



Structural Test Report

Piazza PTSLB and PTLB

F2 (Out-of-Plane) and F3 (Gravity)

1/14/2021

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BACKGROUND

The PiazzaStone track and clip system is designed for lightweight stone attachment to structures. Various combinations of PiazzaStone clips can be used on their own or in conjunction with a track in accordance with design requirements.

To accurately reflect the final version of the PTSLB and PTLB clips after extensive engineering and development work, PiazzaStone has requested that The Steel Network, the exclusive manufacturer of its clips, conduct the required tests for out-of-plane and gravity loading conditions.

PURPOSE OF CURRENT TESTS

The present tests were conducted to evaluate the strength in the gravity direction of:

- The PTSLB and PTLB clips in the F2 (out-of-plane) direction. As explained in the summary, a single test of the PTSLB400-54 is sufficiently conservative to cover all six clips in this direction.
- The PTLB clips in the F3 (gravity) direction. A separate test is required for each clip due to the differences in eccentric loading and differences in the number and pattern of fasteners.

These tests were required to determine the appropriate connection ASD value in the various conditions present during the installation and end state of these clips.

EQUIPMENT

The following equipment was used:

1. Test setups illustrated by Figure 1, Figure 2, and Figure 3
2. A hydraulic cylinder capable of applying excess of 50 kips of linear load
3. A load cell capable of measuring load at 0.5s increments
4. Linear potentiometers capable of measuring 1.5" or 6" of linear deflection as needed
5. Angle, plate, and block fixtures to locate the test specimens
6. Socket-head cap screws to secure the test samples to the stationary block and pillow block, respectively
7. A National Instruments program to record incoming data from the strain gauge and potentiometers in a CSV file with a time stamp and date stamp
8. A Microsoft Excel worksheet developed to calculate clip ASD and LRFD design loads in accordance with AISI S100-16, Chapter K
9. A Microsoft Excel worksheet developed to calculate connection design loads based on screw orientation

PROCEDURE

In the F2 test, the track was attached to the vertical face of a structural steel L-angle. The horizontal face of this angle was firmly attached to a rigid stationary block. The clip itself was attached to a separate L-angle which was firmly attached to a movable pillow-block, through which the load was applied. See Figure 1 for details.



Figure 1: F2 Test Setup

The 6" linear potentiometer was placed on the L-angle which was bolted into the movable pillow block and a 1.5" linear potentiometer was attached to the backside of the stationary L-angle to account for minor deflections in this part of the test bench.

Load was applied until failure. After the completion of the test, the data was analyzed in accordance with AISI S100-16, Section K.

In the F3 test, the track was attached to the horizontal face of a plate bolted down into a stationary block. The clip itself was attached to a large welded fixture and plate assembly which was firmly attached to a movable pillow-block, through which the load was applied. See Figure 2 for details.

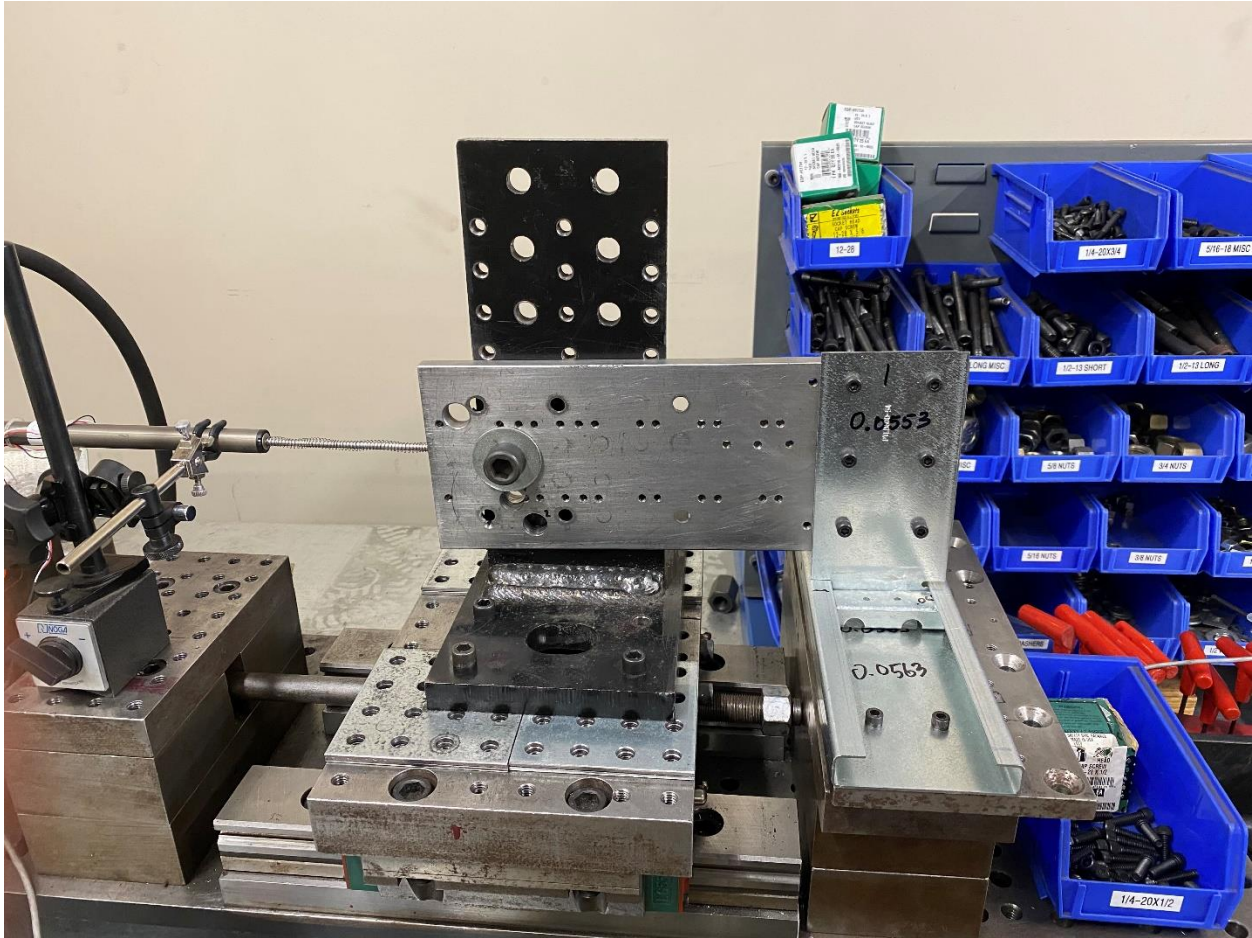


Figure 2: F3 Test Setup

The 6" linear potentiometer was placed on the large welded fixture which was bolted into the movable pillow block.

Load was applied until failure. After the completion of the test, the data was analyzed in accordance with AISI S100-16, Section K.

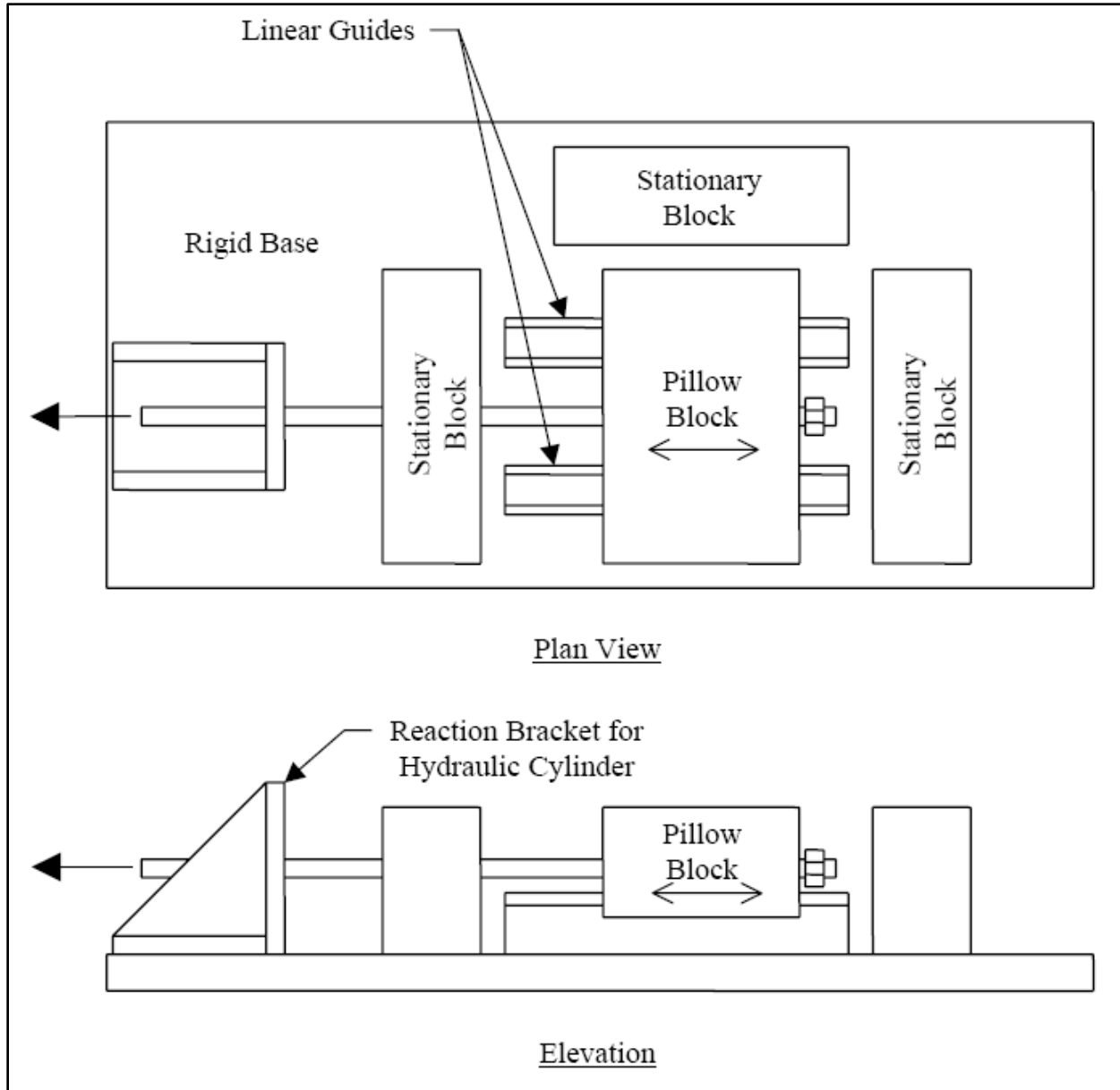


Figure 3: Test Apparatus Diagram

TEST MATRIX

Product	F1	F2	F3	M1
Piazza PTSLB400-54		X		
Piazza PTLB200-54			X	
Piazza PTLB400-54			X	
Piazza PTLB600-54			X	

RESULTS

Piazza PTSLB400-54 F2

Design Information (lbs)	
ASD	299
Ω	3.50
LRFD	478
ϕ	0.457
Nominal	531
Ultimate	1047

Piazza PTLB400-54 F3

Design Information (lbs)	
ASD	286
Ω	3.50
LRFD	458
ϕ	0.457
Nominal	509
Ultimate	1002

Piazza PTLB200-54 F3

Design Information (lbs)	
ASD	292
Ω	3.50
LRFD	467
ϕ	0.457
Nominal	519
Ultimate	1021

Piazza PTLB600-54 F3

Design Information (lbs)	
ASD	292
Ω	3.50
LRFD	467
ϕ	0.457
Nominal	519
Ultimate	1021

OBSERVATIONS

Piazza PTSLB400-54 F2

The clip deflected in the direction the load was applied. The track also deflected away from the stationary L-angle at the higher loads. The applied load increased at a gentle slope until about 1200 lbs on average, where it peaked and then began decreasing. This peak on the graph represents the point at which the clip began to fail.

The clip failed in all test cases by material tearing at the slot which fits around the track flange. No screws sheared. The tests were quite consistent with a low coefficient of variation.

Piazza PTLB200-54 F3

As the hydraulic cylinder was pumped, the load increased linearly up to approximately 800 lbs at the serviceability limit. After this point it began sloping gently up to a maximum of approximately 1200 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track.

At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test. No screws sheared. The tests were consistent with a low coefficient of variation, though the deflection at which the final failure occurred was somewhat inconsistent.

Piazza PTLB400-54 F3

As the hydraulic cylinder was pumped, the load increased with a steep curve up to approximately 800 lbs at the serviceability limit. After this point it began sloping gently up to a maximum of approximately 1200 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track.

At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test. No screws sheared. The tests were consistent with a low coefficient of variation, and the consistency of the deflection at which the final failure occurred was significantly improved from the PTLB200-54.

Piazza PTLB600-54 F3

As the hydraulic cylinder was pumped, the load increased with a steep s-shaped curve up to approximately 1050 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track.

At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test. Test 3 had a noticeably lower serviceability load, which is best explained as settling between the clip heel and track during the early stages of the test.

SUMMARY OF RESULTS

In summary, the following ASD values are recommended for these Piazza clips. The test results from the PTSLB400-54 F2 can be applied for the out-of-plane direction on all sizes of the PTSLB and the PTLB clips. The reasons for this are that there is no eccentric loading on the fasteners in the out-of-plane direction, the PTSLB400-54 contains the minimum number of fasteners of all the clips, and the failure mode is assumed to be consistent in this direction due to identical clip material geometry.

The results are thus as follows:

- PTSLB (all sizes) F2 Allowable Load: **299 lbs**
- PTLB (all sizes) F2 Allowable Load: **299 lbs**
- PTLB200-54 F3 Allowable Load: **292 lbs**
- PTLB400-54 F3 Allowable Load: **286 lbs**
- PTLB600-54 F3 Allowable Load: **292 lbs**

Evaluation of eccentric loading in the fastener group and the shear capacity of an individual fastener in the Piazza Stone material is the responsibility of the design professional. However, the following screw group factors (SGF) are recommended for eccentric loading evaluation of the PTLB clips contained in this report. The calculations supporting these SGF values are appended to this report.

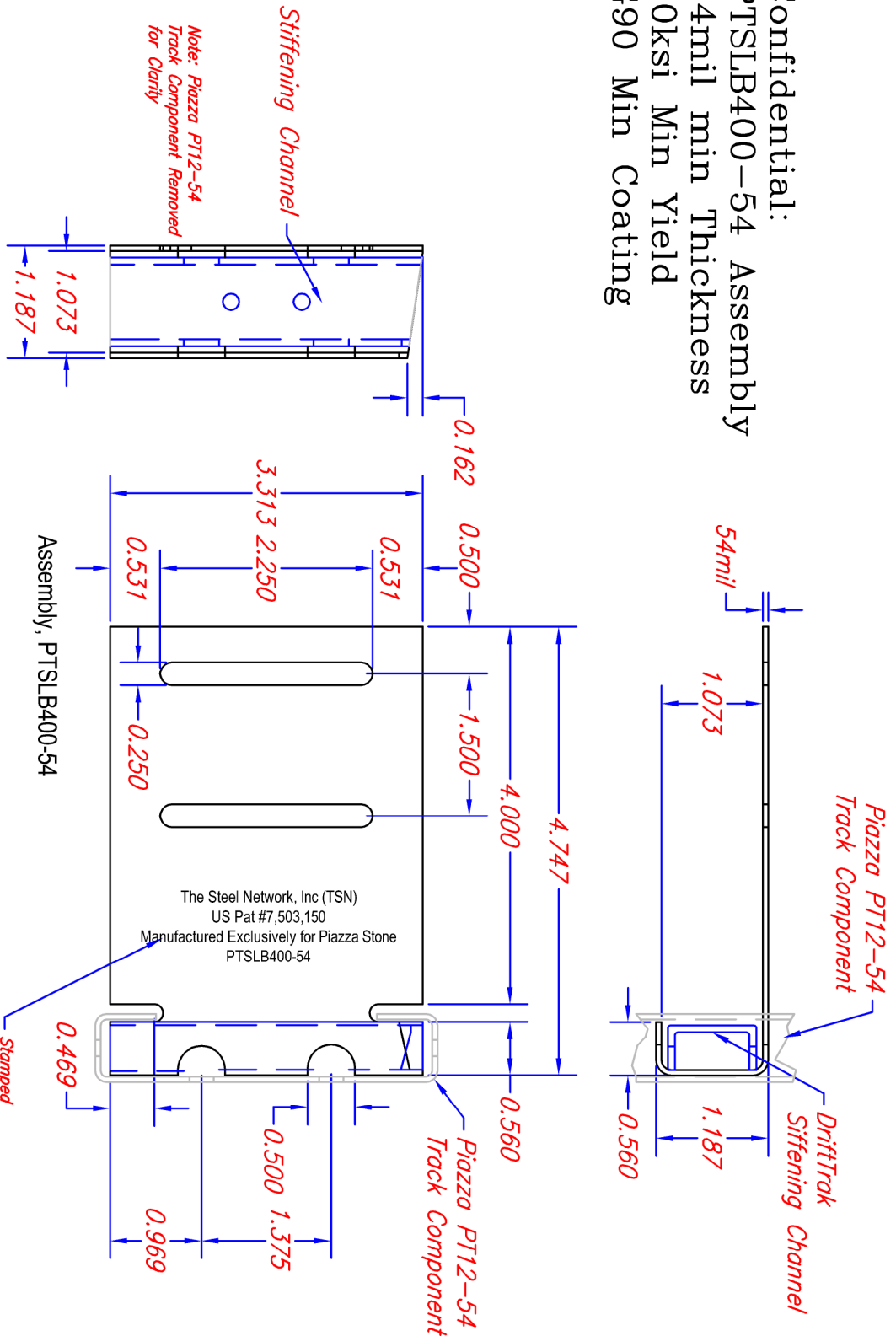
- Recommended PTLB200-54 F3 SGF: **0.83**
- Recommended PTLB400-54 F3 SGF: **1.22**
- Recommended PTLB600-54 F3 SGF: **1.65**

The F2 and F3 results above which apply to the PTLB600-54 can also conservatively be applied to the PTLB-45°-54, since the F2 failure mode would be identical and the eccentricity of the load in the F3 direction is smaller.

ATTACHMENTS

The attachments which follow contain detailed test information from each structural test mentioned in this report. In addition, there are drawings of each clip which was tested. Last, there are Screw Group Factor calculations for the F3 direction for the PTLB200-54, PTLB400-54, and PTLB600-54.

Confidential:
 PTSLB400-54 Assembly
 54mil min Thickness
 50ksi Min Yield
 G90 Min Coating



PART NUMBER		REVISION	
PTSLB400-54 Assy			
DRAWN	APPROVED		
cbs	mjh		
DATE	DATE		
2/14/2020	2/14/2020		

MATERIAL SPECIFICATION
ASTM A 1009 ST30H
50ksi Min Yield Strength
63ksi Min Tensile Strength
0.0538" Min Base Metal Thickness
0.0553" Min Coated Thickness
G90 Min Coating or Approved Equivalent

TOLERANCE	HARD COPY LOCATIONS
1.00" and Under: ±0.031"	Production File
1.00"-2.00": ±0.047"	
Over 2.00": ±0.062"	
Holes and Slots: ±0.005"	
Angles: ±1.5°	
Inside Radius = 1.5x(thickness)	

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Piazza PTSLB400-54 F2

Test #	Load @ 1/8 in	Max Load Unscaled
1	622	1209
2	652	1218
3	600	1154

Test ID	PTSLB400-54-1-F2	
Date	2/20/2020	
Standard	AISI S100-16, Chapter K	
Avg Max Load Unscaled	1194	
Strength Scale Factor	0.877	
Thickness Scale Factor	1	
Avg Scaled Max Load/F.S.	299	
Avg Load @ 1/8 in	625	

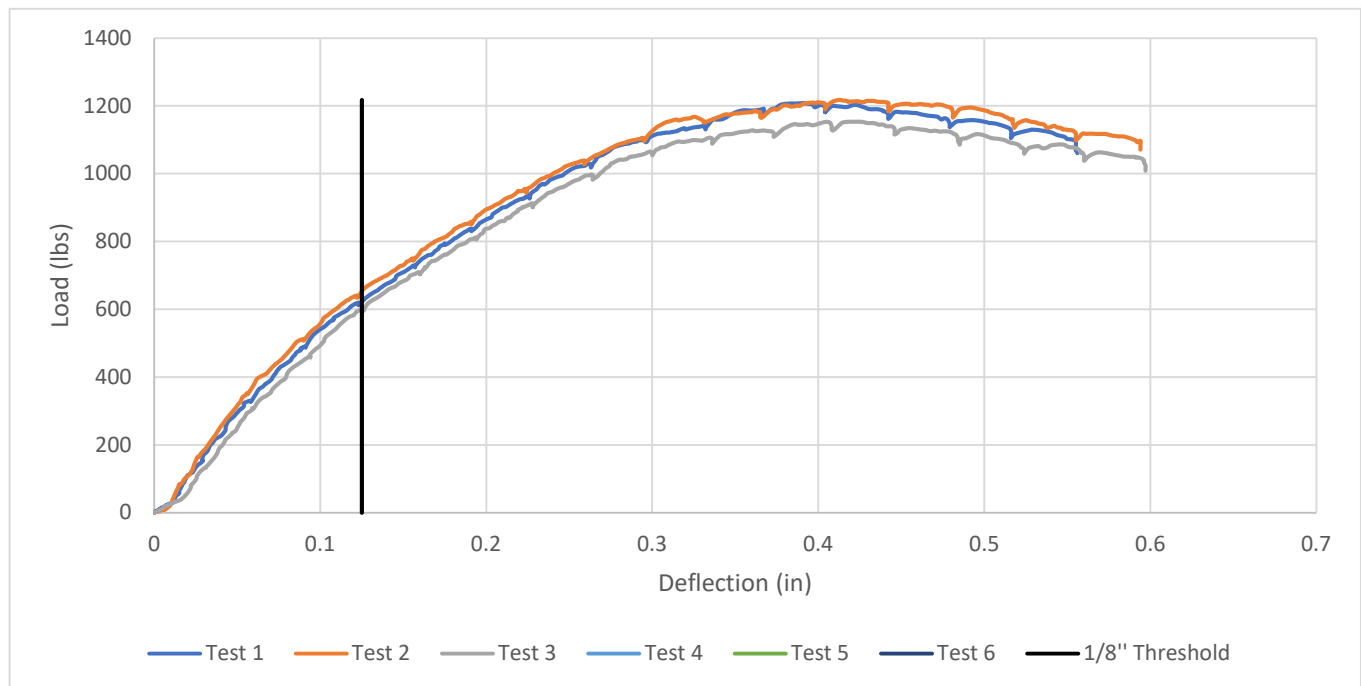
Design Information (lbs)	
ASD	299
Ω	3.50
LRFD	478
ϕ	0.457
Nominal	531
Ultimate	1047

Sensors Calibrated?	Yes
AISI Test Type	Screw Connections
Failure Mode	Clip material tearing

Test Results

The clip deflected in the direction the load was applied. The track also deflected away from the stationary L-angle at the higher loads. The applied load increased at a gentle slope until about 1200 lbs on average, where it peaked and then began decreasing. This peak on the graph represents the point at which the clip began to fail.

The clip failed in all test cases by material tearing at the slot which fits around the track flange.



Test Sample Information

Specified Clip Material Properties	
Steel Grade	ASTM A1003 ST50H
Coating	ASTM A653 G90
Specified Yield Strength (ksi)	50
Specified Tensile Strength (ksi)	65
Specified Design Thickness (in)	0.0566

ASTM A370 Tested Material Properties	
Material Property Source	ASTM A370 Test by Steel Mill
Actual Yield Strength	57
Actual Tensile Strength	77
Elongation	27
Material Test Vendor	N/A
Material Test Number	N/A

Measured Thicknesses	
Sample	Actual Thickness
Test 1	0.0576
Test 2	0.0574
Test 3	0.0578



Pre Test

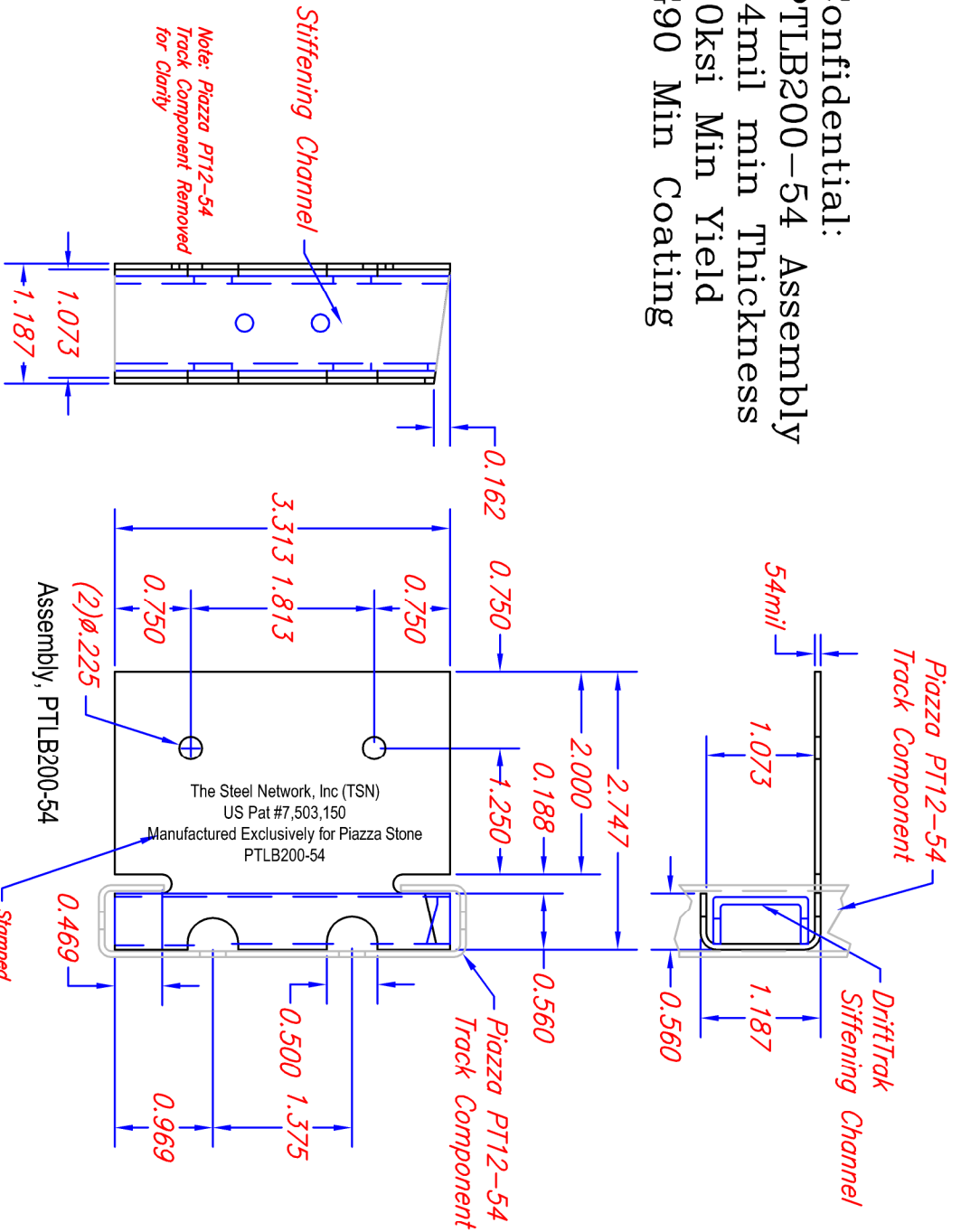


Mid Test



Post Test

Confidential:
 PTLB200-54 Assembly
 54mil min Thickness
 50ksi Min Yield
 G90 Min Coating



PART NUMBER		REVISION	
PTLB200-54 Assy			
DRAWN	APPROVED		
cbs	mjh		
DATE	DATE		
2/14/2020	2/14/2020		

MATERIAL SPECIFICATION
ASTM A-103 ST50H
50ksi Min Yield Strength
63ksi Min Tensile Strength
0.0338" Min Base Metal Thickness
0.0553" Min Coated Thickness
G90 Min Coating or Approved Equivalent

TOLERANCE	HARDCOPY LOCATIONS
1.00" and Under: ±0.031"	Production File
1.00"-2.00": ±0.047"	
Over 2.00": ±0.062"	
Holes and Slots: ±0.005"	
Angles: ±1.5°	
Inside Radius = 1.5x(thickness)	

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Piazza PTLB200-54

Test #	Load @ 1/8 in	Max Load Unscaled
1	815	1196
2	750	1185
3	704	1215

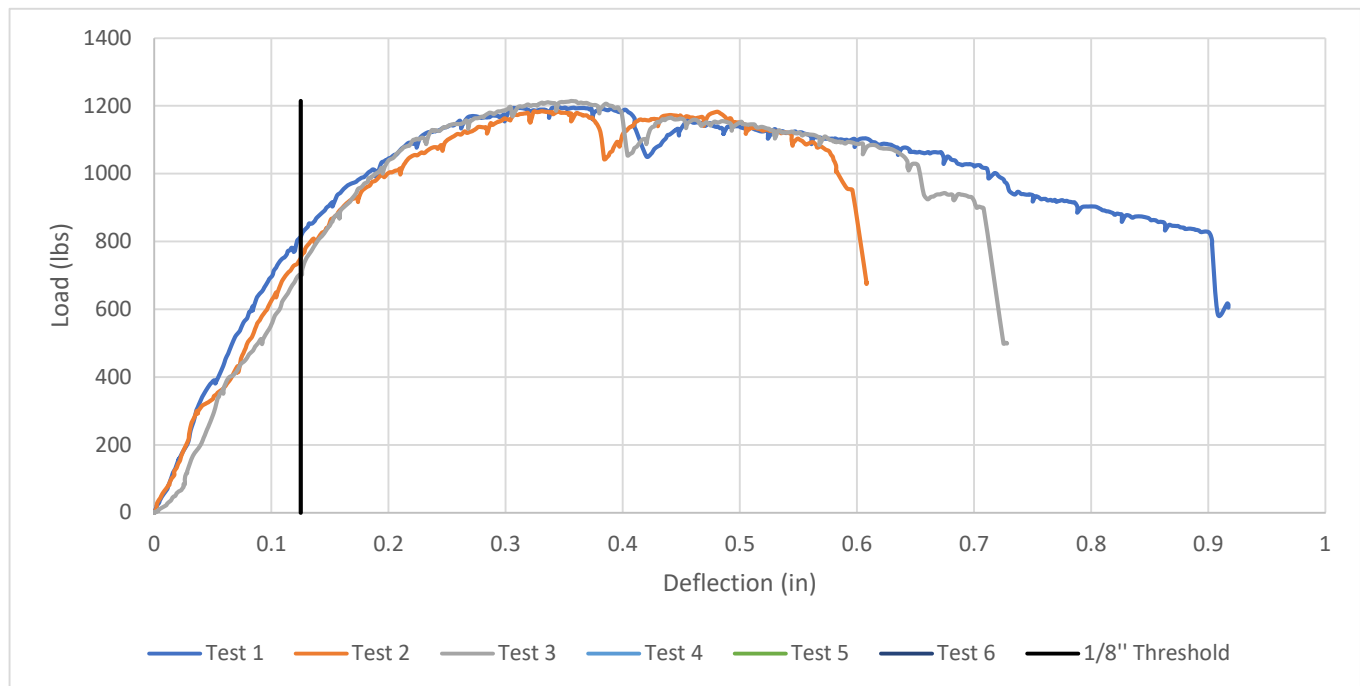
Test ID	PTLB200-54-1-F3	
Date	2/21/2020	
Standard	AISI S100-16, Chapter K	
Avg Max Load Unscaled	1199	
Strength Scale Factor	0.852	
Thickness Scale Factor	1	
Avg Scaled Max Load/F.S.	292	
Avg Load @ 1/8 in	756	

Design Information (lbs)	
ASD	292
Ω	3.50
LRFD	467
ϕ	0.457
Nominal	519
Ultimate	1021

Sensors Calibrated?	Yes
AISI Test Type	Screw Connections
Failure Mode	Clip material yielding

Test Results

As the hydraulic cylinder was pumped, the load increased linearly up to approximately 800 lbs at the servicability limit. After this point it began sloping gently up to a maximum of approximately 1200 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track. At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test.



Test Sample Information

Specified Clip Material Properties	
Steel Grade	ASTM A1003 ST50H
Coating	ASTM A653 G90
Specified Yield Strength (ksi)	50
Specified Tensile Strength (ksi)	65
Specified Design Thickness (in)	0.0566

ASTM A370 Tested Material Properties	
Material Property Source	ASTM A370 Test by Steel Mill
Actual Yield Strength	58.7
Actual Tensile Strength	82.9
Elongation	28
Material Test Vendor	N/A
Material Test Number	N/A

Measured Thicknesses	
Sample	Actual Thickness
Test 1	0.0568
Test 2	0.0565
Test 3	0.0565



Post Test



Post Test

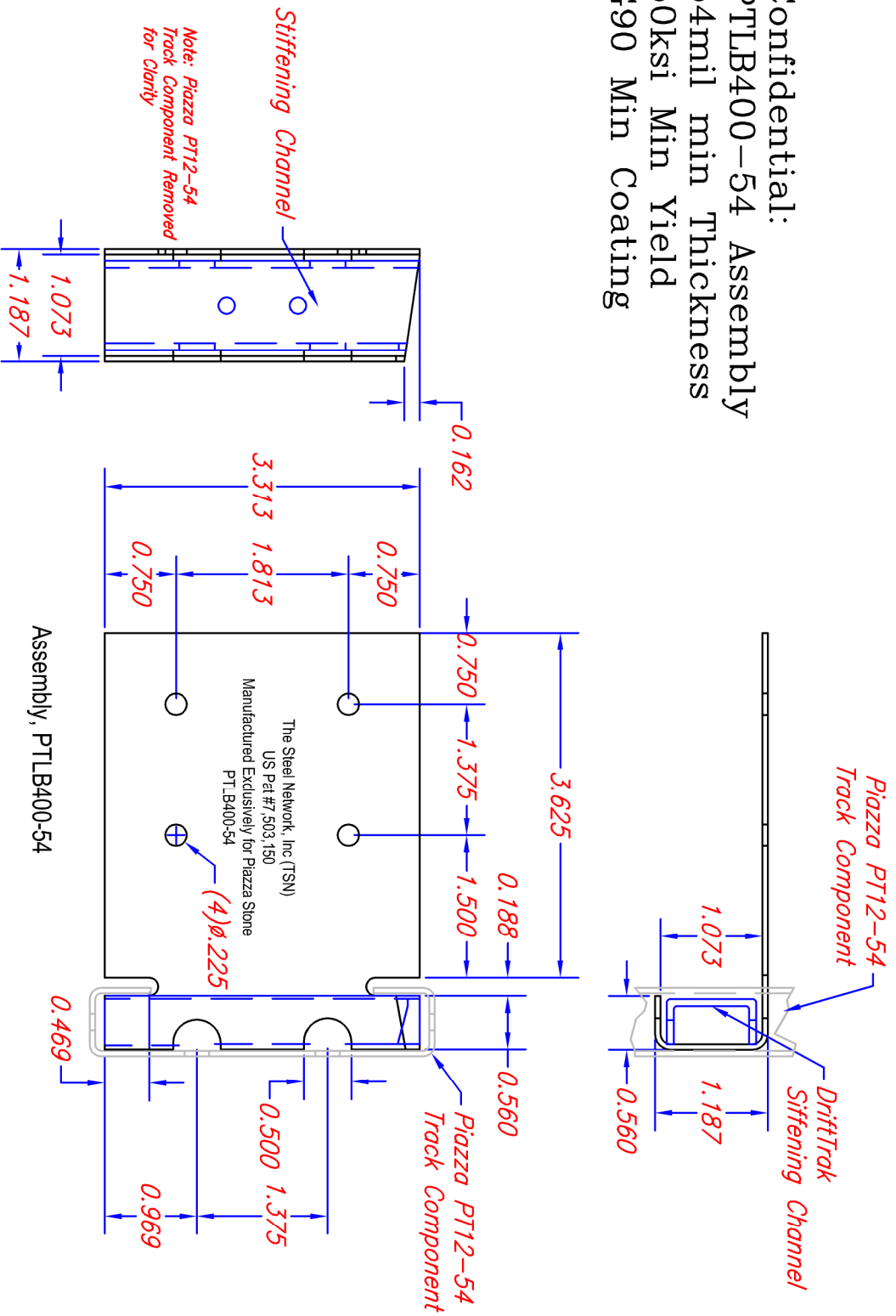


Post Test

SCREW GROUP FACTOR CALCULATOR

Product	Piazza PTLB200-54					
# of Screws in Group	2					
Vertical Load	1000	lbs	Notes -X is the direction of the Eccentricity measurement -Y is the direction of the Load -Resulting Screw Group Factor is in BLUE			
Eccentricity	1.997	in.				
% of bending moment to group	100					
Resulting Torsional M	1997	in-lb				
Screw Group Data & Results						
Screw Count	Coord. from C.G.		Direct Shear	Torsional Shear		Total Shear
	X	Y	Y	Y	X	
	in.	in.	lbs	lbs	lbs	lbs
1	0	0.90625	-500.00	0.00	1101.79	1209.94
2	0	-0.9063	-500.00	0.00	-1101.79	1209.94
3	0	0	0.00	0.00	0.00	0.00
4	0	0	0.00	0.00	0.00	0.00
5	0	0	0.00	0.00	0.00	0.00
6	0	0	0.00	0.00	0.00	0.00
7	0	0	0.00	0.00	0.00	0.00
8	0	0	0.00	0.00	0.00	0.00
9	0	0	0.00	0.00	0.00	0.00
10	0	0	0.00	0.00	0.00	0.00
11	0	0	0.00	0.00	0.00	0.00
12	0	0	0.00	0.00	0.00	0.00
13	0	0	0.00	0.00	0.00	0.00
14	0	0	0.00	0.00	0.00	0.00
15	0	0	0.00	0.00	0.00	0.00
16	0	0	0.00	0.00	0.00	0.00
17	0	0	0.00	0.00	0.00	0.00
18	0	0	0.00	0.00	0.00	0.00
19	0	0	0.00	0.00	0.00	0.00
lx, ly, I total	0	1.64258	1.6426			1209.94
				Screw Group Factor		0.83

Confidential:
 PTLB400-54 Assembly
 54mil min Thickness
 50ksi Min Yield
 G90 Min Coating



PART NUMBER		REVISION	
PTLB400-54 Assy			
DRAWN	APPROVED		
cbs	mjh		
DATE	DATE		
2/14/2020	2/14/2020		

MATERIAL SPECIFICATION
ASTM A 1009 ST50H
50ksi Min Yield Strength
63ksi Min Tensile Strength
0.0538" Min Base Metal Thickness
0.0553" Min Coated Thickness
G90 Min Coating or Approved Equivalent

TOLERANCE	HARD COPY LOCATIONS
1.00" and Under: ±0.031"	Production File
1.00"-2.00": ±0.027"	
Over 2.00": ±0.024"	
Holes and Slots: ±0.005"	
Angles: ±1.5°	
Inside Radius = 1.5X(thickness)	

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Piazza PTLB400-54 F3

Test #	Load @ 1/8 in	Max Load Unscaled
1	787	1168
2	765	1155
3	829	1209

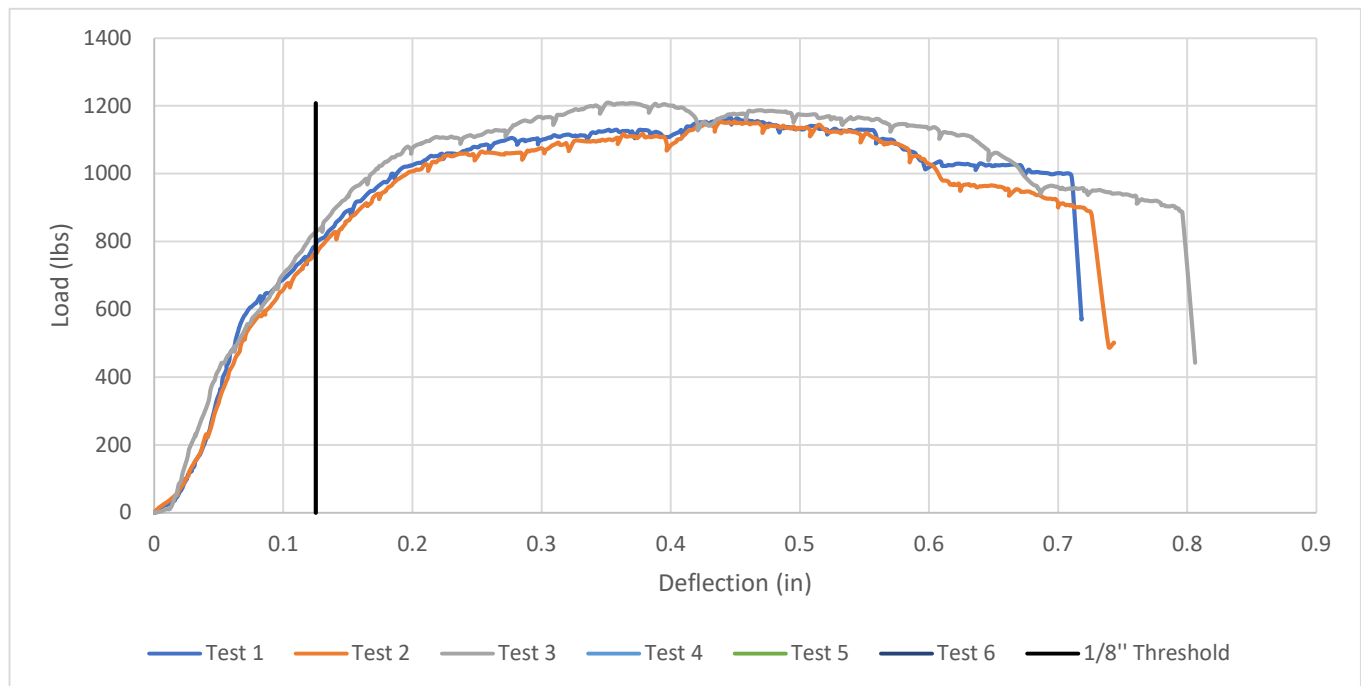
Test ID	PTLB400-54-1-F3	
Date	2/21/2020	
Standard	AISI S100-16, Chapter K	
Avg Max Load Unscaled	1177	
Strength Scale Factor	0.852	
Thickness Scale Factor	1	
Avg Scaled Max Load/F.S.	286	
Avg Load @ 1/8 in	794	

Design Information (lbs)	
ASD	286
Ω	3.50
LRFD	458
ϕ	0.457
Nominal	509
Ultimate	1002

Sensors Calibrated?	Yes
AISI Test Type	Screw Connections
Failure Mode	Clip material yielding

Test Results

As the hydraulic cylinder was pumped, the load increased with a steep curve up to approximately 800 lbs at the servicability limit. After this point it began sloping gently up to a maximum of approximately 1200 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track. At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test.



Test Sample Information

Specified Clip Material Properties	
Steel Grade	ASTM A1003 ST50H
Coating	ASTM A653 G90
Specified Yield Strength (ksi)	50
Specified Tensile Strength (ksi)	65
Specified Design Thickness (in)	0.0566

ASTM A370 Tested Material Properties	
Material Property Source	ASTM A370 Test by Steel Mill
Actual Yield Strength	58.7
Actual Tensile Strength	82.9
Elongation	28
Material Test Vendor	N/A
Material Test Number	N/A

Measured Thicknesses	
Sample	Actual Thickness
Test 1	0.0568
Test 2	0.067
Test 3	0.0567



Post Test



Most Test

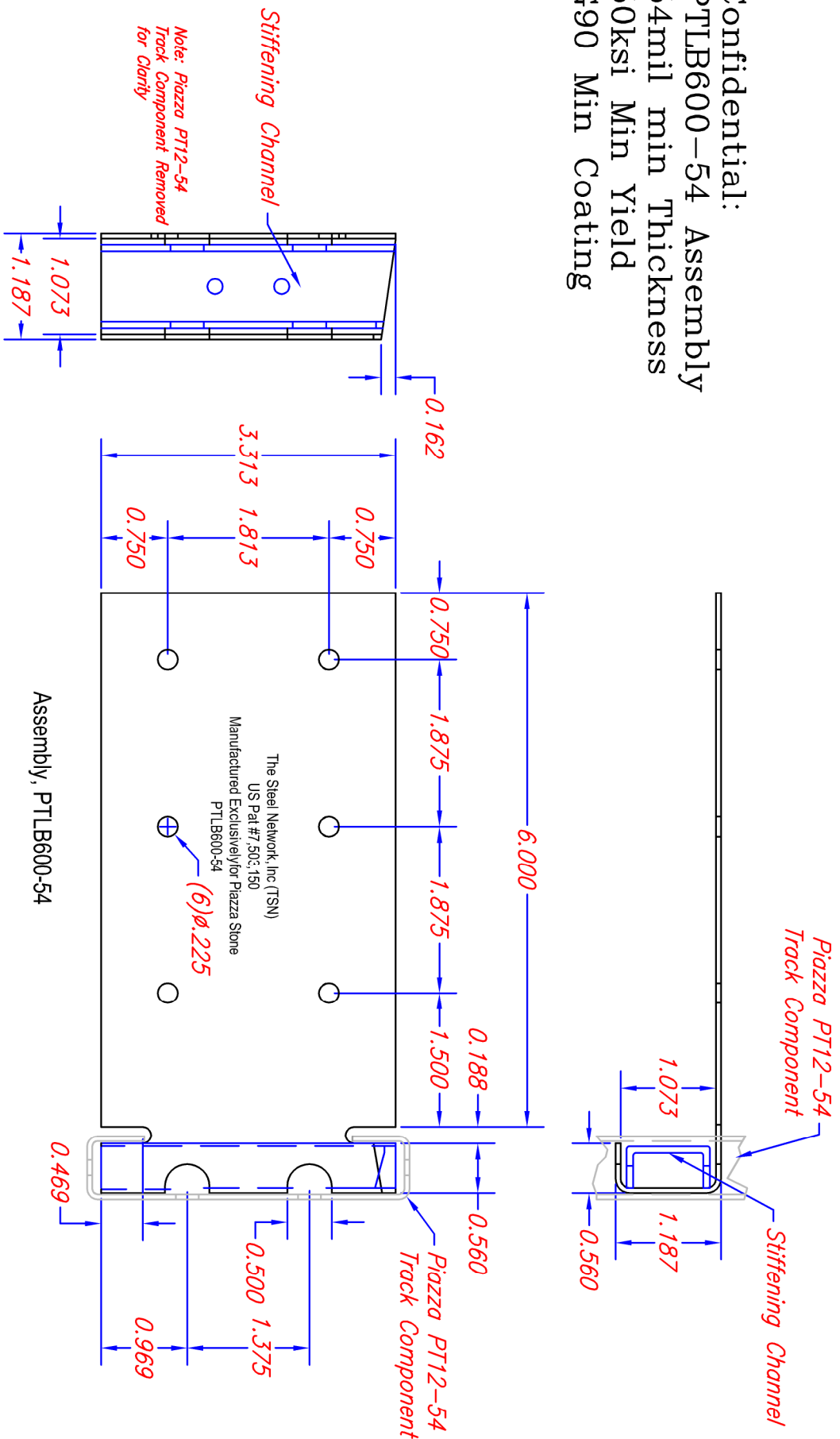


Post Test

SCREW GROUP FACTOR CALCULATOR

Product	Piazza PTLB400-54					
# of Screws in Group	4					
Vertical Load	1000	lbs	Notes -X is the direction of the Eccentricity measurement -Y is the direction of the Load -Resulting Screw Group Factor is in BLUE			
Eccentricity	2.9345	in.				
% of bending moment to group	100					
Resulting Torsional M	2934.5	in-lb				
Screw Group Data & Results						
Screw Count	Coord. from C.G.		Direct Shear	Torsional Shear		Total Shear
	X	Y	Y	Y	X	
	in.	in.	lbs	lbs	lbs	lbs
1	-0.6875	0.90625	-250.00	-389.79	513.81	820.57
2	0.6875	0.90625	-250.00	389.79	513.81	532.49
3	-0.6875	-0.9063	-250.00	-389.79	-513.81	820.57
4	0.6875	-0.9063	-250.00	389.79	-513.81	532.49
5	0	0	0.00	0.00	0.00	0.00
6	0	0	0.00	0.00	0.00	0.00
7	0	0	0.00	0.00	0.00	0.00
8	0	0	0.00	0.00	0.00	0.00
9	0	0	0.00	0.00	0.00	0.00
10	0	0	0.00	0.00	0.00	0.00
11	0	0	0.00	0.00	0.00	0.00
12	0	0	0.00	0.00	0.00	0.00
13	0	0	0.00	0.00	0.00	0.00
14	0	0	0.00	0.00	0.00	0.00
15	0	0	0.00	0.00	0.00	0.00
16	0	0	0.00	0.00	0.00	0.00
17	0	0	0.00	0.00	0.00	0.00
18	0	0	0.00	0.00	0.00	0.00
19	0	0	0.00	0.00	0.00	0.00
lx, ly, I total	1.89063	3.28516	5.1758			820.57
				Screw Group Factor		1.22

Confidential:
 PTLB600-54 Assembly
 54mil min Thickness
 50ksi Min Yield
 G90 Min Coating



PART NUMBER		REVISION	
PTLB600-54 Assy			
DRAWN	APPROVED		
cbs	mjh		
DATE	DATE		
2/14/2020	2/14/2020		

MATERIAL SPECIFICATION
ASTM A 1009 ST30H
50ksi Min Yield Strength
65ksi Min Tensile Strength
0.0538" Min Base Metal Thickness
0.0553" Min Coated Thickness
G90 Min Coating or Approved Equivalent

TOLERANCE	HARD COPY LOCATIONS
1.00" and Under: $\pm 0.031"$	Production File
Over 1.00" - 2.00": $\pm 0.047"$	
Over 2.00": $\pm 0.062"$	
Holes and Slots: $\pm 0.005"$	
Angles: $\pm 1.5^\circ$	
Inside Radius = 1.5x(thickness)	

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 US Patent #7,503,150
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Piazza PTLB600-54 F3

Test #	Load @ 1/8 in	Max Load Unscaled
1	667	1029
2	652	1089
3	292	1074

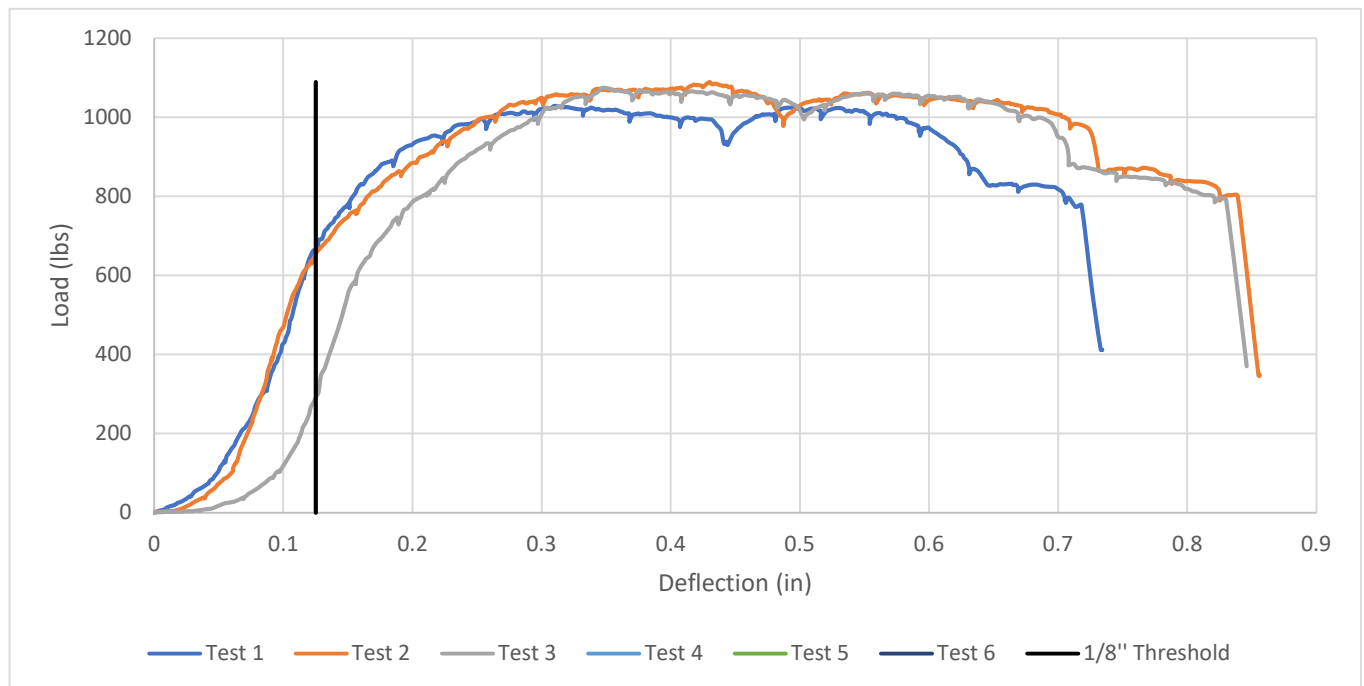
Test ID	PTLB600-54-1-F3	
Date	2/21/2020	
Standard	AISI S100-16, Chapter K	
Avg Max Load Unscaled	1064	
Strength Scale Factor	0.96	
Thickness Scale Factor	1	
Avg Scaled Max Load/F.S.	292	
Avg Load @ 1/8 in	537	

Design Information (lbs)	
ASD	292
Ω	3.50
LRFD	467
ϕ	0.457
Nominal	519
Ultimate	1021

Sensors Calibrated?	Yes
AISI Test Type	Screw Connections
Failure Mode	Clip material yielding

Test Results

As the hydraulic cylinder was pumped, the load increased with a steep s-shaped curve up to approximately 1050 lbs. The load then began slowly decreasing due to a slight rotation of the clip heel inside the track. At a certain point, this rotation continued far enough that the clip slipped out of the track on the far side, ending the test. Test 3 had a noticeably lower servicability load, which is best explained as settling between the clip heel and track during the early stages of the test.

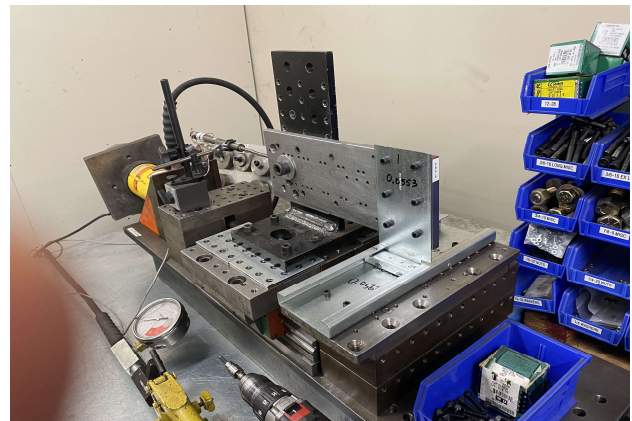


Test Sample Information

Specified Clip Material Properties	
Steel Grade	ASTM A1003 ST50H
Coating	ASTM A653 G90
Specified Yield Strength (ksi)	50
Specified Tensile Strength (ksi)	65
Specified Design Thickness (in)	0.0566

ASTM A370 Tested Material Properties	
Material Property Source	ASTM A370 Test by Steel Mill
Actual Yield Strength	52.1
Actual Tensile Strength	72
Elongation	28
Material Test Vendor	N/A
Material Test Number	N/A

Measured Thicknesses	
Sample	Actual Thickness
Test 1	0.0553
Test 2	0.0556
Test 3	0.0558



Pre Test



Mid Test



Post Test

SCREW GROUP FACTOR CALCULATOR

Product	Piazza PTLB600-54					
# of Screws in Group	6					
Vertical Load	1000	lbs	<div style="border: 1px solid black; padding: 5px;"> Notes -X is the direction of the Eccentricity measurement -Y is the direction of the Load -Resulting Screw Group Factor is in BLUE </div>			
Eccentricity	4.122	in.				
% of bending moment to group	100					
Resulting Torsional M	4122	in-lb				
Screw Group Data & Results						
Screw Count	Coord. from C.G.		Direct Shear	Torsional Shear		Total Shear
	X	Y	Y	Y	X	
	in.	in.	lbs	lbs	lbs	lbs
1	-1.875	0.90625	-166.67	-406.99	196.71	606.44
2	0	0.90625	-166.67	0.00	196.71	257.82
3	1.875	0.90625	-166.67	406.99	196.71	310.56
4	-1.875	-0.9063	-166.67	-406.99	-196.71	606.44
5	0	-0.9063	-166.67	0.00	-196.71	257.82
6	1.875	-0.9063	-166.67	406.99	-196.71	310.56
7	0	0	0.00	0.00	0.00	0.00
8	0	0	0.00	0.00	0.00	0.00
9	0	0	0.00	0.00	0.00	0.00
10	0	0	0.00	0.00	0.00	0.00
11	0	0	0.00	0.00	0.00	0.00
12	0	0	0.00	0.00	0.00	0.00
13	0	0	0.00	0.00	0.00	0.00
14	0	0	0.00	0.00	0.00	0.00
15	0	0	0.00	0.00	0.00	0.00
16	0	0	0.00	0.00	0.00	0.00
17	0	0	0.00	0.00	0.00	0.00
18	0	0	0.00	0.00	0.00	0.00
19	0	0	0.00	0.00	0.00	0.00
lx, ly, l total	14.0625	4.92773	18.99			606.44
				Screw Group Factor		1.65