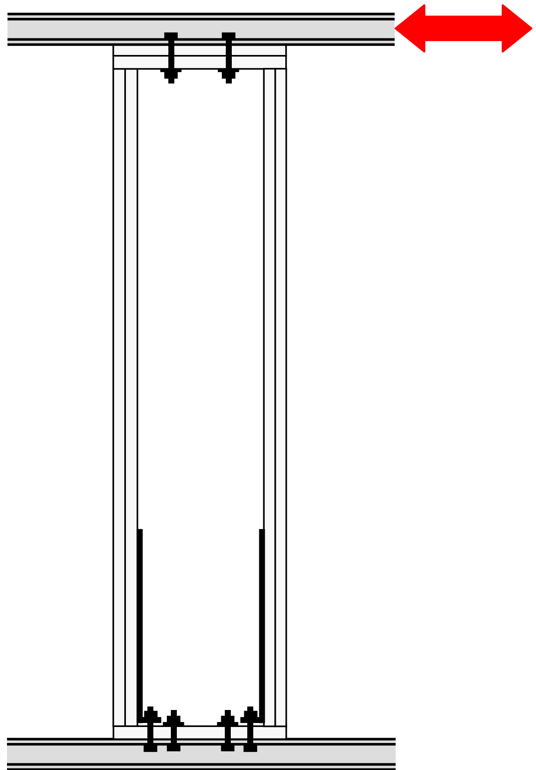
Walls 02FAc



Walls:	02FAc1	02FAc2	02FAc3
Manufactured:	**June 19, 1998**[1]	**June 19, 1998**[1]	**June 18, 1998**[1]
MOE data files:	2fac1s.prn	2fac2s.prn	2iam2s.prn
MOE_{plates} (10^6 psi)			
MOE_{studs} (10^6 psi)	1.93	1.68	1.78
$Density_{plates}$ (kg/m^3)			
$Density_{studs}$ (kg/m^3)	524	530	500
Date tested:	**July 21, 1998**	**July 23, 1998**	**July 27, 1998**[2]
Time tested:	18:32	12:51	18:01
LTC files:	alex_cyc	alexcyc	30alexcy
Data files:	02FAc1.dat	02FAc2.dat	02FAc3.dat
Excel files:	02FAc1_data 02FAc1_UTP	02FAc2_data 02FAc2_UTP	02FAc3_data 02FAc3_UTP
Photo files:	491-500	512-524	585-589

1 Sheathing attached with ¾-in. edge distance.
2 Tie-down anchors were installed half hour before the test.

Load Regime

Load regime: The proposed displacement protocol was a function of the parameter called the *first major event* (FME). The value of the FME used by other researchers varies between 0.1and 0.8 in. This test series was used to tune up the load regime, including the FME value, exciting frequency, and data sampling frequency. The sequence of phases is shown in Table 02FAc.

Table FAc. Displacement Protocol.

Phase #	1	2	3	4	5	6	7	8	9	10	11	12	etc
Number of cycles	1	1	1	3	3	3	3	3	3	3	3	3	3
Amplitude, %FME	25	50	75	100	200	300	400	500	600	700	800	900	etc.

Wall 02FAc1

Load regime: This was the first cyclic test in this project. The test was conducted at 0.2 Hz exciting frequency with 0.2-in. FME. To make the response period closer to that observed during earthquakes, the exciting frequency should be increased. The sampling frequency was set similar to the monotonic tests at 15 Hz. The load-deflection curve shows that the sampling frequency should be increased because the peak readings might be missed.

Observations: The wall exhibited extremely ductile performance with the elastic stiffness 35% higher than in monotonic tests 02FAm. It started yielding at 0.6-in. amplitude and the peak load was reached between 3.2 and 3.4-in. deflection. The uplift and sheathing displacement measurements showed symmetrical response on both sides of the positive and negative envelopes. There was no strength degradation between initial and stabilized cycles until 4.0-in. phase, when a significant decrease of resistance occurred.

Failure mode: After 96 cycles of loading, many sheathing nails failed in fatigue along bottom and top plates and the left stud (Photos 494, 498). Other nails pulled out of wood (Photo 496). Right stud remained not separated from top plate and from sheathing.

Wall 02FAc2

Load regime: The test was conducted at 0.4 Hz exciting frequency with 0.2-in. FME. Unfortunately, at large displacements (approximately 3 in.) the hydraulic pump did not produce the target stroke and this affected the accuracy of results. The exciting frequency had to be reduced in the consecutive tests. The sampling frequency was set at 30 Hz. The results showed that readings did not match the peaks of amplitudes. It is desirable to use even number of readings per cycle, e.g. 25 Hz sampling rate would be best matching frequency. The FME should be increased to reduce number of cycles.

Observations: The wall exhibited very similar performance with 02FAc1 wall. The elastic stiffness and strength differed less than 8%. The wall started yielding at 0.5-0.8 in. and maintained nearly peak resistance (0.42 Kip/ft.) through 4.4-in. amplitude. At 3-in. amplitude, the ram did not produce the target displacement; therefore, there was an apparent load decrease during this phase. As seen from Figures 02FAc2-a and b, the maximum resistance was restored at 3.4-in. amplitude.

Failure mode: The plastic yielding developed through the end of the test. At 4.6-in. amplitude, the load gradually dropped 15% of peak load. By the end of the test, not a single nail failed in fatigue. Sheathing nails at corners pulled out of wood about ½ in (Photo 517). Nails along both studs began pulling out (Photos 520 – 521). After 70 cycles of loading, the wall did not reach failure.

Wall 02FAc3

Load regime: The test was conducted at 0.25 Hz exciting frequency with 0.3-in. FME. The sampling frequency was set at 25 Hz. This protocol was used for all consequent tests in this project.

Observations: The wall exhibited very similar performance with 02FAc1 wall. The elastic stiffness and strength differed less than 3%. The wall started yielding at 0.6 in. and the peak load was sustained between 3.0 and 4.2-in. deflections. The uplift and sheathing displacement measurements showed symmetrical response on both sides of the positive and negative envelopes. There was no significant strength degradation between initial and stabilized cycles and no significant decrease of resistance was observed until 5-in. amplitude.

Failure mode: The failure occurred at approx. 5-in. amplitude. At failure, sheathing almost instantly unzipped from the left end stud and left corners at the top and bottom plates. After 63 cycles of loading, 50% of sheathing nails along the left stud failed in fatigue; other nails pulled out of wood. At the bottom plate: one nail failed in fatigue, two corner nails pulled out of wood about ½ in. The nail in the left corner tore through sheathing edge. At the top plate, corner nails pulled out of wood about ½ in. (Photos 587, 588). Note, nail fatigue was not observed until about 5-in. amplitude.

General

Forces in anchor bolts: Figure 02FAc3-g illustrates an example of the observed relationship between the wall deflection and tension forces in the anchor bolts. The initial tension between 3.5 and 4.0 Kips was applied to the bolts before the test. The graph shows that on the negative stroke, the tension in Bolt #1 remained at the initial level. When the direction of the loading reversed (the second quarter of the cycle), the bolt tension went down and continued decreasing until approximately half of the positive stroke. As the positive stroke approached the peak, so did the tension in the bolt#1. Bolt #2 generally produced the mirror image response. Similar relationships were recorded during the other tests. Depending on the location of the tie-down anchor relative to the bottom plate, the peak forces in the bolts might increase or decrease. If there was no or small gap, then the forces in the anchor bolts generally decreased during the test, and the envelope curves of these forces had a downward slope. The anchors contributed the minimum to the wall resistance in this case. On the opposite, if there was a large gap between the anchor and the bottom plate, then the envelope was upward and resembled the shape of the load-deflection curve.

Framing properties: The relatively stiff performance of walls likely due to the high quality of framing lumber (density more than 500 kg/m^3) and MOE more than 1.7×10^6 psi.

Table 02FAc1. Data summary.

Specimen	**02FAc1**	**Per unit length**	
Tie-Down Anchors		**cyclic test**	
Wall length		**2.00ft.**	**0.609m**
Date: 7-21-1998 **Time:** 18:32			
EEEP Parameters	**units**	**initial**	**stabilized**
Peak unit load, v_{peak}	Kip/ft. KN/m	0.454 6.622	0.423 6.173
Drift at peak load, Δ_{peak}	in. mm	3.318 84.27	3.114 79.10
Yield unit load, v_{yield}	Kip/ft. KN/m	0.406 5.924	0.377 5.501
Drift at yield load, Δ_{yield}	in. mm	0.599 15.21	0.531 13.49
Proportional limit, $0.4v_{peak}$	Kip/ft. KN/m	0.182 2.649	0.169 2.469
Drift at prop. limit, $\Delta@0.4v_{peak}$	in. mm	0.268 6.80	0.238 6.06
Unit load at failure or $0.8v_{peak}$	Kip/ft. KN/m	0.363 5.297	0.338 4.938
Drift at failure, $\Delta_{failure}$	in. mm	4.079 103.59	3.926 99.72
Shear modulus, G @$0.4v_{peak}$	Kip/in. KN/mm	5.438 0.952	5.709 1.000
Work until failure per unit length	Kip·ft./ft. KN·m/m	3.124 13.897	3.045 13.545
Unit load, $v_{1/300}$ @ 0.32 in. (8.13 mm)	Kips/ft. KN/m	0.201 2.937	0.197 2.873
Unit load, $v_{1/200}$ @ 0.48 in.(12.19 mm)	Kips/ft. KN/m	0.253 3.685	0.243 3.540
Unit load, $v_{1/100}$ @ 0.96 in. (24.38 mm)	Kips/ft. KN/m	0.343 5.012	0.328 4.780
Unit load, $v_{1/60}$ @ 1.6 in. (40.64 mm)	Kips/ft. KN/m	0.402 5.863	0.379 5.527
EVDR @v_{peak}		0.112	0.113

SEAOSC parameters		**units**	**negative**	**positive**	**average**
Yield Limit State	v_{YLS}	Kips/ft. KN/m	-0.294 -4.290	0.221 3.232	0.258 3.761
	Δ_{YLS}	in. mm	-0.606 -15.40	0.396 10.05	0.501 12.72
	G'_{YLS}	Kip/in. KN/mm	3.879 0.679	4.480 0.785	4.116 0.721
Strength Limit State	v_{SLS}	Kips/ft. KN/m	-0.461 -6.720	0.447 6.523	0.454 6.622
	Δ_{SLS}	in. mm	-3.217 -81.71	3.419 86.84	3.318 84.27
	G'_{SLS}	Kip/in. KN/mm	1.145 0.201	1.046 0.183	1.094 0.192

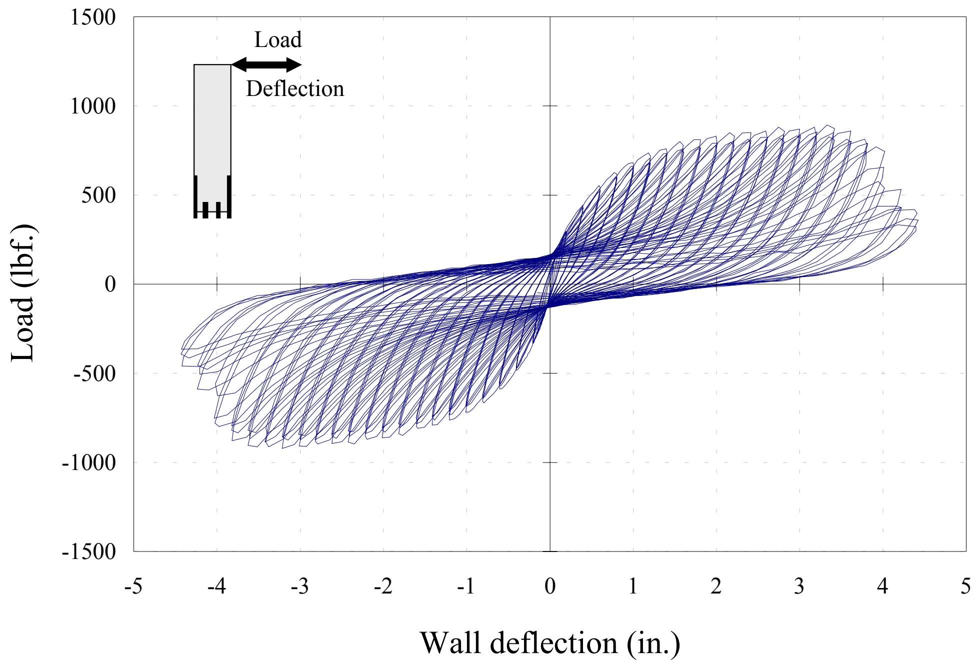


Figure 02FAc1- a. Observed load-deflection curve[1].

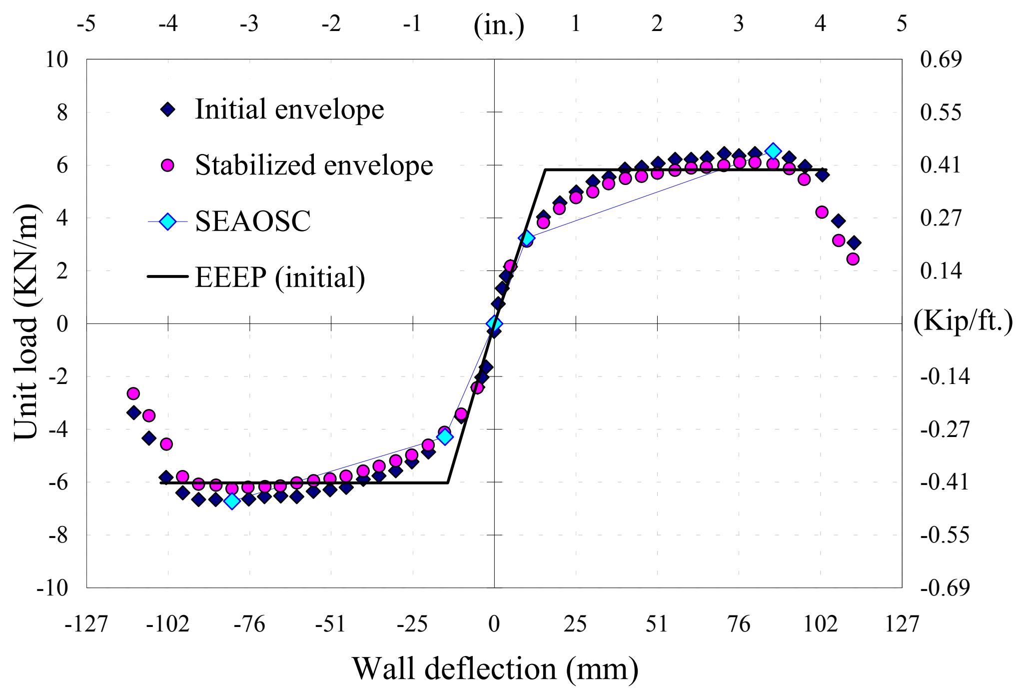


Figure 02FAc1- b. Envelopes, SEAOSC, and EEEP curves[2].

[1] The scale of the graph varies between test series.
[2] The scale of the graph is uniform between test series for comparison purposes.

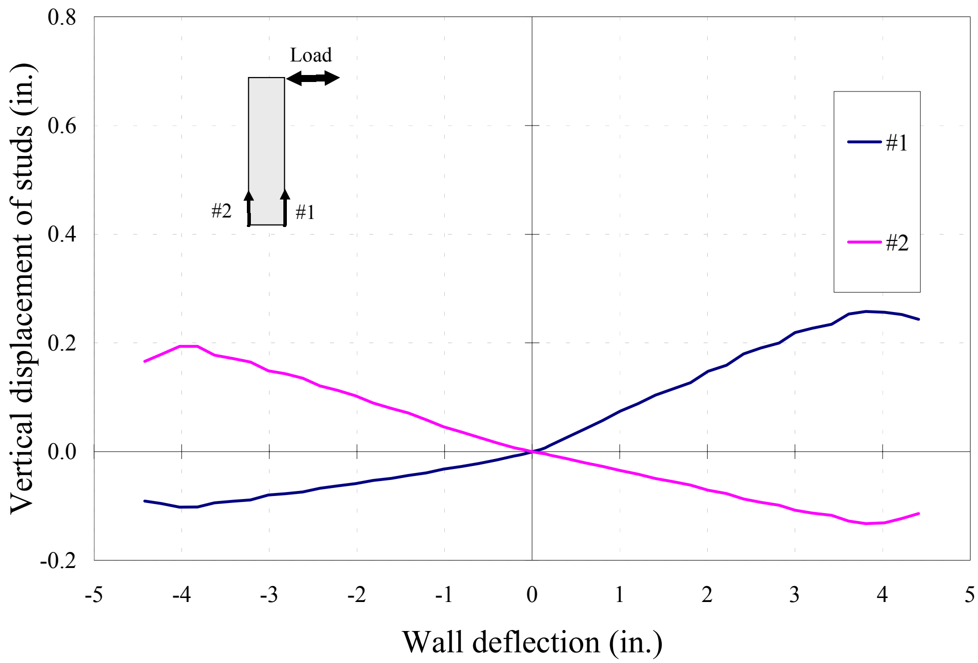


Figure 02FAc1- c. Vertical displacement of studs (initial envelope).

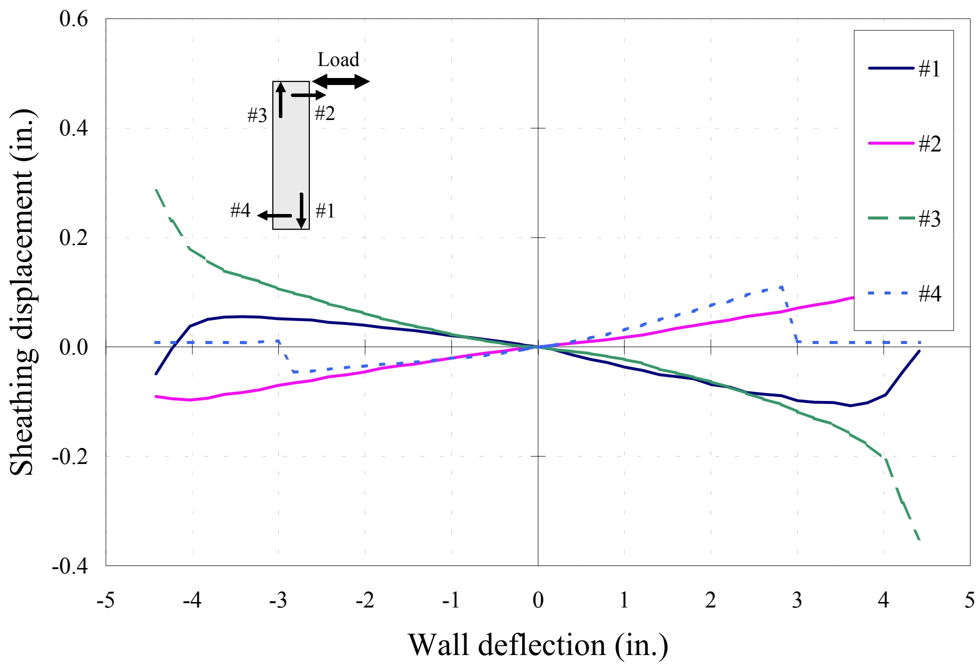


Figure 02FAc1- d. Sheathing displacement (initial envelope).

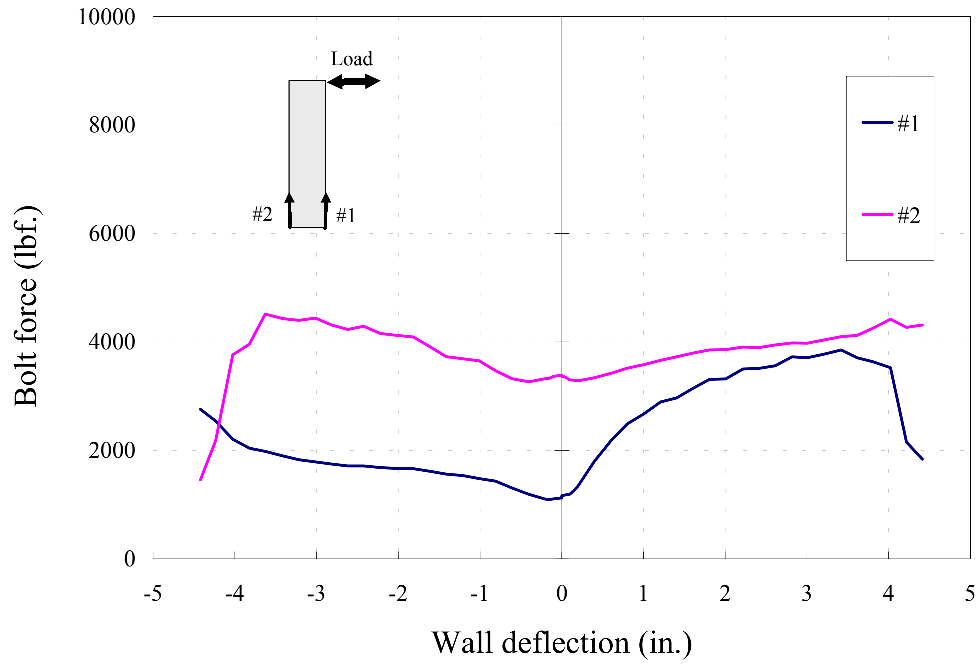


Figure 02FAc1- e. Forces in anchor bolts (initial envelope).

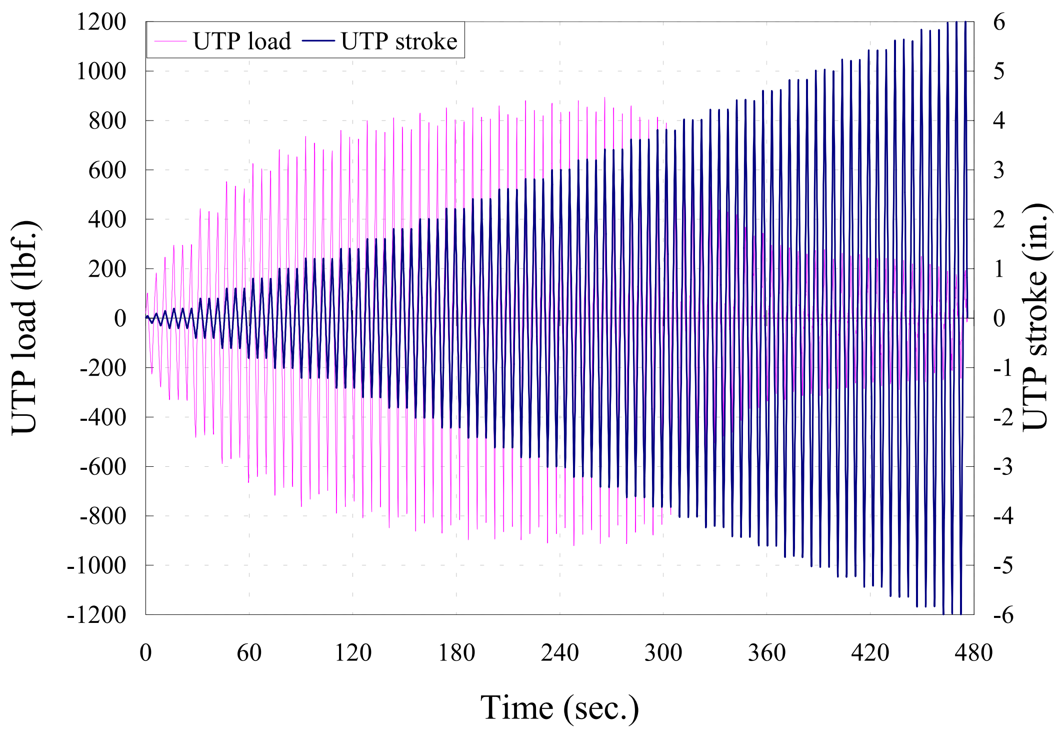


Figure 02FAc1- f. Load- and displacement-time record.

Table 02FAc2. Data summary.

Specimen	**02FAc2**	**Per unit length**	
Tie-Down Anchors		**cyclic test**	
Wall length		**2.00ft.**	**0.609m**
Date: 7-23-1998 **Time:**	12:51		
EEEP Parameters	**units**	**initial**	**stabilized**
Peak unit load, v_{peak}	Kip/ft. KN/m	0.424 6.180	0.400 5.837
Drift at peak load, Δ_{peak}	in. mm	2.833 71.96	3.426 87.03
Yield unit load, v_{yield}	Kip/ft. KN/m	0.389 5.677	0.364 5.308
Drift at yield load, Δ_{yield}	in. mm	0.530 13.46	0.491 12.46
Proportional limit, $0.4v_{peak}$	Kip/ft. KN/m	0.169 2.472	0.160 2.335
Drift at prop. limit, $\Delta@0.4v_{peak}$	in. mm	0.231 5.86	0.216 5.48
Unit load at failure or $0.8v_{peak}$	Kip/ft. KN/m	0.378 5.516	0.357 5.213
Drift at failure, $\Delta_{failure}$	in. mm	4.452 113.07	4.499 114.26
Shear modulus, G $@0.4v_{peak}$	Kip/in. KN/mm	5.879 1.029	5.942 1.041
Work until failure per unit length	Kip·ft./ft. KN·m/m	3.523 15.669	3.712 16.511
Unit load, $v_{1/300}$ @ 0.32 in. (8.13 mm)	Kips/ft. KN/m	0.204 2.984	0.198 2.895
Unit load, $v_{1/200}$ @ 0.48 in.(12.19 mm)	Kips/ft. KN/m	0.257 3.746	0.247 3.605
Unit load, $v_{1/100}$ @ 0.96 in. (24.38 mm)	Kips/ft. KN/m	0.386 5.640	0.373 5.440
Unit load, $v_{1/60}$ @ 1.6 in. (40.64 mm)	Kips/ft. KN/m	0.121 8.593	0.121 7.666
EVDR $@v_{peak}$		0.125	0.115

SEAOSC parameters		**units**	**negative**	**positive**	**average**
Yield Limit State	v_{YLS}	Kips/ft. KN/m	-0.317 -4.626	0.335 4.881	0.326 4.754
	Δ_{YLS}	in. mm	-0.812 -20.61	0.803 20.39	0.807 20.50
	G'_{YLS}	Kip/in. KN/mm	3.125 0.547	3.334 0.584	3.229 0.565
Strength Limit State	v_{SLS}	Kips/ft. KN/m	-0.414 -6.034	0.433 6.326	0.424 6.180
	Δ_{SLS}	in. mm	-2.839 -72.11	2.827 71.81	2.833 71.96
	G'_{SLS}	Kip/in. KN/mm	1.165 0.204	1.227 0.215	1.196 0.209

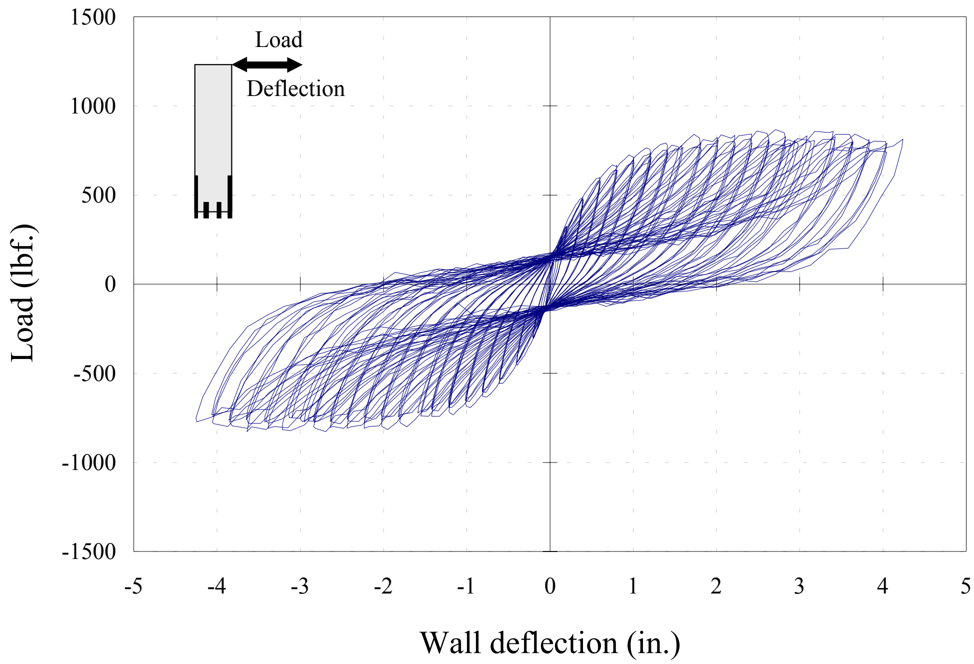


Figure 02FAc2- a. Observed load-deflection curve.

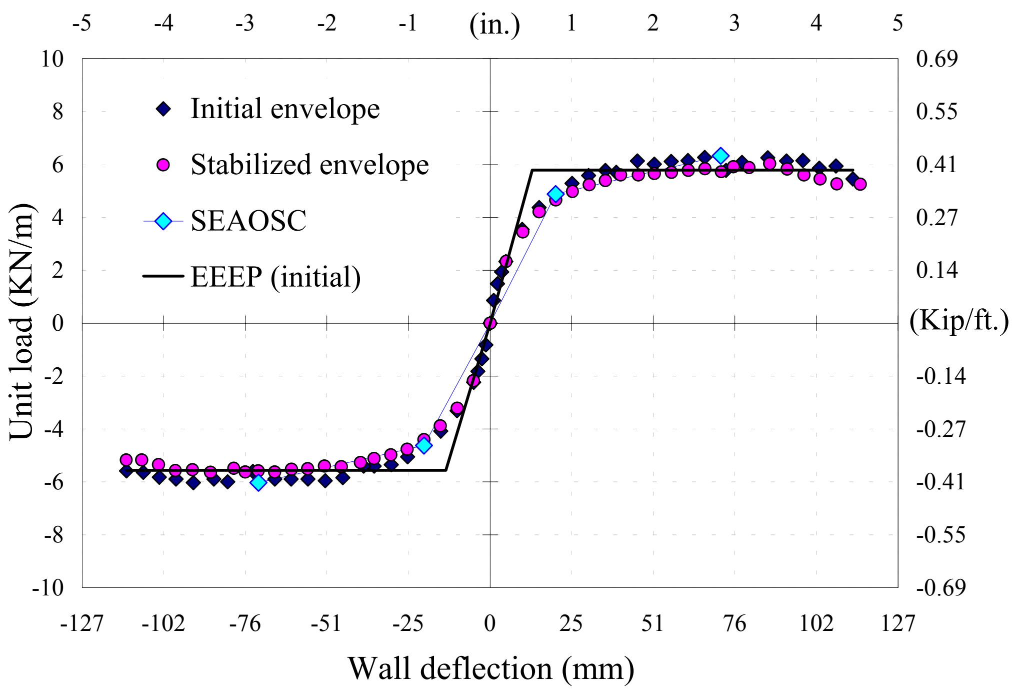


Figure 02FAc2- b. Envelopes, SEAOSC, and EEEP curves.

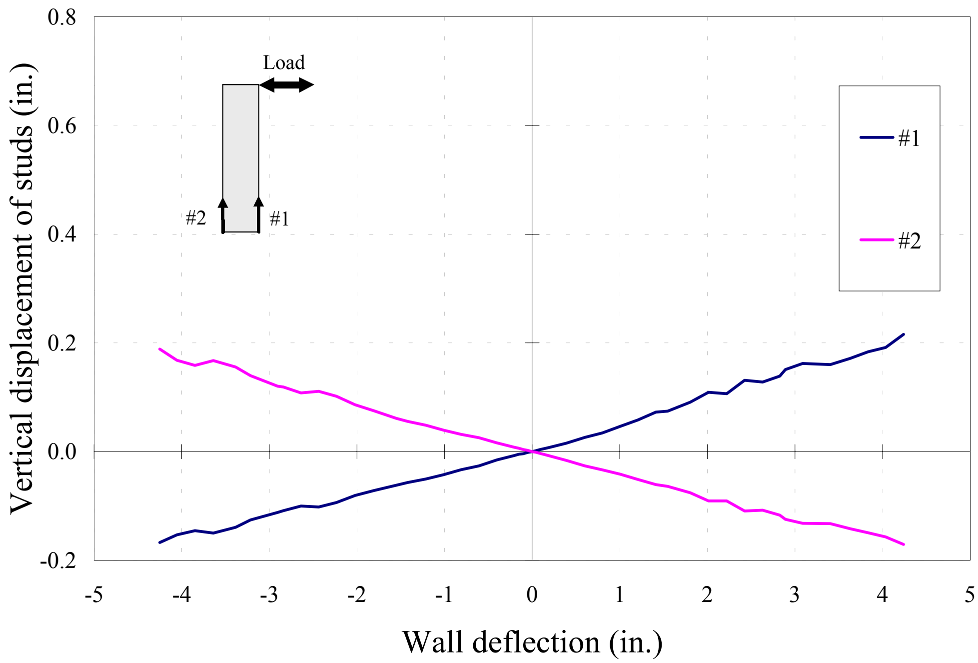


Figure 02FAc2- c. Vertical displacement of studs (initial envelope).

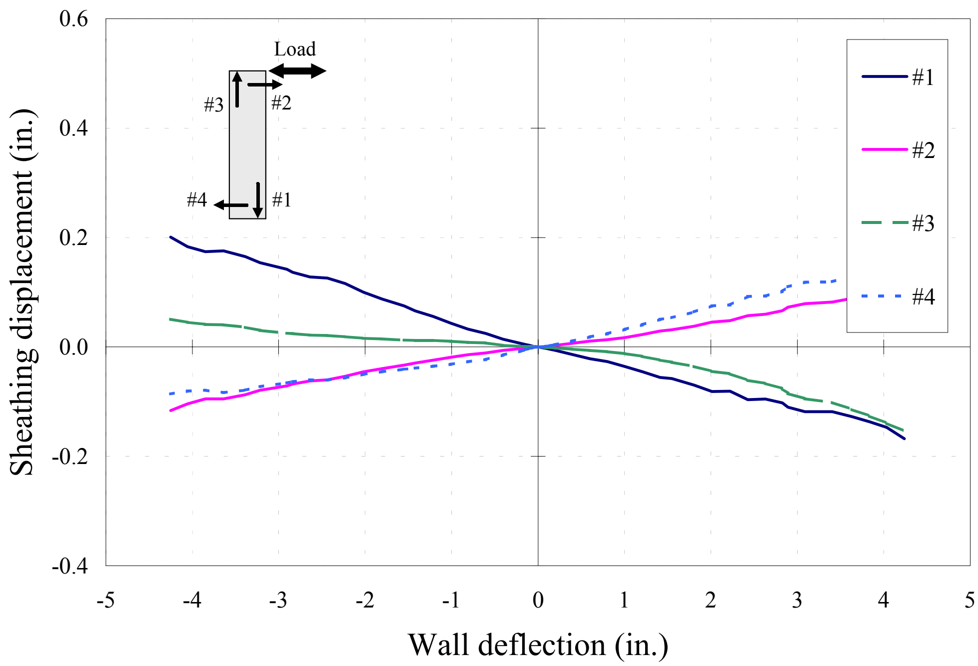


Figure 02FAc2- d. Sheathing displacement (initial envelope).

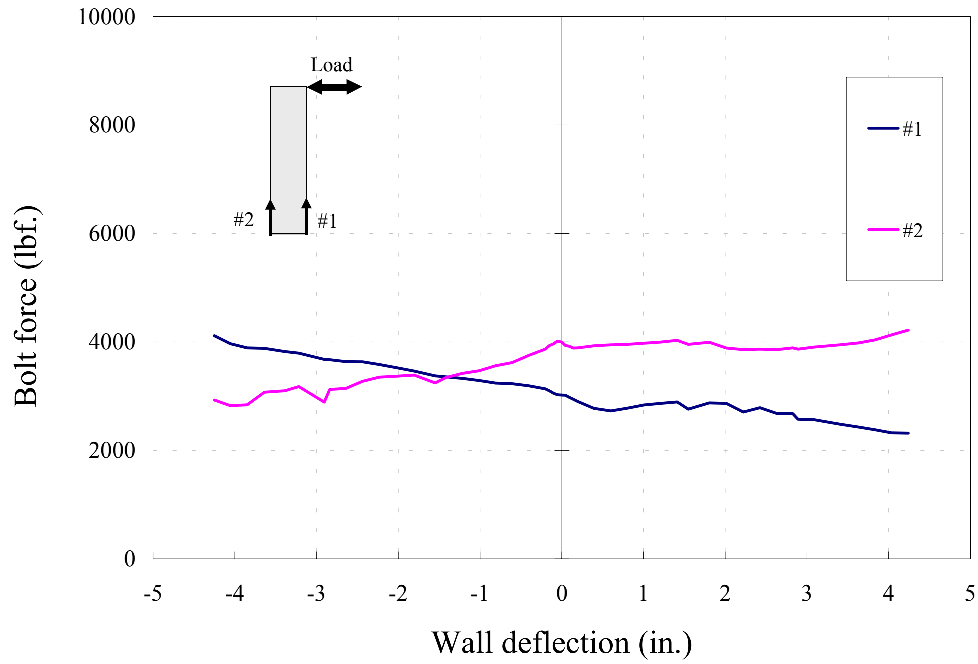


Figure 02FAc2- e. Forces in anchor bolts (initial envelope).

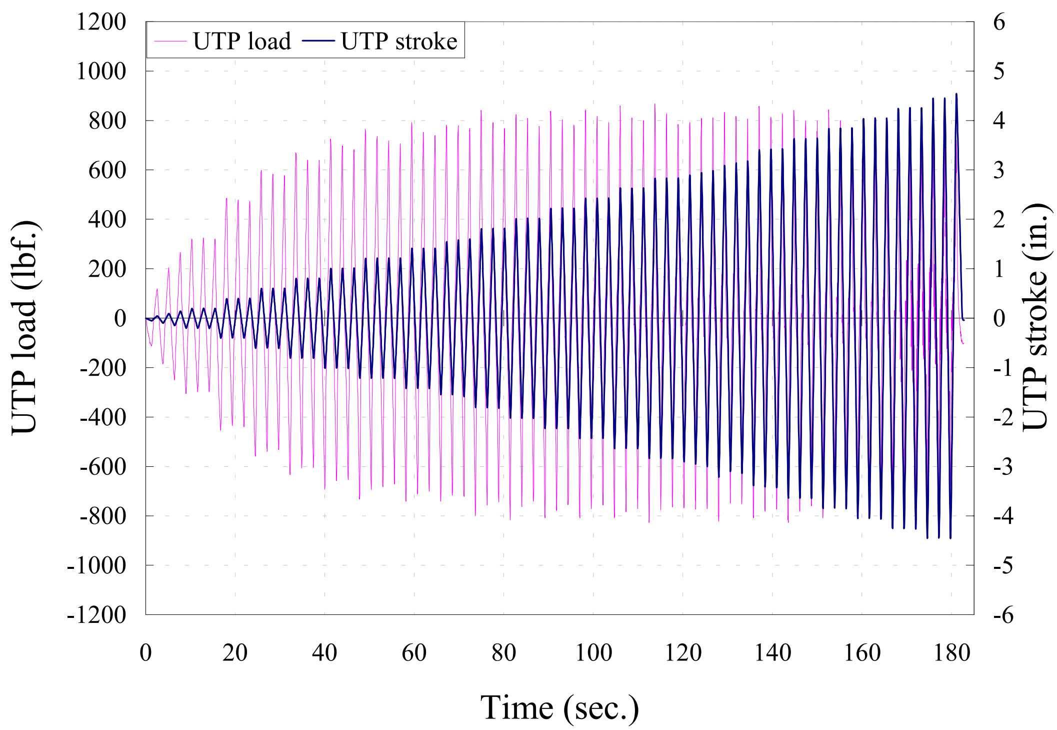


Figure 02FAc2- f. Load- and displacement-time record.

Table 02FAc3. Data summary.

Specimen	**02FAc3**	**Per unit length**	
Tie-Down Anchors		**cyclic test**	
Wall length		**2.00ft.**	**0.609m**
Date: 7-27-1998 **Time:**	18:01		
EEEP Parameters	**units**	**initial**	**stabilized**
Peak unit load, v_{peak}	Kip/ft. KN/m	0.442 6.457	0.403 5.888
Drift at peak load, Δ_{peak}	in. mm	3.454 87.73	3.778 95.96
Yield unit load, v_{yield}	Kip/ft. KN/m	0.404 5.894	0.370 5.399
Drift at yield load, Δ_{yield}	in. mm	0.582 14.78	0.584 14.84
Proportional limit, $0.4v_{peak}$	Kip/ft. KN/m	0.177 2.583	0.161 2.355
Drift at prop. limit, $\Delta@0.4v_{peak}$	in. mm	0.255 6.48	0.255 6.47
Unit load at failure or $0.8v_{peak}$	Kip/ft. KN/m	0.354 5.166	0.323 4.711
Drift at failure, $\Delta_{failure}$	in. mm	5.384 136.75	5.191 131.84
Shear modulus, G $@0.4v_{peak}$	Kip/in. KN/mm	5.555 0.973	5.067 0.887
Work until failure per unit length	Kip·ft./ft. KN·m/m	3.678 16.361	3.867 17.199
Unit load, $v_{1/300}$ @ 0.32 in. (8.13 mm)	Kips/ft. KN/m	0.200 2.921	0.196 2.859
Unit load, $v_{1/200}$ @ 0.48 in.(12.19 mm)	Kips/ft. KN/m	0.243 3.542	0.234 3.412
Unit load, $v_{1/100}$ @ 0.96 in. (24.38 mm)	Kips/ft. KN/m	0.334 4.877	0.314 4.578
Unit load, $v_{1/60}$ @ 1.6 in. (40.64 mm)	Kips/ft. KN/m	0.387 5.648	0.361 5.268
EVDR $@v_{peak}$		0.122	0.122

SEAOSC parameters		**units**	**negative**	**positive**	**average**
Yield Limit State	v_{YLS}	Kips/ft. KN/m	-0.276 -4.035	0.194 2.838	0.235 3.437
	Δ_{YLS}	in. mm	-0.609 -15.48	0.296 7.52	0.453 11.50
	G'_{YLS}	Kip/in. KN/mm	3.630 0.636	5.259 0.921	4.162 0.729
Strength Limit State	v_{SLS}	Kips/ft. KN/m	-0.454 -6.625	0.431 6.290	0.442 6.457
	Δ_{SLS}	in. mm	-3.932 -99.86	2.977 75.61	3.454 87.73
	G'_{SLS}	Kip/in. KN/mm	0.924 0.162	1.158 0.203	1.025 0.179

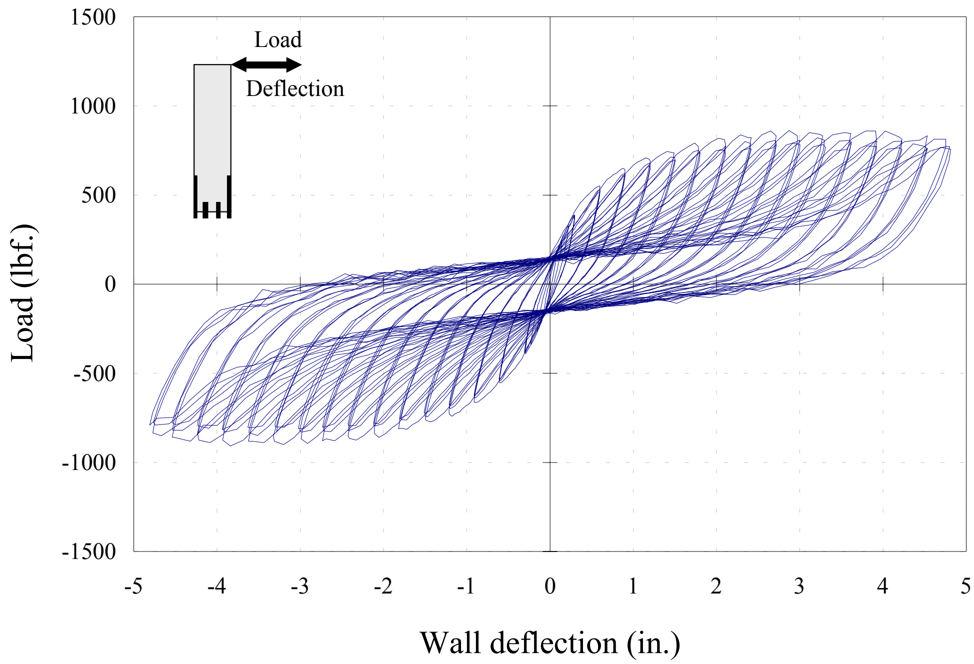


Figure 02FAc3- a. Observed load-deflection curve.

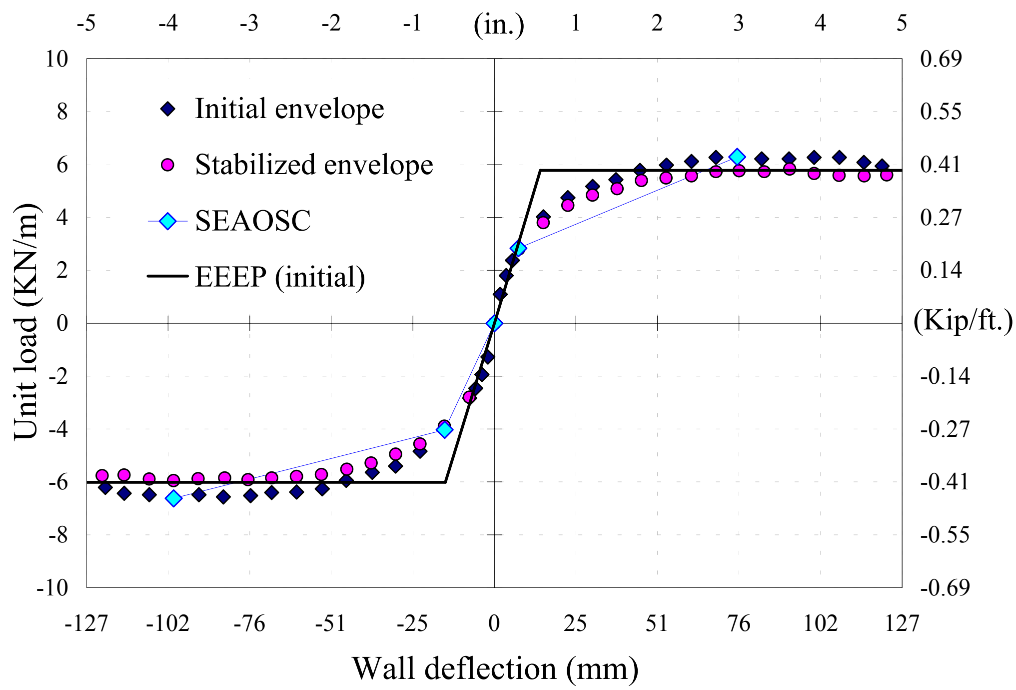


Figure 02FAc3- b. Envelopes, SEAOSC, and EEEP curves.

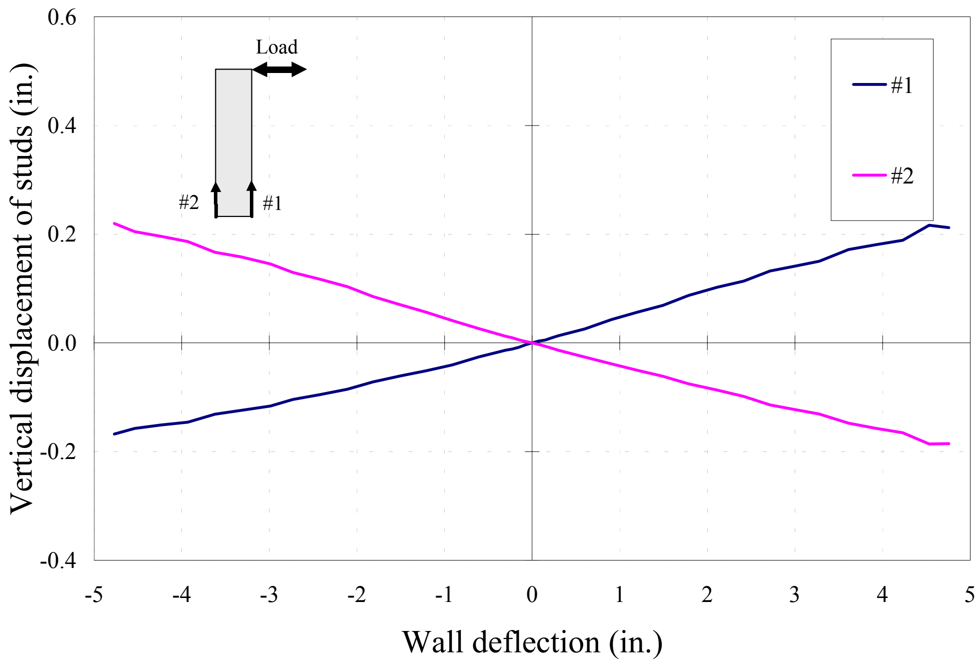


Figure 02FAc2- c. Vertical displacement of studs (initial envelope).

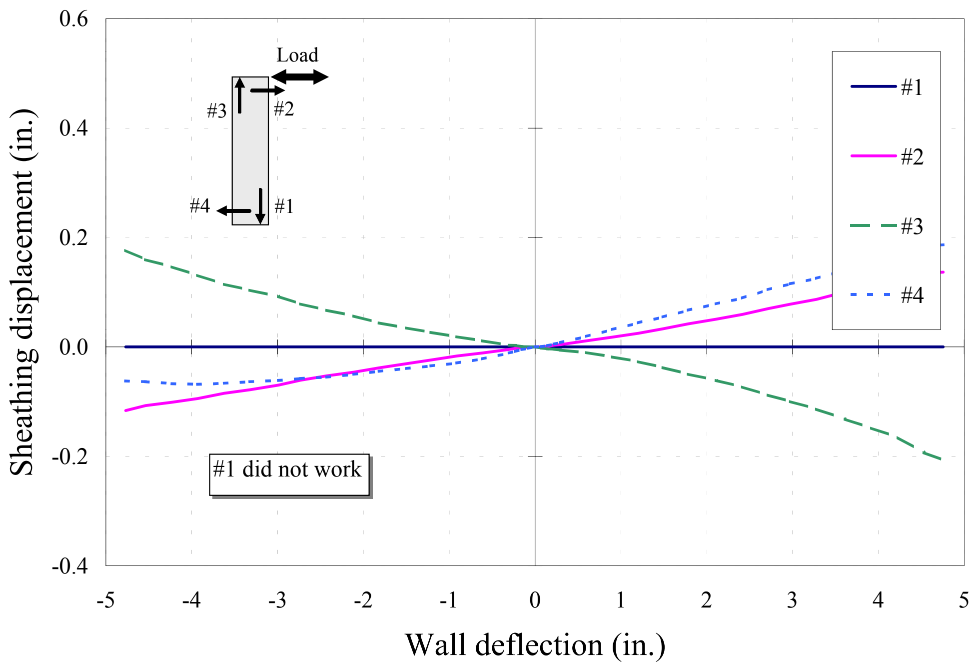


Figure 02FAc3- d. Sheathing displacement (initial envelope).

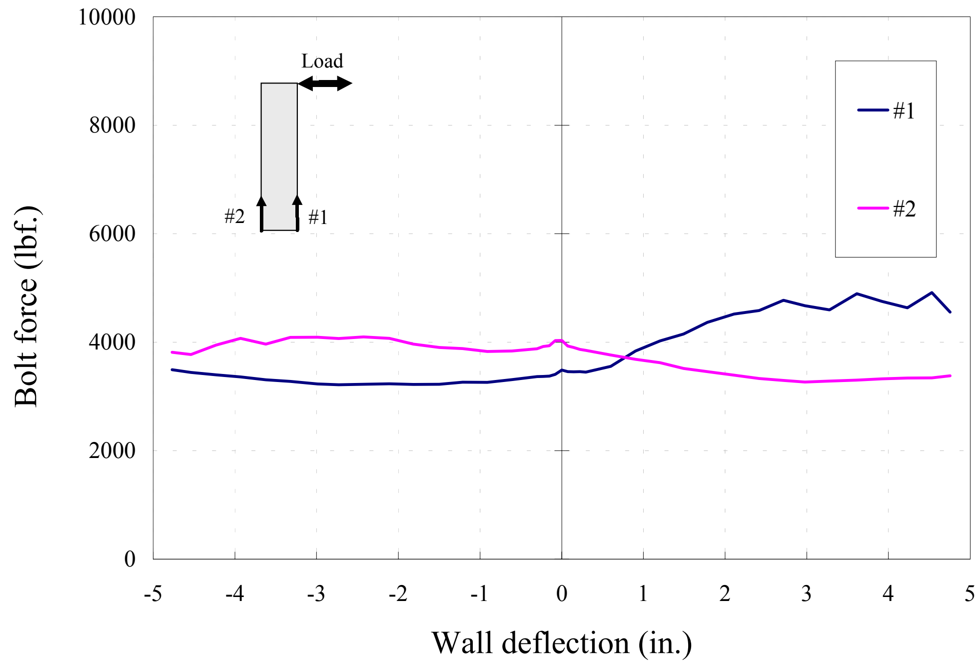


Figure 02FAc3- e. Forces in anchor bolts (initial envelope).

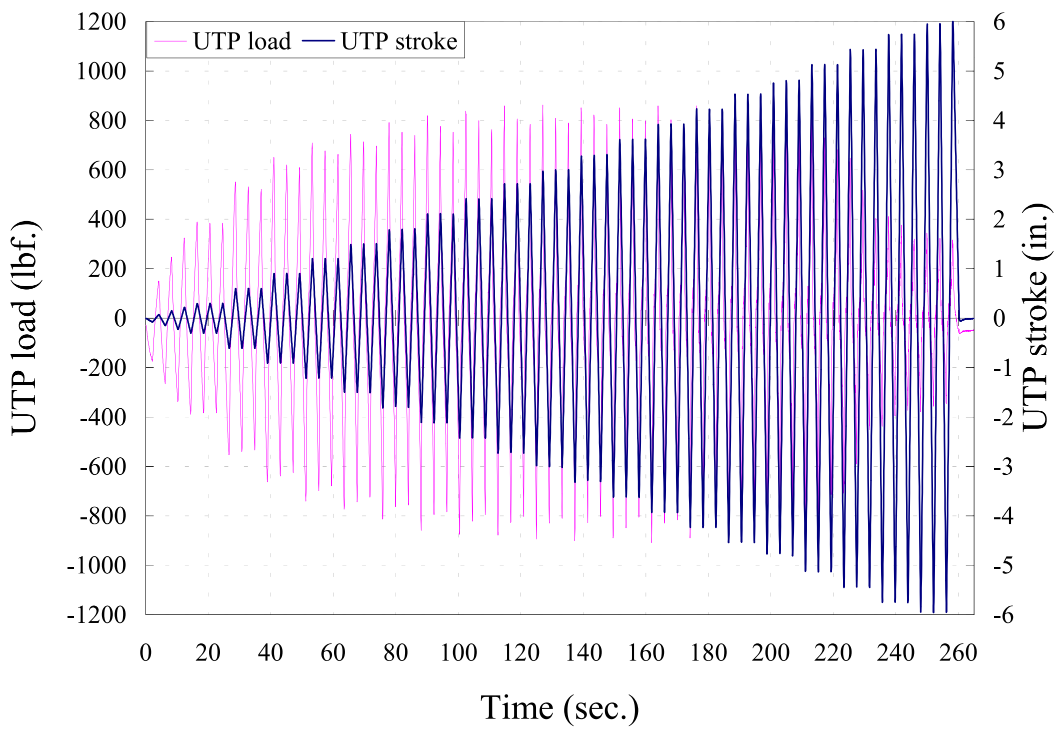


Figure 02FAc3- f. Load- and displacement-time record.

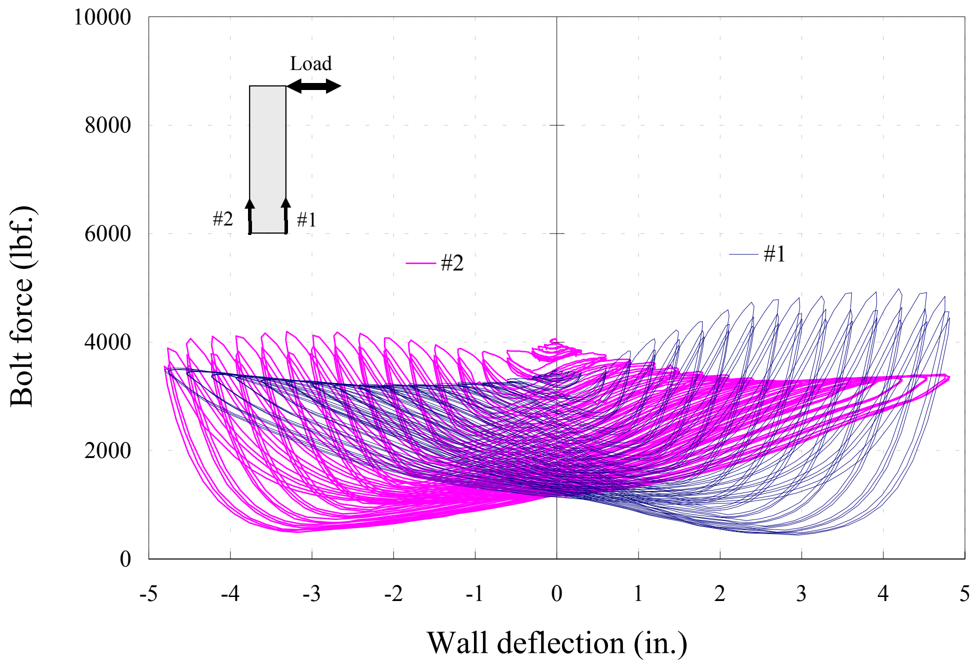


Figure 02FAc3- g. Observed forces in anchor bolts.