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Evaluation of the Compressive Strength, Tensile Strength, and Shear Force Resistance of two Steel Holder Products

Test Report-No: 2025-0022

Client:

Contact: *Inna Bukach | Rustam Badalov*
Company: *JustRemedy LLC, DBA Steelholder*
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Purpose of the Test:

Determination of the compressive strength, maximum tensile strength, and shear force resistance of two Steel holder products.

Test Program:

Center for Packaging and Unit Load Design's custom tensile strength test.
Center for Packaging and Unit Load Design's custom shear strength test.
ISO 8611 Test 3AB – Compression test for blocks.

Test Period:

07/06/2025 - 07/15/2025

Test Performed By:

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1. Executive Summary

Compression Strength Test

The static compression strength of the steel holder adjustable support was investigated. Two (2) specimens were cut into 6.00 in. x 17.25 in. pieces, assembled with a 17.50 in. bottom support beam. Load was applied at the intersection between the components. The steel holder assembly and the rigid bar survived 24 hours under 25,000 lbs. without signs of damage. The measured strength of the steel holder assembly was at 100,000 lbs while the measured strength of the rigid bar was 160,000 lbs. These results indicated that each steel holder assembly (D1) and rigid bar (D2) can support at least 25,000 lbs. with a safety factor of 4 and 6, respectively. This load capacity applies as long as the structure is fully supported on a rigid surface, and it does not account for other support conditions or handling scenarios. More information about the tests can be found in **Chapter 3**.

Tensile Strength Test

The maximum tensile strength of the steel holder adjustable beams was investigated. Tension force was applied to the handle of two (2) adjustable beams with dimensions 12.50 in. x 5.88 in. x 4.75 in. The tension force of the rigid bar (12.38 in x 4.00 in. x 4.13 in.) was also investigated with this method. The results indicated that the handle supports at least 300 lbf before failure. More information about the test can be found in **Chapter 4.**

Shear Strength Test

The maximum shear strength to break the connections for each of the support beams was investigated. A support beam connection was constrained on one side to simulate ground support, while a vertical tension force was applied on the connection until failure was reached. The results indicated that the support beam connection can withstand at least 120 lbf in this condition, before the connection fails. A fully constrained scenario was also investigated, with the connection reaching at least 1,000 lbf before failure. More information about the test can be found in **Chapter 5.**

2. Test Specimens

Compression strength test

The Steel holder adjustable pallet design consisted of 2 side adjustable pallet beams (a, b) placed on a rigid support beam (c). The dimensions for the assembly were 25.13 in. x 17.50 in. x 4.75 in. (L x W x H). The overall weight of the assembly was 33.60 lbs. Two (2) assembly specimens were tested. The Steel holder rigid bar dimensions were 16.94 in. x 4.06 in. x 3.94 in. (L x W x H) and the average weight of the structure was 10.00 lbs. Two (2) rigid bar specimens were investigated. A representative picture of the Steel holder adjustable pallet assembly and the Steel holder rigid bar is presented in **Figure 1**.

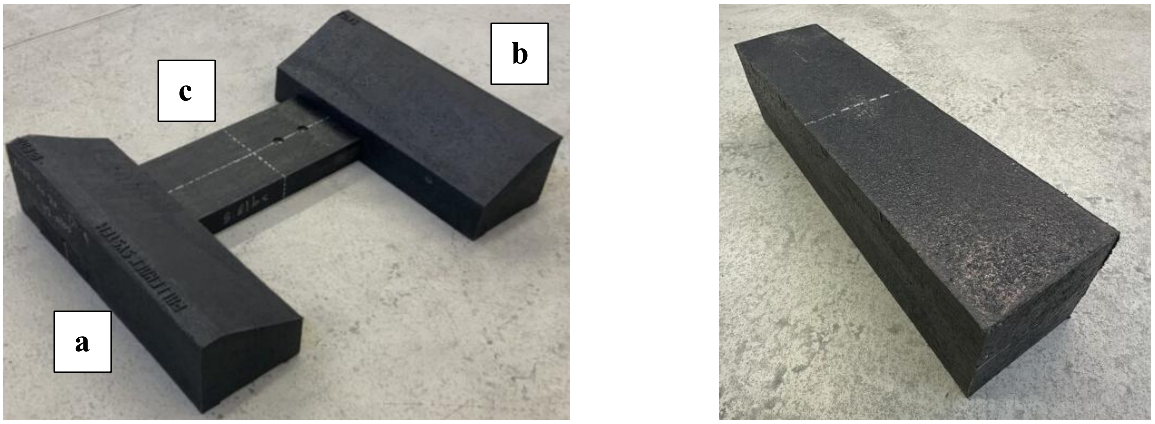

Figure 1: Steel holder adjustable pallet assembly (left) and rigid bar (right).

Tensile strength test

The dimensions of the Steel holder adjustable pallet beam samples used for the tensile strength test were 12.50 in. x 5.88 in. x 4.75 in. (L x W x H). The average weight of the samples was 10.30 lbs. Two (2) adjustable beams were tested as part of the protocol. The rigid bar dimensions were 12.38 in. x 4.12 in. x 4.00 in. (L x W x H). The weight of the tested sample was 7.40 lbs. One (1) rigid bar sample was tested as part of the protocol. A representative picture of the rigid beam is presented in **Figure 2**.

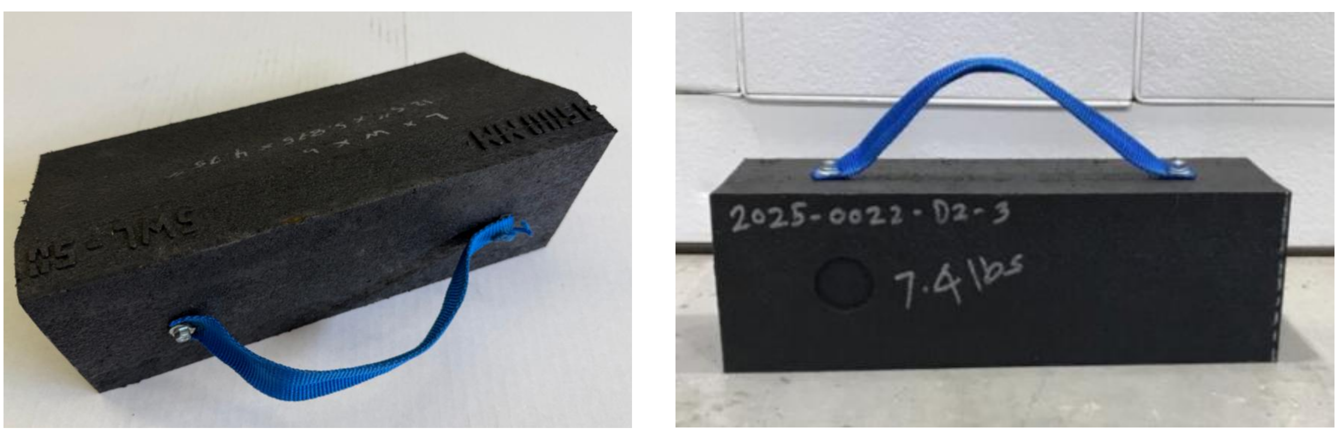

Figure 2: Representative view of the adjustable beam (left) and the rigid bar (right) tensile test samples.

Shear strength test

The dimensions of the Steel holder rigid support beams used for the shear strength test were 25.06 in. x 5.88 in. x 1.69 in. (L x W x H). The tested sample weight was 6.60 lbs. The connection in the assembly was formed by a major piece (a) of dimensions 14.69 in x 6.00 in. x 1.63 in. (L x W x H) and a minor piece (b) of dimensions 10.50 in x 6.00 x 1.63 in. (L x W x H). A circular cut (0.88 in. in diameter) was made to the major piece in the assembly, to pull the structure as part of the test. A representative drawing of the major piece in the assembly is presented in **Figure 3**. A representative picture of the assembly is presented in **Figure 4**.

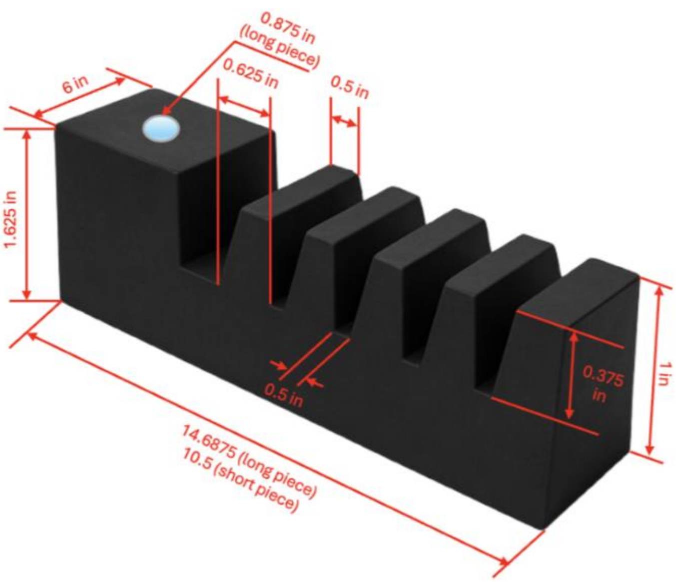

Figure 3: Representative drawing of the major connection piece.

Figure 4: Representative view of the rigid support beam connection.

3. Compression Strength Test

Steel Holder Adjustable Pallet Assembly

The compression strength of the steel holder was investigated following the guidelines of ISO 8611 (2021) - Test 3 A-B – Block compression test. A Tinius Olson compression tester, equipped with four 10,000 lbs. load cells was used for the testing. During the test, four (4) 4 in. wide box-beams, and a 2.13 in. thick rigid plate were used to fully support the specimen. A custom load applicator was built out of plywood with dimensions of 25 in. x 9 in. x 6.44 in. with chamfers to fit the steel holder. The dimensions for the tested assembly were 25.12 in. x 17.50 in. x 4.75 in. The experimental setup is presented in **Figure 5**. Each half of the steel holder was loaded with 25,000 lbs. for 24 hours. The assembly survived the 24-hour test without damage. A representative view of a steel holder section after the test is shown in **Figure 6**. The results of this test are presented in **Table 1**.

Figure 5: Representative compression test view: Steel holder adjustable pallet assembly.

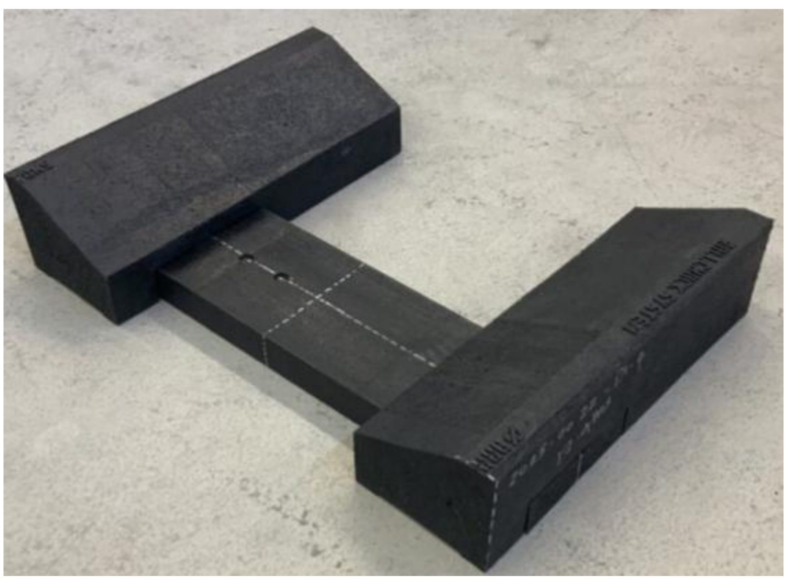

Figure 6: Representative view of the steel holder adjustable pallet assembly after testing.

Table 1: Results of the compression test for the Steel holder adjustable pallet assembly. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample ID	Applied creep load (lbs.)	Initial deflection after applying creep load (in.)	Creep Deflection after 48 Hrs.	Deflection after 2 Hrs. Relax (in.)
D1-1	25,000	0.50	1.19	0.52
D1-2	25,000	0.55	0.89	0.43
Average	-	0.52	1.04	0.48
St. dev.	-	0.04	0.21	0.06
COV (%)	-	7	20	13

Following the compression test, the assembly was loaded until failure. A Satec universal test machine (UTM, model M300WHVL), equipped with a 300,000 lbs. load cell was used for testing. A custom load applicator was built out of plywood with dimensions of 25 in. x 9 in. x 6.44 in. with chamfers to fit the steel holder was used to distribute the payload. The experimental setup is presented in **Figure 7**. The results indicate that the steel holder assembly has a strength of at least 100,000 lbs., before showing signs of damage. The results of this test are presented in **Table 2**. The creep and strength testing results indicate that each steel holder assembly can support 25,000 lb safely with a safety factor of four. This load capacity applies as long as the adjustable pallet assembly is supported on a rigid surface, and it does not account for other support conditions or handling scenarios.

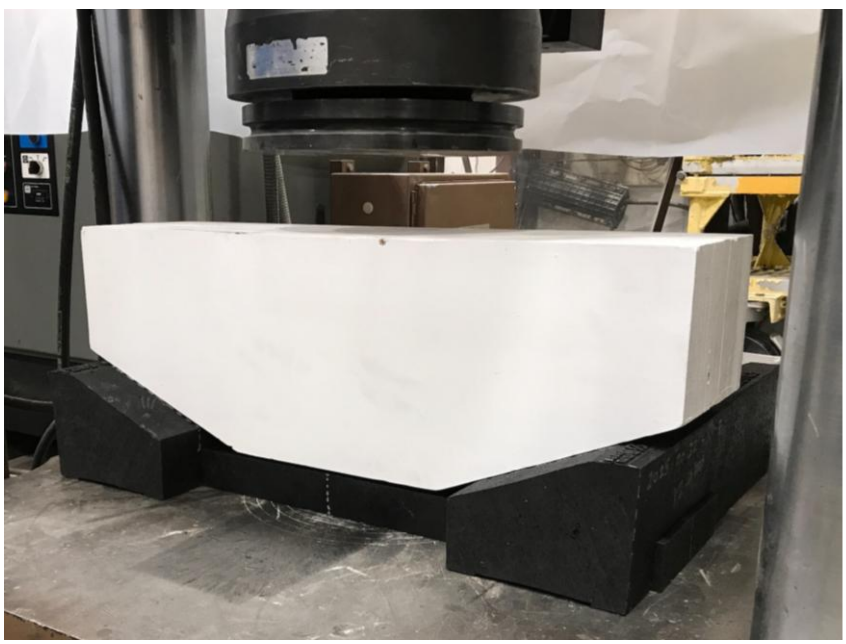

Figure 7: Representative fail test view: Steel holder adjustable pallet assembly.

Table 2: Results of the failure test for the Steel holder adjustable pallet assembly. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample	Max force (lbf.)
D1-1	78,846.79
D1-2	100,747.72
Average	89,797.26
St. Dev.	15,486.29
COV (%)	17.25

Steel Holder Rigid Beam

The compression strength of the steel holder rigid bar was investigated following the guidelines of ISO 8611 (2021) - Test 3 A-B – Block compression test. A Tinius Olson compression tester, equipped with four 10,000 lbs. load cells was used for the testing. During the test, five (5) 4 in. wide box-beams, and a 2.13 in. thick rigid plate were used to fully support the specimen. The experimental setup is presented in **Figure 8**. Each rigid bar sample was loaded with 25,000 lbs. for 24 hours, without damage. A representative view of the bar after the test is shown in **Figure 9**. The results indicate that the static load capacity of the steel holder rigid bar is at least 25,000 lbs. The results of this test are presented in **Table 3**. This load capacity applies as long as the bar is fully supported on a rigid surface, and it does not account for other support conditions or handling scenarios.

Figure 8: Representative compression test view: Steel holder rigid beam.

Figure 9: Representative view of the steel holder rigid bar after testing.

Table 3: Results of the compression test for the Steel holder rigid bar. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample	Applied creep load (lbs.)	Initial deflection after applying creep load (in.)	Creep Deflection after 48 Hrs.	Deflection after 2 Hrs. Relax (in.)
D2-1	25,000	0.43	0.51	0.12
D2-2	25,000	0.52	0.67	0.11
Average	-	0.48	0.59	0.11
St. dev	**-**	0.06	0.12	0.00
COV (%)	**-**	13	20	1

Following the compression test, the rigid bar was loaded until failure. A Satec Universal test machine (UTM, model M300WHVL), equipped with a 300,000 lbs. load cell was used for testing. A custom load applicator was built out of aluminum with dimensions 19.00 in. x 4.50 x 3.00 in. to distribute the payload. The experimental setup is presented in **Figure 10**. The results indicate that the steel holder rigid bar can support at least 160,000 lbs., before showing major deformation damage. The results of this test are presented in Table 4. This load capacity applies as long as the rigid bar is supported on a rigid surface, and it does not account for other support conditions or handling scenarios.

Figure 10: Representative failure test view: Steel holder rigid bar.

Table 4: Results of the failure test for the Steel holder rigid bar. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample ID	Max force (lbf.)
D2-1	161,008.97
D2-2	159,936.69
Average	160,472.83
St. Dev.	758.22
COV (%)	0.47

4. Tensile Strength Test

The tensile strength of the handle in the Steel holder was investigated following a custom testing protocol. An MTS universal testing machine equipped with a 10,000 lbs. load cell was used for the testing. During the test, three (3) 16.00 in. x 2.5 in. x 0.25 in. rigid metal planks were used to fully support the specimens. Two (2) samples of the adjustable beam with dimensions 12.50 in. x 5.88 in. x 4.75 in. (L x W x H) and one (1) handle in a rigid bar of dimensions 12.38 in. x 4.12 in. x 4.00 in. (L x W x H) were evaluated as part of the testing protocol. A tension force was applied on the tested samples until the handle reached failure. The experimental setup is presented in **Figure 11**. The results indicate that the tensile strength of the handle is at least 300 lbf. The results of this test are presented in **Table 5**. A comparison of the maximum tensile strength for the tested samples is presented in **Figure 12**. The failure mode for this test was tearing of the handle at the connection with the steel holder. A representative picture of this failure mode is presented in **Figure 13**.

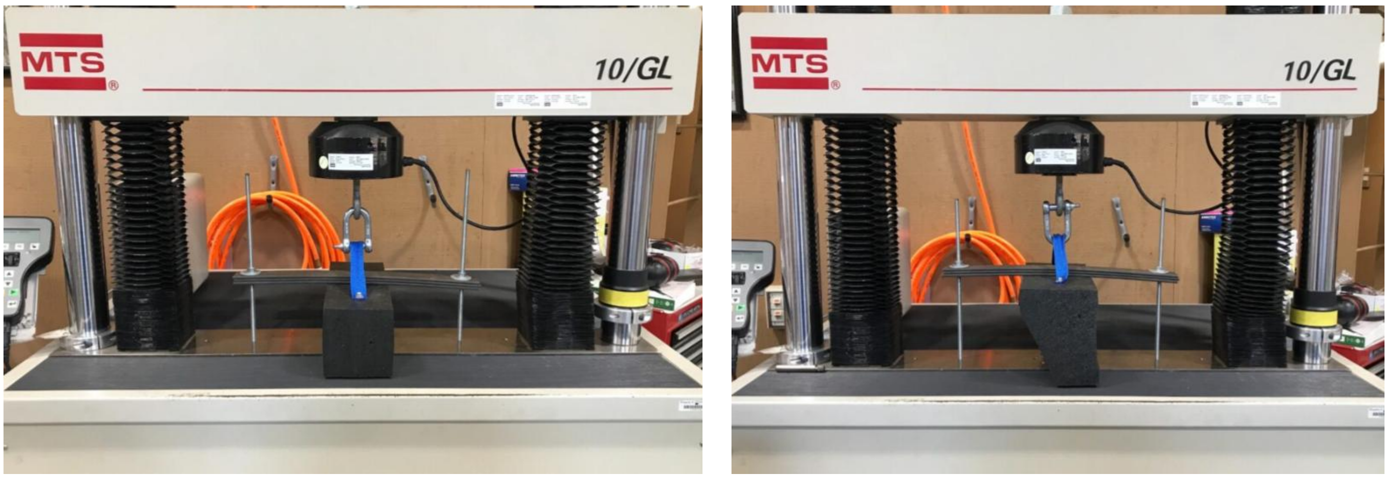

Figure 11: Representative tensile strength test view: rigid bar (left) and adjustable beam (right).

Table 5: Results of the tensile strength test for the Steel holder components. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample	Max tension force (lbf.)	Displacement at failure (in.)
D1-5	316.27	1.05
D1-6	308.26	1.10
D2-3	326.53	1.18
Average	317.02	1.11
St. Dev.	9.16	0.06
COV (%)	2.89	5.73

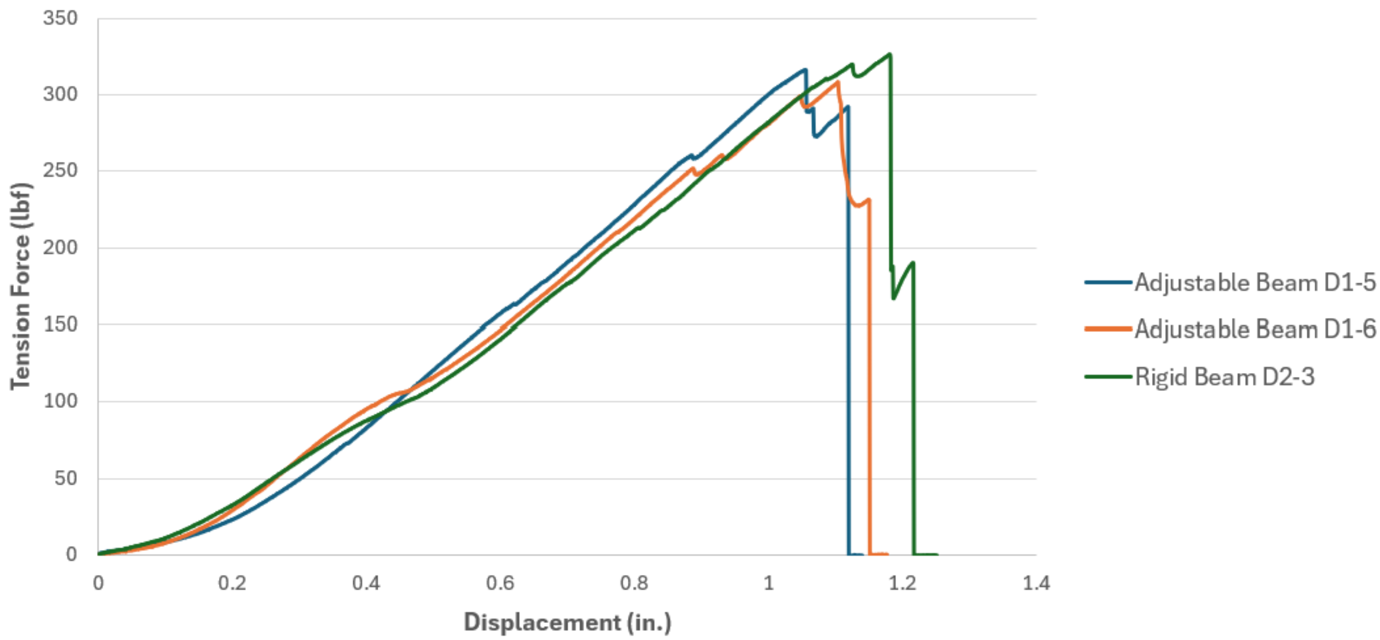

Figure 12: Maximum tensile strength comparison.

Figure 13: Representative picture of the failure mode in the Steel Holder.

5. Shear Strength Test

Unconstrained Condition

The shear strength of the connection in the Steel Holder rigid support beams investigated following a custom testing protocol. An MTS universal testing machine equipped with a 50,000 lbs. load cell was used for the testing. During the test, one (1) 12.00 in. x 12.00 in. x 3.50 in. triangular wooden block stopper was used to fully support the major piece in the connection. The minor piece was constrained with a 13.50 in. x 3.75 in. x 3.00 in. wooden block stopper clamped to the rigid surface of the equipment. Two (2) samples of the rigid support beams with dimensions 25.06 in. x 5.88 in. x 1.69 in. (L x W x H) were evaluated as part of the testing protocol. A tension force was applied on the tested samples until the connection reached failure. Failure was determined when the serrated portion of the major support beam was not connected to the equivalent section of the minor support beam. The experimental setup is presented in **Figure 14**. The results indicate that the shear strength of the connection in this support condition is at least 120 lbf. The results of this test are presented in **Table 6**. A comparison of the maximum shear strength for the tested samples is presented in **Figure 15**. A representative picture of the failure mode for this test is presented in **Figure 16**.

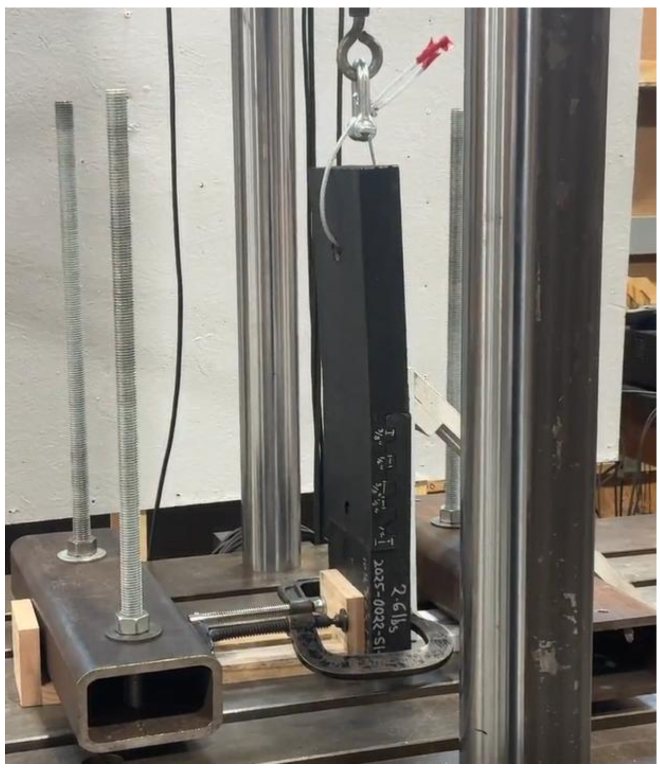

Figure 14: Representative shear strength test view: Unconstrained Condition.

Table 6: Results of the shear strength test (unconstrained) for the Steel holder connection. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample	Max tension force (lbf)	Displacement at failure (in.)
D3-1	124.33	0.86
D3-2	126.93	0.75
Average	125.63	0.81
St. Dev.	1.84	0.08
COV (%)	1.47	9.90

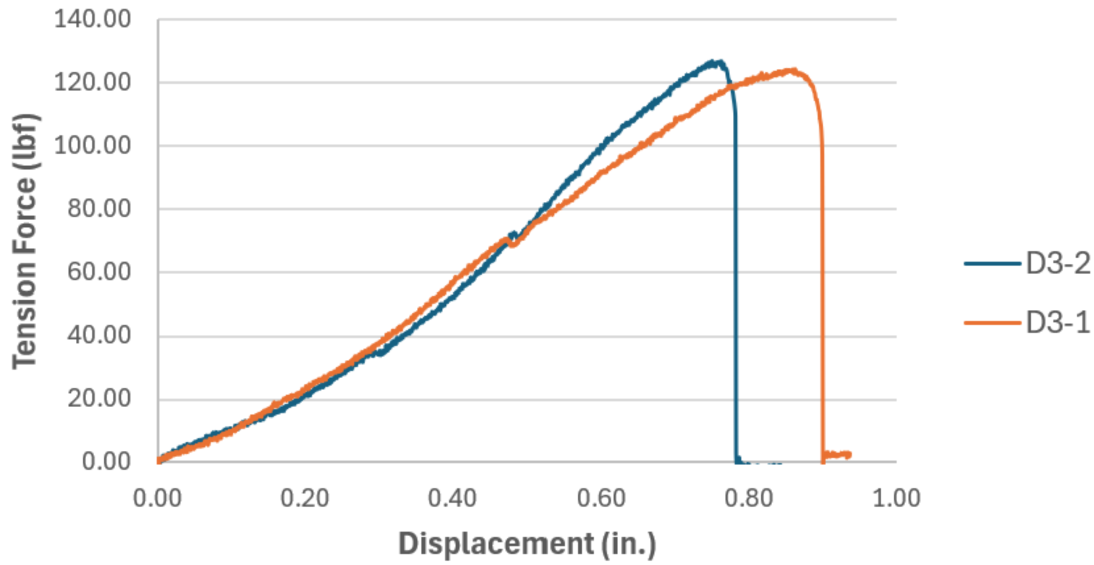

Figure 15: Maximum shear strength comparison (unconstrained condition).

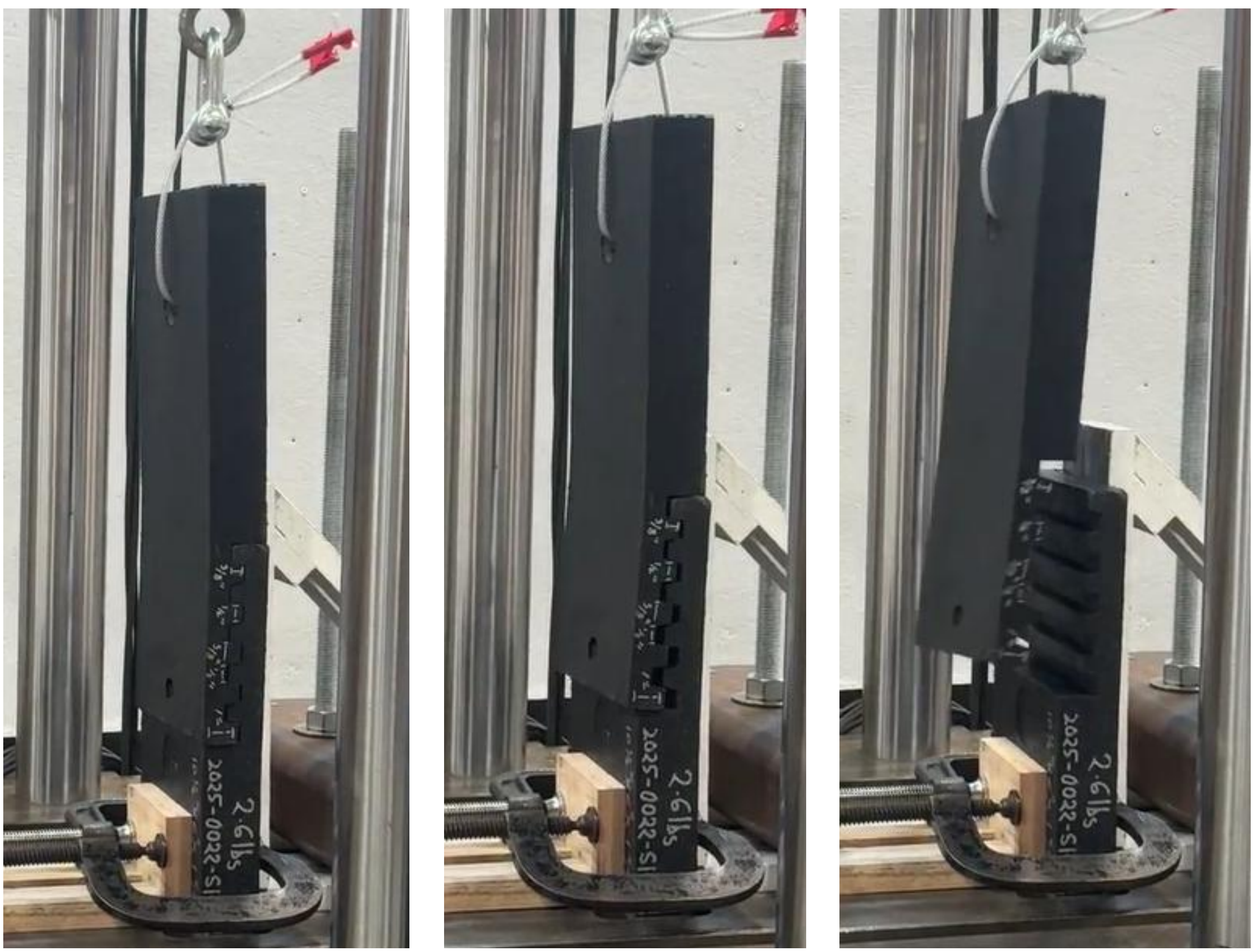

Figure 16: Representative picture of the failure mode in the Steel Holder: Initial condition (left), during testing (middle), and at point of failure (right).

Fully Constrained condition

The shear strength of the connection in the Steel Holder rigid support beams investigated following a custom testing protocol. An MTS universal testing machine equipped with a 50,000 lbs. load cell was used for the testing. During the test, two (2) 13.00 in x 2.00 in. x 0.75 in. metal triangular stoppers were used to fully support the connected pieces. Two (2) samples of the rigid support beams with dimensions 25.06 in. x 5.88 in. x 1.69 in. (L x W x H) were evaluated as part of the testing protocol. A tension force was applied on the tested samples until the connection reached failure. Failure was determined when the serrated portion of the major support beam was not connected to the equivalent section of the minor support beam. The experimental setup is presented in **Figure 17**. The results indicate that the shear strength of the connection in this support condition is at least 1,092 lbf. The results of this test are presented in **Table 7**. A comparison of the maximum shear strength for the tested samples is presented in **Figure 18**. A representative picture of the failure mode for this test is presented in **Figure 19**.

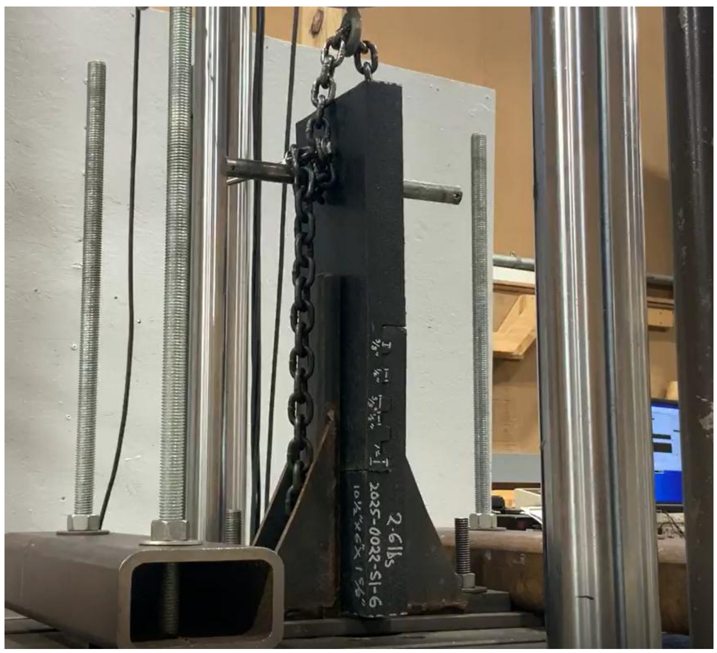

Figure 17: Representative shear strength test view: Constrained Condition.

Table 7: Results of the shear strength test (unconstrained) for the Steel holder connection. St. dev. - Standard Deviation, COV - Coefficient of Variation.

Sample	Max tension force (lbf)	Displacement at failure (in.)
D3-1	1092.53	0.84
D3-2	1156.93	0.85
Average	1124.73	0.84
St. Dev.	45.54	0.00
COV (%)	4.05	0.49

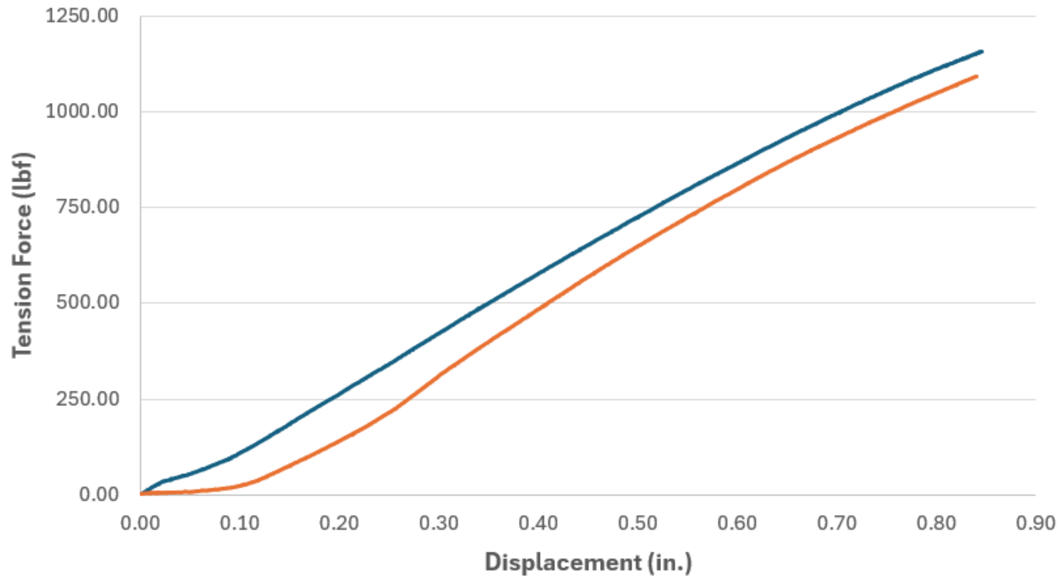

Figure 18: Maximum shear strength comparison (constrained condition).

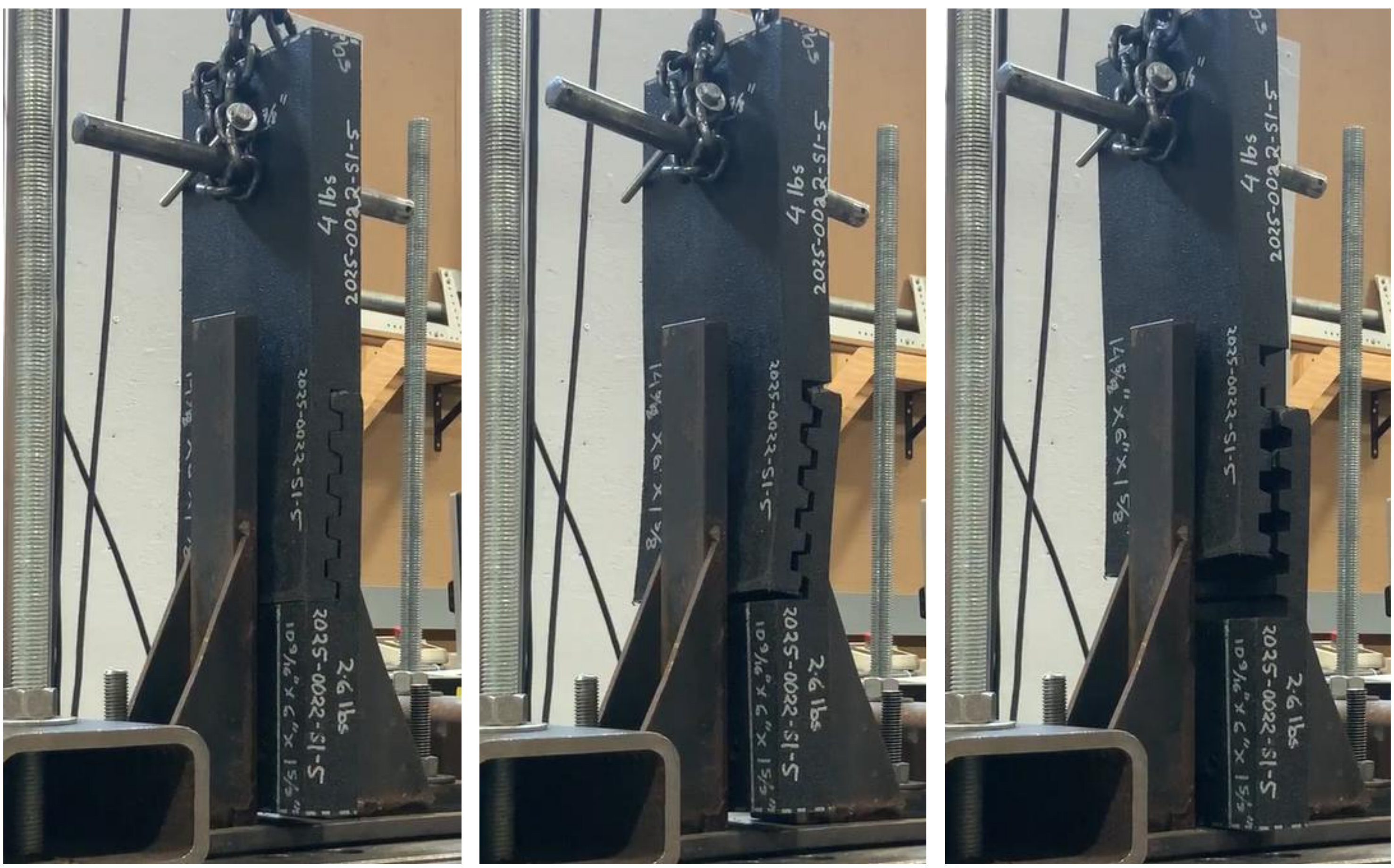

Figure 19: Representative picture of the failure mode in the Steel Holder: Initial condition (left), during testing (middle), and at point of failure (right).

6. Standard Terms and Conditions

The Virginia Tech Center for Packaging and Unit Load Design (CPULD) recognizes that cost-effective testing is a matter of subjective judgment as determined by the Client. Therefore, we offer a range of testing services to meet the specifications of each Client. The Scope of Work Statement forms the sole contractual understanding between the herein named Client and CPULD, and is the result of the information and objectives provided by the Client, and any other written communications (including emails) which may serve to augment or modify the terms herein.

Standards and Accuracy: All lab testing will be done on a best-efforts basis in accordance with the specified or applicable Standards (ISO, ASTM, etc.) to the degree specified by the Client and/or CPULD, or to the limits of the laboratory. Due to the nature of Standards testing, it is likely that Standards will change over time, as will the degree to which CPULD can adhere to them. Client is advised that deviations from the published Standards may affect the degree to which the results are transferrable or generalizable. While CPULD takes reasonable measures to ensure accuracy in testing, variations are to be expected.

Materials: In the absence of specifications to the contrary in the Scope of Work Statement, all materials supplied by the Client (including but not limited to products, tools, equipment, pallets, packaging materials, etc.) will be disposed of by CPULD two weeks after CPULD submits the final report to the Client and will not be returned to the Client at the conclusion of testing.

Timing of Deliverables: Client is advised that testing cannot begin until the Scope of Work Statement is signed and delivered to CPULD, the required fee or down payment must be paid, and all materials to be provided by the Client are actually received at CPULD. If materials are not provided in a timely manner, the tests may not be completed in accordance with the time estimates provided in the Scope of Work Statement. From time to time, additional testing materials to be provided by the Client may be required to complete the testing process, in which case completion of testing may be affected. As an academic research center, the demands of the academic calendar at Virginia Tech may also affect the availability of test equipment and testing personnel, which may impact timetables.

Reports: The deliverable testing report(s) shall not be reproduced, except in full, without the written approval of CPULD.

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Disputes: In the event of a dispute of any sort relating to any aspect of this Scope of Work Statement and the performance of CPULD (including but not limited to research, testing, or deliverables) produced by CPULD, the Client shall notify CPULD in writing within 30 days of receipt of the last deliverable under the agreed-upon Scope of Work