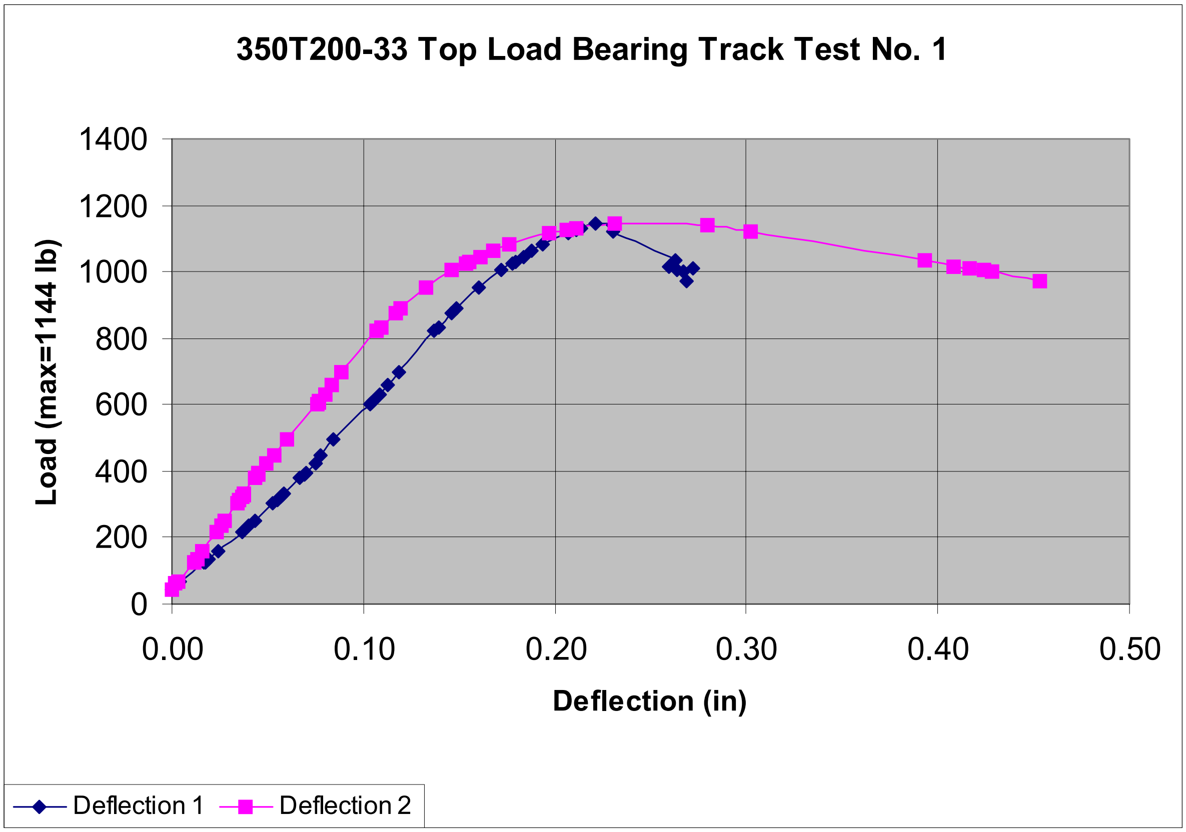
[6] *National Design Specification (NDS), Supplement,* 1997 Edition. American Forest & Paper Association, American Wood Council. Washington, DC. 1997.

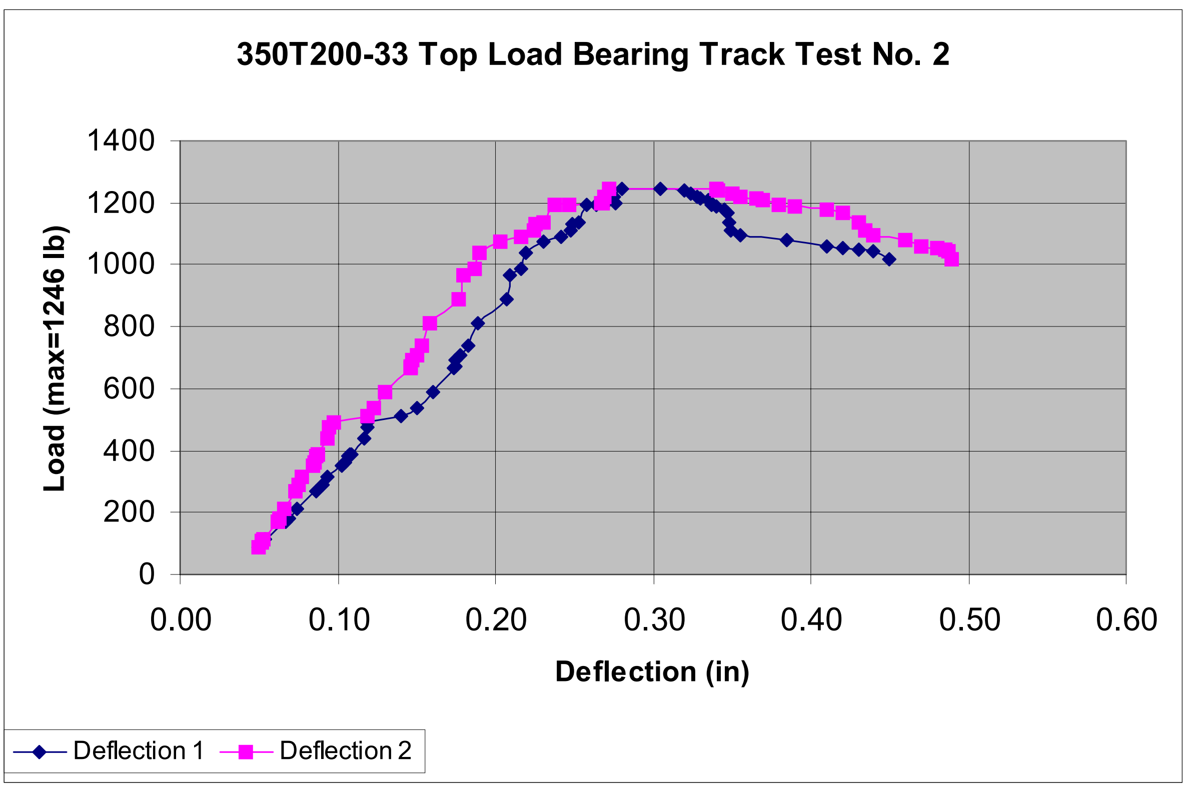
[7] AISI *Specification for the Design of Cold-Formed Steel Structural Members*, 1996 Edition. American Iron and Steel Institute (AISI), Washington, DC. June 1997.

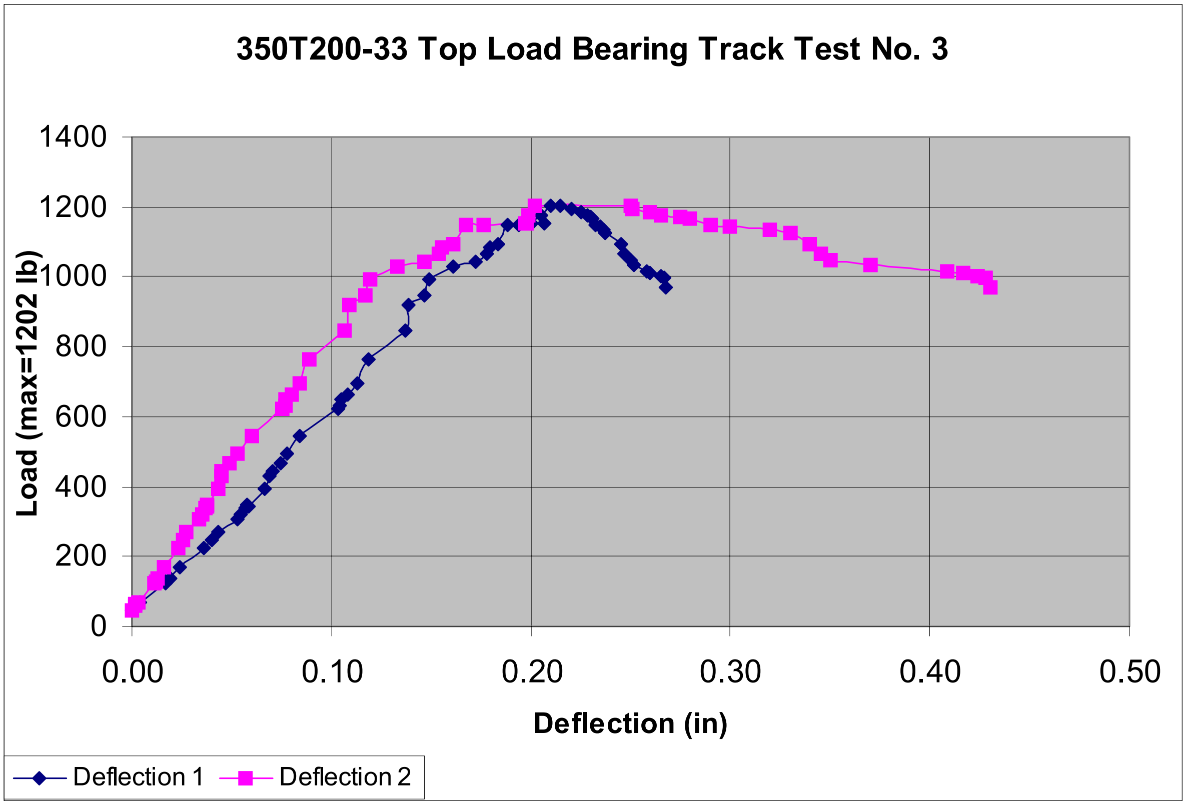
APPENDIX A

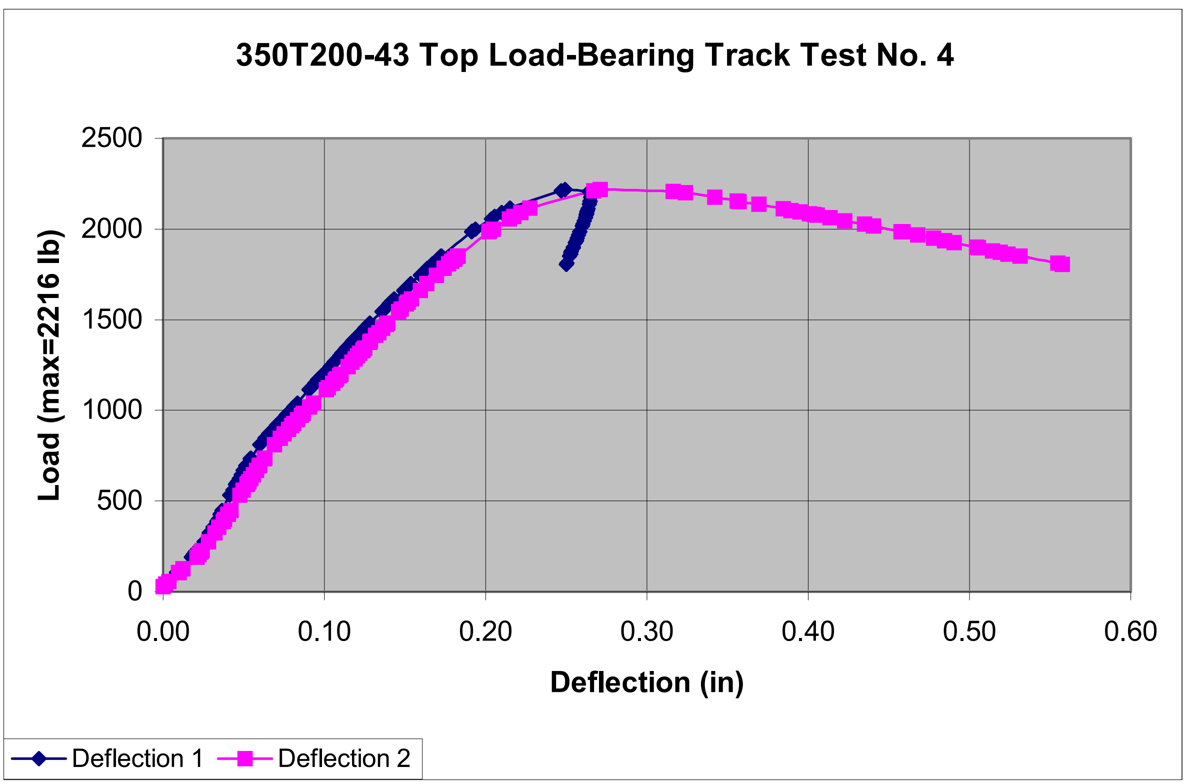
Test Plots for Load-Bearing Top Track Assemblies

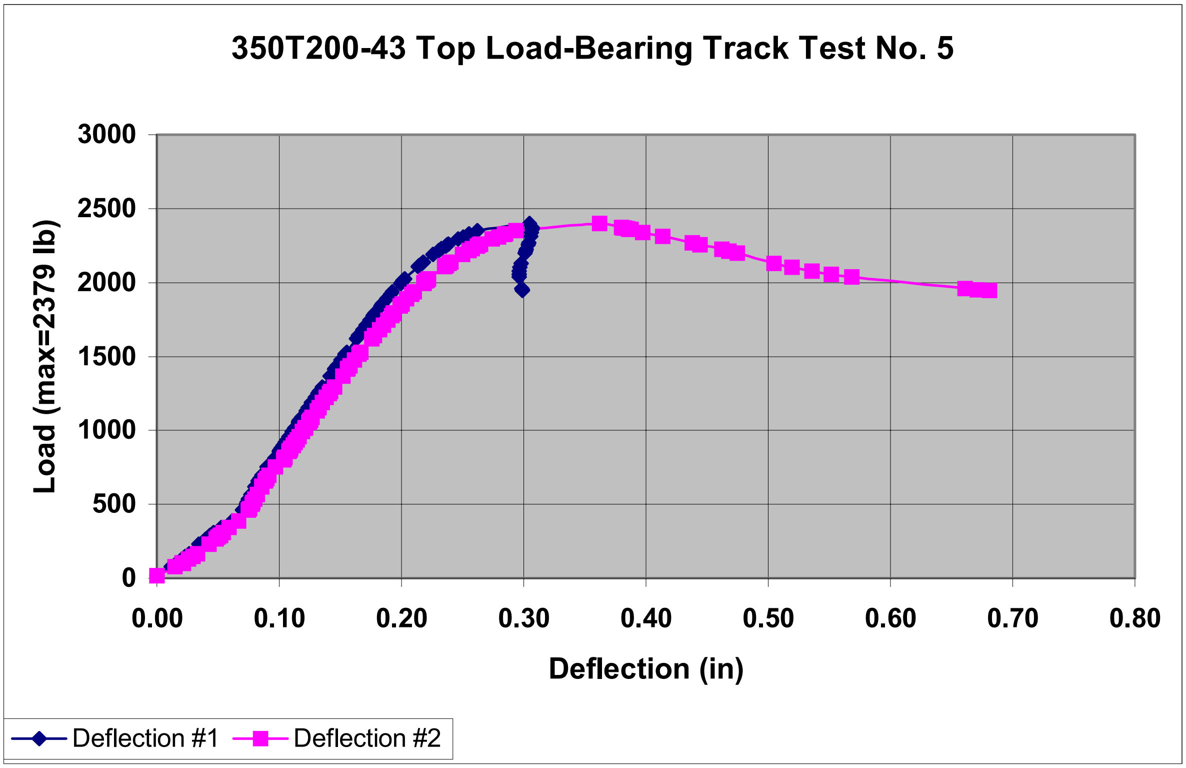
Cold-Formed Steel Top Load Bearing Tracks

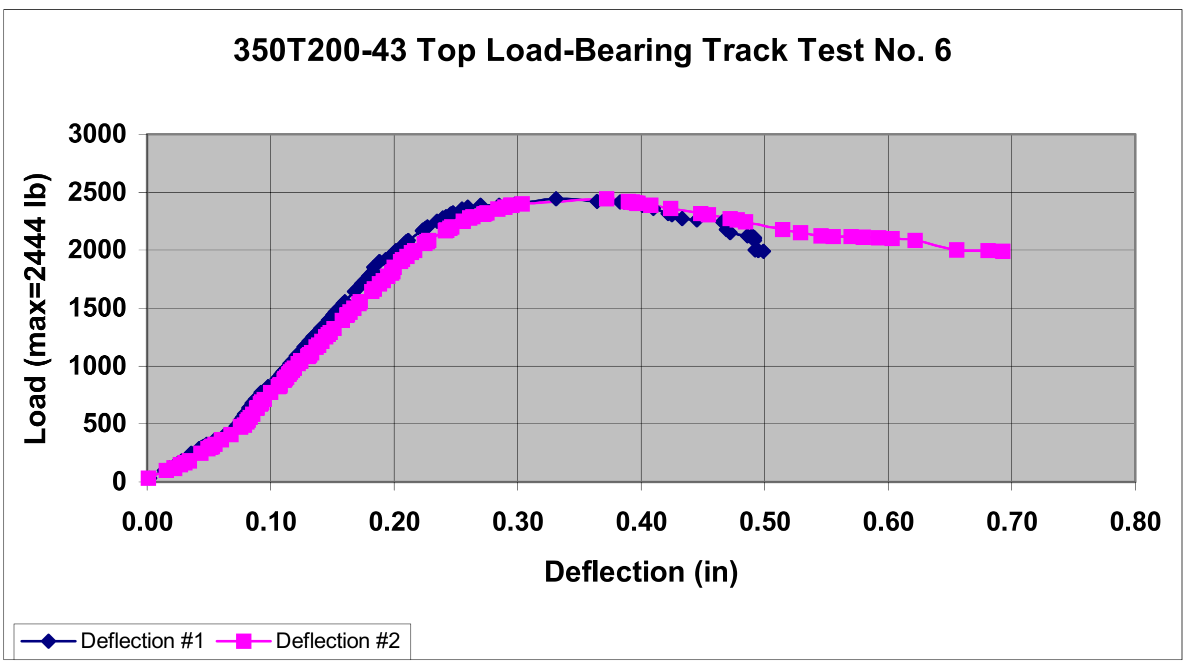

350T200-33 Top Load Bearing Track Test No. 1
Load (max=1144 lb)
1400
1200
1000
800
600
400
200
0
0.00
0.10
0.20
0.30
0.40
0.50
Deflection (in)
Deflection 1
Deflection 2

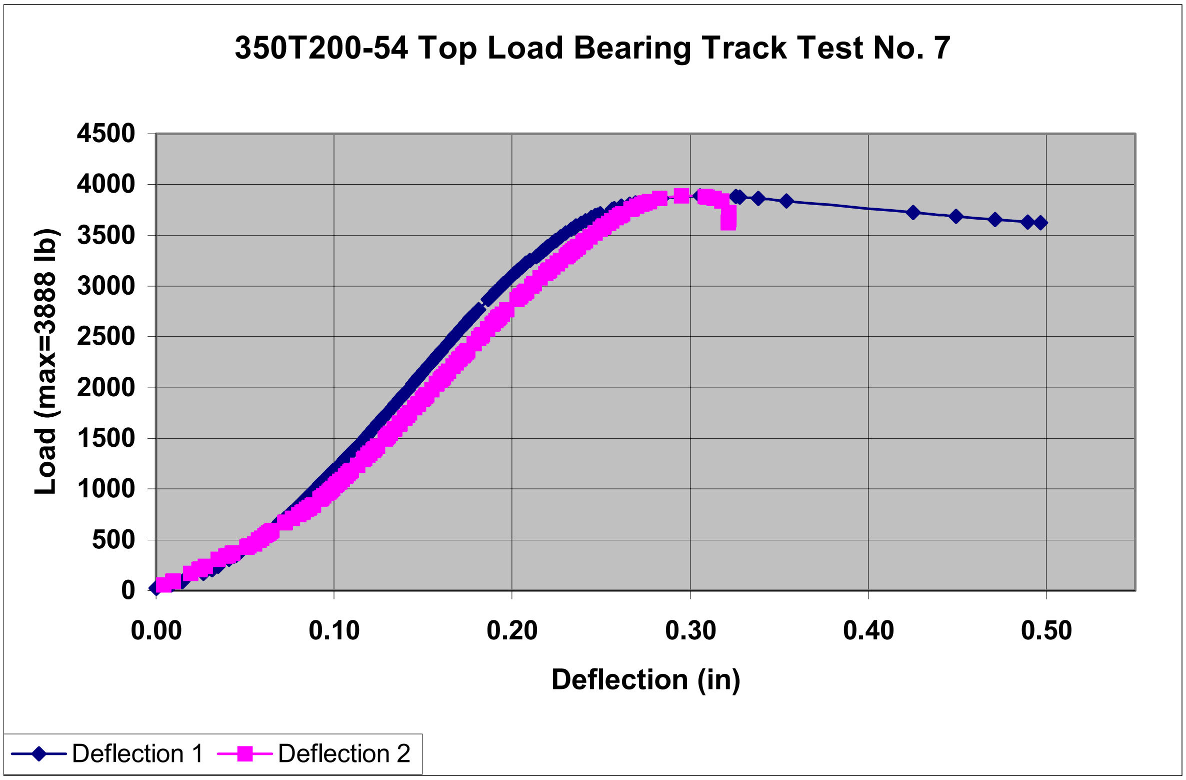

350T200-33 Top Load Bearing Track Test No. 2
Load (max=1246 lb)
1400
1200
1000
800
600
400
200
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Deflection (in)
Deflection 1
Deflection 2

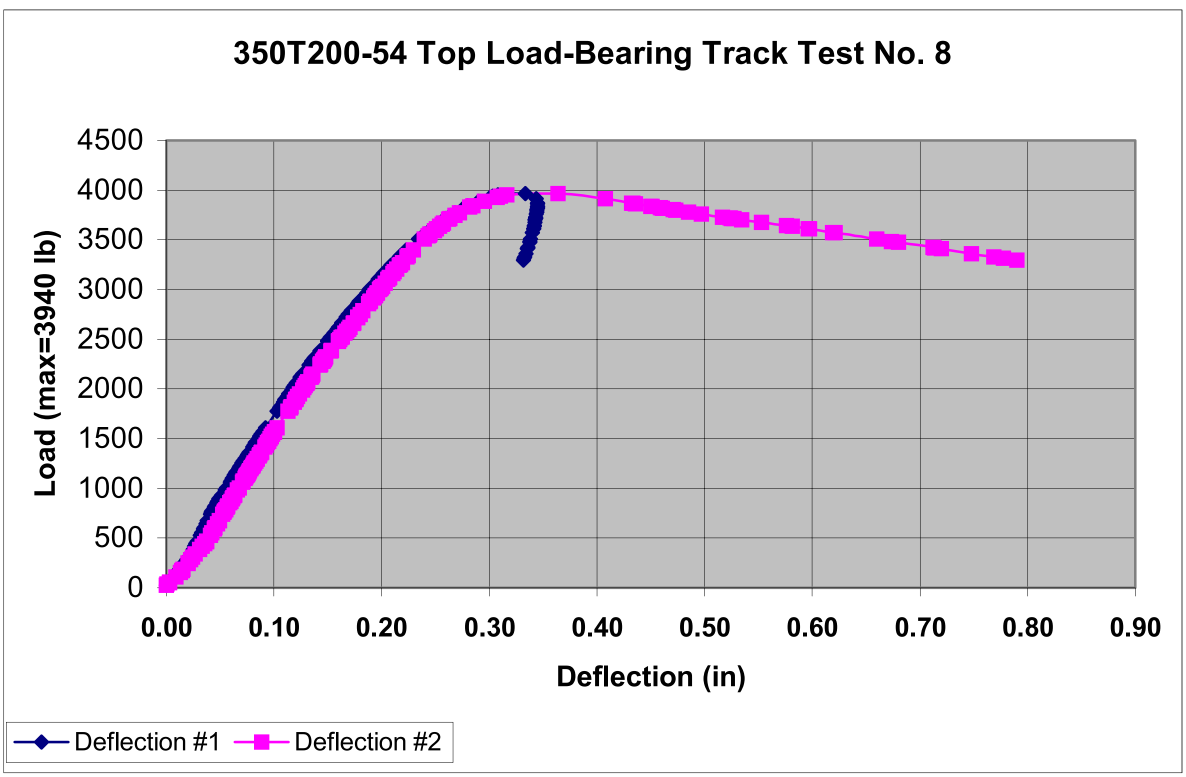

350T200-33 Top Load Bearing Track Test No. 3
1400
1200
1000
800
600
400
200
0
0.00
0.10
0.20
0.30
0.40
0.50
Load (max=1202 lb)
Deflection (in)
Deflection 1
Deflection 2

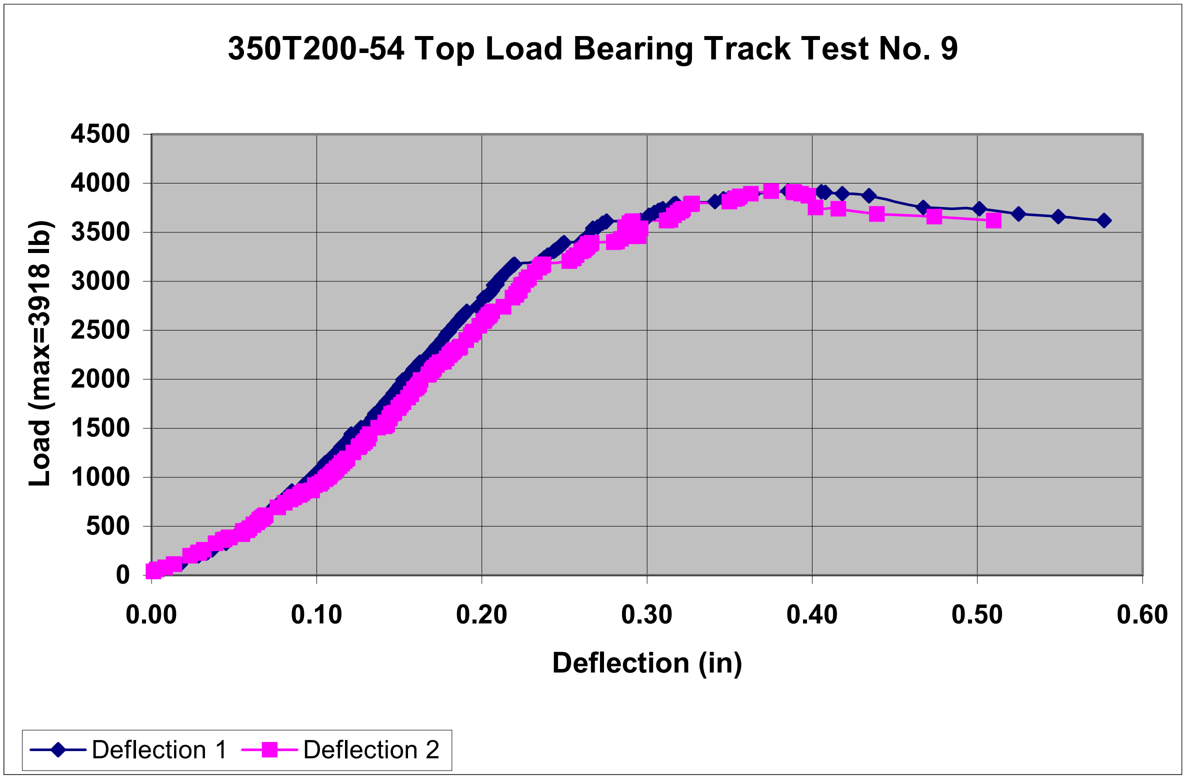

350T200-43 Top Load-Bearing Track Test No. 4
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Load (max=2216 lb)
Deflection (in)
Deflection 1
Deflection 2

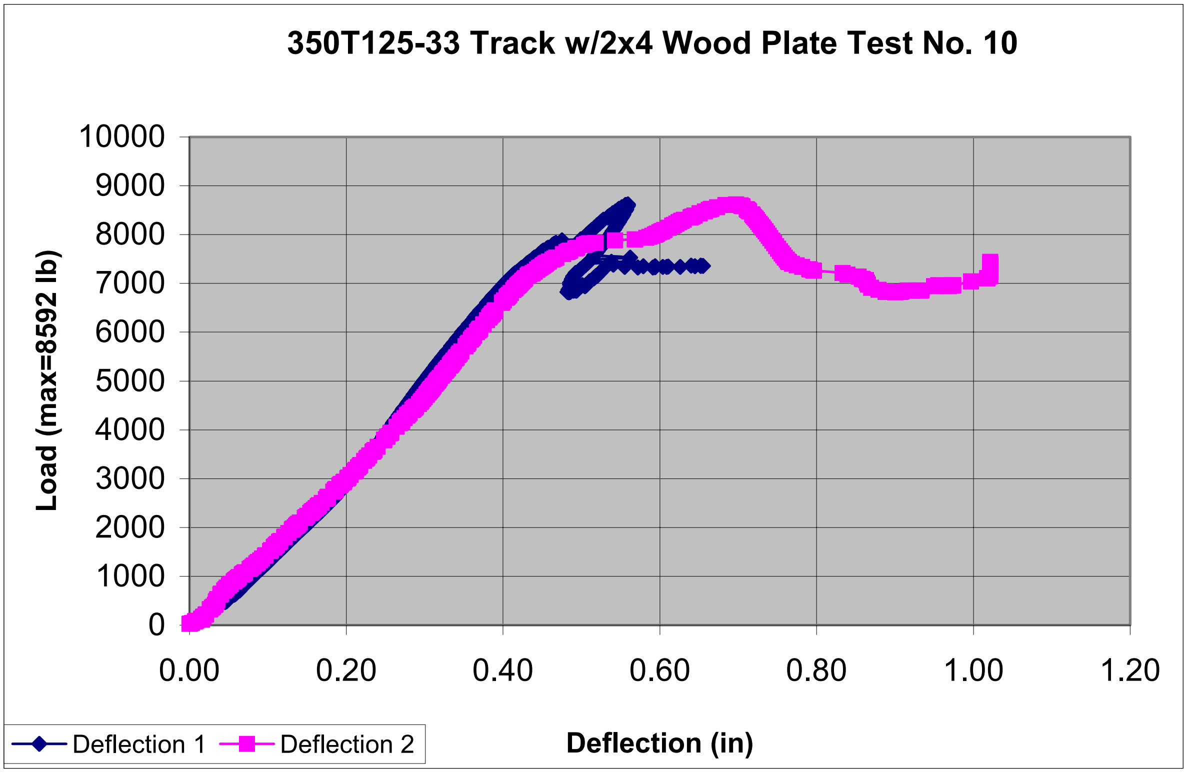

350T200-43 Top Load-Bearing Track Test No. 5
Load (max=2379 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Deflection (in)
Deflection #1
Deflection #2

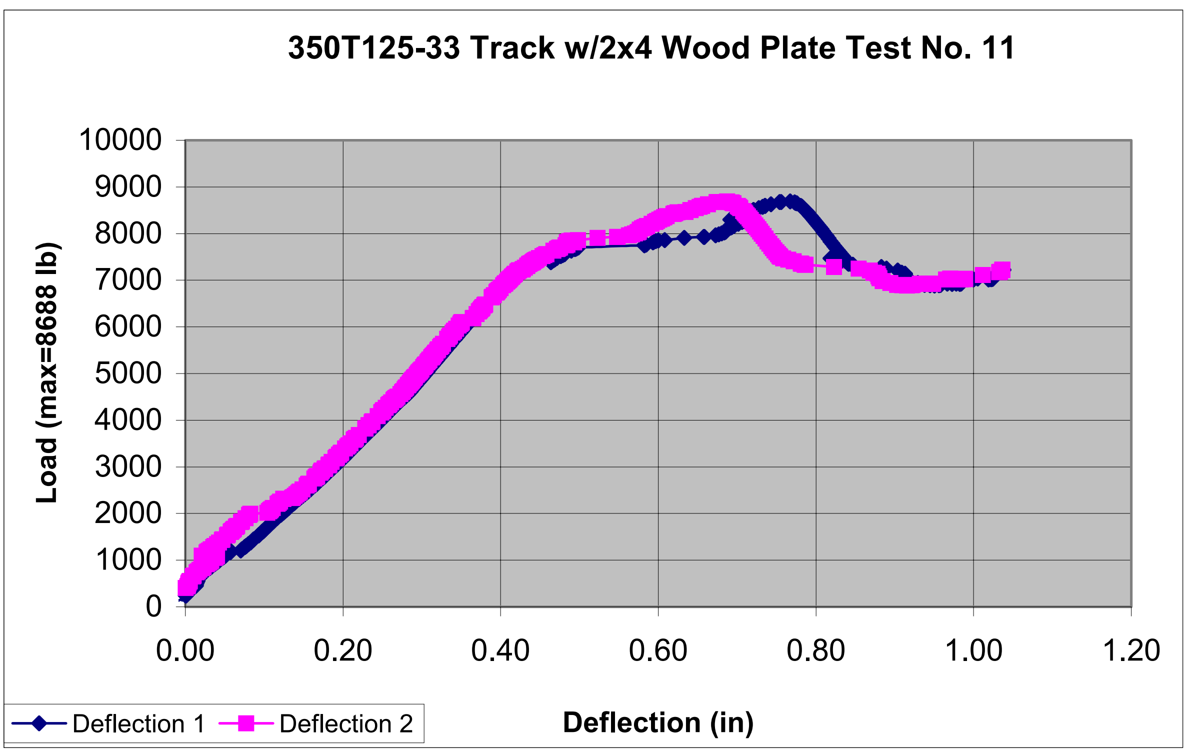

350T200-43 Top Load-Bearing Track Test No. 6
Load (max=2444 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Deflection (in)
Deflection #1
Deflection #2

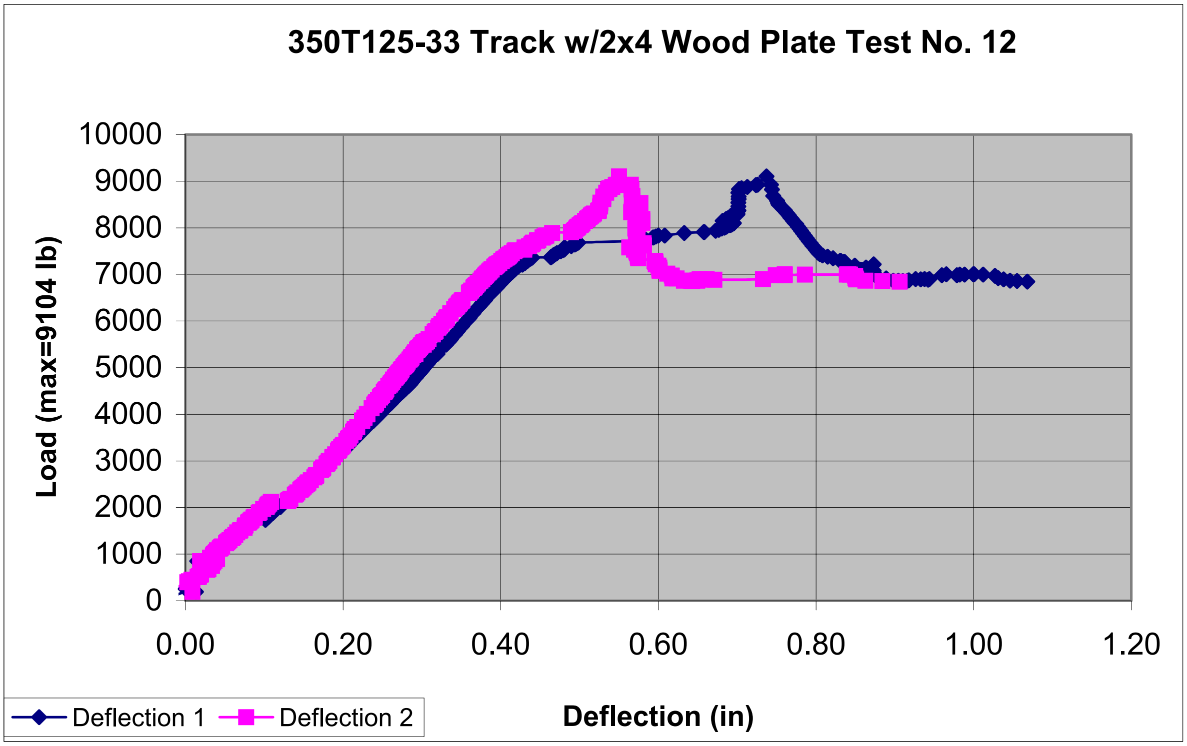

350T200-54 Top Load Bearing Track Test No. 7
Load (max=3888 lb)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
Deflection (in)
Deflection 1
Deflection 2

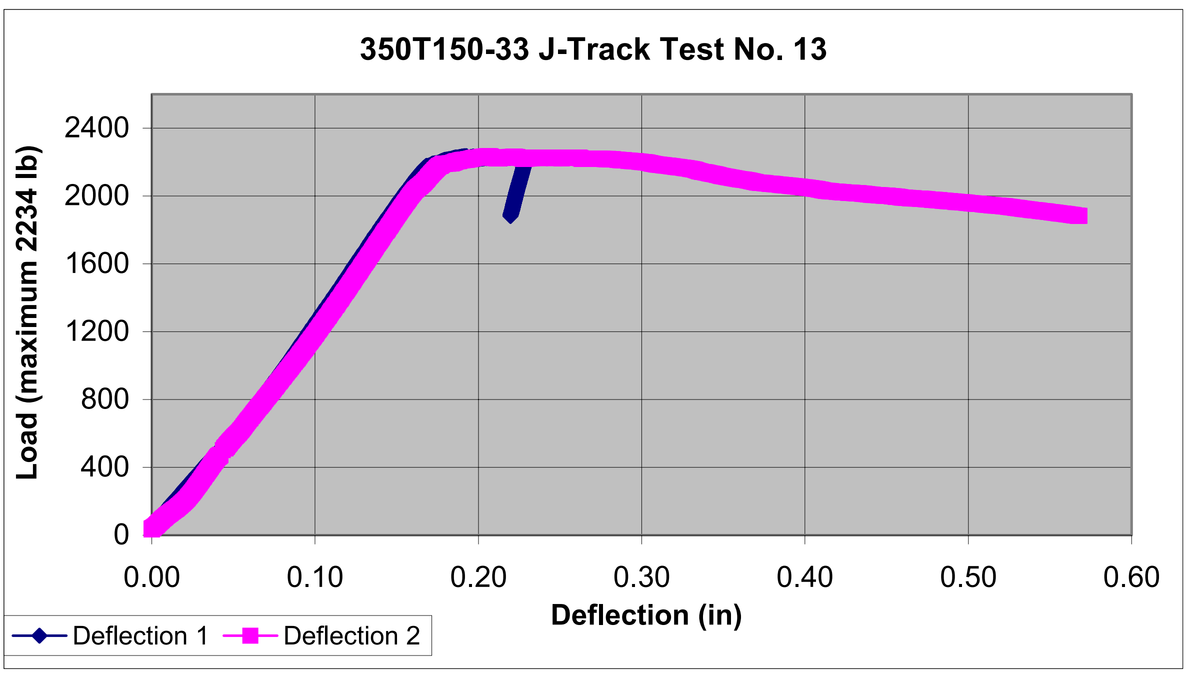

350T200-54 Top Load-Bearing Track Test No. 8
Load (max=3940 lb)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
Deflection (in)
Deflection #1
Deflection #2

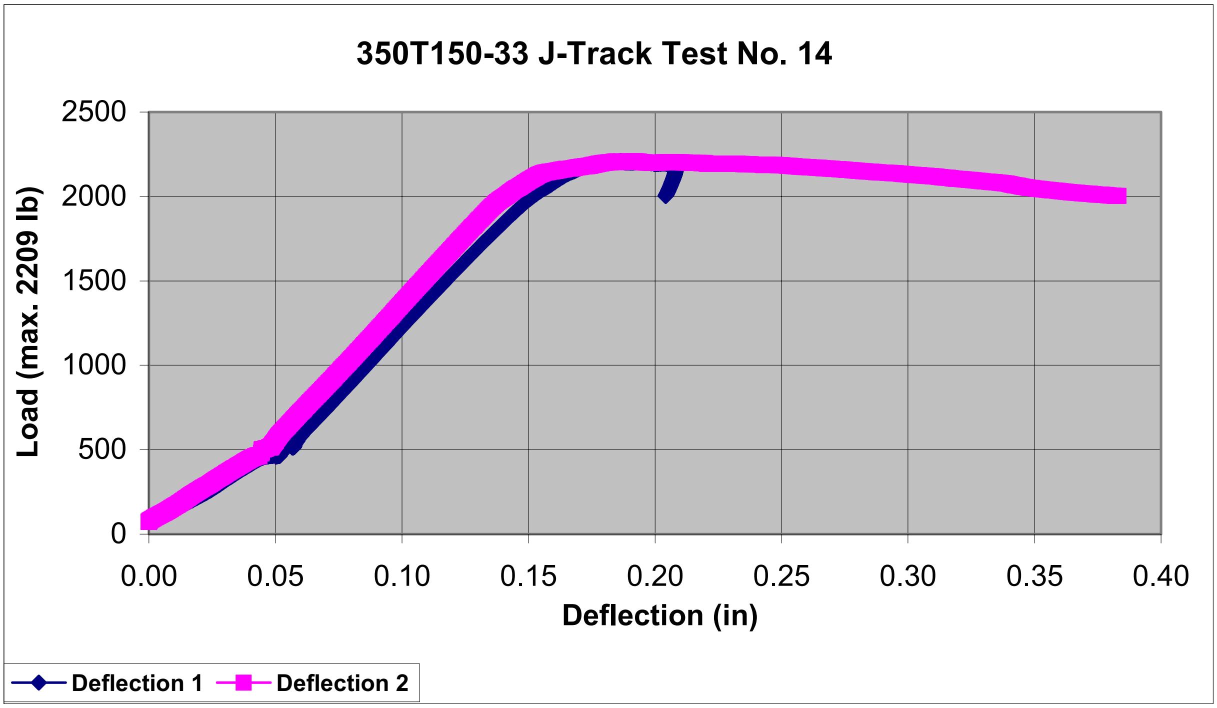

350T200-54 Top Load Bearing Track Test No. 9
Load (max=3918 lb)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Deflection (in)
Deflection 1
Deflection 2

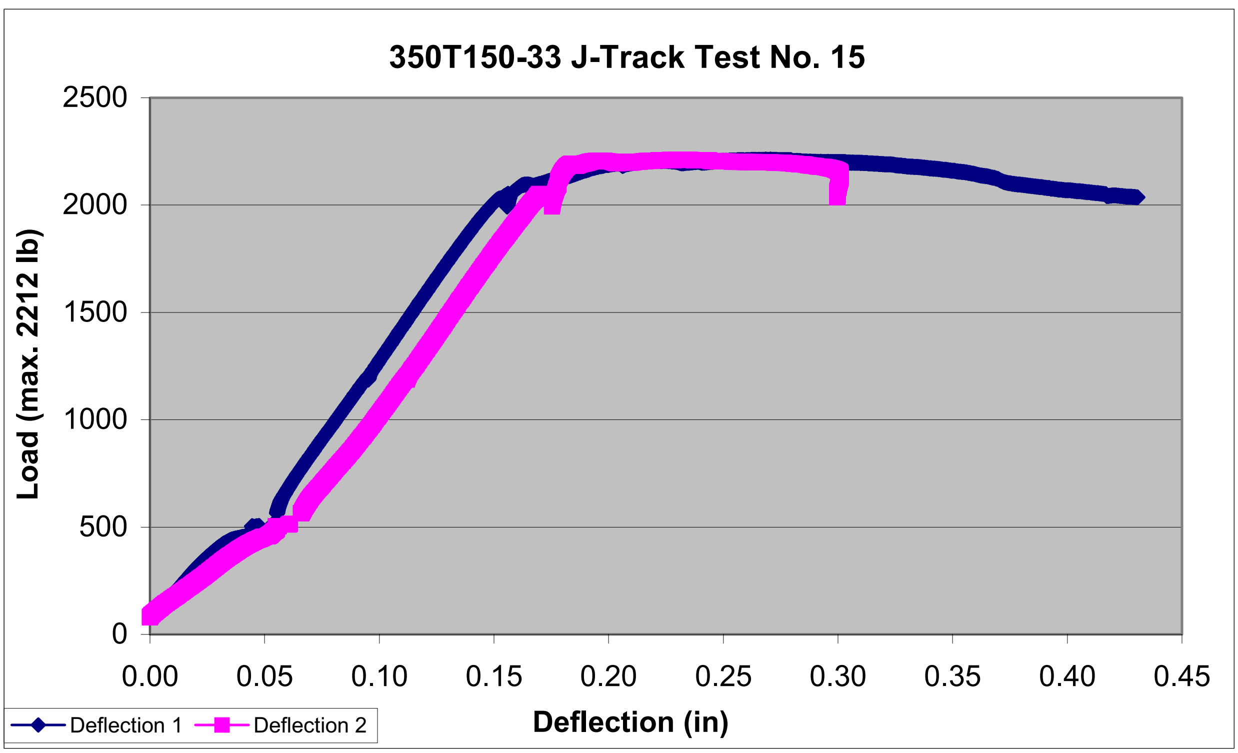

350T125-33 Track w/2x4 Wood Plate Test No. 10
Load (max=8592 lb)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Deflection 1
Deflection 2
Deflection (in)

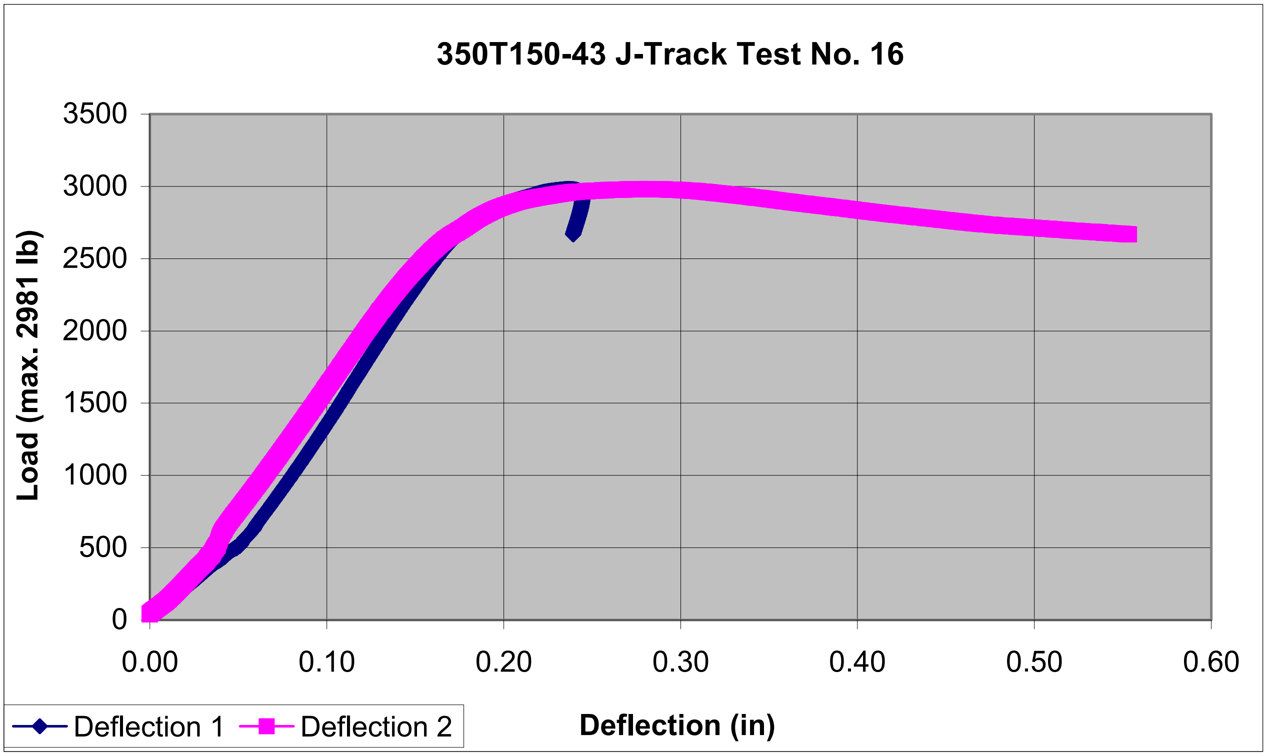

350T125-33 Track w/2x4 Wood Plate Test No. 11
Load (max=8688 lb)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Deflection 1
Deflection 2
Deflection (in)

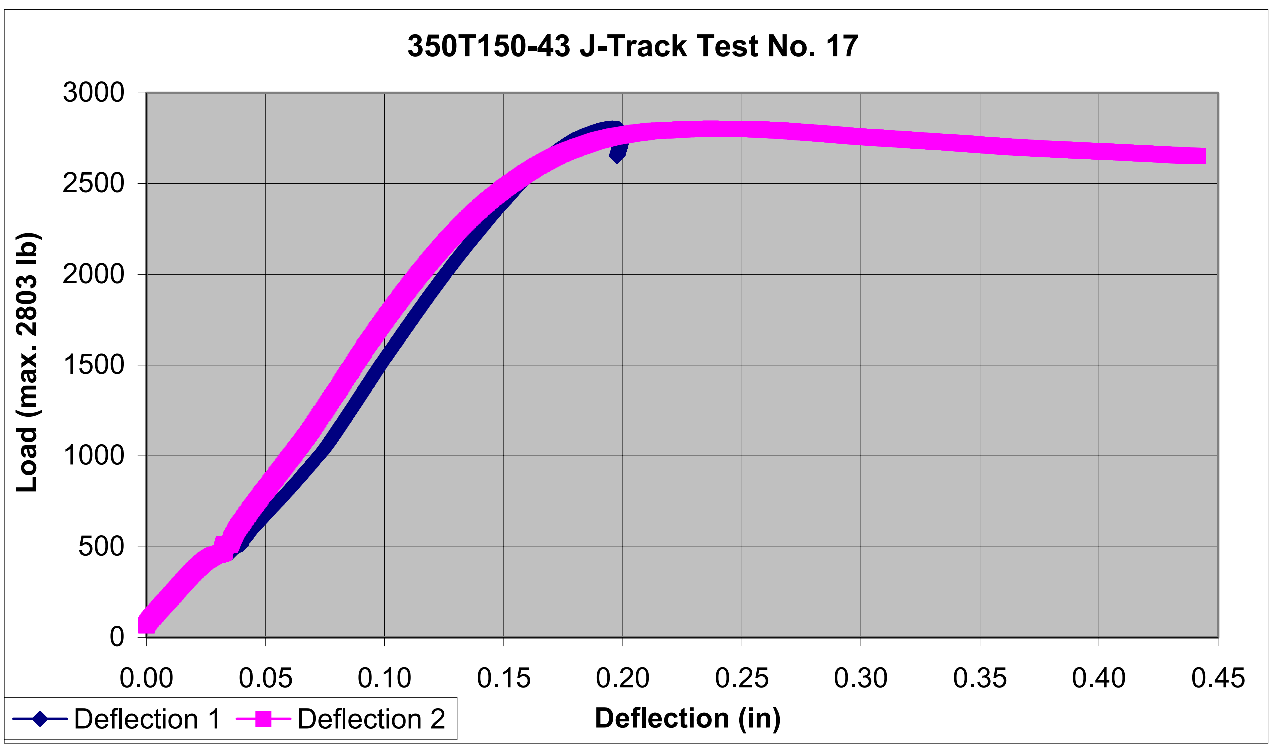

350T125-33 Track w/2x4 Wood Plate Test No. 12
Load (max=9104 lb)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Deflection (in)
Deflection 1
Deflection 2

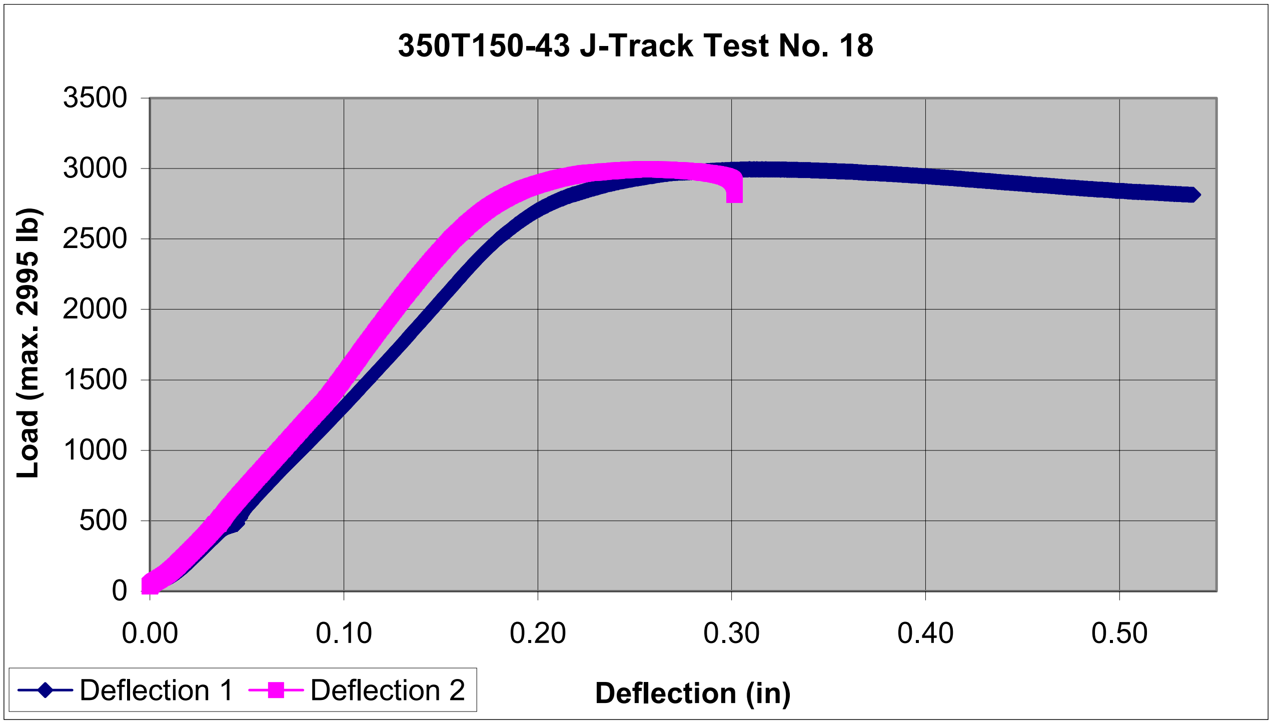

350T150-33 J-Track Test No. 13
Load (maximum 2234 lb)
2400
2000
1600
1200
800
400
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Deflection (in)
Deflection 1
Deflection 2

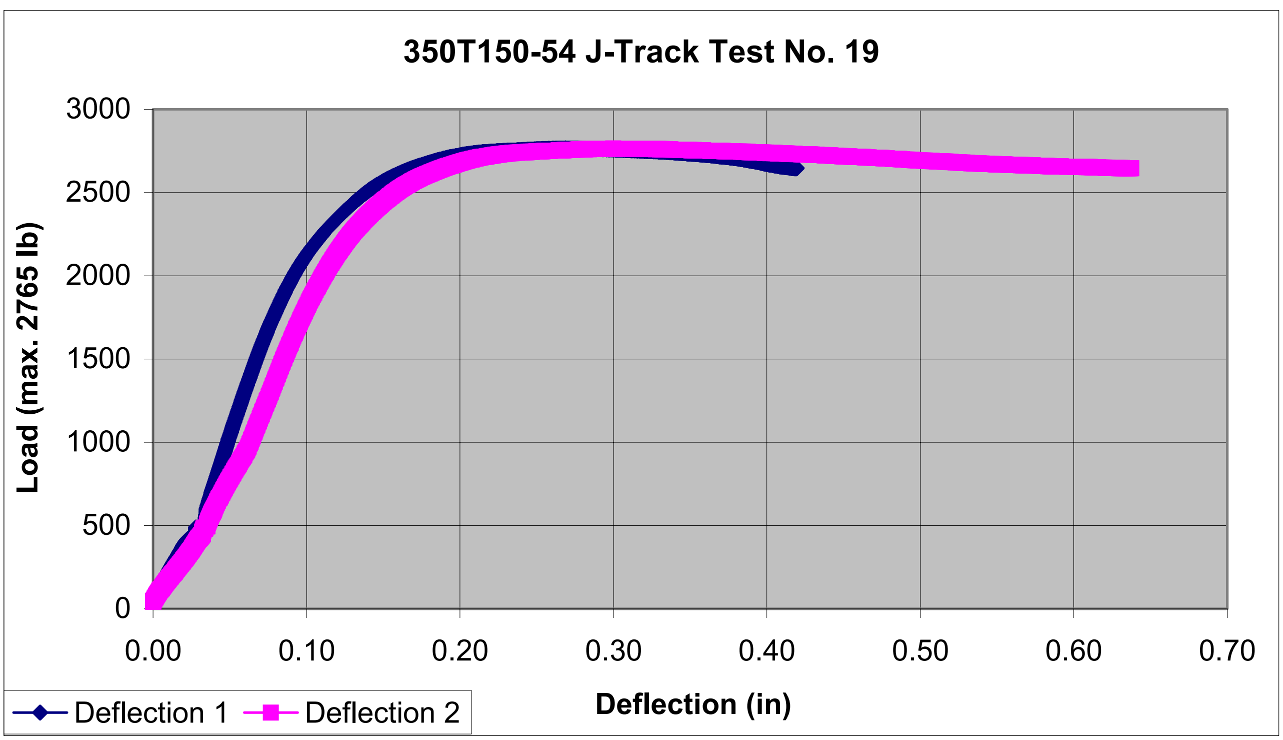

350T150-33 J-Track Test No. 14
Load (max. 2209 lb)
2500
2000
1500
1000
500
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Deflection (in)
Deflection 1
Deflection 2

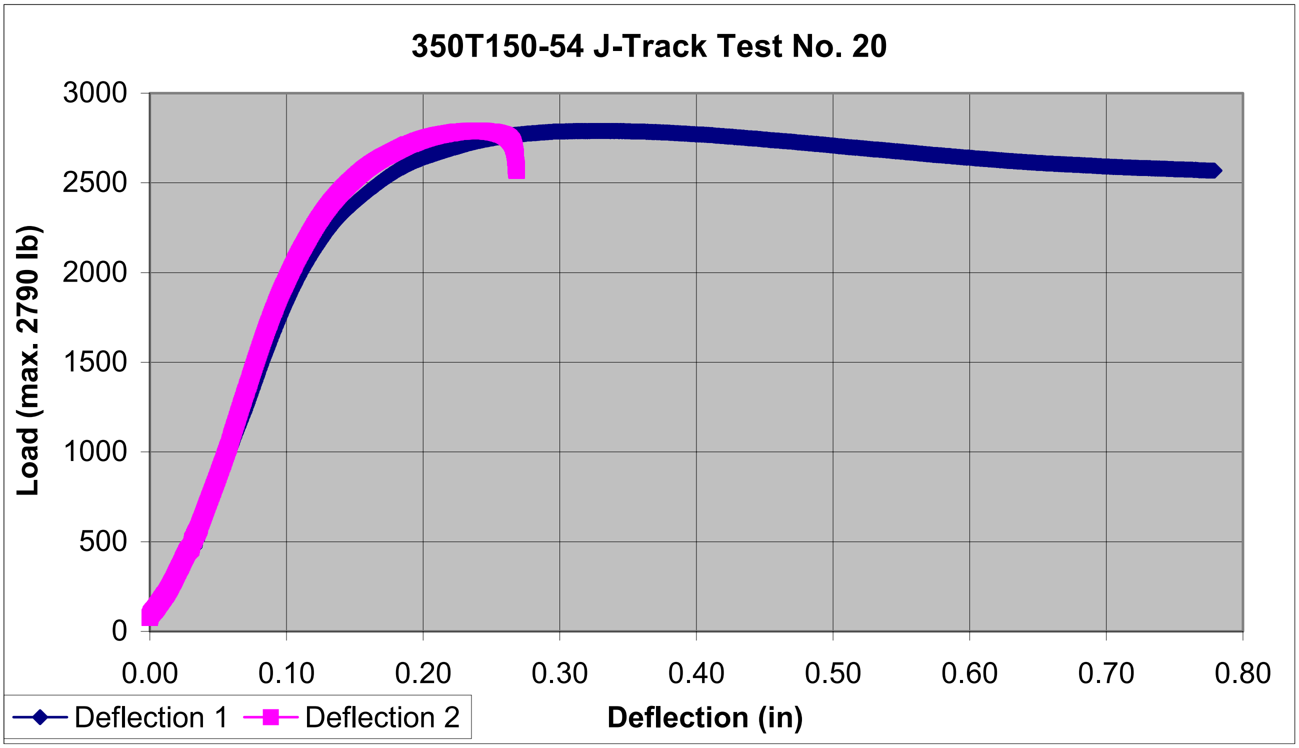

350T150-33 J-Track Test No. 15
Load (max. 2212 lb)
2500
2000
1500
1000
500
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Deflection (in)
Deflection 1
Deflection 2

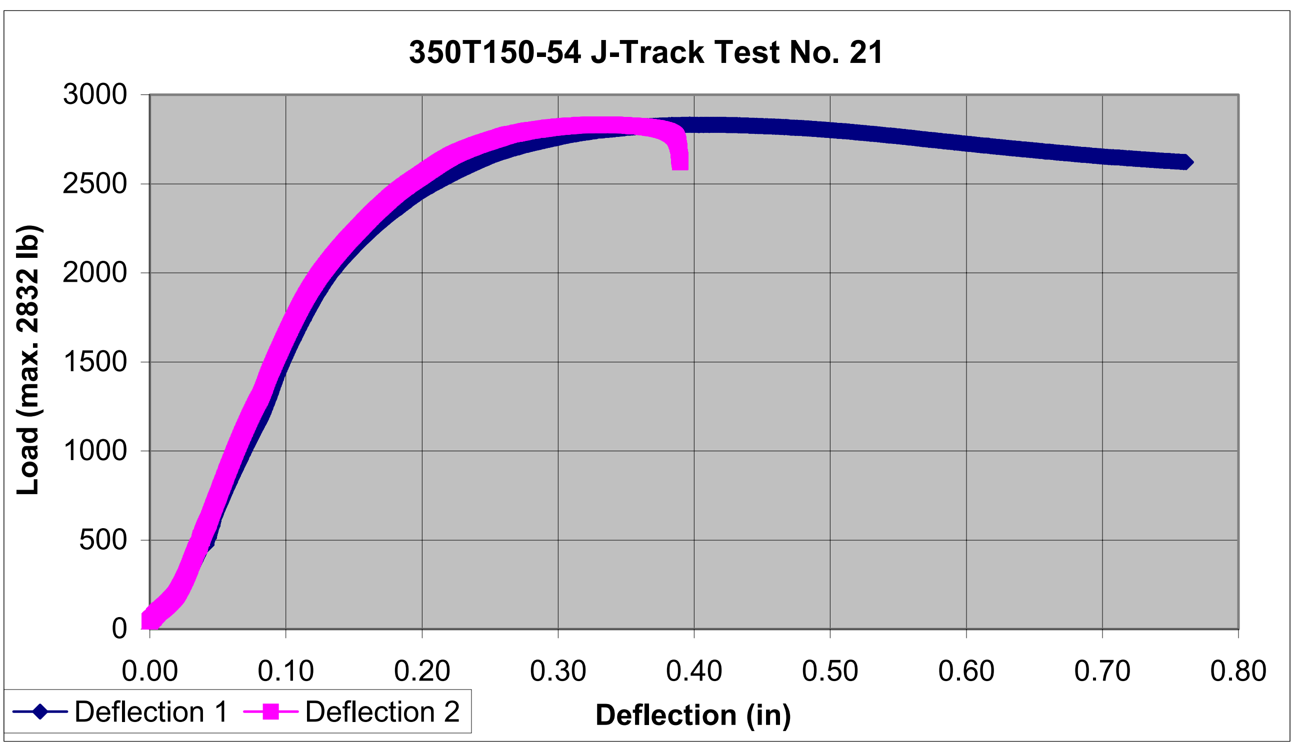

350T150-43 J-Track Test No. 16
Load (max. 2981 lb)
3500
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
Deflection (in)
Deflection 1
Deflection 2


350T150-43 J-Track Test No. 17
Load (max. 2803 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Deflection (in)
Deflection 1
Deflection 2


350T150-43 J-Track Test No. 18
Load (max. 2995 lb)
3500
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
Deflection (in)
Deflection 1
Deflection 2


350T150-54 J-Track Test No. 19
Load (max. 2765 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Deflection (in)
Deflection 1
Deflection 2


350T150-54 J-Track Test No. 20
Load (max. 2790 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Deflection (in)
Deflection 1
Deflection 2


350T150-54 J-Track Test No. 21
Load (max. 2832 lb)
3000
2500
2000
1500
1000
500
0
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Deflection (in)
Deflection 1
Deflection 2

APPENDIX B

Physical Properties of Steel Members

Cold-Formed Steel Top Load Bearing Tracks

Physical and Mechanical Properties of Steel Tracks

Steel Angle Designation	Yield Point [1] (psi)	Tensile Strength [1] (psi)	Uncoated Thickness [2] (in.)	Elongation [3] (Percent)
350T200-33	35,620	44,250	0.0337	21.3
350T200-33	33,250	44,680	0.0339	21.9
350T200-33	33,980	45,210	0.0336	20.8
Average	**34,283**	**44,713**	**0.0337**	**21.3**
Standard Deviation	**1214**	**481**	**0.0002**	**0.55**
COV	**0.0354**	**0.0108**	**0.0045**	**0.0258**
350T200-43	37,760	47,200	0.0459	20.6
350T200-43	38,420	46,450	0.0454	21.5
350T200-43	38,110	47,250	0.0451	22.3
Average	**38,097**	**46,967**	**0.0455**	**21.5**
Standard Deviation	**330**	**448**	**0.0004**	**0.85**
COV	**0.0087**	**0.0095**	**0.0089**	**0.0396**
350T200-54	47,680	64,230	0.0551	22.8
350T200-54	49,560	62,460	0.0545	23.4
350T200-54	49,210	65,130	0.0548	24.0
Average	**48,817**	**63,940**	**0.0548**	**23.4**
Standard Deviation	**1,000**	**1,358**	**0.0003**	**0.60**
COV	**0.0205**	**0.0212**	**0.0055**	**0.0256**
350T150-33	34,440	44,630	0.0335	21.7
350T150-33	34,210	45,020	0.0334	21.2
350T150-33	33,820	44,120	0.0339	21.0
Average	**34,157**	**44,590**	**0.0336**	**21.3**
Standard Deviation	**313**	**451**	**0.0003**	**0.36**
COV	**34,157**	**0.0101**	**0.0079**	**0.0169**

For SI: 1 inch = 25.4 mm, 1 psi = 0.0703 kg/cm^2, 1 lb. = 4.448 N.

[1] Yield point and tensile strength are actual yield point and tensile strength from coupons cut from the web of the angle specimen and tested per ASTM A370 [3].

[2] Uncoated thickness is the bare steel thickness of the steel angle as tested per ASTM A90 [4].

[3] Tested in accordance with ASTM A370 [3] for a two-inch gauge length.

Physical and Mechanical Properties of Steel J-Tracks

Steel Angle Designation	Yield Point [1] (psi)	Tensile Strength [1] (psi)	Uncoated Thickness [2] (in.)	Elongation [3] (Percent)
350T150-33	34,698	48,868	0.0341	22.2
350T150-33	35,740	49,832	0.0362	24.4
350T150-33	36,020	48,695	0.0333	23.6
Average	**35,486**	**49,132**	**0.0345**	**23**
Standard Deviation	**697**	**613**	**0.0015**	**1.1**
COV	**0.0196**	**0.0125**	**0.0434**	**0.0476**
350T150-43	38,820	46,940	0.0447	19.9
350T150-43	39,020	47,250	0.0451	21.8
350T150-43	37,910	48,130	0.0454	21.7
Average	**38,583**	**47,440**	**0.0451**	**21**
Standard Deviation	**592**	**617**	**0.0004**	**1.1**
COV	**0.0153**	**0.0130**	**0.0078**	**0.0506**
350T150-54	50,160	65,130	0.0547	25.2
350T150-54	49,850	63,980	0.0548	24.5
350T150-54	49,190	64,060	0.0551	24.8
Average	**49,733**	**64,390**	**0.0549**	**25**
Standard Deviation	**495**	**642**	**0.0002**	**0.4**
COV	**0.0100**	**0.0100**	**0.0038**	**0.0141**

For SI: 1 inch = 25.4 mm, 1 psi = 0.0703 kg/cm^2, 1 lb. = 4.448 N.

[1] Yield point and tensile strength are actual yield point and tensile strength from coupons cut from the web of the angle specimen and tested per ASTM A370 [3].

[2] Uncoated thickness is the bare steel thickness of the steel angle as tested per ASTM A90 [4].

[3] Tested in accordance with ASTM A370 [3] for a two-inch gauge length.

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Research Report RP-03-5

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