CONNECT-EZ LOAD TEST REPORT
Phase I

Series "V" - 12 x 12

University of Cincinnati

June 16, 2011

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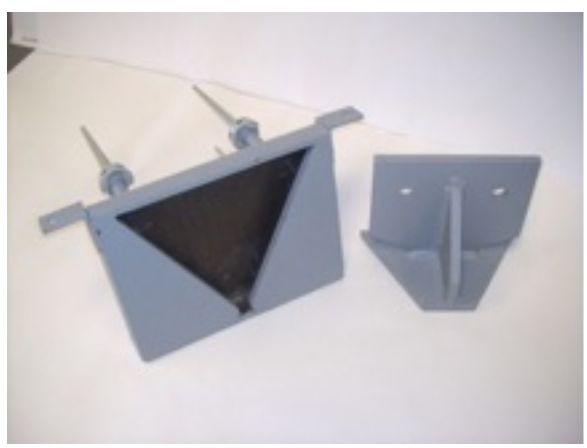


1. Introduction

The CONNECT-EZ series of connection devices eliminate the need for the field welding of connections between steel and concrete structural components during the steel erection process. Furthermore, the devices are designed as a mechanical load transfer device allowing connections to be made remotely.

The main advantages offered by the CONNECT-EZ system are as follows:

- ***Economy:*** Smaller erection crews with fewer skilled welders and less equipment will be needed, and, hence, costs will be reduced.
- ***Speed:*** Elimination of welding speeds erection.
- ***Safety:*** Remotely engaged, mechanical connection reduces the need for workers on ladders, scaffolds, or hydraulic lifts.
- ***Quality:*** Uncertainties of field welding are eliminated with mechanical connection.
- ***Inspection:*** Readily visible connection components allow structural inspections to be conducted quickly, safely, and confidently; while standing on the floor.

2. Experimental Setup

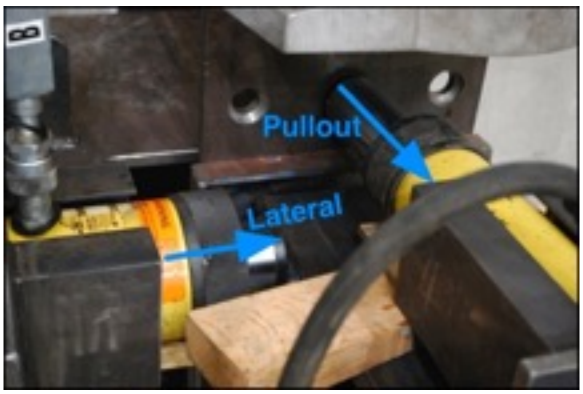
In order to understand the behavior and capacity of CONNECT-EZ devices, a series of load tests was conducted. The focus of this phase of testing was on the CONNECT-EZ (C-EZ) “V” 12x12 devices. The test apparatus (Figure 1) allowed application of lateral load simultaneously with gravity, pullout, or uplift loads that were transferred from the C-EZ bearing-seat to the C-EZ chamber and from the C-EZ chamber to four ¾-inch diameter steel studs. The tests were performed at the University of Cincinnati Large Scale Test Facility (UCLSTF).

Figure 1 Test Setup

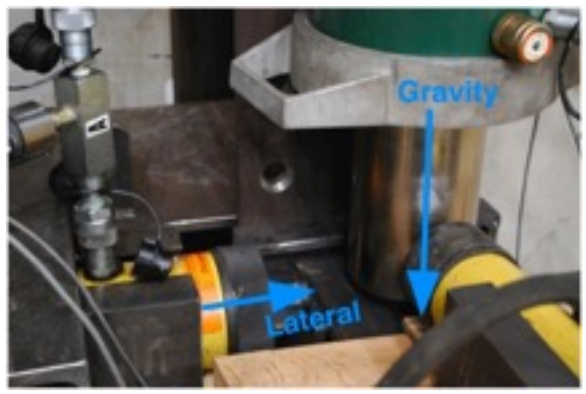
The load combinations were applied according to the protocol shown in Table 1. A pair of hydraulic jacks, shown in Figure 2, was used for the various loading combinations. The locations of various hydraulic jacks are shown in Figure 3. Calibrated pressure transducers were used to electronically measure and record the applied loads.

Table 1 Loading Combinations

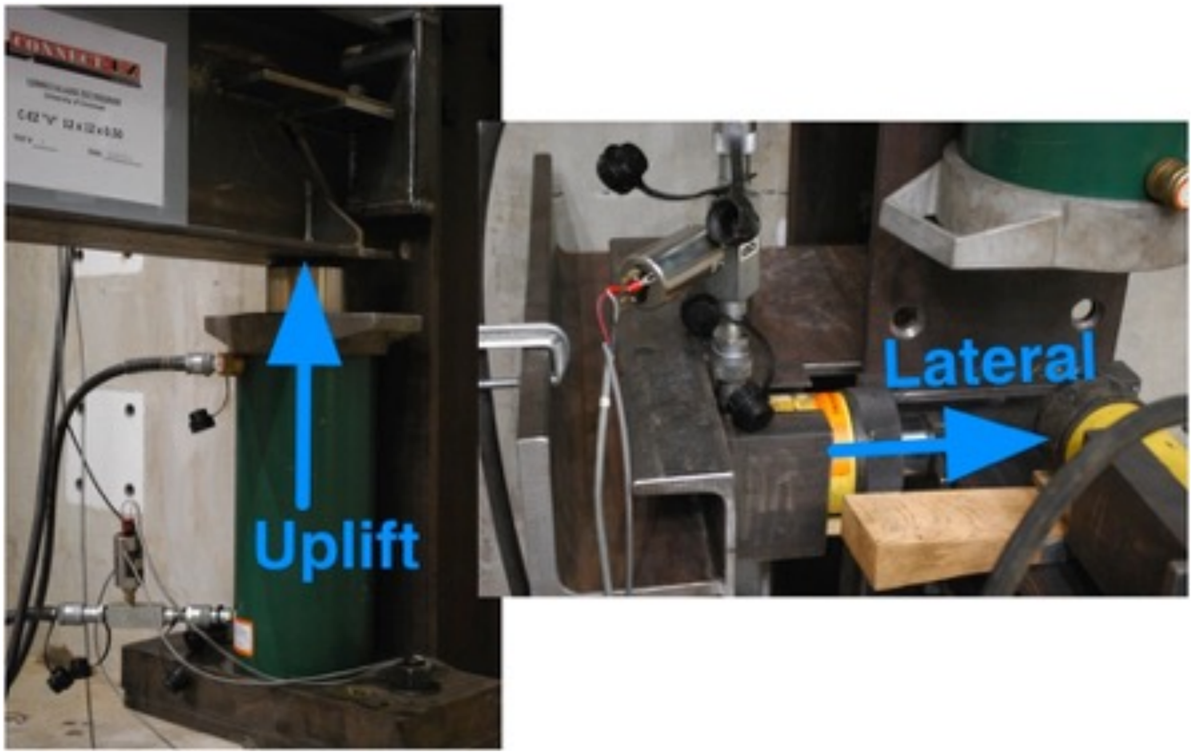
Case	Loads
1	Lateral + Pullout
2	Lateral + Uplift
3	Lateral + Gravity



(a) Lateral + Pullout



(b) Lateral + Gravity



(c) Lateral + Uplift

Figure 2 Hydraulic Jacks

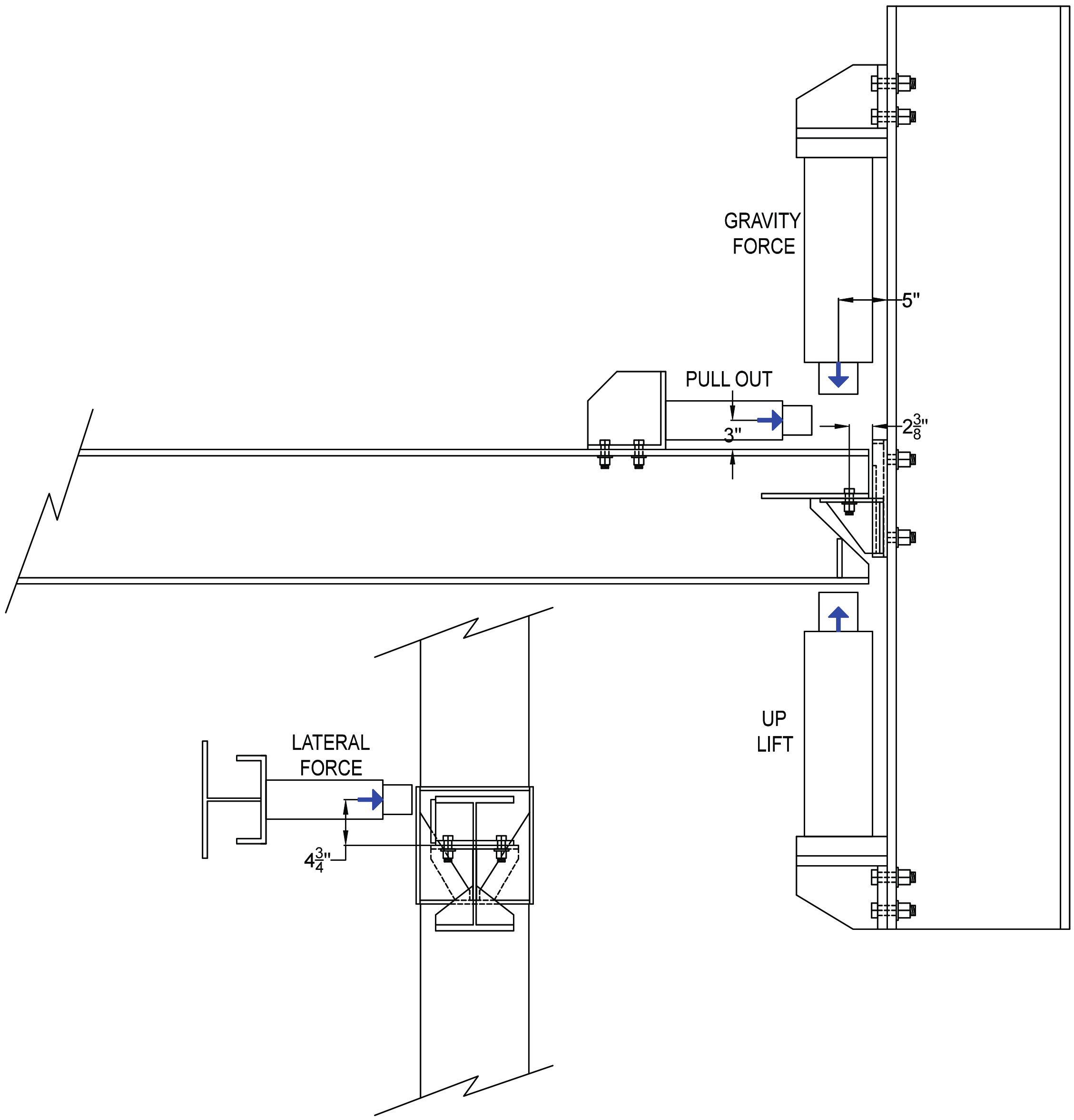


Figure 3 Locations of Hydraulic Jacks

3. Loading Protocol

The levels of various loads were established based on the following criteria.

3.1. Gravity

The gravity, working load was determined by using the "Safe Load" for 72 DLH 17 long span joist (SJI Joist and Joist Girder, Standard ASD Load Table).

Reaction	Working Load	Safety Factor	Ultimate Load

58.4 kips / 2 = 29.2 kips	30.0 kips	X 2.5	75.0 kips

3.2. Uplift

Reaction	Working Load	Safety Factor	Ultimate Load
Dead load: (72DLH17: 56#/lf @ 6.5ft spacing) plus 1.6#/sf (22 ga. wide rib "B" deck) = 10.22 #/sf **Uplift wind load**: - 30 #/sf **Joist span**: 100 ft. **Joist spacing**: 6.5 ft. **Reaction**: -6430 # or -6.5 kips	-6.5 kips	X 2.5	-16.3

3.3 Pullout (i.e., load perpendicular to the plane of the concrete surface)

Reaction	Working Load	Safety Factor	Ultimate Load
Wind load: 30 #/sf **Surface width**: 6.5 ft. **Surface height**: 50 ft. **Reaction**: 4875 # or 5.0 kips	5.0 kips	X 2.5	12.5 kips

3.4 Lateral (i.e., load parallel to the plane of the concrete surface)

Reaction	Working Load	Safety Factor	Ultimate Load
Wind load: 600 #/lft **Joist spacing**: 6.5 ft. **Reaction**: 3900 # or 4.0 kips	4.0 kips	X 2.5	10.0 kips

The tests were conducted according to the sequences shown in Table 2.

Table 2 Loading Sequence

Sequence	Lateral	Pullout	Uplift	Gravity
1	4.0	5.0	x	x
2	4.0	12.5	x	x
3	4.0	x	6.5	x

4	10.0	x	6.5	x
5	4.0	x	16.3	x
6	4.0	x	x	30.0
7	10.0	x	x	30.0
8	4.0	x	x	75.0
9	4.0	x	x	Failure

4. Test Specimens

In this series of tests, the following connectors were tested.

a. C-EZ "V" 12x12x0.5 with the seat welded to the inside face of the chamber
b. C-EZ "V" 12x12x0.375 with the seat welded to the inside face of the chamber
c. C-EZ "V" 12x12x0.375 with the seat not welded
d. C-EZ "V" 12x12x0.25 with the seat welded to the inside face of the chamber

5. Test Results

5.1 C-EZ "V" 12x12x0.50 – Seat Welded

In this specimen, the back edge of the seat was welded (1/4 inch x 5 inch fillet) to the inside face of the chamber. The measured loads are summarized in Table 3. The specimen failed at 70 kips. The failure was due to fracture of the top two studs, as shown in Figure 4. The failure load corresponds to a factor of safety of 2.33.

Table 3 Test Results – C-EZ "V" 12x12x0.5 – Seat Welded

Sequence	Lateral	Pullout	Uplift	Gravity
1	---	5.4	X	x
	4.7	5.1	x	x
2	4.2	12.6	x	x
3	4.0	x	6.3*	x
4	9.7*	x	5.4*	x
5	4.3	x	15.9+	x
6	---	x	x	30.4**
	4.1	x	x	28.3*
7	10.4	x	x	26.9*

8	3.6*	x	x	70.0 (F.S. = 2.33)

+ The support beam began to uplift after applying 9.7 kips, and loading was stopped.
*The hydraulic pressure dropped after achieving the target load.
** Maximum applied load

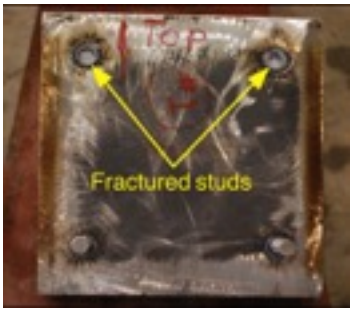


Figure 4 Failure Mode

<u>5.2 C-EZ "V" 12x12x0.375 - Seat Welded</u>

In this specimen, the back edge of the seat was welded (1/4 inch x 6 inch fillet) to the inside face of the chamber. The test results are summarized in Table 4. After applying 76 kips of gravity load, the gusset plate under the seat began to yield, as shown in Figure 5. At 97.2 kips, the weld between the seat and the chamber began to fracture after noticeable bending of the seat (see Figure 6), and testing was stopped. After weld fracture, the connection was still able to resist 63.5 kips of gravity load, which corresponds to a safety factor of 2.12, and 2.3 kips of lateral load. Considering the excessive bending of the seat and residual capacity, the failure mode is classified as ductile. The failure load corresponds to a safety factor of 3.24.

Table 4 Test Results – C-EZ “V” 12x12x0.375 – Seat Welded

Sequence	Lateral	Pullout	Uplift	Gravity
1	4.4	---	x	x
	3.9*	5.1	x	x
2	4.0	12.6	x	x
3	6.3	x	5.2*	x
4	9.6+	x	4.9*	x
5	4.0	x	13.3	x
	3.8*	x	14.6**	x
6	---	x	x	32.1**
	4.0	x	x	28.0*

7	10.2	x	x	31.2
8	4.6	x	x	76.3
9	3.7*	x	x	97.2 (F.S. = 3.24)

+ The support beam began to uplift after applying 9.7 kips.
*The hydraulic pressure dropped after achieving the target load.
** Maximum applied load.

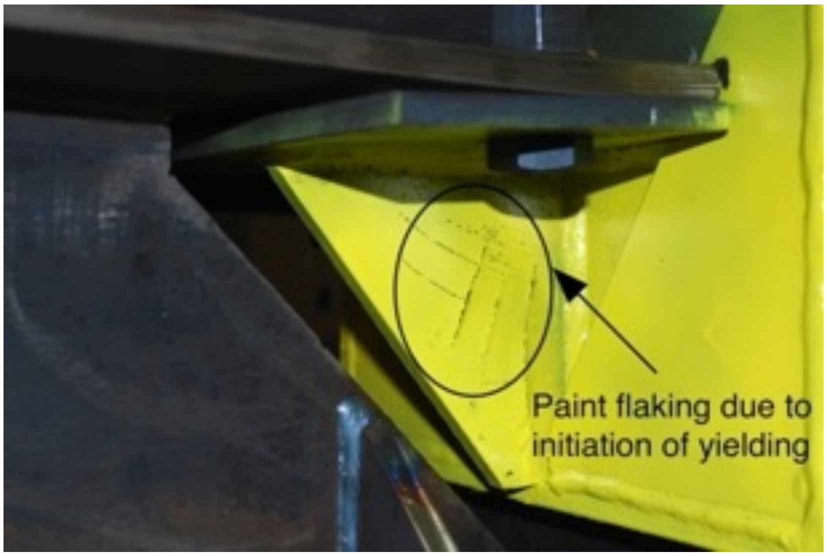
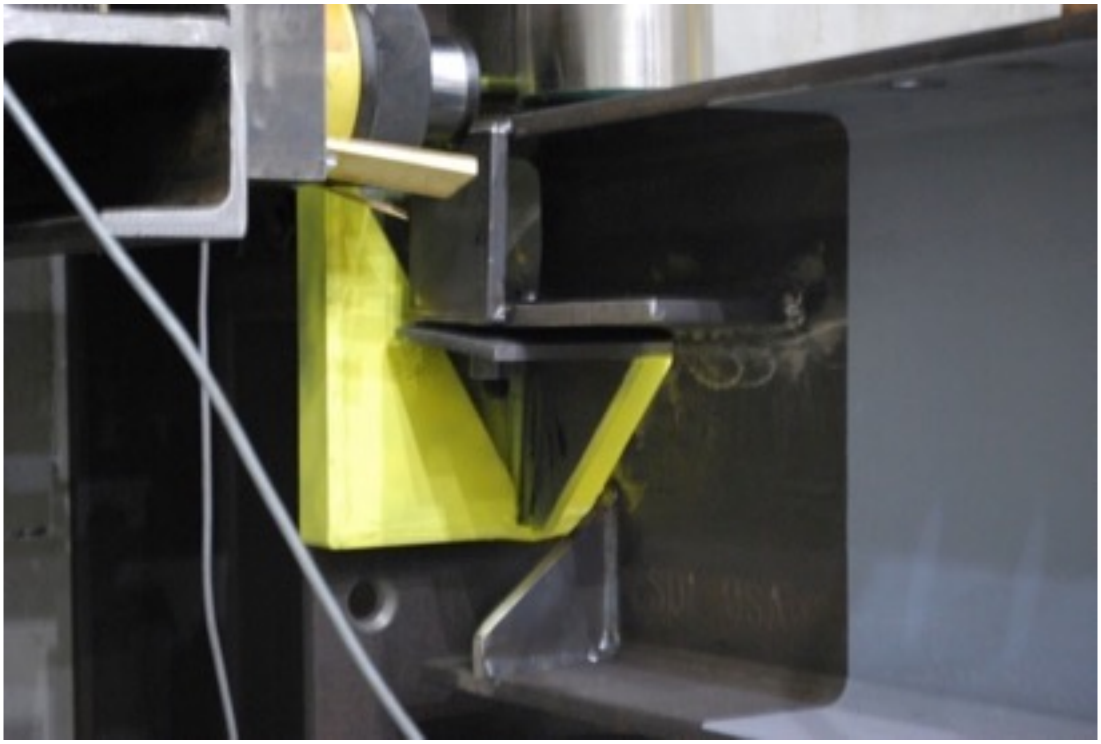
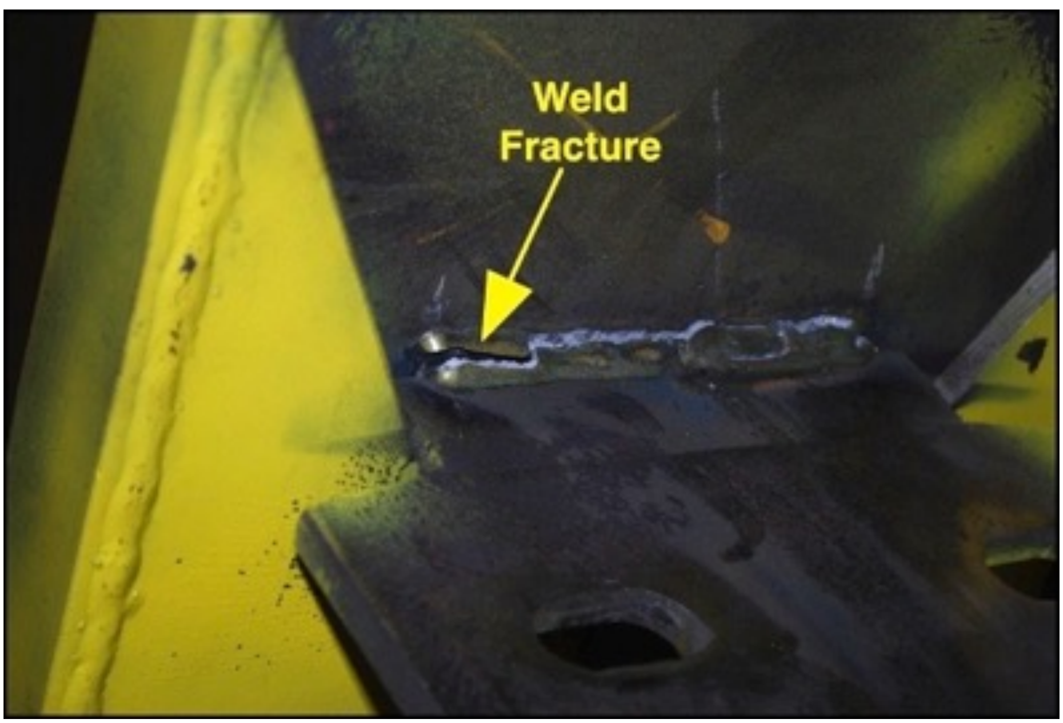


Figure 5 Initiation of Yielding



(a) Prior to Weld Fracture



(b) Weld Fracture

Figure 6 Failure of Specimen

5.3 C-EZ "V" 12x12x0.375 - Seat Not Welded

The seat was not welded in this specimen. As a result, uplift loads were not applied. The test results are summarized in Table 5. After developing 67.4 kips of gravity load (which corresponds to a safety factor of 2.25), the chamber's bottom plate directly below the seat began to fail, as seen from Figure 7. The failure mode was ductile, and was due to weld fracture accompanied by plate bending. The gusset plate had begun to yield as evident by paint flaking.

Table 5 Test Results – C-EZ "V" 12x12x0.375 - Seat not welded

Sequence	Lateral	Pullout	Uplift	Gravity
1	4.2	---	x	x
	3.9*	5.0	x	x
2	4.4	12.6	x	x
3	x	x	x	x
4	x	x	x	x
5	x	x	x	x
6	---	x	x	31.0
	3.9*	x	x	27.5*
7	9.8**	x	x	29.6*
8	4.4	x	x	67.4 (F.S. = 2.25)

*The hydraulic pressure dropped after achieving the target load.
** Maximum applied load.

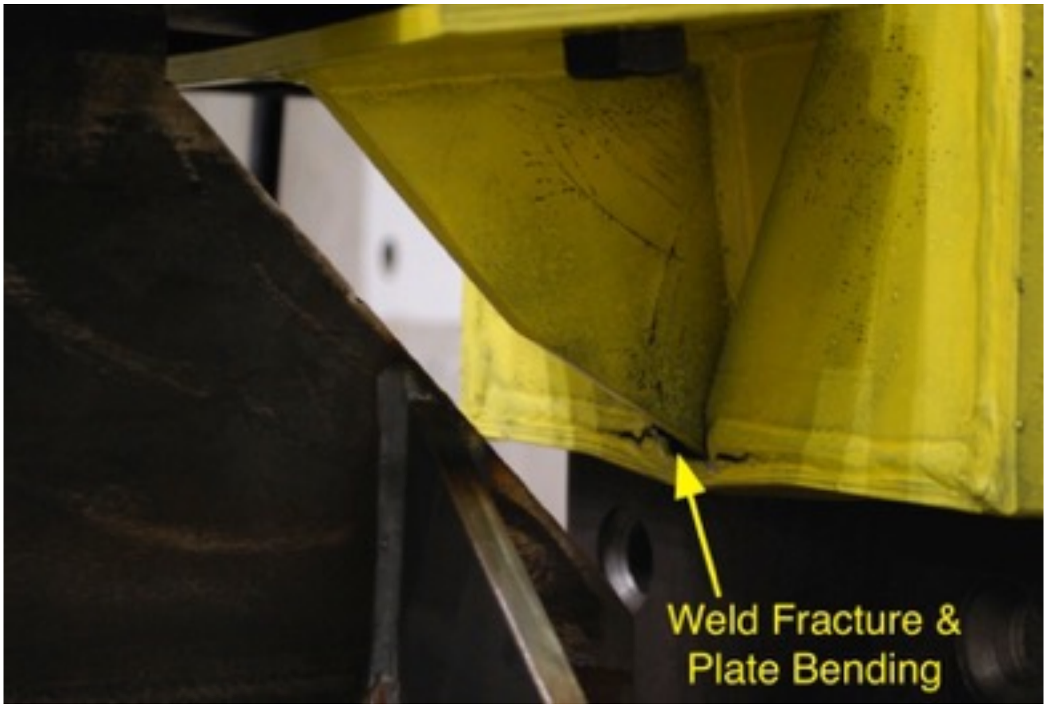


Figure 7 Failure Pattern at Peak Load

Beyond the initial weld fracture and plate bending, the connection was able to resist additional loads. It was able to resist 5.5 kips of lateral load and 49.5 kips of gravity, both of which exceed the service level loads of 4 kips and 30 kips, respectively. Due to excessive deflection of the loading beam, the lateral load was removed and the gravity load was increased to 54.5 kips. At this load the weld fracture and plate bending had spread over a large portion of the chamber, refer to Figure 8, and loading was stopped.

Figure 8 Condition of the Connection at the Conclusion of Testing

5.4 C-EZ "V" 12x12x0.25 - Seat Welded

This connection was able to resist 70.0 kips of gravity load – refer to Table 6. This load corresponds to a safety factor of 2.33. The seat had been welded to the back plate of the chamber. The back plate of the chamber experienced large deformations as the seat rotated. The failure mode was very ductile. Excessive bending of the back plate is evident from Figure 9.

The back edge of the seat was welded (1/4 inch x 6 inch fillet) to the inside face of the chamber.

Table 6 Test Results – C-EZ "V" 12x12x0.25 - Seat welded

Sequence	Lateral	Pullout	Uplift	Gravity
1	4.7	5.1	x	x
2	4.2	12.6	x	x
3	---	x	8.6**	x
	4.3	x	6.6	x
4	4.9	x	6.0*	x
	6.7+	x	5.3*	x
5	3.1	x	16.1**	x
	4.0	x	14.7*	x
6	---	x	x	30.2**
	4.1	x	x	28.3*
7	5.5	x	x	28.0*
	10.4	x	x	26.9*
8	4.2	x	x	22.2*
	3.6*	x	x	70.0 (F.S. = 2.33)

+ The loading was stopped at 6.7 kips due to excessive bending in the seat.
*The hydraulic pressure dropped after achieving the target load.
** Maximum applied load

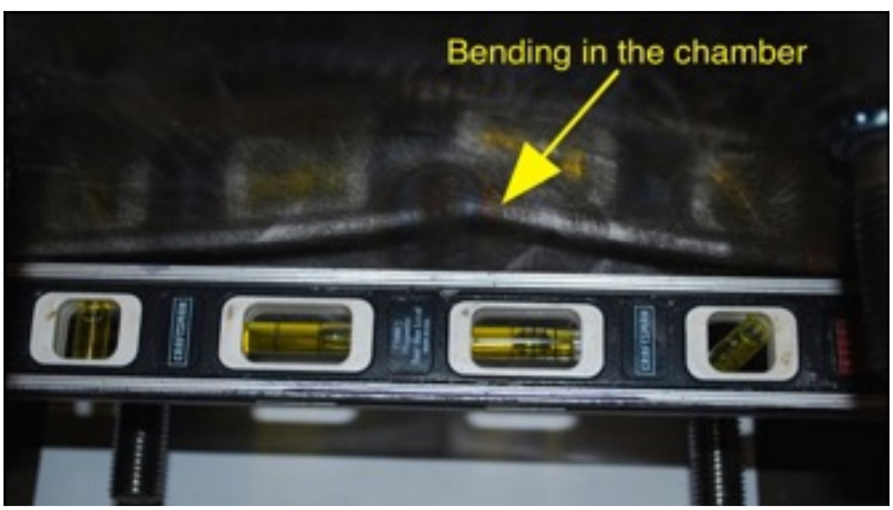


Figure 9 Bending on the Back Plate in the Chamber

6. Summary and Observations

The devices were able to develop and exceed the expected working loads by a safety factor of at least 2.25. The loadings applied in this series of tests equals or exceeds the combinations of dead and live loads (gravity, wind, and seismic) that would reasonably be expected to be resisted by a structure in 90% of the regions of the United States.

The failure modes were generally ductile with the exception of stud fracture in CV-EZ “V” 12x12x0.5 device. Nevertheless, the studs fractured at a load 233% larger than the working load, and it occurred after excessive bending in the seat angle. In this case, the observed stud fracture may be classified as “ductile” because of excessive visual deformations prior to failure.

The specimens for this series of tests were not embedded in concrete. The focus of these tests was to demonstrate the performance and capacity of the Connect-EZ system to transfer loads between the C-EZ bearing-seat and the C-EZ chamber and between the C-EZ chamber and four attached ¾ inch diameter steel studs. The structural engineer’s design of the studs to transfer loads from the CONNECT-EZ devices to a concrete section may be accomplished according to well-established methods available in Appendix D of ACI 318 and/or the PCI Design Handbook (the sections related to design of embedded steel plates and studs).

A larger number of test data and detailed reliability analyses are necessary to develop strength reduction factors. Development of strength reduction factors was not within the scope of this series of tests.

For further information or questions please contact:

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APPENDIX A – STUD CAPACITY

The capacity of the studs was computed based on the provisions from ACI Appendix D. The eccentricities between the connection and the gravity and lateral loads produce moments. These moments result in a tensile force in the top stud closer to the point of application of the lateral load.

The studs in specimen C-EZ "V" 12x12x0.50 – Seat Welded fractured. The stud capacity was computed based on the following assumptions: (a) the lateral load is distributed equally among the studs, and (b) the studs on the compression face of the connection resist 75% of the shear due to gravity load. Various parameters and the computed capacities are shown in Table A.1. By ignoring the strength reduction factors, which is reasonable when evaluating test specimens with known properties and dimensions, the gravity load corresponding to the expected stud capacity is 71 kips. This value is nearly identical to 70 kips at which the studs in this specimen fractured.

Table A.1 Computed Gravity Load at Stud Capacity

n	1		1	
d	0.75	in.	0.75	in.
$A_{se,N}$	0.44	in.^{2}	0.44	in.^{2}
f_{uta}	61	ksi	61	ksi
N_{sa}	26.95	kips	26.95	kips
ϕ	0.75		1.00	
ϕN_{sa}	20.21	kips	26.95	kips
$A_{se,V}$	0.44	in.^{2}	0.44	in.^{2}
V_{sa}	26.95	kips	26.95	kips
ϕ	0.65		1.00	
ϕV_{sa}	17.52	kips	26.95	kips
Eccentricity of gravity load	5	in.	5	in.
Eccentricity of lateral load	4.75	in.	4.75	in.
Vertical distance between the top & bottom studs	8	in.	8	in.
Horizontal distance between the top studs	5.5	in.	5.5	in.
Applied lateral load (shear)	4	kips	4	kips
% of shear in each stud due to lateral load	25%		25%	

% of shear in the top suds due to gravity load	25%		25%	
Computed gravity load at stud capacity	50	kips	71	kips

Refer to Appendix D for definition of various variables.