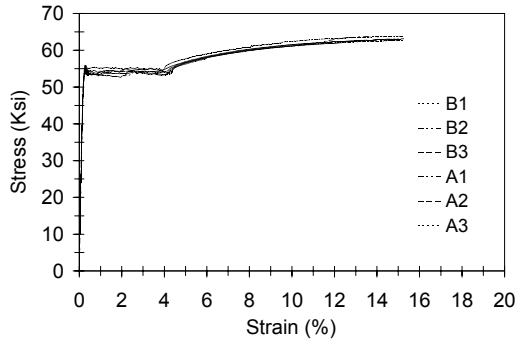
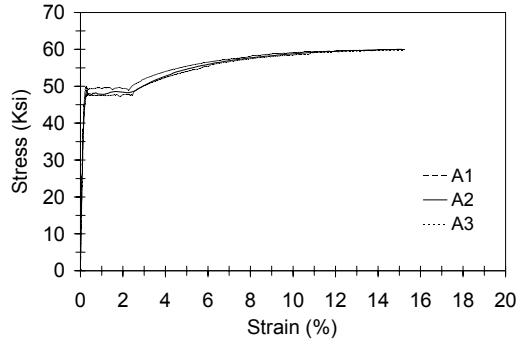


Appendix A

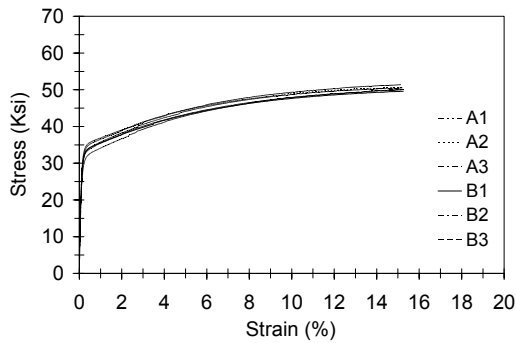
Coupon test results



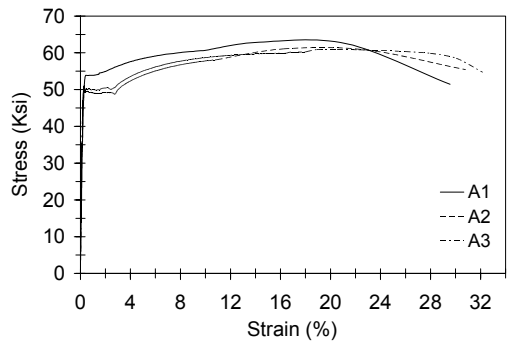
(a) 3VL20 deck



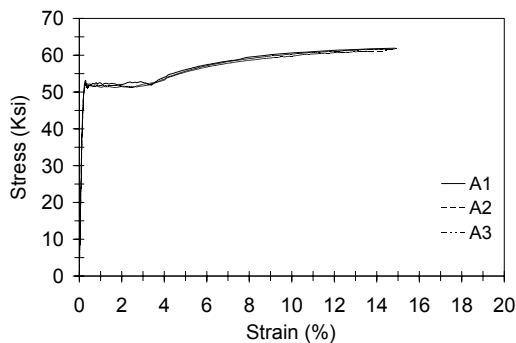
(b) 3VL18 deck



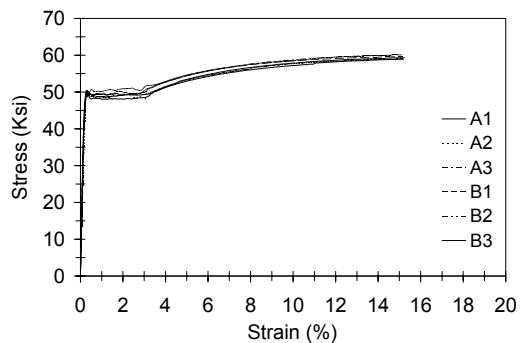
(c) 3VL16 deck used in group #1



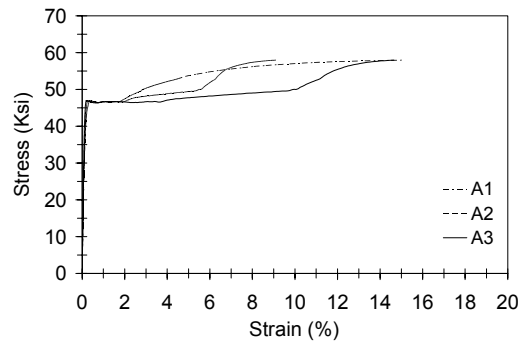
(d) 3VL16 deck used in group #2



(e) 2VL20 deck



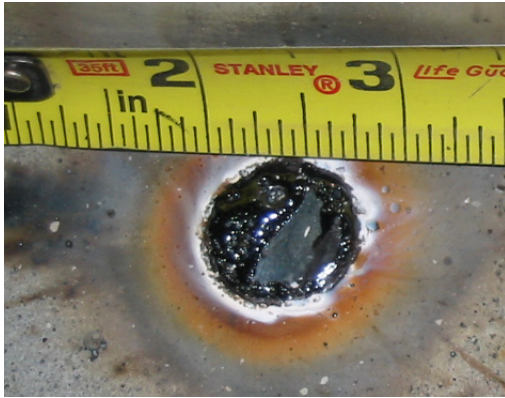
(f) 2VL18 deck



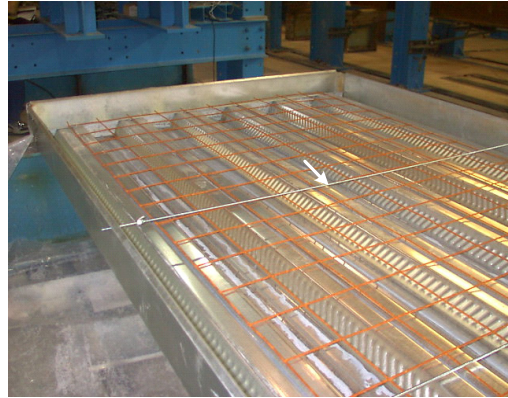
(g) 2VL16 deck

Appendix B

B.1 Full scale specimens



(a) Puddle weld



(b) Tie rods



(c) Deck form ready to receive concrete



(d) Full scale slab ready for testing



(e) Potentiometer at interior end



(f) Potentiometer at exterior end

B.2 Small scale specimens



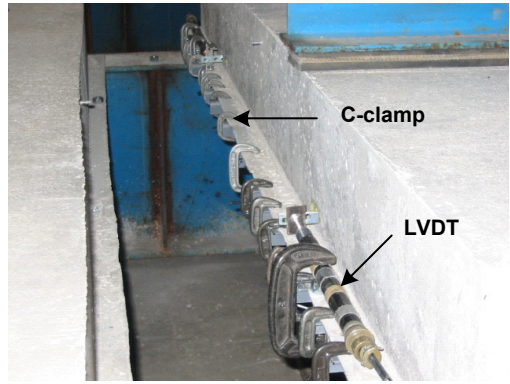
(a) Test in progress



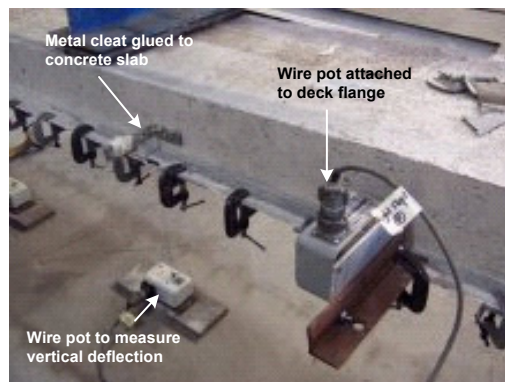
(b) Angle straps underneath the slab



(c) Potentiometer at slab end



(d) LVDT and C-clamp at slab edge



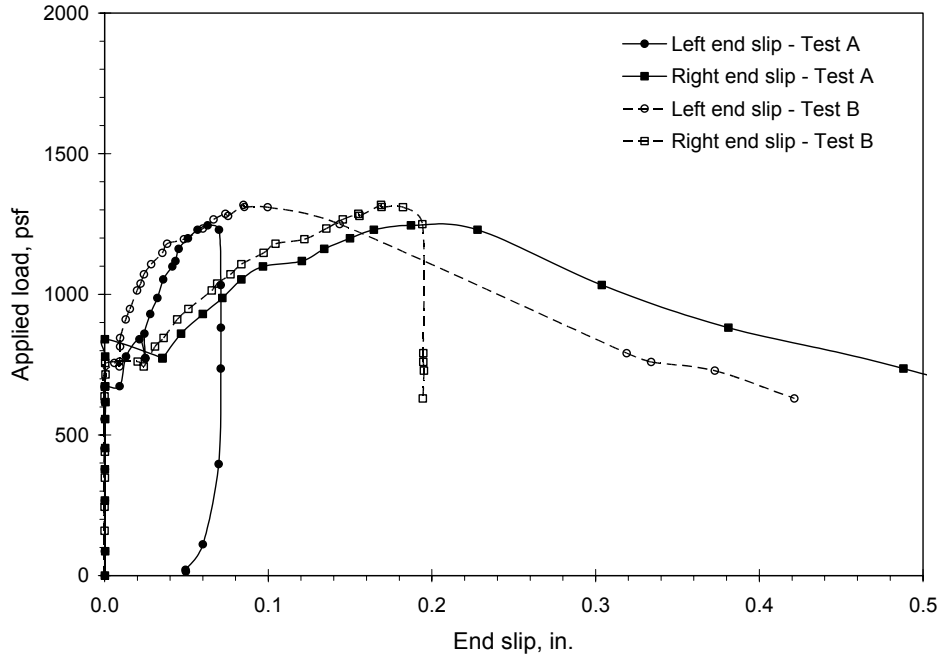
(e) Wire pot for measuring end slip and deflection



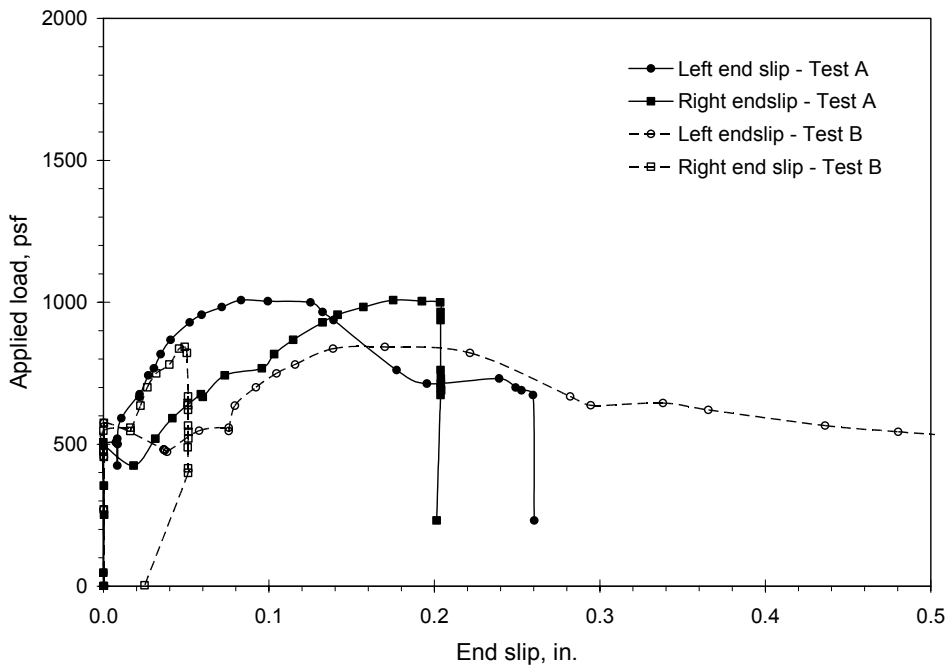
(f) Wire pot at slab end

Appendix C

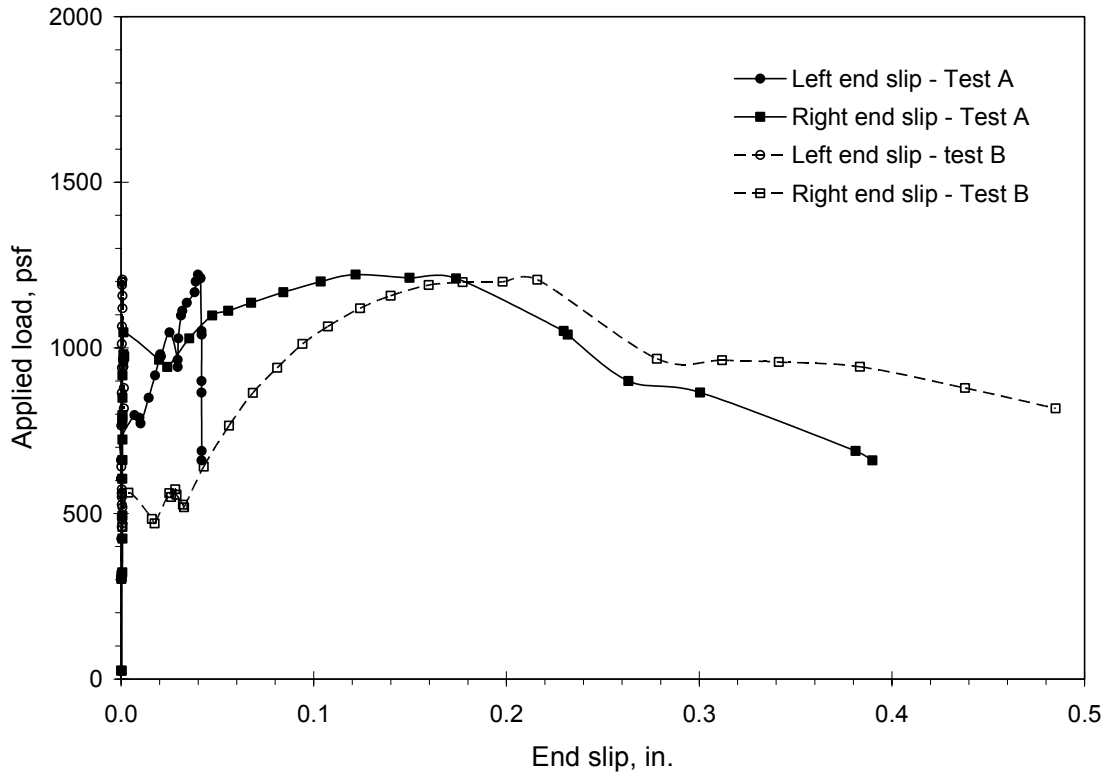
C.1 Test results: Loads versus end slips for small scale specimens in series #1



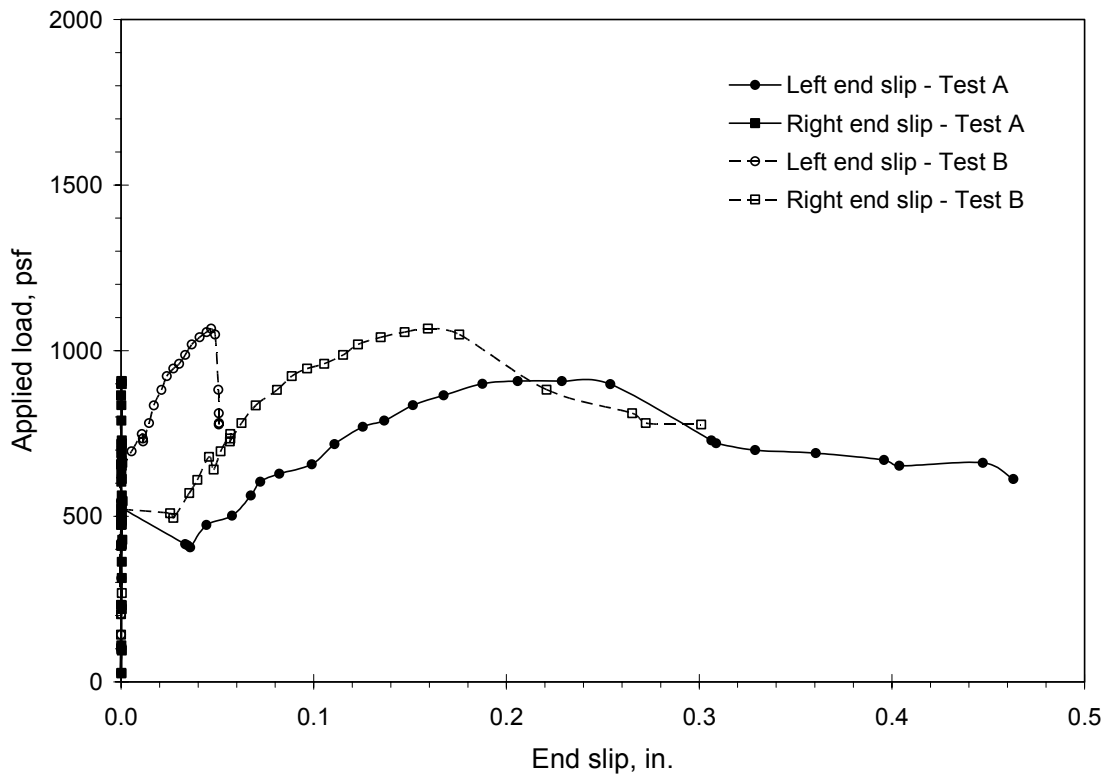
Test # 13: 3VL16-8-7.5-22 with straps



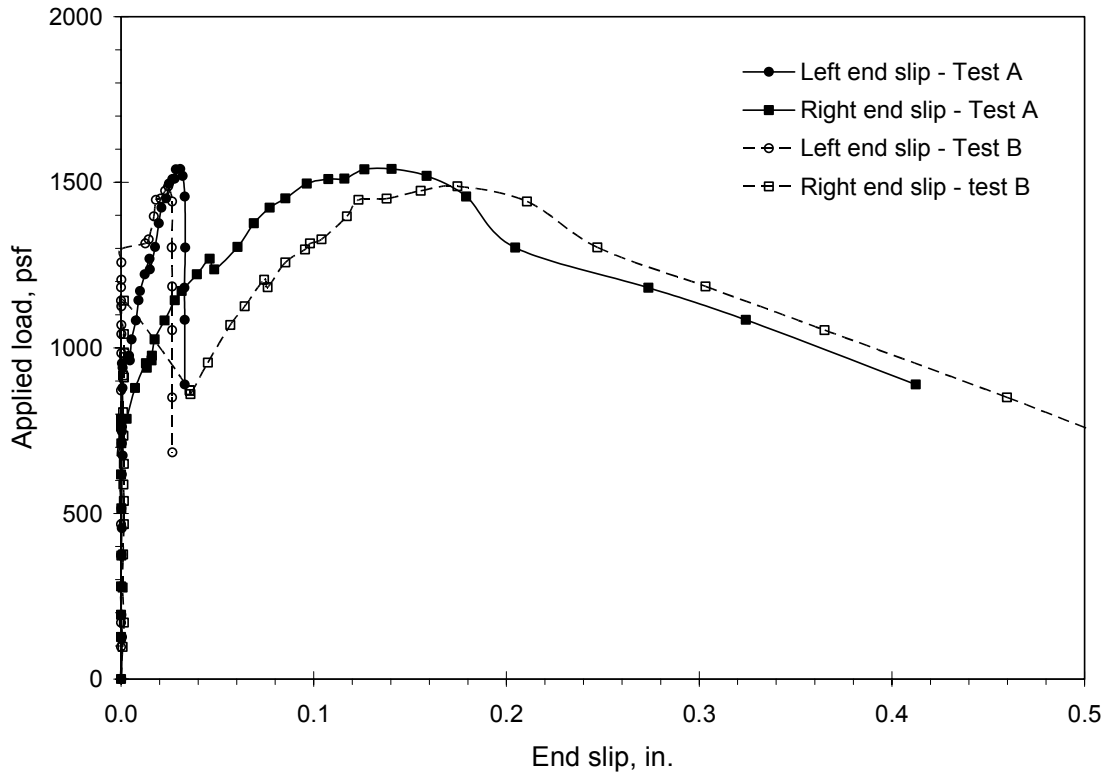
Test #14: 3VL16-8-7.5-22 without straps



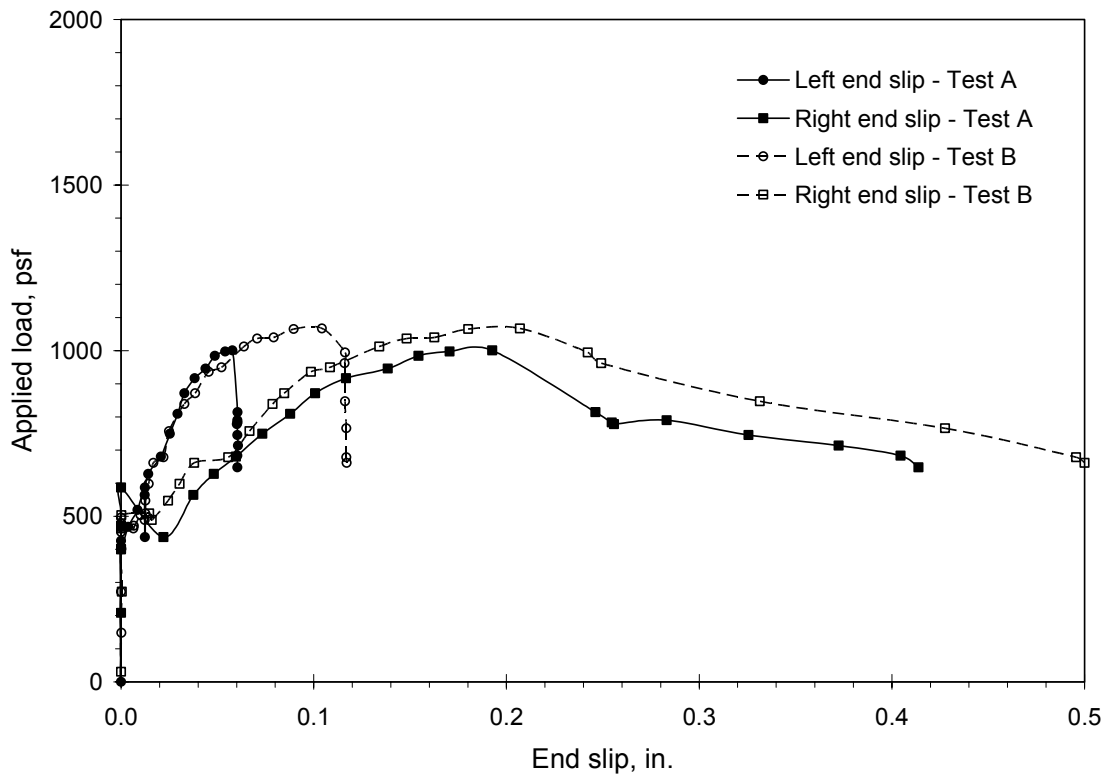
Test #15: 3VL16-8-7.5-26 with straps



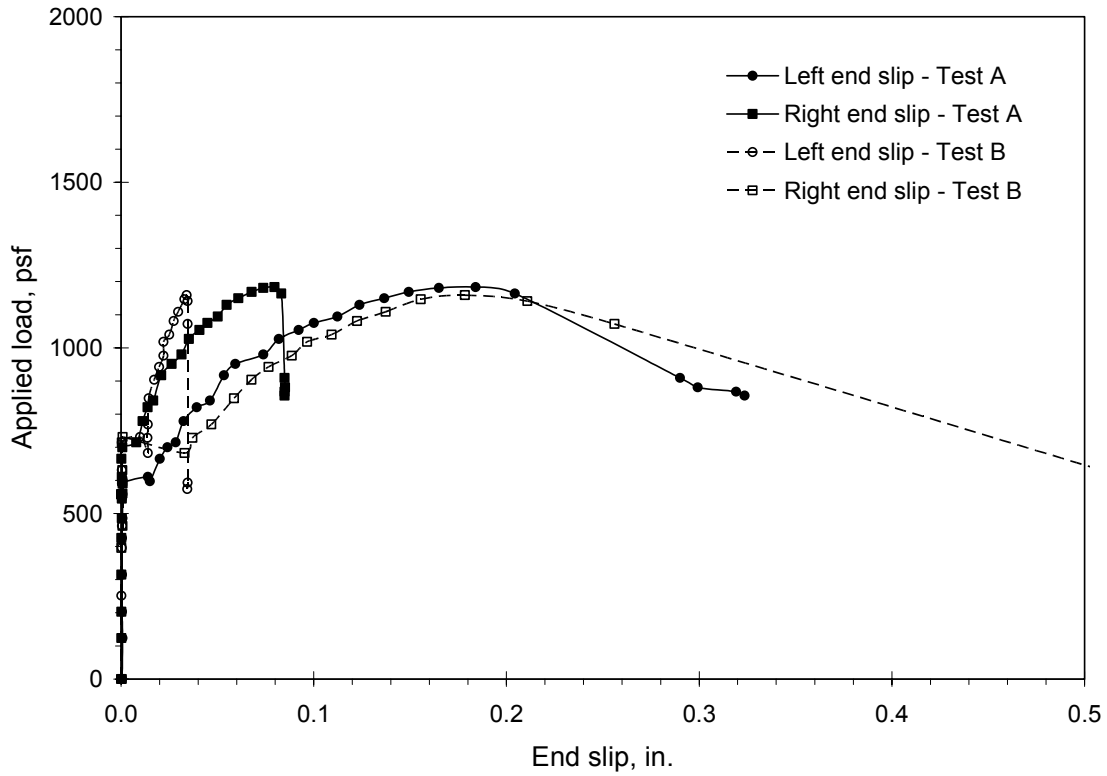
Test #16: 3VL16-8-7.5-26 without straps



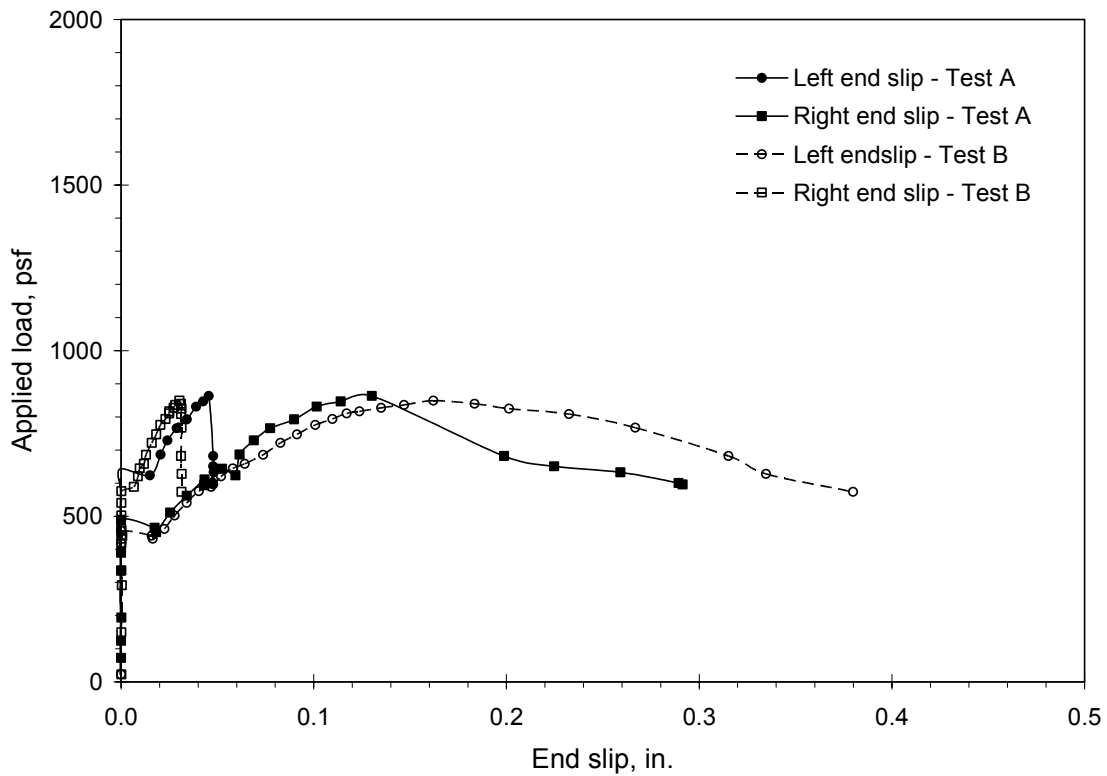
Test #17: 3VL16-8-7.5-30 with straps



Test #18: 3VL16-8-7.5-30 without straps



Test #19: 3VL16-8-6.5-22 with straps

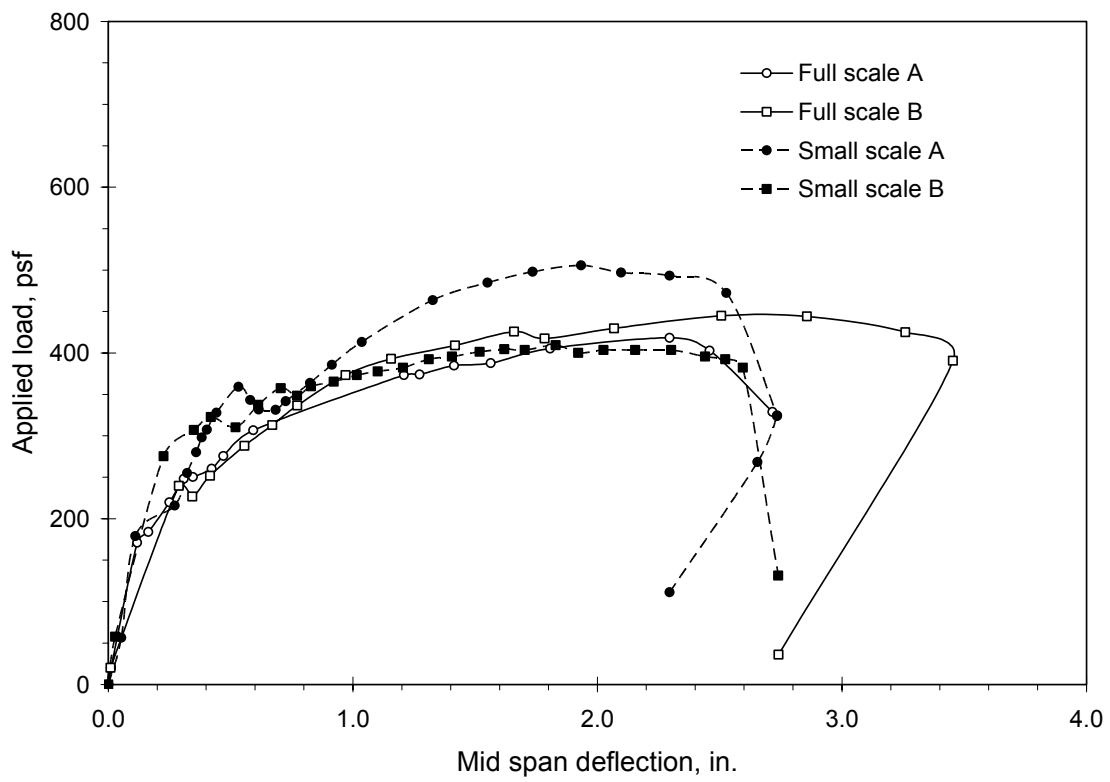
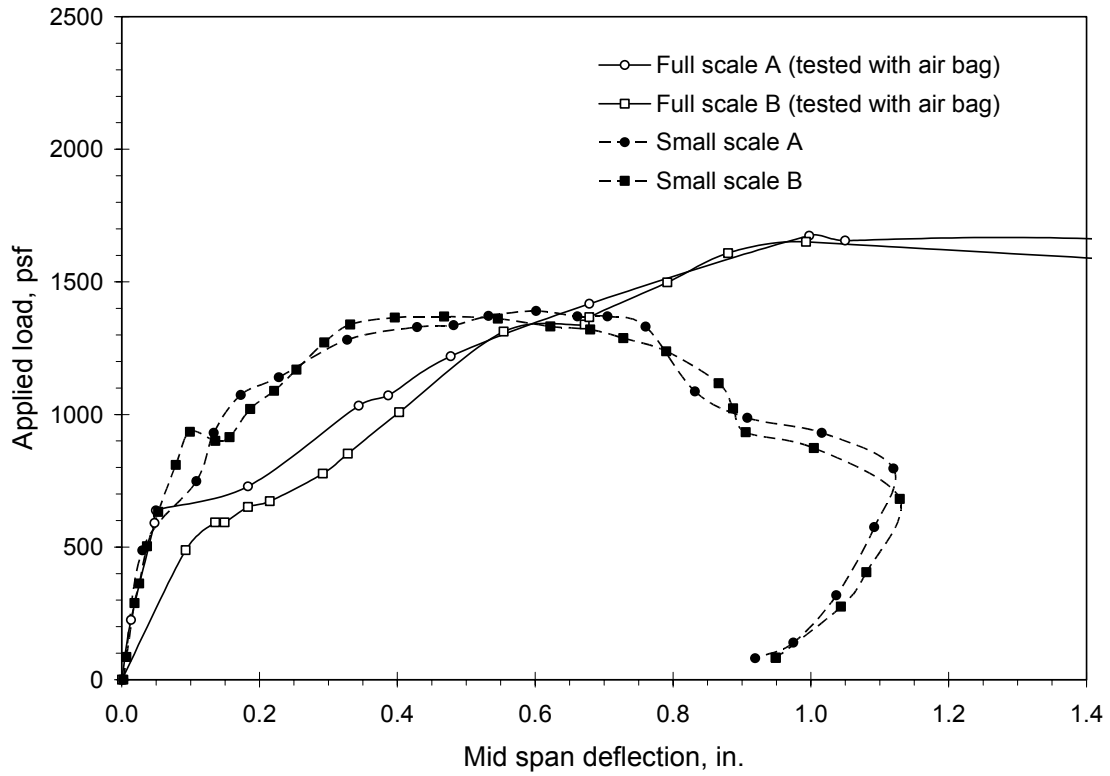


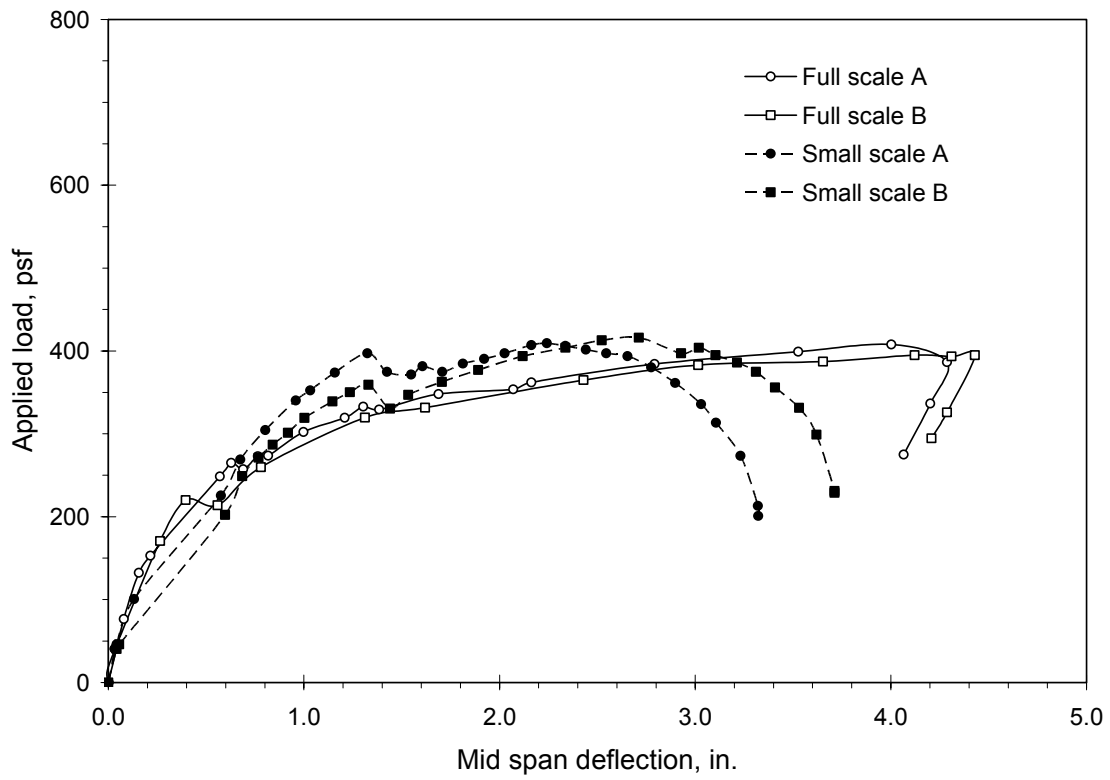
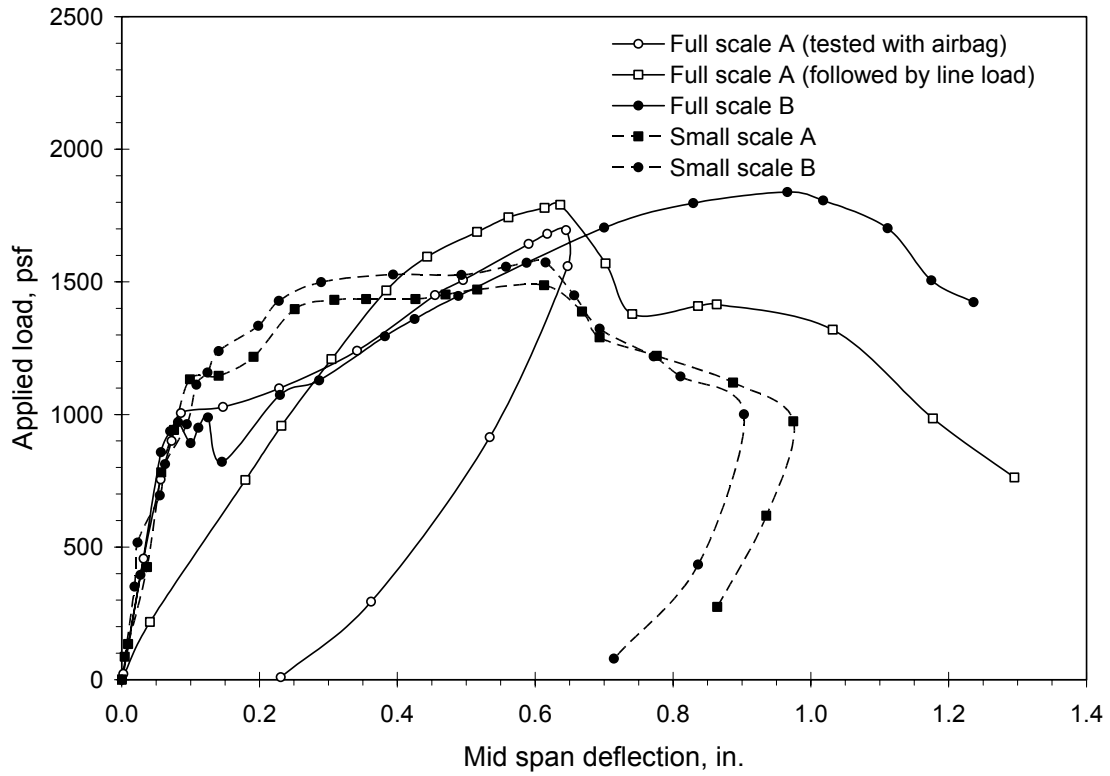
Test #20: 3VL16-8-5-22 with straps

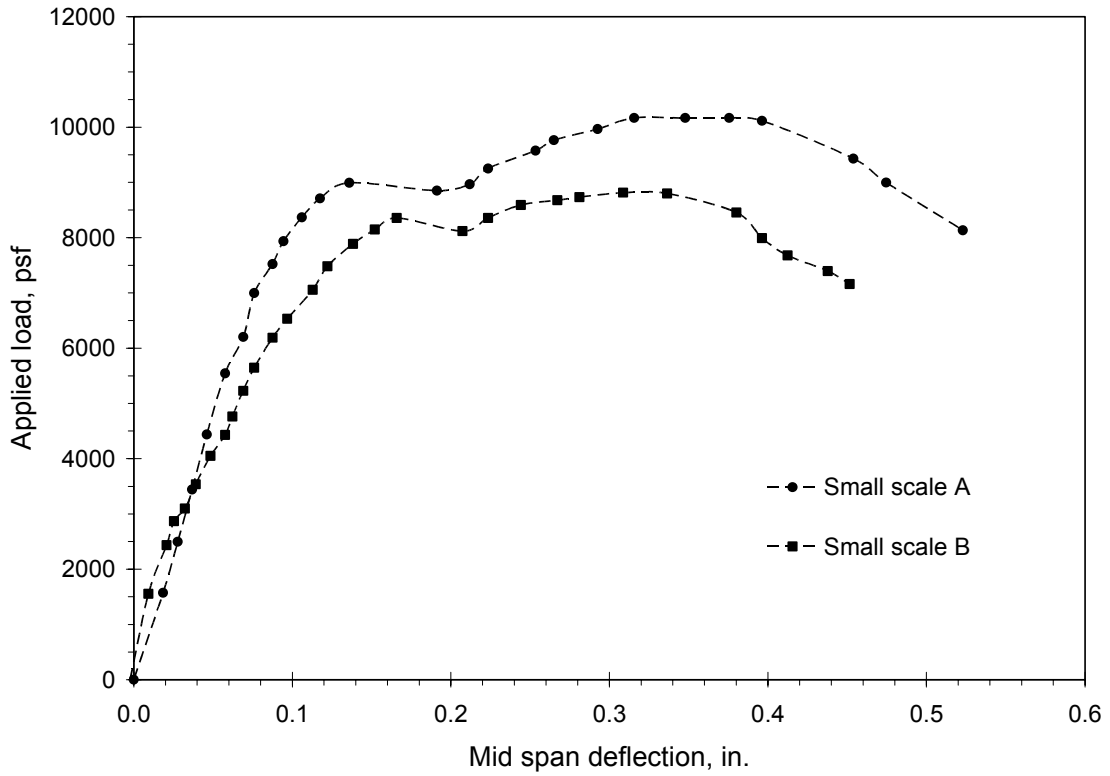
C.2 Test results: Loads versus mid span deflections for full scale and small scale specimens in series #2

Summary of maximum load and the corresponding deflections

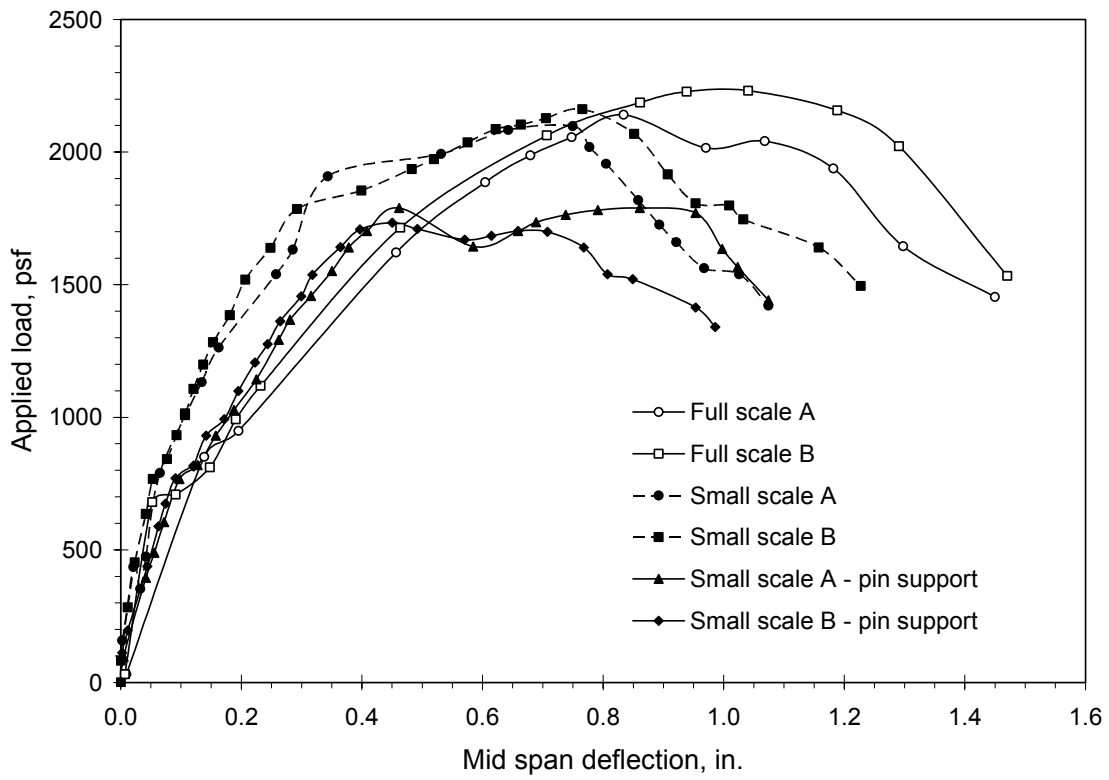
Specimen ID	Test	Full scale tests		Small scale tests	
		Max. load (psf)	Mid-span deflection at max. load (in.)	Max. load (psf)	Mid-span deflection at max. load (in.)
3VL20-8-7.5	A	1670	1.004	1390	0.601
	B	1650	0.990	1370	0.468
3VL20-11-5	A	420	2.253	510	1.933
	B	450	2.509	410	1.829
3VL18-8-7.5	A	1790	0.644	1490	0.613
	B	1840	0.968	1570	0.615
3VL18-13-5	A	390	2.900	410	2.241
	B	390	2.890	420	2.712
3VL16-4-7.5	A	-	-	10170	0.316
	B	-	-	8820	0.309
3VL16-8-7.5	A	2140	0.832	2100	0.749
	B	2230	1.041	2160	0.766
3VL16-10-7.5	A	-	-	1350	0.952
	B	-	-	1190	0.935
3VL16-12-5	A	-	-	610	2.005
	B	-	-	610	1.917
3VL16-14-5	A	380	3.367	430	3.152
	B	410	3.429	440	3.225
2VL20-7-6.5	A	1540	0.523	1600	0.339
	B	1460	0.542	1480	0.283
2VL20-9-4	A	460	1.366	480	1.213
	B	480	1.527	460	1.413
2VL18-7-6.5	A	1940	0.681	1830	0.433
	B	1790	0.584	1950	0.364
2VL18-11-4	A	430	1.620	450	2.012
	B	470	1.911	450	2.359
2VL16-7-6.5	A	1860	0.425	2620	0.426
	B	2380	0.658	2390	0.439
2VL16-12-4	A	480	2.123	470	3.237
	B	470	2.309	500	2.276



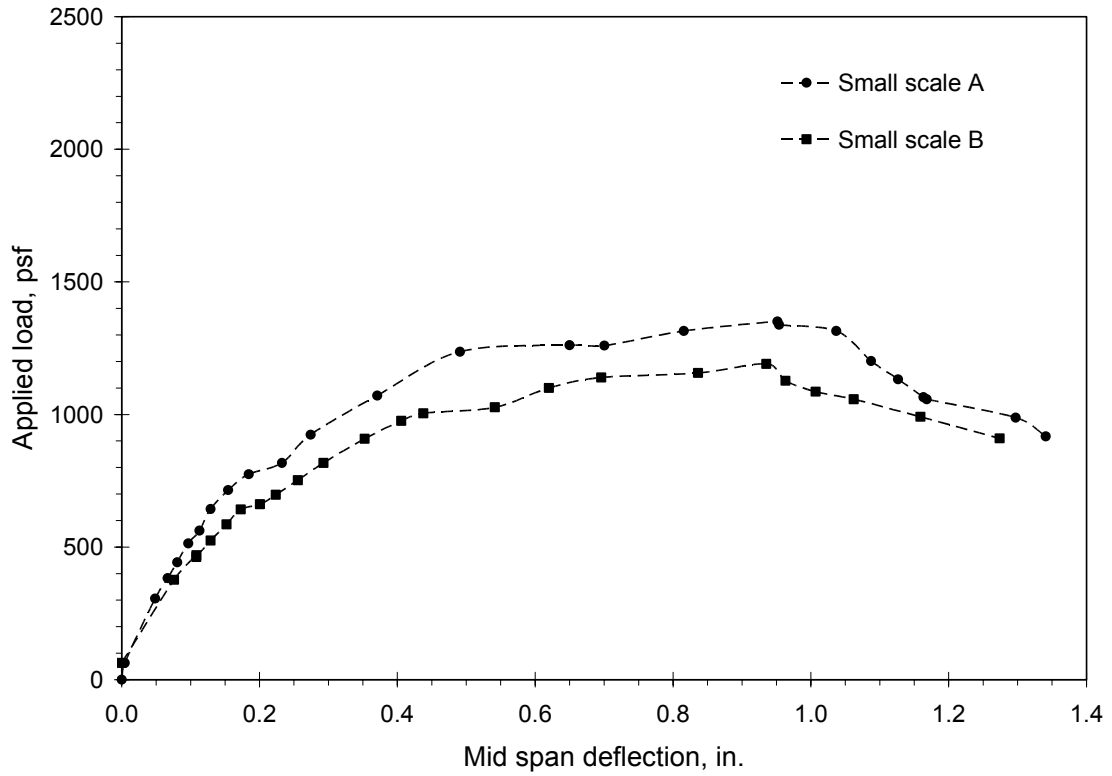




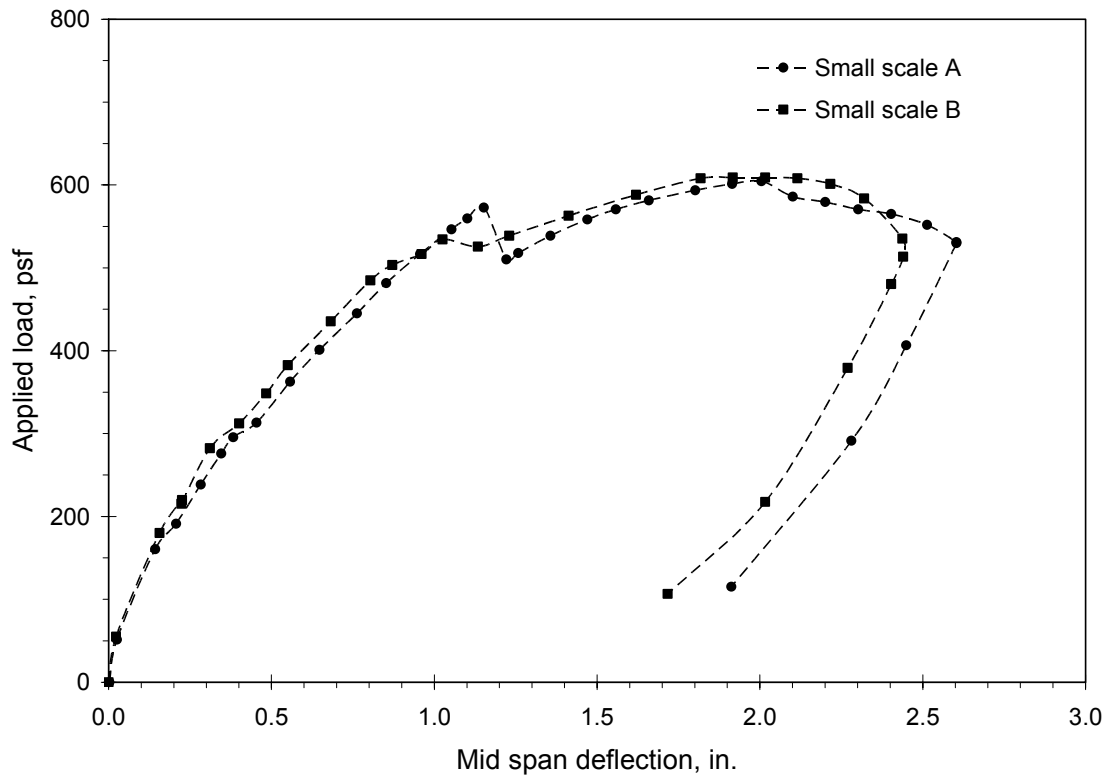
3VL16-4-7.5



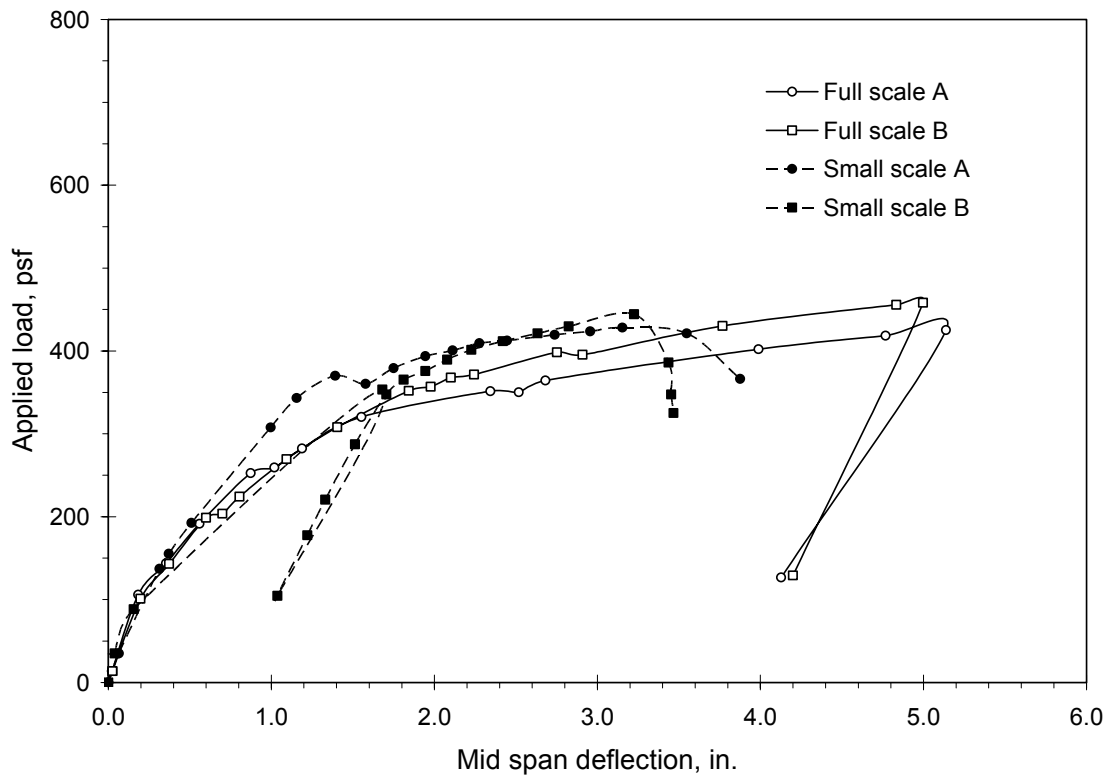
3VL16-8-7.5



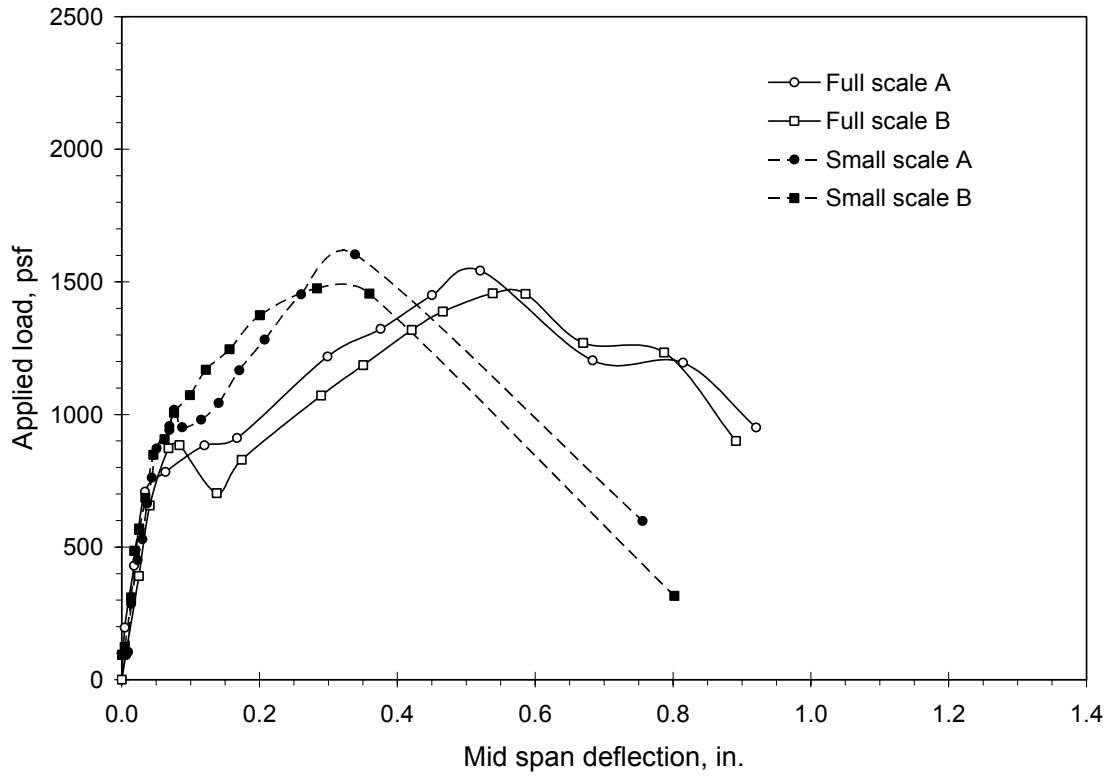
3VL16-10-7.5



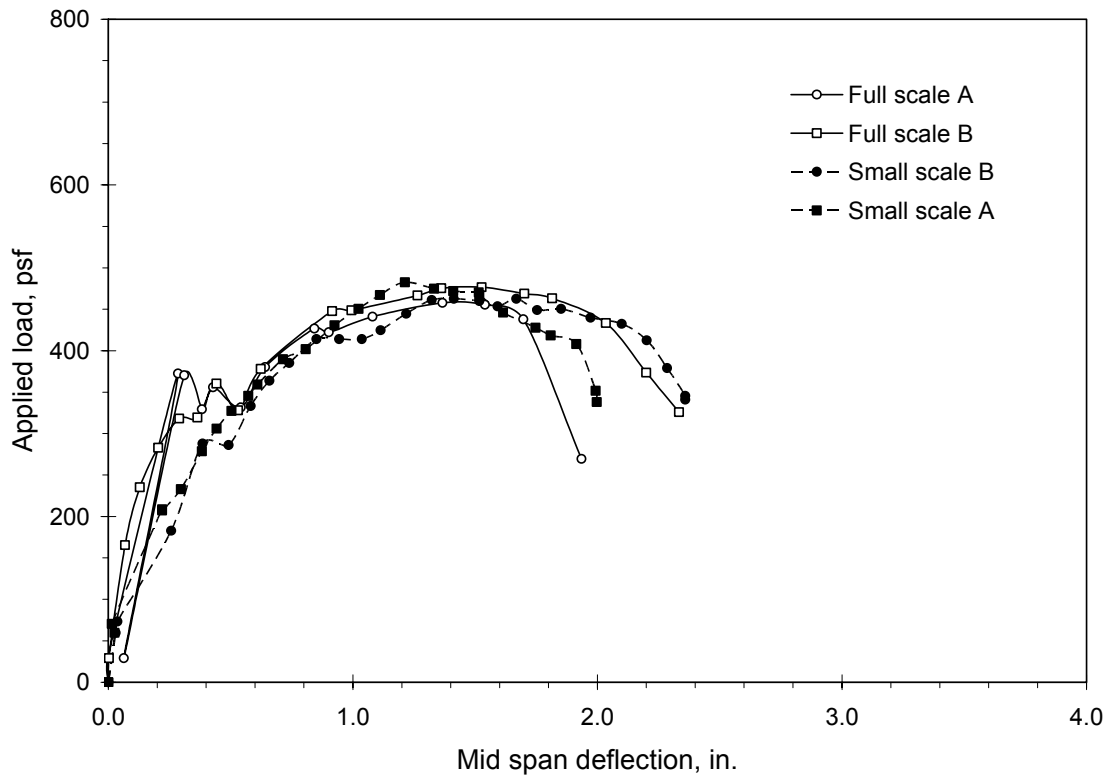
3VL16-12-5



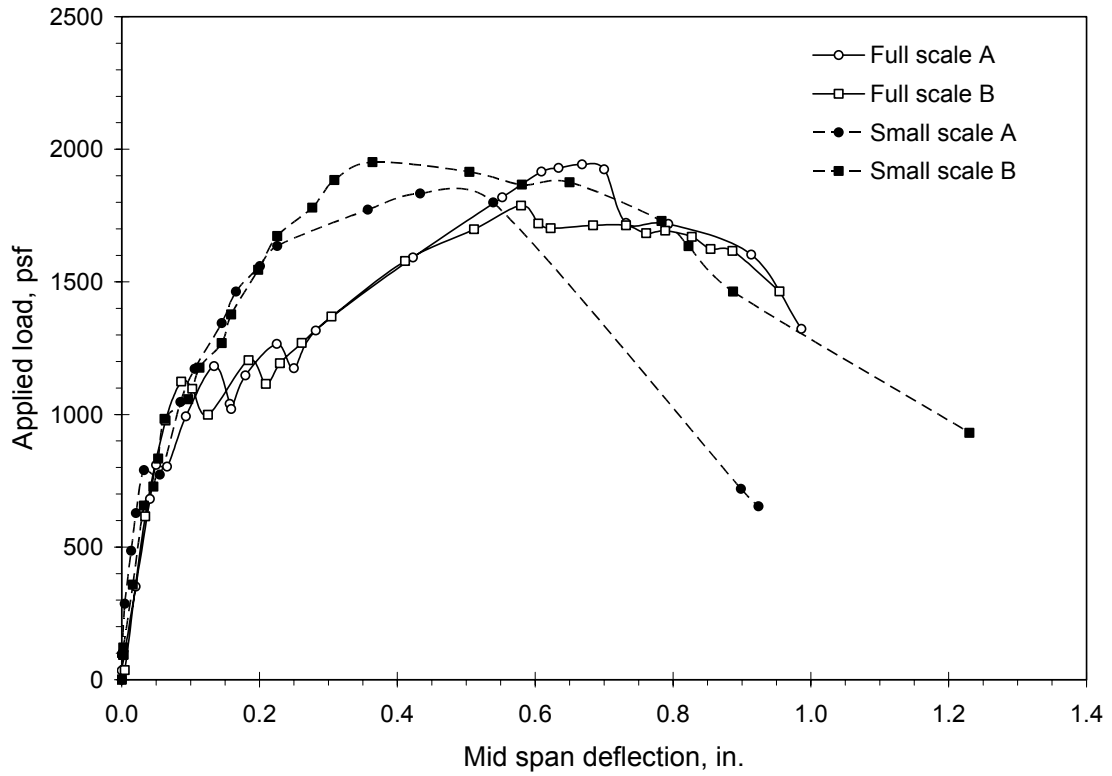
3VL16-14-5



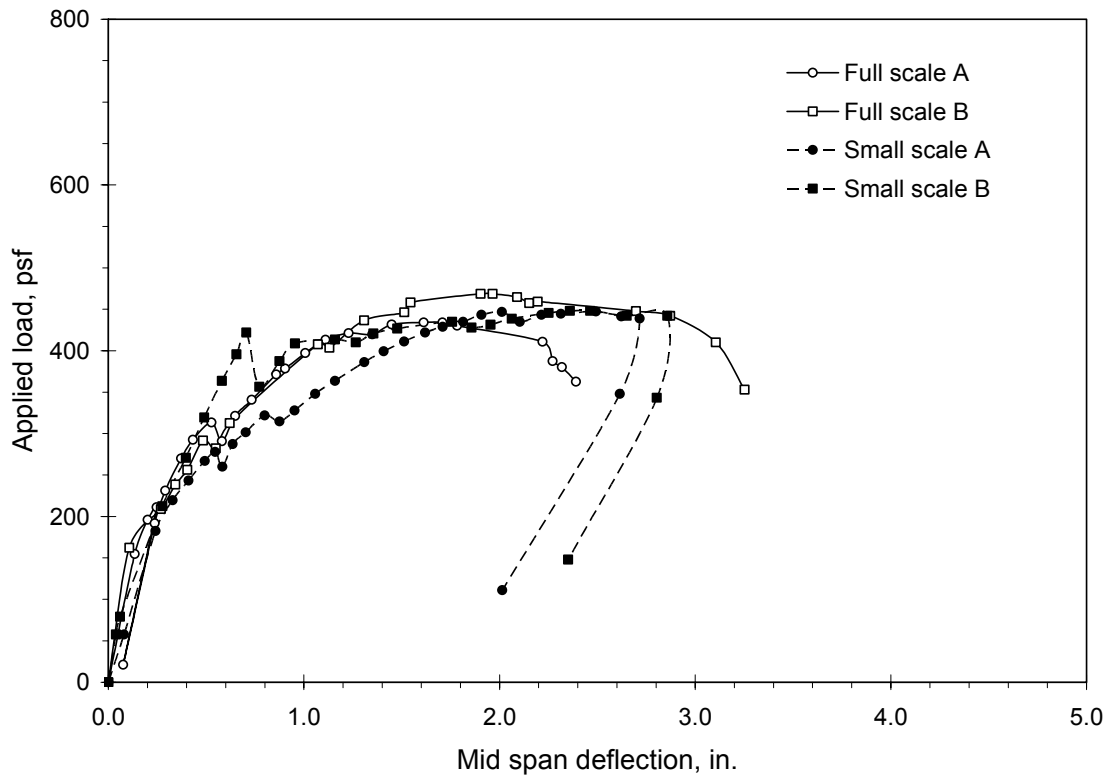
2VL20-7-6.5



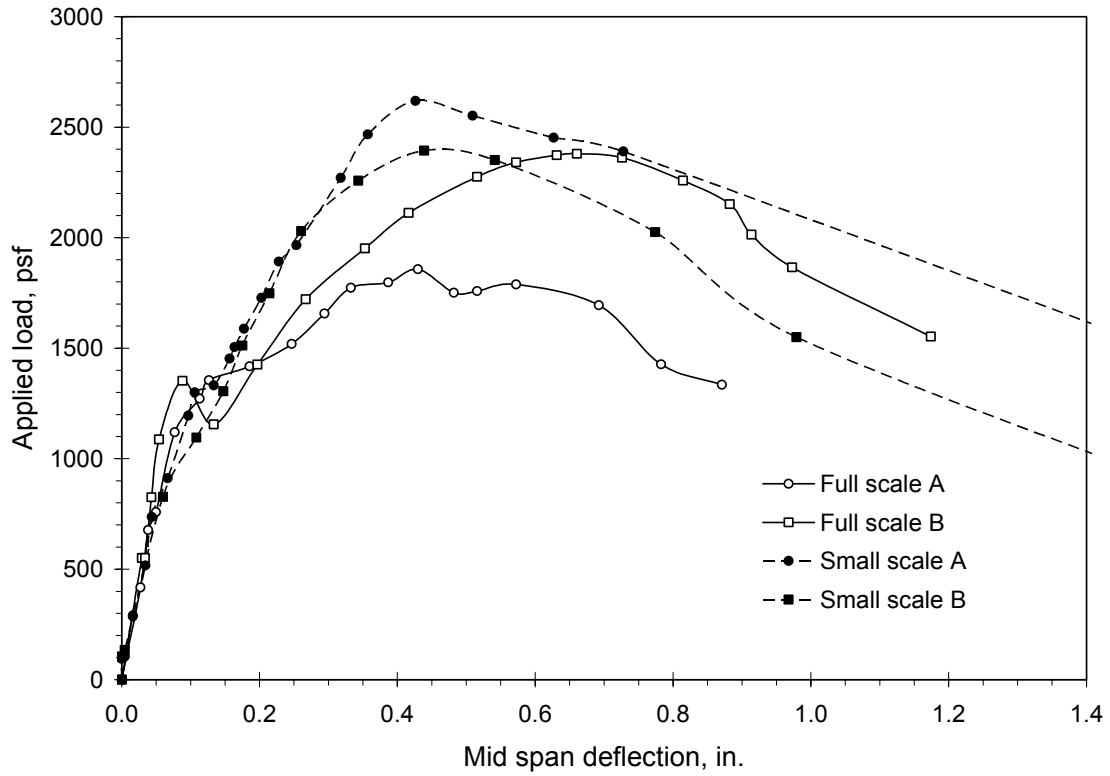
2VL20-9-4



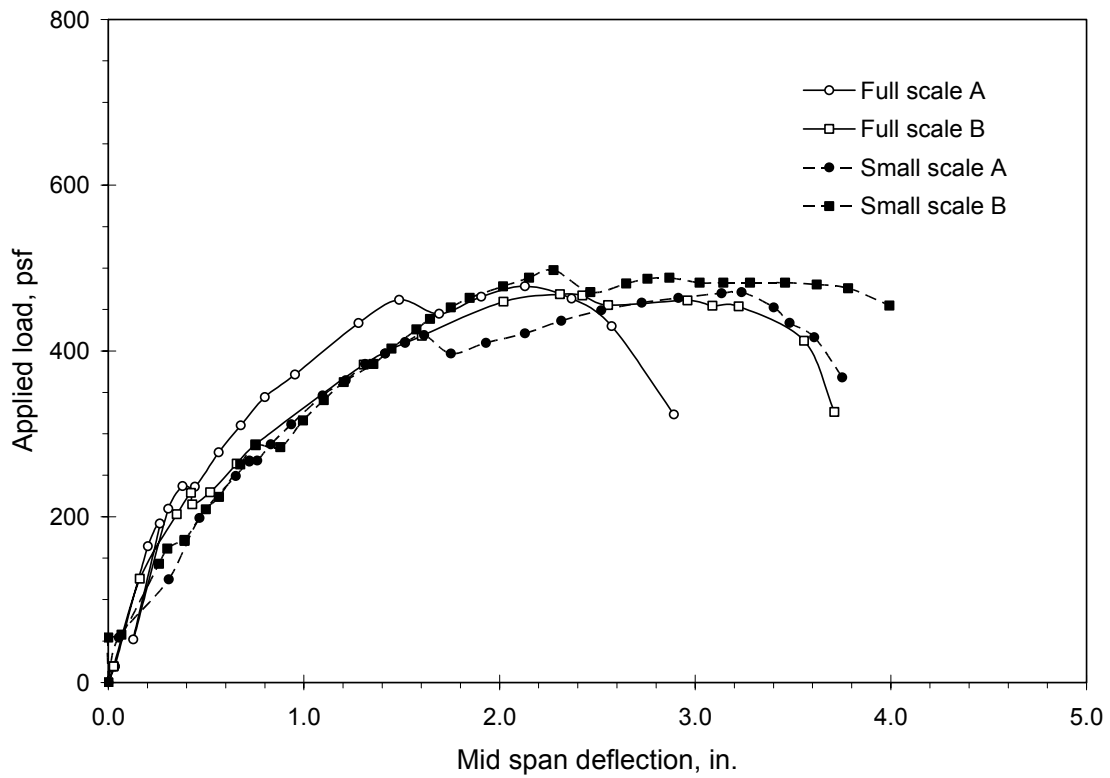
2L18-7-6.5



2VL18-11-4



2VL16-7-6.5

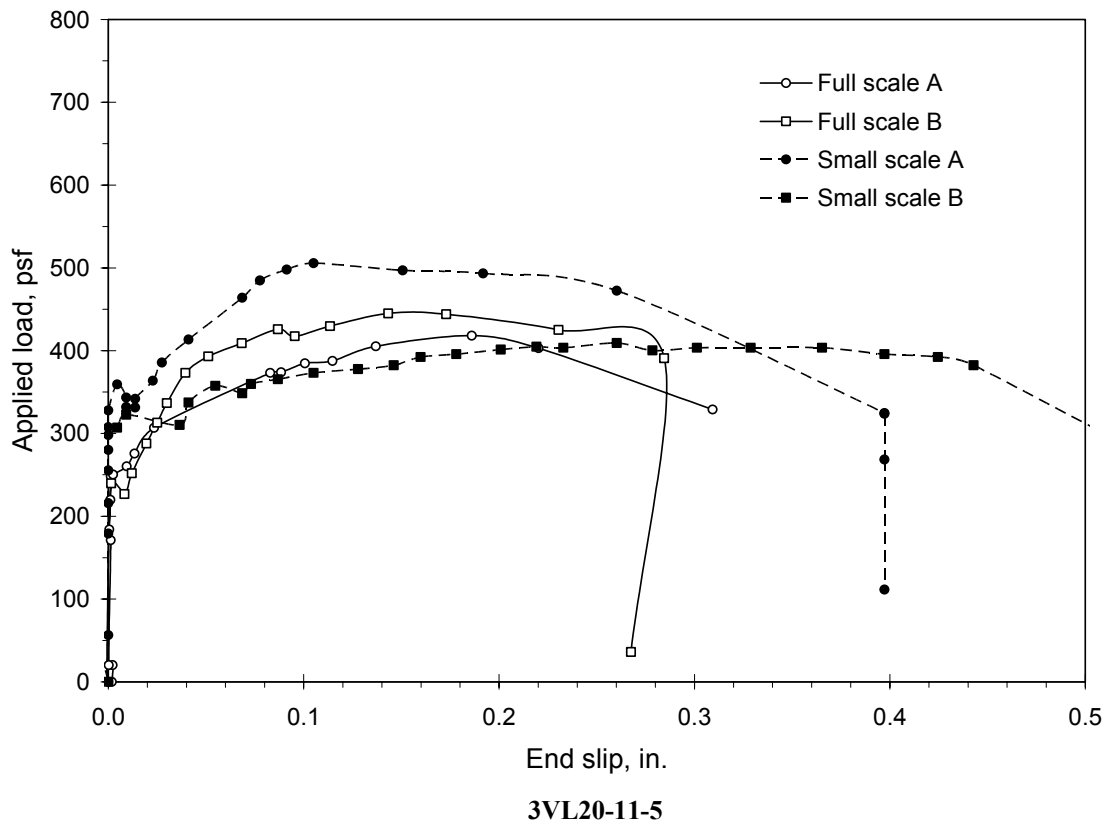
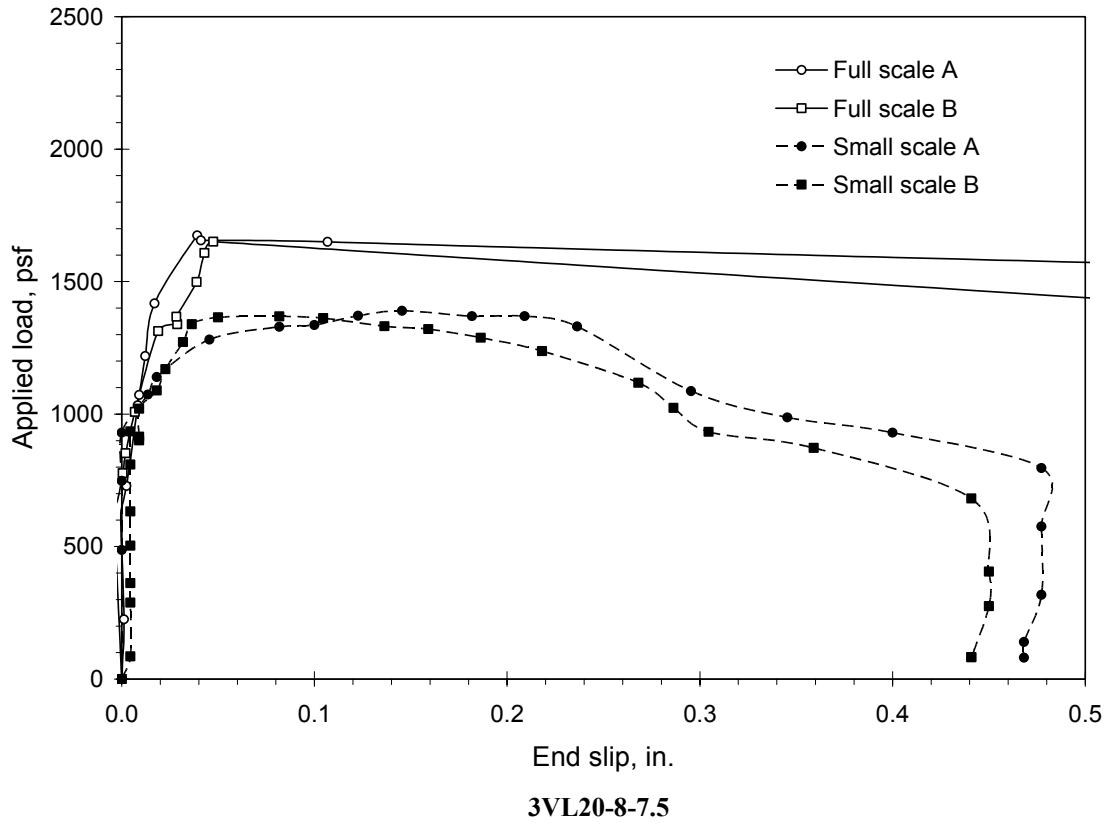


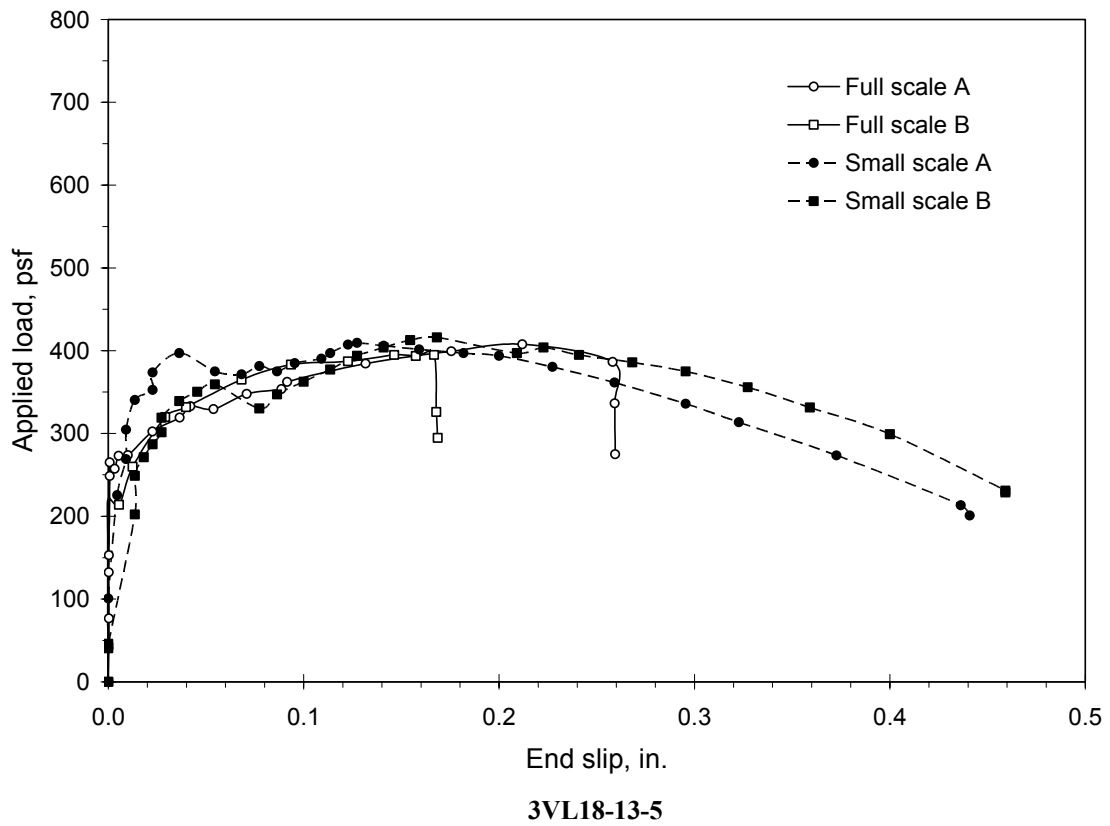
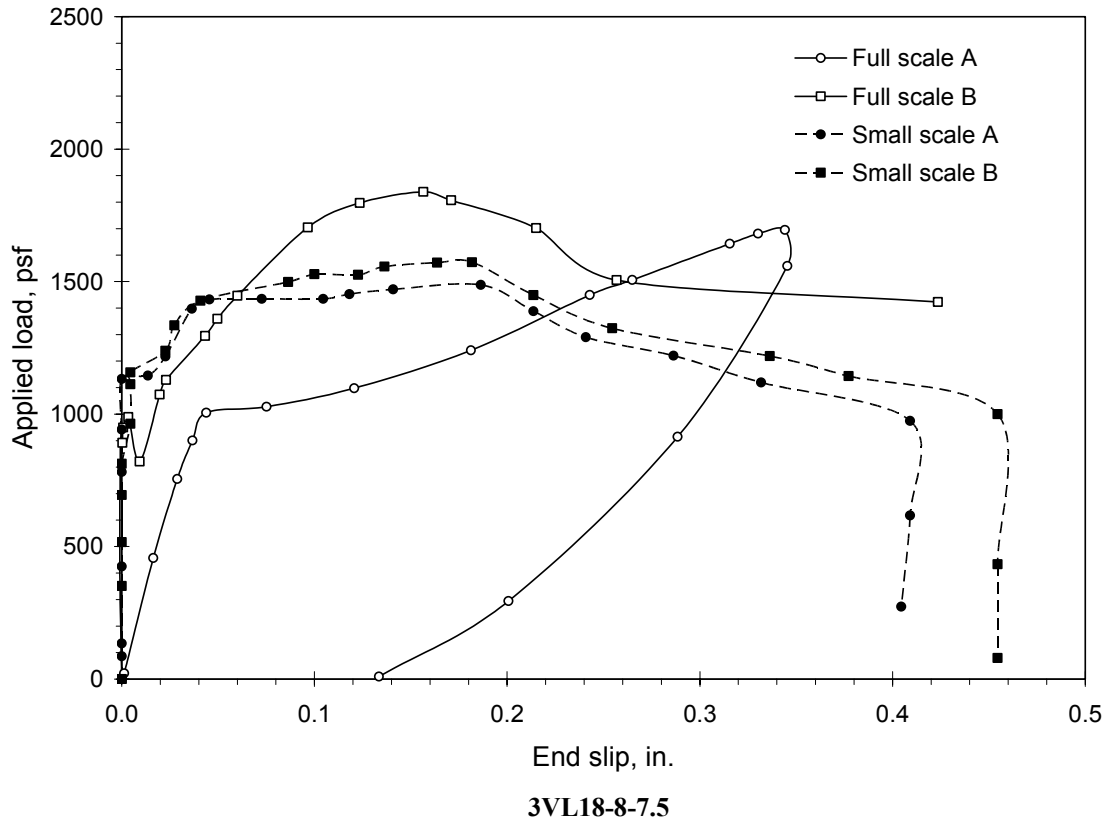
2VL16-12-4

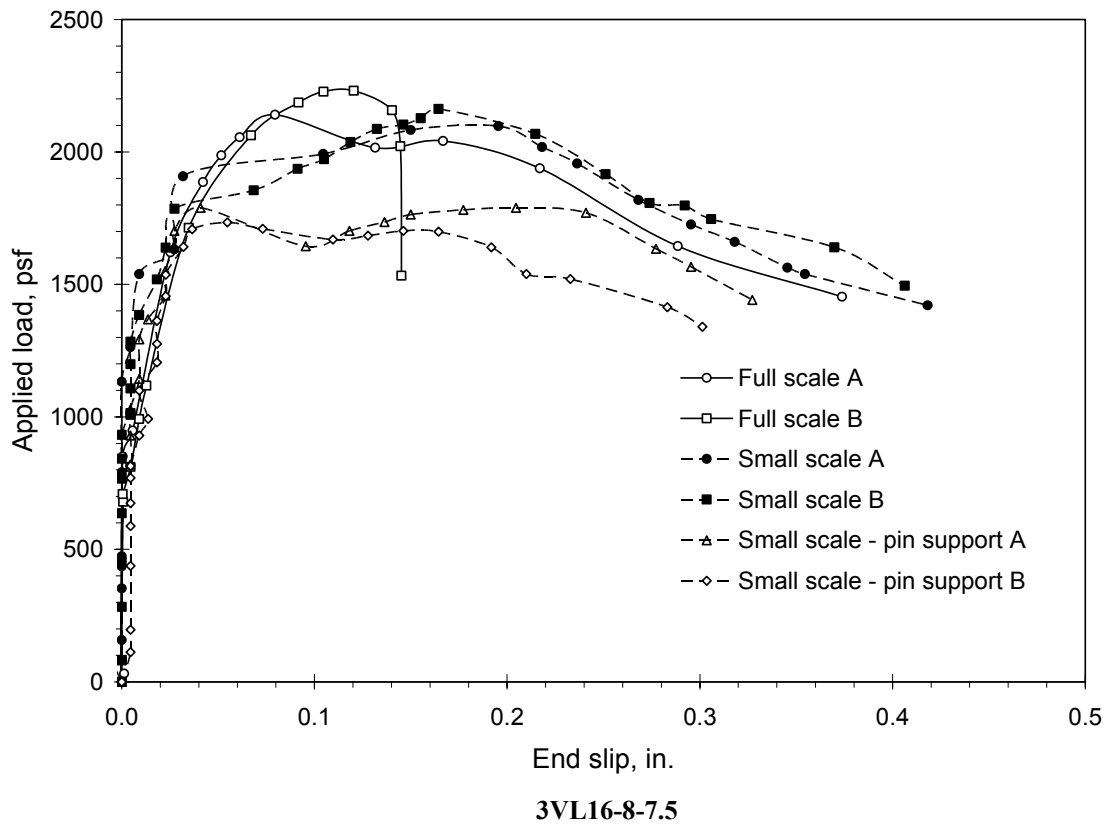
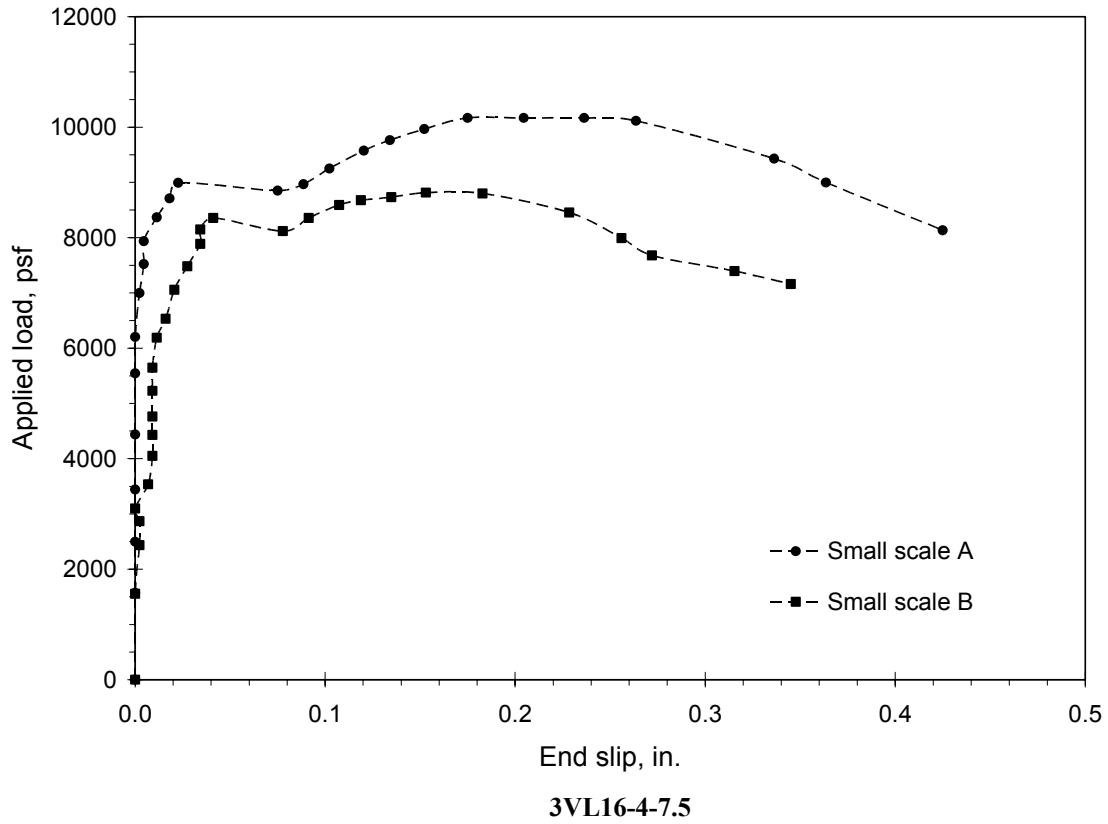
C.3 Test results: Loads versus end slips for full scale and small scale specimens in series #2

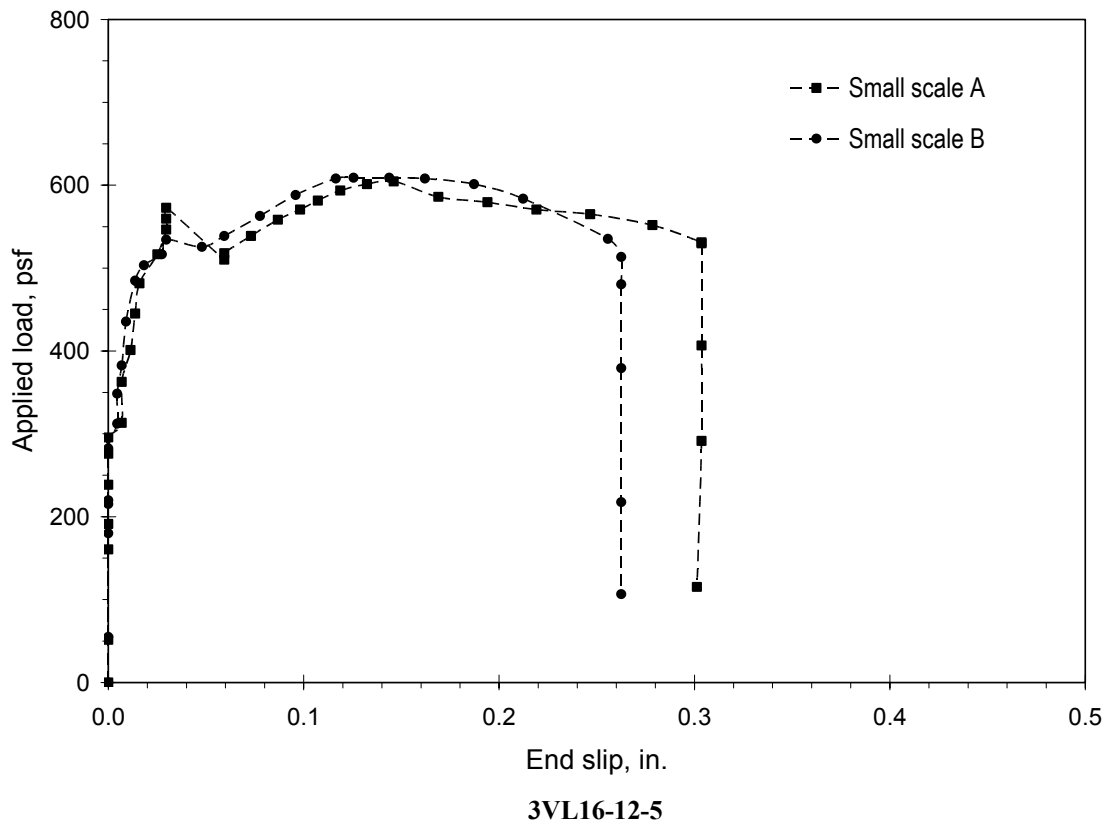
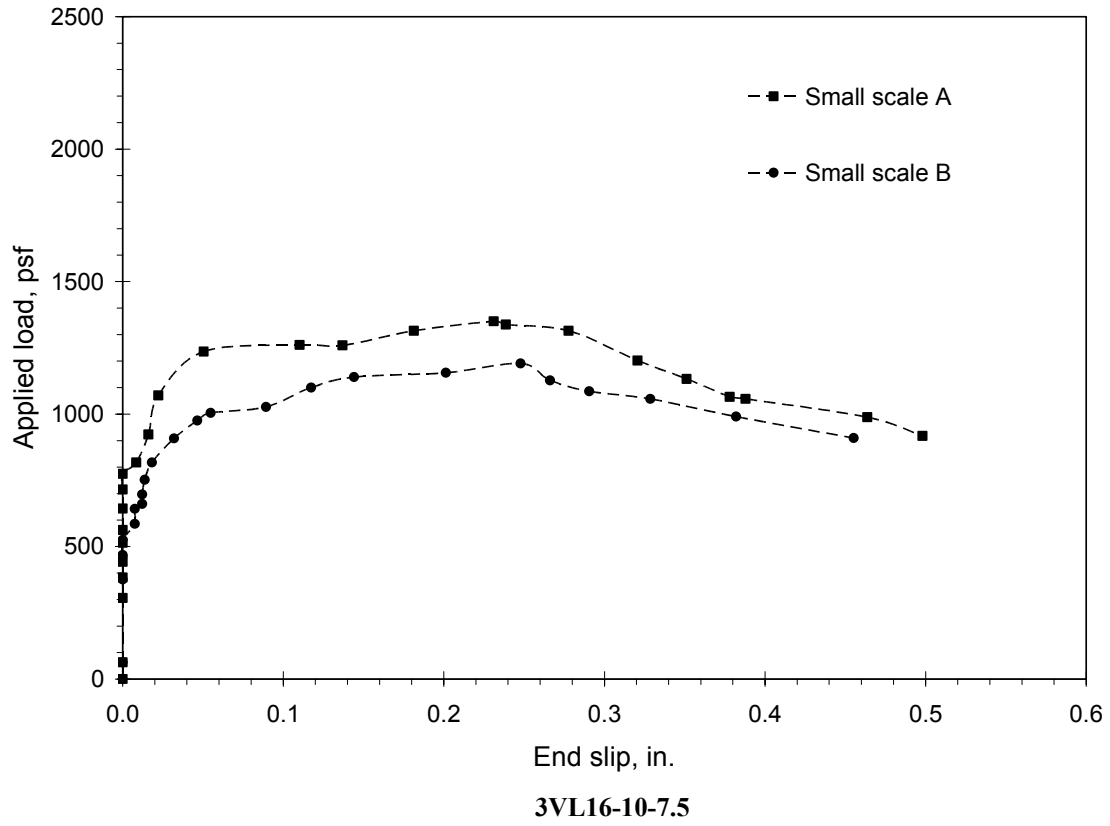
Summary of maximum loads and the corresponding end slips.

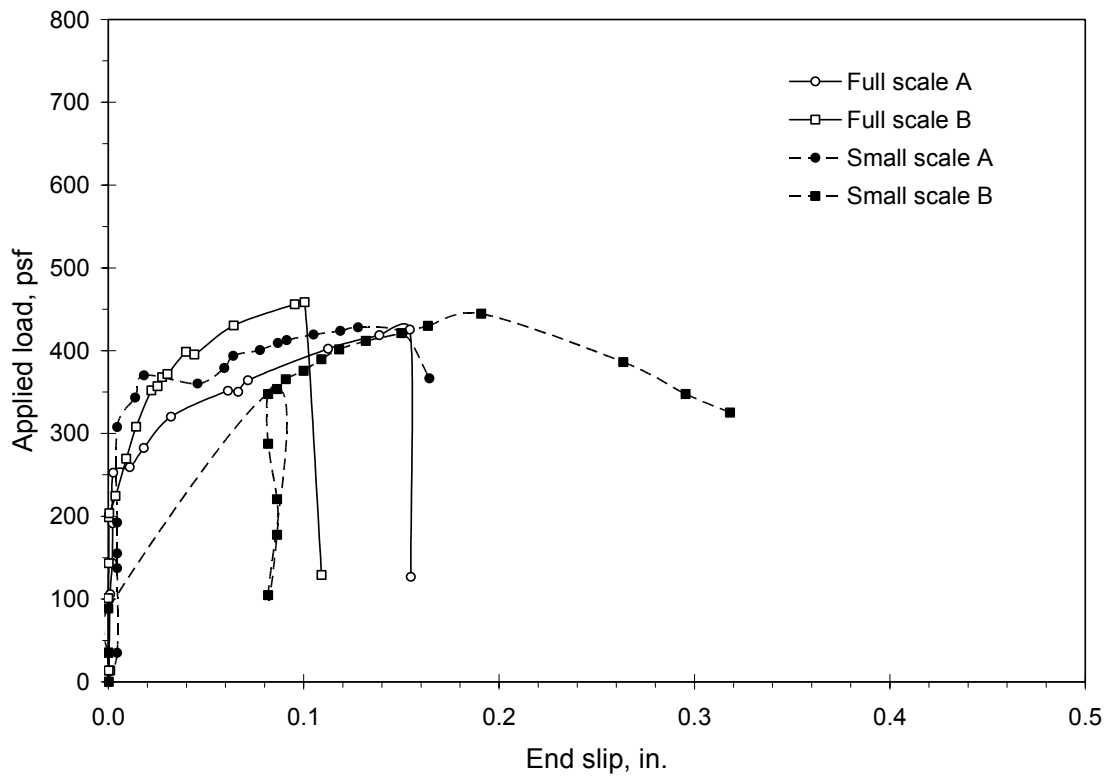
Specimen ID	Test	Full scale tests		Small scale tests	
		Max. load (psf)	End slip at max. load (in.)	Max. load (psf)	End slip at max. load (in.)
3VL20-8-7.5	A	1670	0.049	1390	0.149
	B	1650	0.048	1370	0.074
3VL20-11-5	A	420	0.186	510	0.103
	B	450	0.143	410	0.267
3VL18-8-7.5	A	1790	0.344	1490	0.183
	B	1840	0.157	1570	0.182
3VL18-13-5	A	390	0.135	410	0.13
	B	390	0.087	420	0.157
3VL16-4-7.5	A	-	-	10170	0.175
	B	-	-	8820	0.153
3VL16-8-7.5	A	2140	0.080	2100	0.198
	B	2230	0.121	2160	0.172
3VL16-10-7.5	A	-	-	1350	0.231
	B	-	-	1190	0.248
3VL16-12-5	A	-	-	610	0.146
	B	-	-	610	0.126
3VL16-14-5	A	380	0.094	430	0.133
	B	410	0.055	440	0.177
2VL20-7-6.5	A	1540	0.051	1600	0.039
	B	1460	0.052	1480	0.077
2VL20-9-4	A	460	0.120	480	0.098
	B	480	0.109	460	0.108
2VL18-7-6.5	A	1940	0.085	1830	0.197
	B	1790	0.083	1950	0.072
2VL18-11-4	A	430	0.070	450	0.133
	B	470	0.039	450	0.137
2VL16-7-6.5	A	1860	0.049	2620	0.037
	B	2380	0.085	2390	0.041
2VL16-12-4	A	480	0.109	470	0.211
	B	470	0.057	500	0.060



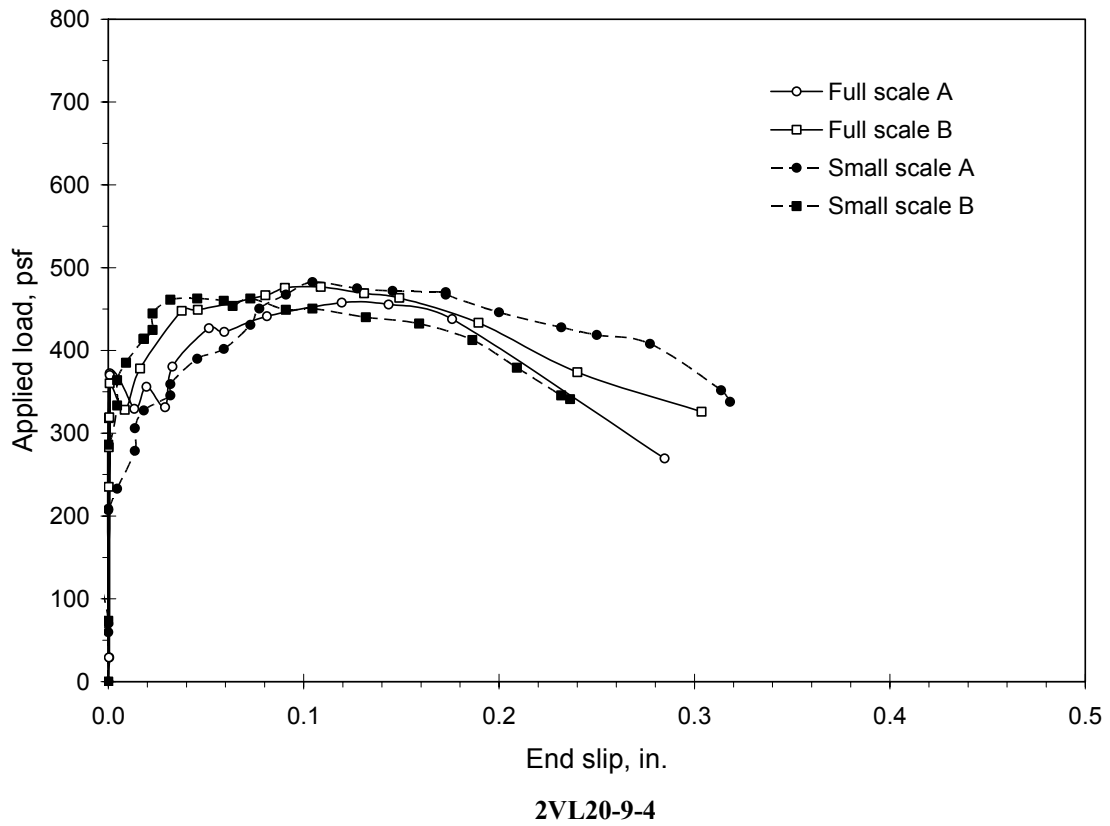
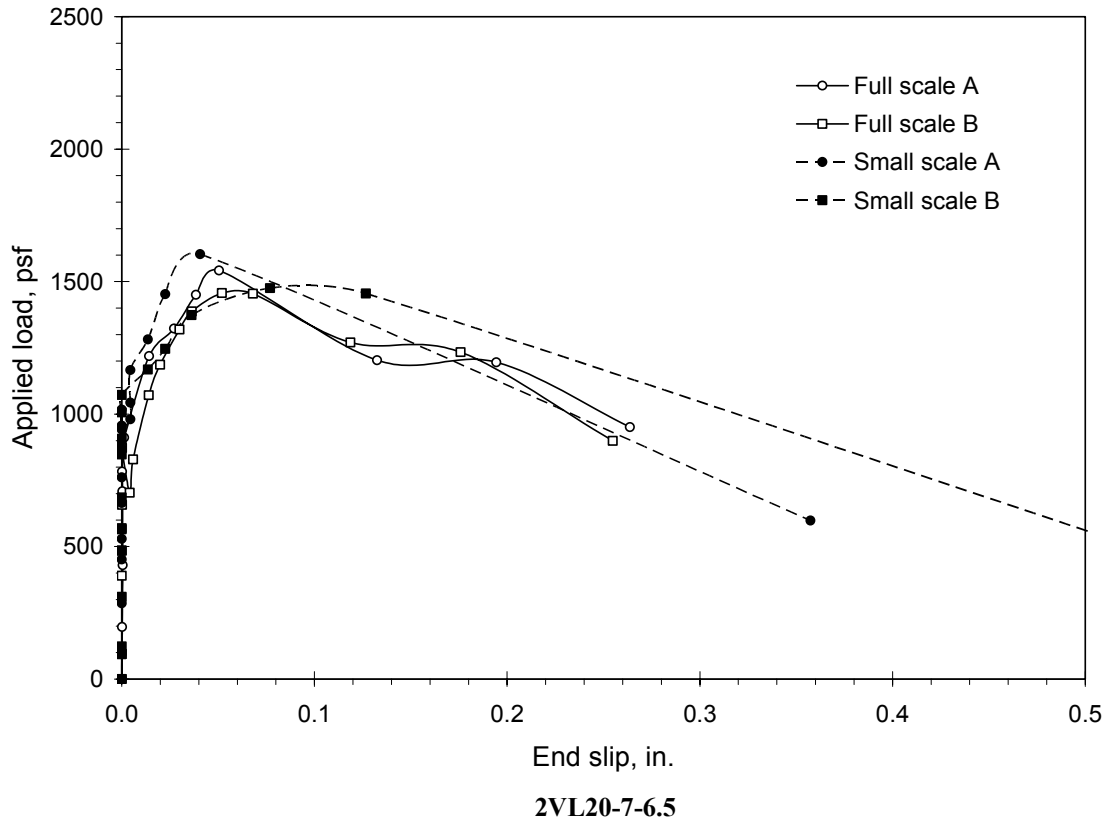


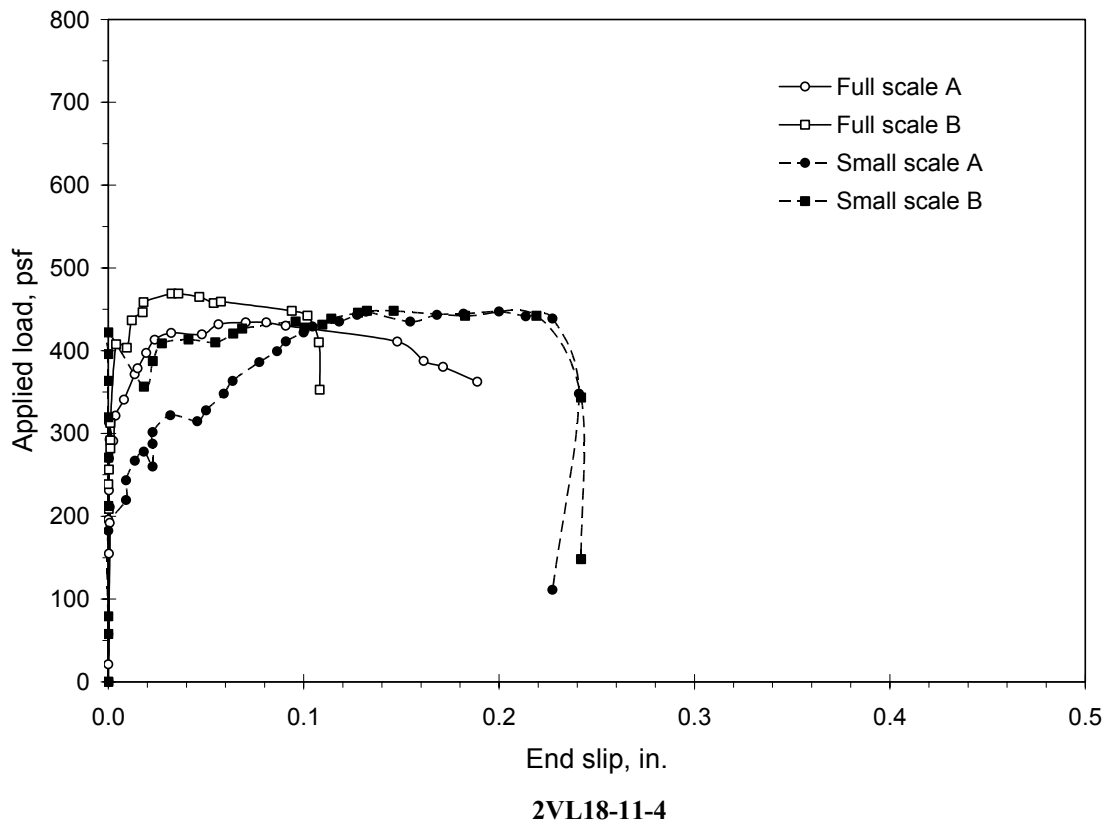
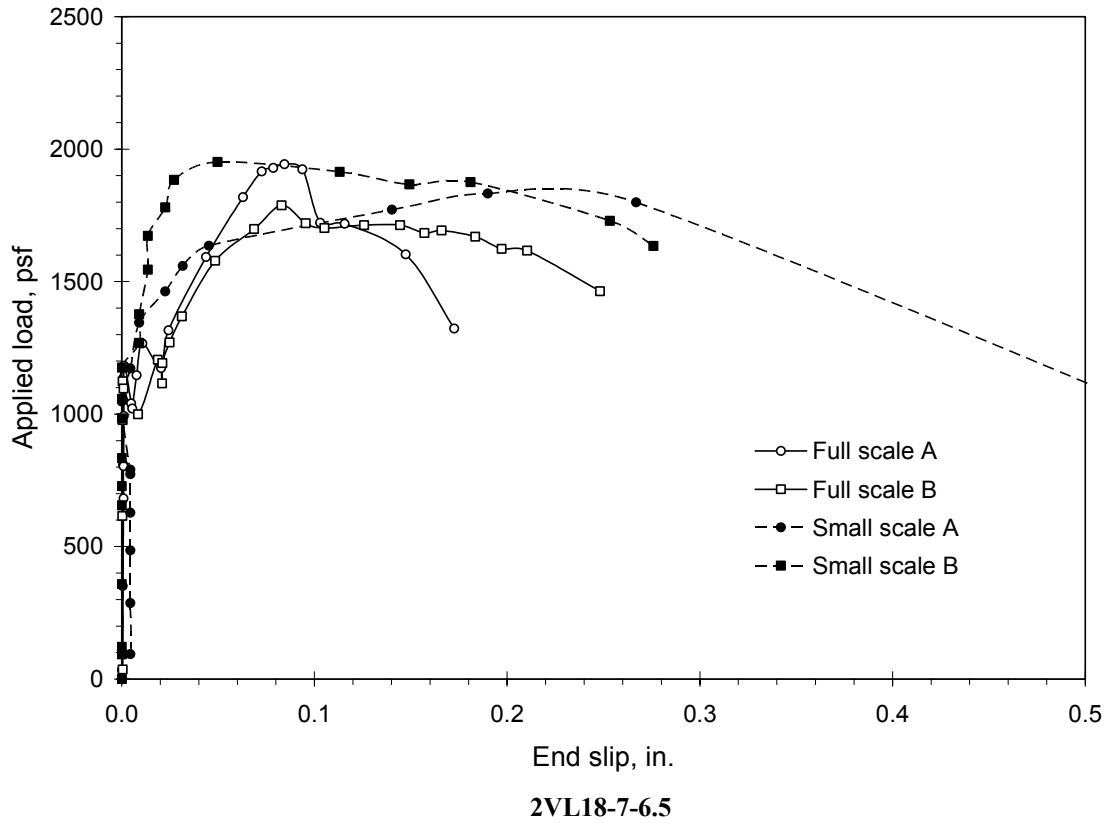


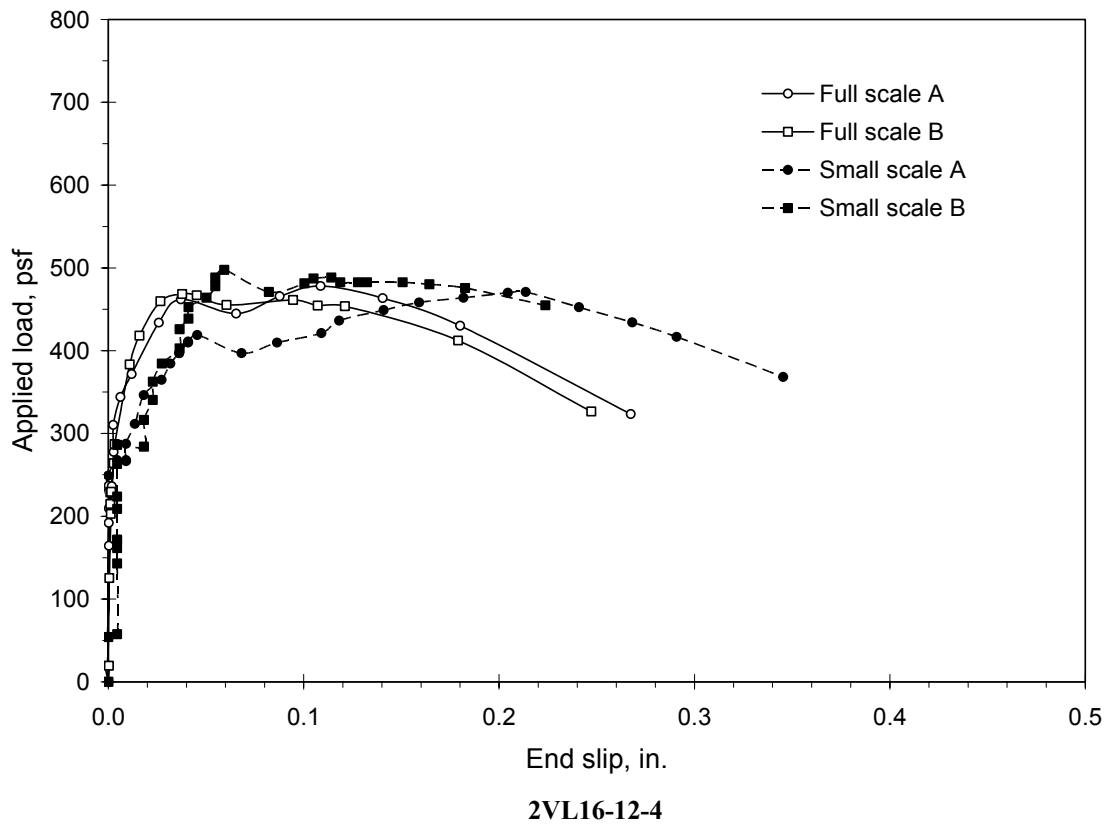
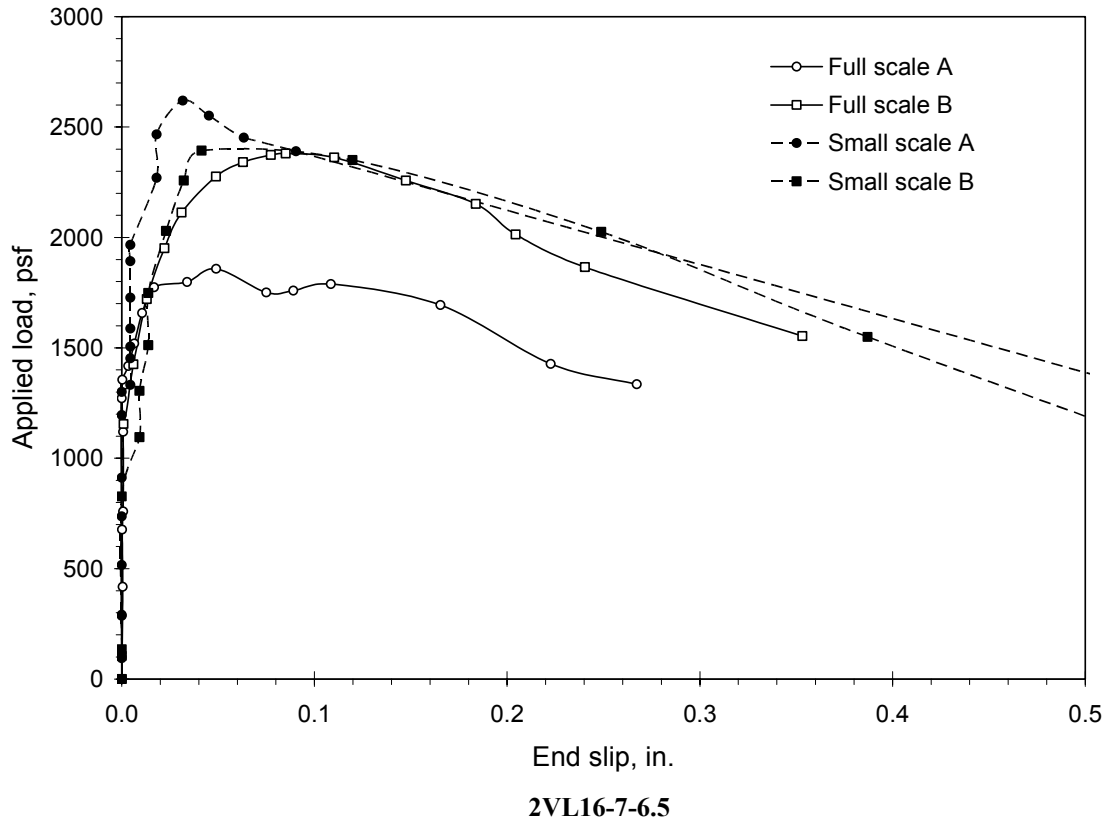




3VL16-14-5

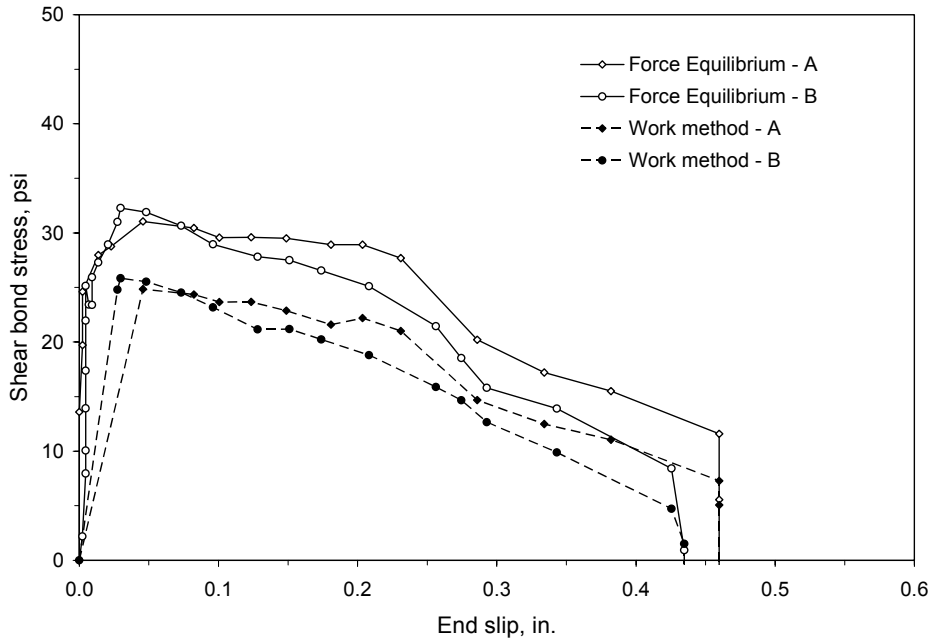




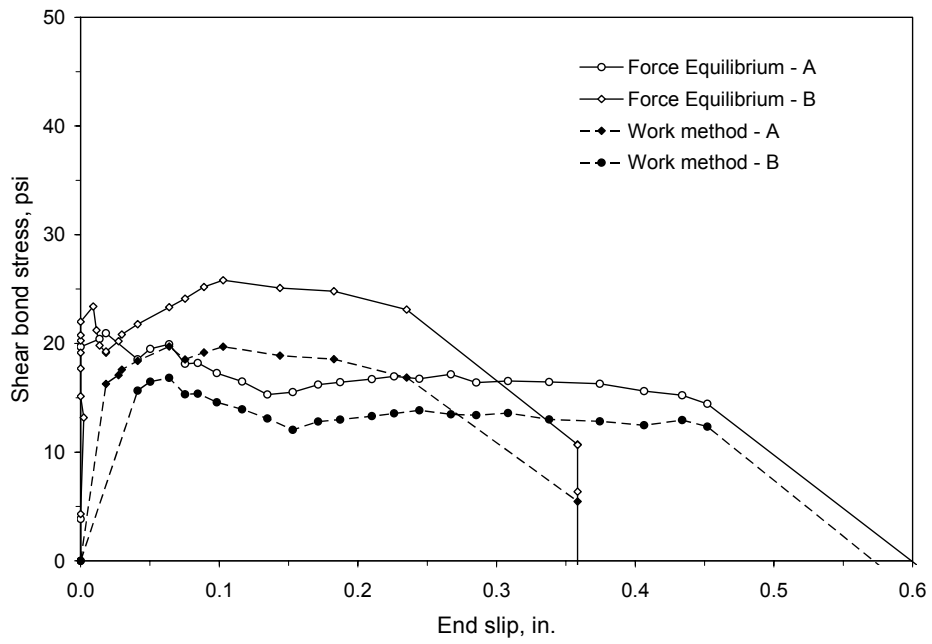


Appendix D

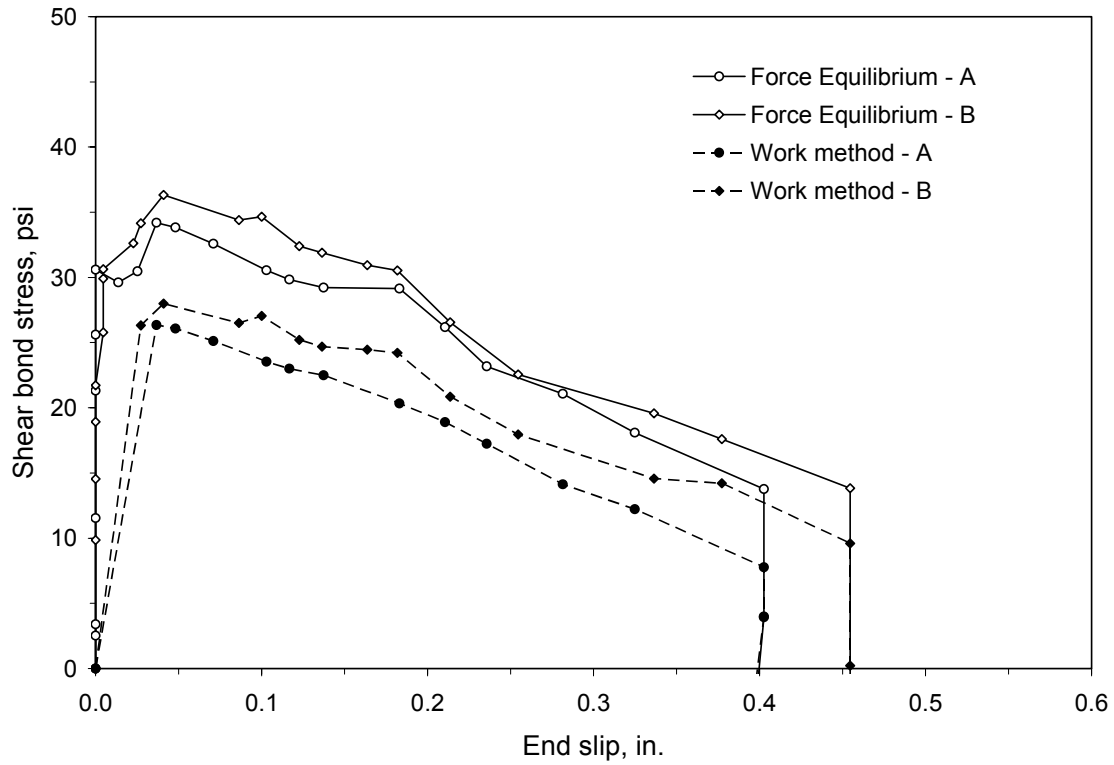
Shear bond stresses versus end slips for small scale specimens.



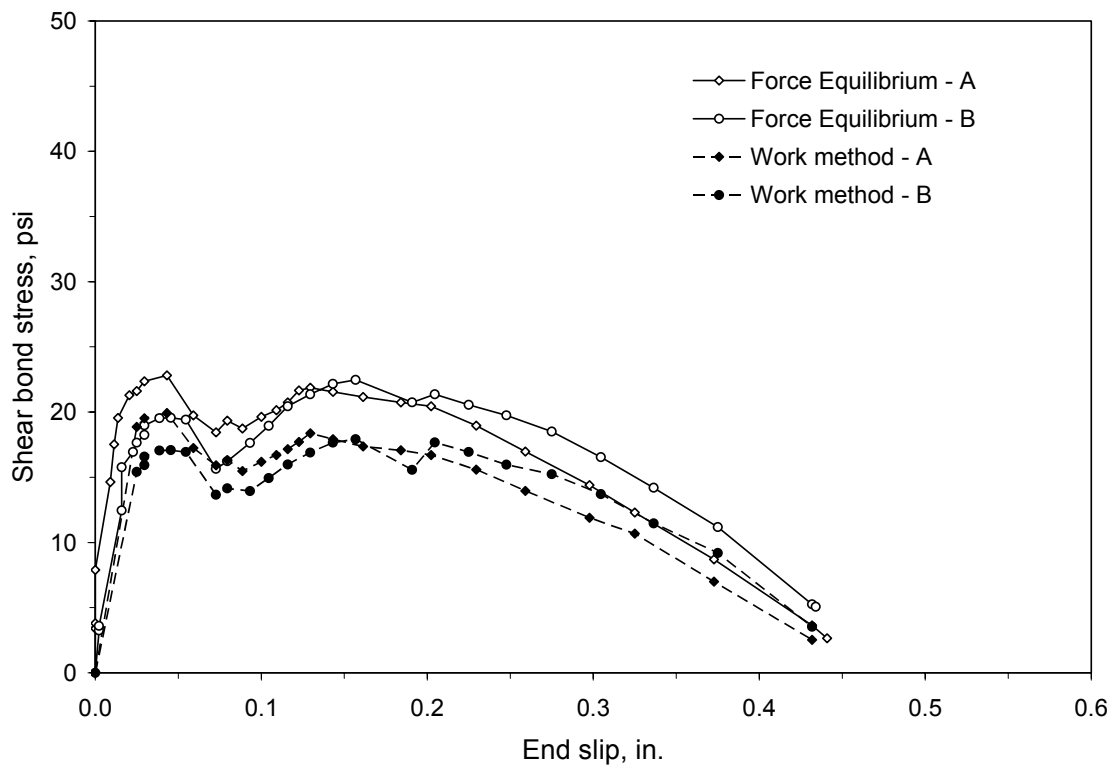
3VL20-8-7.5



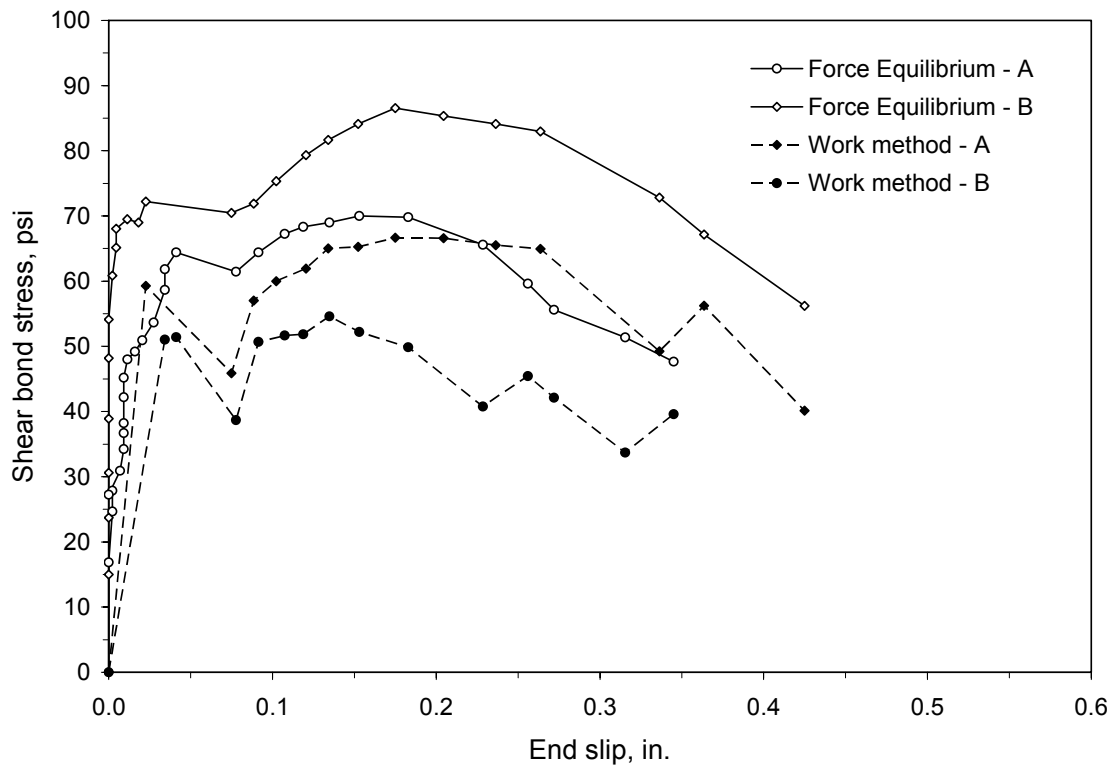
3VL20-11-5



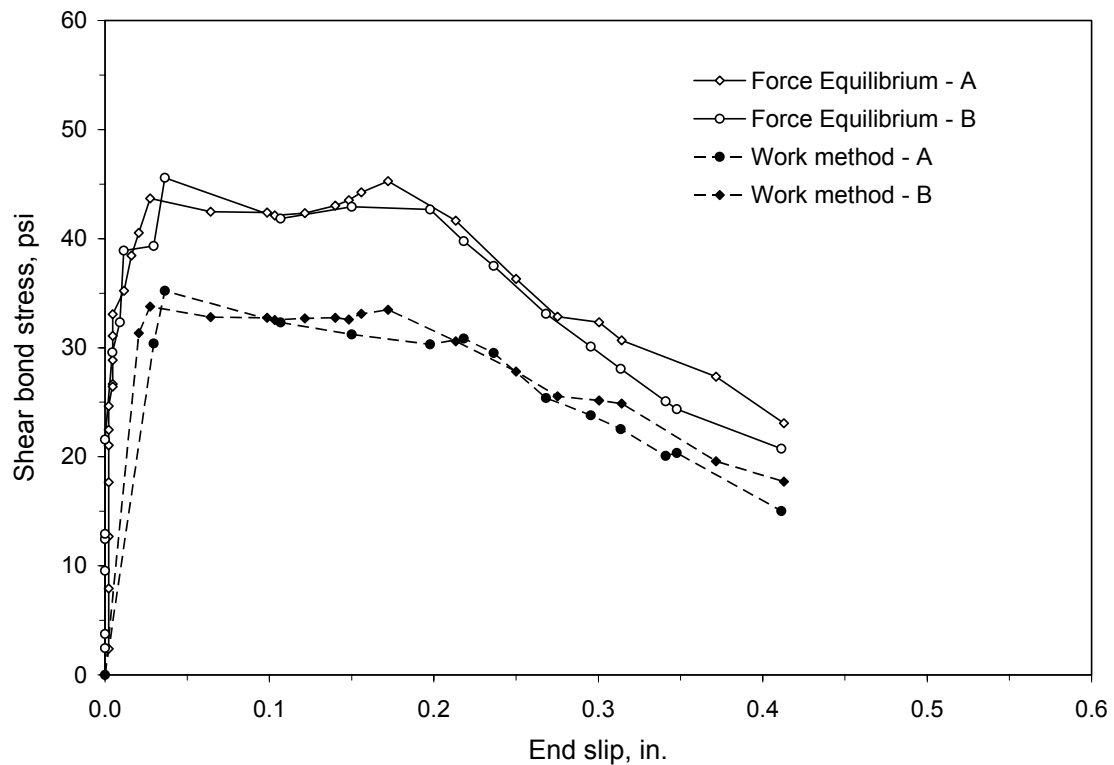
3VL18-8-7.5



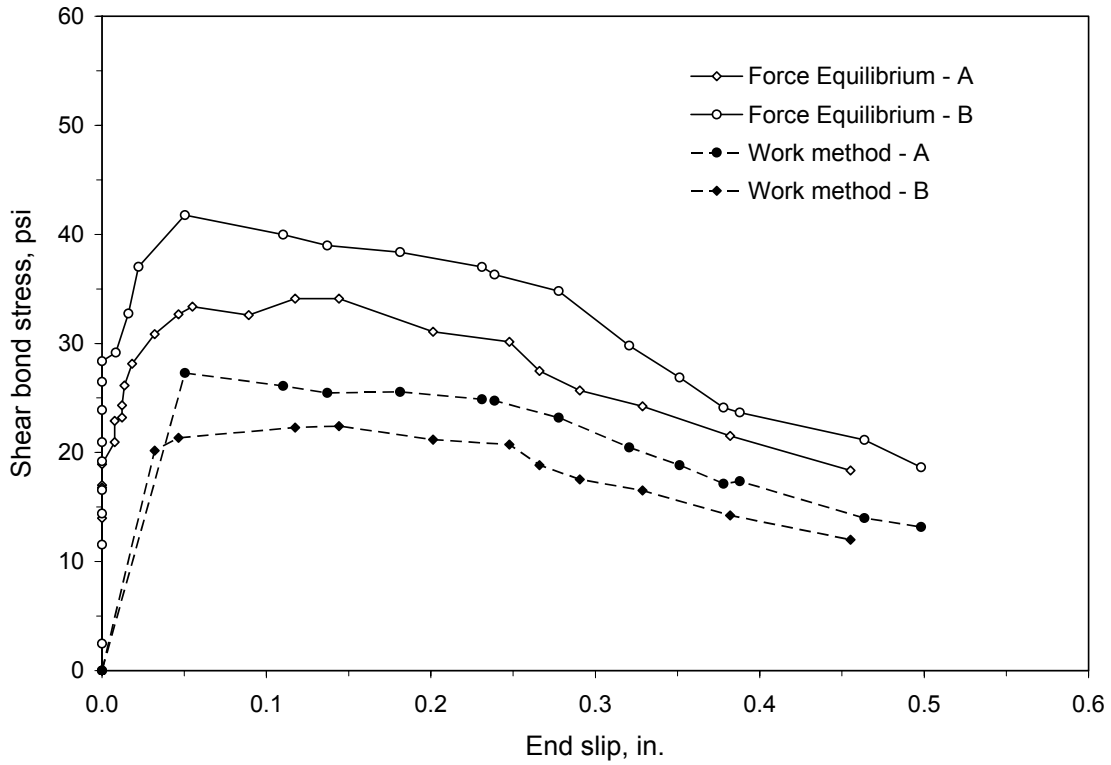
3VL18-13-5



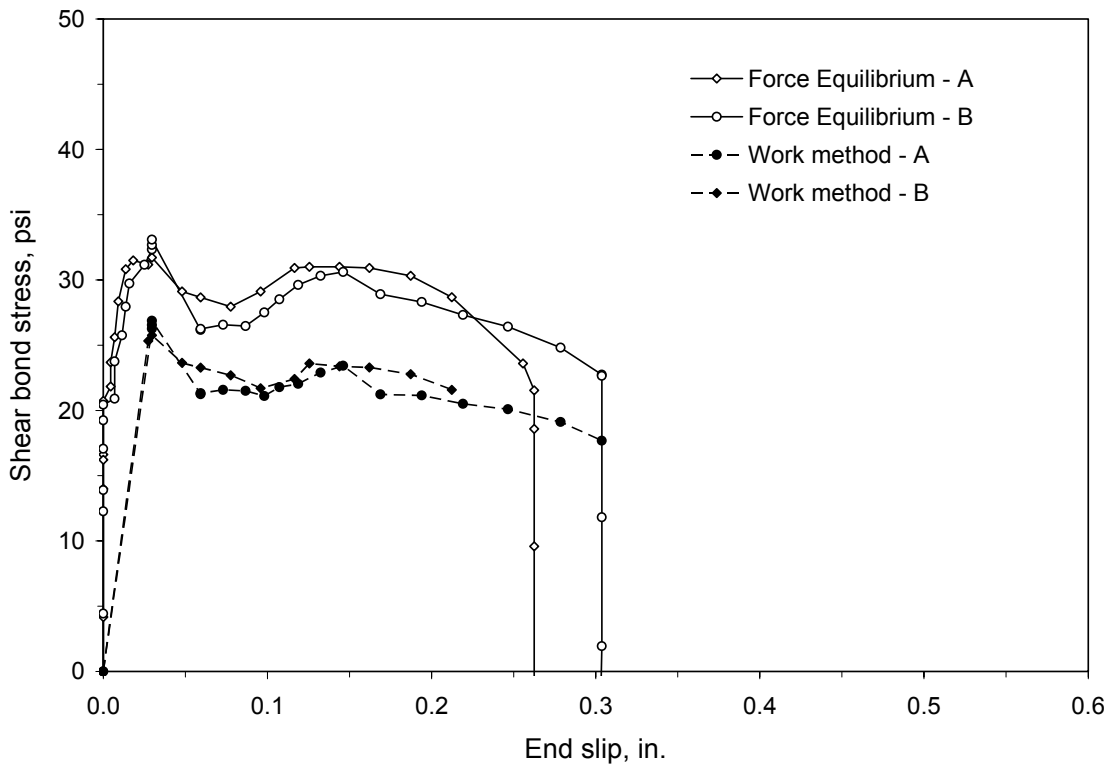
3VL16-4-7.5



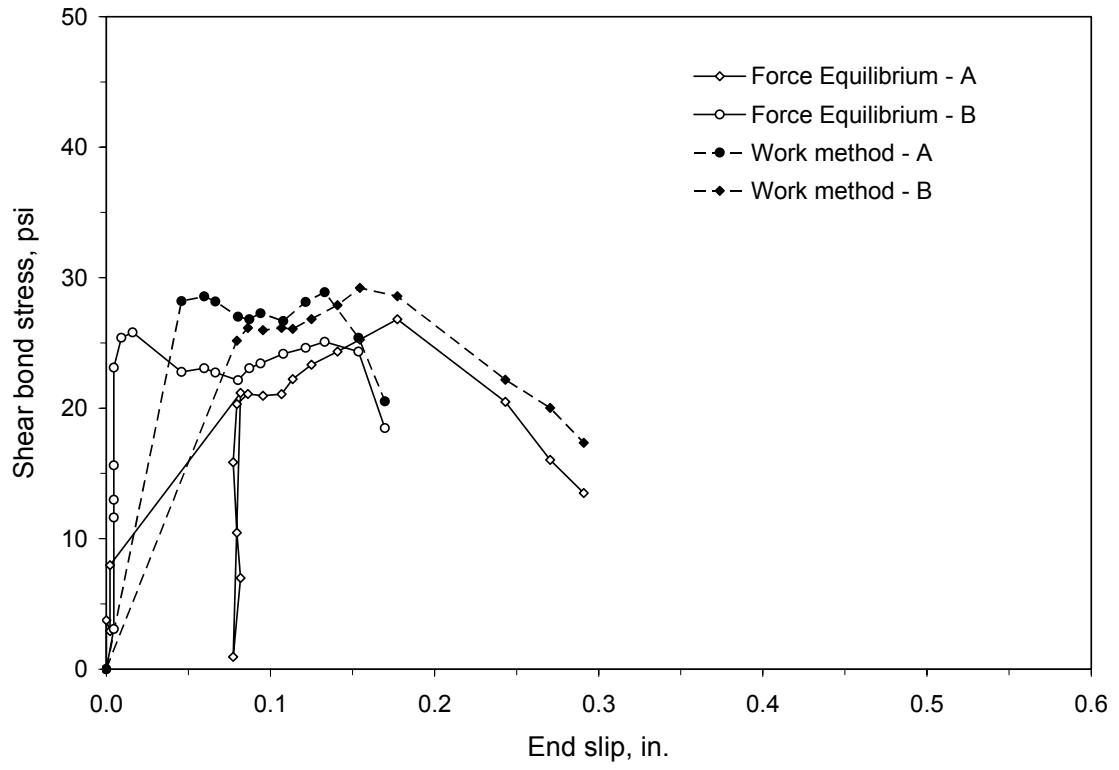
3VL16-8-7.5



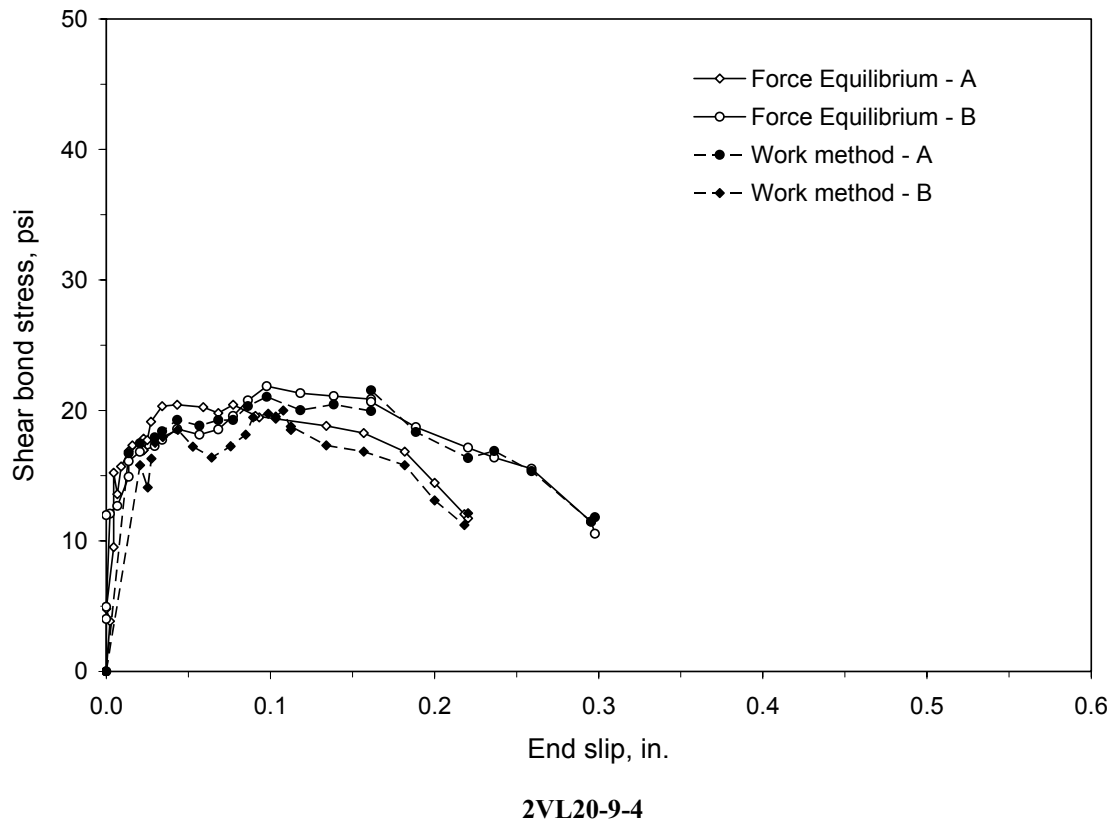
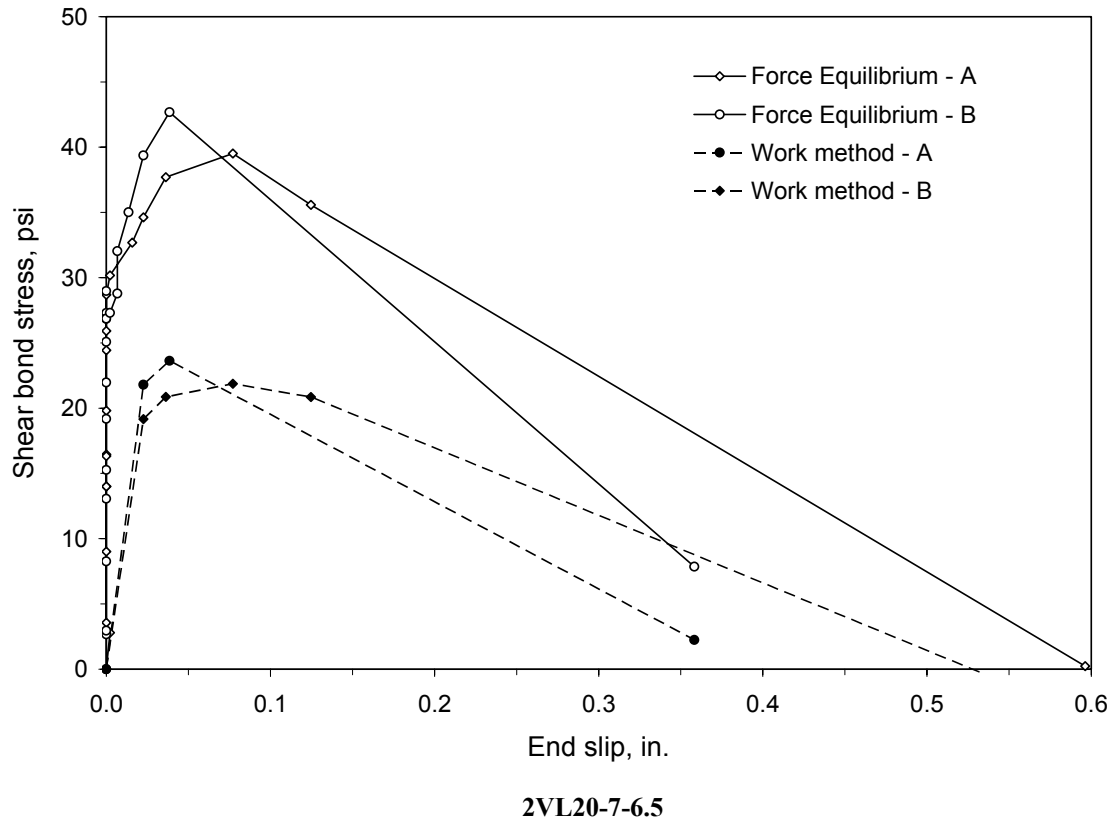
3VL16-10-7.5

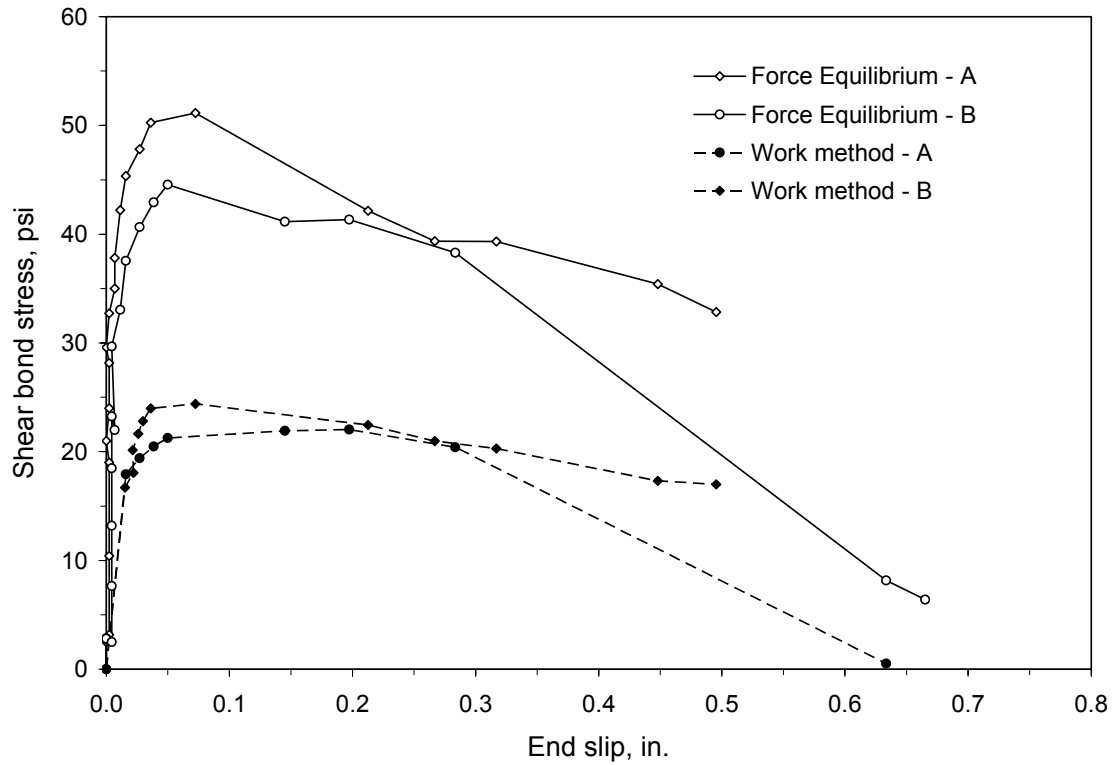


3VL16-12-5

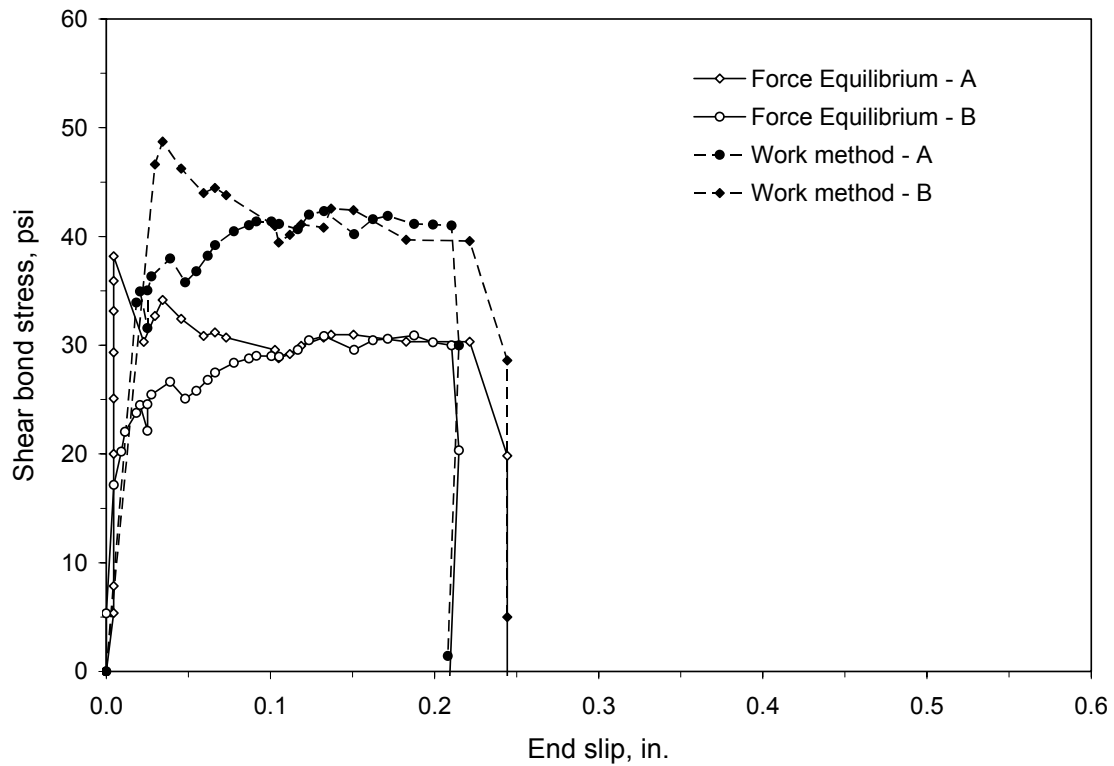


3VL16-14-5

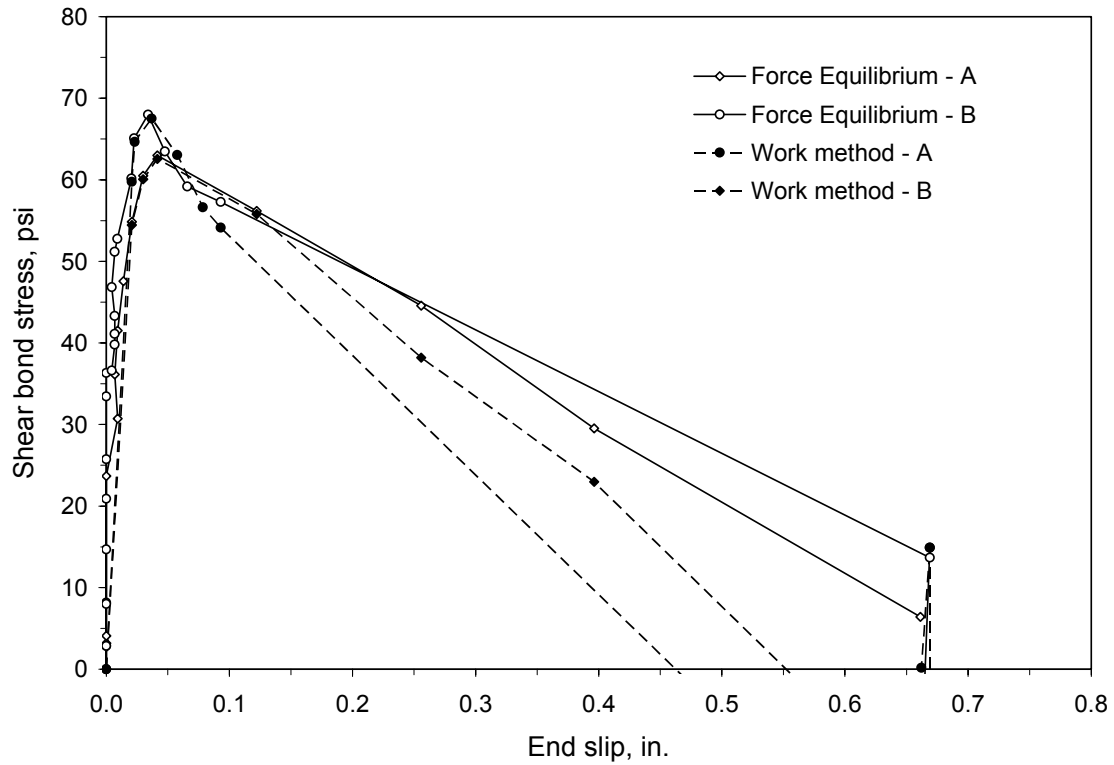




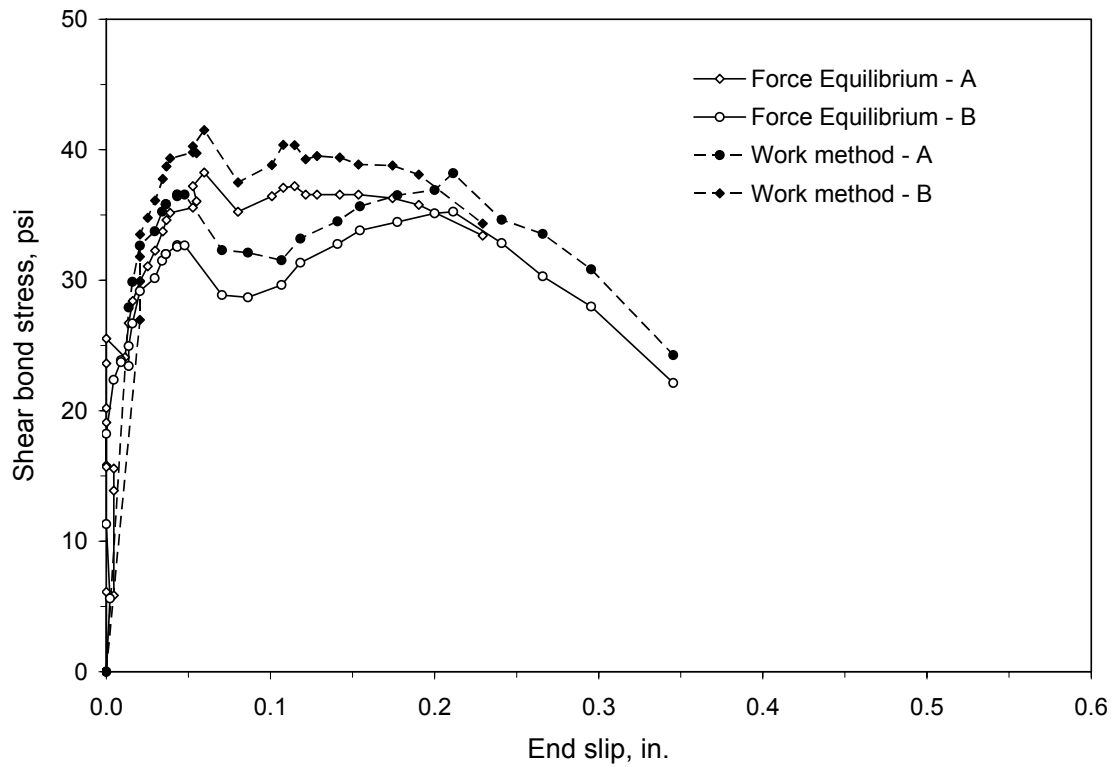
2VL18-7-6.5



2VL18-11-4



2VL16-7-6.5



2VL16-12-4

Appendix E

Sample of ABAQUS input file

```
*HEADING
Abaqus input file for model 3VL16-8-7.5
Written by: Redzuan Abdullah
Mesh: Coarse mesh
      4 layers for concrete above top flange
      2" deep, 216 elements for concrete, 72 for steel
Units: in., lbf, s
**PARTS
**part-1: concrete
*part, name=part-1
*end part
**part-2: sheeting
*part, name=part-2
*end part
*****
**BEGIN ASSEMBLY
*****
*assembly, name=assembly
**
*instance, name=concslab, part=part-1
*node, nset=left
2, 3.625, 0., 0.
3, 6.0, 0., 0.
4, 0., 3.0, 0.
5, 2.375, 3.0, 0.
6, 6.0, 3.0, 0.
28, 0., 7.5, 0.
29, 2.375, 7.5, 0.
30, 6., 7.5, 0.
*NGEN, NSET=left
4, 28, 6
5, 29, 6
6, 30, 6
*NCOPY, CHANGE NUMBER=1440, OLD SET=left, SHIFT, NEWSSET=right
0., 0., -48.0
0, 0, 0, 0, 0, 0, 0
*NFILL
left, right, 24, 60
*ELEMENT, TYPE=C3D8R, ELSET=slab
1, 5, 2, 62, 65, 6, 3, 63, 66
2, 10, 4, 64, 70, 11, 5, 65, 71
*ELGEN, ELSET=slab
1, 24, 60, 9
```

```

2, 2, 1, 1, 3, 6, 2, 24, 60, 9
*SOLID SECTION,ELSET=slab, controls=EC-1, MATERIAL=BrittleConcrete
1.0,
*ELEMENT, TYPE=C3D8R, ELSET=toplayer
8, 28, 22, 82, 88, 29, 23, 83, 89
*ELGEN, ELSET=toplayer
8, 2, 1, 1, 24, 60, 9
*SOLID SECTION, ELSET=toplayer, controls=EC-1,
MATERIAL=ElasticConcrete
1.0,
*end instance
*****
*instance, name=steelsheeting, part=part-2
      0.,      -0.0299,      0.
*node, nset=left
2, 3.625, 0., 0.
3, 6.0, 0., 0.
4, 0., 3.0, 0.
5, 2.375, 3.0, 0.
*NCOPY, CHANGE NUMBER=1440, OLD SET=left, SHIFT, NEWSET=right
0., 0., -48.0
0, 0, 0, 0, 0, 0, 0
*NFILL
left, right, 24, 60
*ELEMENT, TYPE=S4R, ELSET=bottomflange
1, 62, 63, 3, 2
*ELGEN, ELSET=bottomflange
1, 24, 60, 3
*ELEMENT, TYPE=S4R, ELSET=topflange
3, 64, 65, 5, 4
*ELGEN, ELSET=topflange
3, 24, 60, 3
*ELEMENT, TYPE=S4R, ELSET=web
2, 65, 62, 2, 5
*ELGEN, ELSET=web
2, 24, 60, 3
*SHELL SECTION, ELSET=bottomflange, controls=EC-2, MATERIAL=steel-
1, SECTION INTEGRATION=GAUSS
0.0598, 3
*SHELL SECTION, ELSET=web, controls=EC-2, MATERIAL=steel-2,
SECTION INTEGRATION=GAUSS
0.0598, 3
*SHELL SECTION, ELSET=topflange, controls=EC-2, MATERIAL=steel-3,
SECTION INTEGRATION=GAUSS
0.0598, 3
*end instance
*****
*****
**DEFINE NODE SET FOR BC, LOADING AND OUTPUT
*****
*nset, nset=support, instance=steelsheeting
122,123

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*nset, nset=slip, instance=conclab
2, 5
*nset, nset=mid-defln, instance=steelsheeting
1442
*nset, nset=mid-defln, instance=conclab
1442
*nset, nset=steelsheeting-left-edge, instance=steelsheeting,
generate
4, 1444, 60
*nset, nset=steelsheeting-right-edge, instance=steelsheeting,
generate
3, 1443, 60
*nset, nset=conc-left-face, instance=conclab, generate
4, 1444, 60
10, 1450, 60
16, 1456, 60
22, 1462, 60
28, 1468, 60
*****
*nset, nset=conc-right-face, instance=conclab, generate
3, 1443, 60
6, 1446, 60
12, 1452, 60
18, 1458, 60
24, 1464, 60
30, 1470, 60
*nset, nset=steelsheeting-right-end, instance=steelsheeting
1442, 1443, 1444, 1445
*nset, nset=conc-right-end, instance=conclab, generate
1442, 1470, 1
*nset, nset=loading-node, instance=conclab
988, 989, 990
*MPC
BEAM, conclab.928, conclab.988
BEAM, conclab.1048, conclab.988
BEAM, conclab.929, conclab.989
BEAM, conclab.1049, conclab.989
BEAM, conclab.930, conclab.990
BEAM, conclab.1050, conclab.990
*****
** CONNECTOR ELEMENTS FOR SHEAR INTERFACE
*****
*ELEMENT, TYPE=CONN3D2, ELSET=at-edges
30001,      steelsheeting.3,      conclab.3
30002,      steelsheeting.63,     conclab.63
30003,      steelsheeting.123,    conclab.123
30004,      steelsheeting.183,    conclab.183
30005,      steelsheeting.243,    conclab.243
30006,      steelsheeting.303,    conclab.303
30007,      steelsheeting.363,    conclab.363
30008,      steelsheeting.423,    conclab.423
30009,      steelsheeting.483,    conclab.483

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30010,	steelsheeting.543,	conclslab.543
30011,	steelsheeting.603,	conclslab.603
30012,	steelsheeting.663,	conclslab.663
30013,	steelsheeting.723,	conclslab.723
30014,	steelsheeting.783,	conclslab.783
30015,	steelsheeting.843,	conclslab.843
30016,	steelsheeting.903,	conclslab.903
30017,	steelsheeting.963,	conclslab.963
30018,	steelsheeting.1023,	conclslab.1023
30019,	steelsheeting.1083,	conclslab.1083
30020,	steelsheeting.1143,	conclslab.1143
30021,	steelsheeting.1203,	conclslab.1203
30022,	steelsheeting.1263,	conclslab.1263
30023,	steelsheeting.1323,	conclslab.1323
30024,	steelsheeting.1383,	conclslab.1383
30025,	steelsheeting.1443,	conclslab.1443

40001,	steelsheeting.4,	conclslab.4
40002,	steelsheeting.64,	conclslab.64
40003,	steelsheeting.124,	conclslab.124
40004,	steelsheeting.184,	conclslab.184
40005,	steelsheeting.244,	conclslab.244
40006,	steelsheeting.304,	conclslab.304
40007,	steelsheeting.364,	conclslab.364
40008,	steelsheeting.424,	conclslab.424
40009,	steelsheeting.484,	conclslab.484
40010,	steelsheeting.544,	conclslab.544
40011,	steelsheeting.604,	conclslab.604
40012,	steelsheeting.664,	conclslab.664
40013,	steelsheeting.724,	conclslab.724
40014,	steelsheeting.784,	conclslab.784
40015,	steelsheeting.844,	conclslab.844
40016,	steelsheeting.904,	conclslab.904
40017,	steelsheeting.964,	conclslab.964
40018,	steelsheeting.1024,	conclslab.1024
40019,	steelsheeting.1084,	conclslab.1084
40020,	steelsheeting.1144,	conclslab.1144
40021,	steelsheeting.1204,	conclslab.1204
40022,	steelsheeting.1264,	conclslab.1264
40023,	steelsheeting.1324,	conclslab.1324
40024,	steelsheeting.1384,	conclslab.1384
40025,	steelsheeting.1444,	conclslab.1444
*ELEMENT, TYPE=CONN3D2, ELSET=at-foldlines		
20001,	steelsheeting.2,	conclslab.2
20002,	steelsheeting.62,	conclslab.62
20003,	steelsheeting.122,	conclslab.122
20004,	steelsheeting.182,	conclslab.182
20005,	steelsheeting.242,	conclslab.242
20006,	steelsheeting.302,	conclslab.302
20007,	steelsheeting.362,	conclslab.362
20008,	steelsheeting.422,	conclslab.422
20009,	steelsheeting.482,	conclslab.482

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20010,    steelsheeting.542,    conclsab.542
20011,    steelsheeting.602,    conclsab.602
20012,    steelsheeting.662,    conclsab.662
20013,    steelsheeting.722,    conclsab.722
20014,    steelsheeting.782,    conclsab.782
20015,    steelsheeting.842,    conclsab.842
20016,    steelsheeting.902,    conclsab.902
20017,    steelsheeting.962,    conclsab.962
20018,    steelsheeting.1022,   conclsab.1022
20019,    steelsheeting.1082,   conclsab.1082
20020,    steelsheeting.1142,   conclsab.1142
20021,    steelsheeting.1202,   conclsab.1202
20022,    steelsheeting.1262,   conclsab.1262
20023,    steelsheeting.1322,   conclsab.1322
20024,    steelsheeting.1382,   conclsab.1382
20025,    steelsheeting.1442,   conclsab.1442
*****
50001,    steelsheeting.5,        conclsab.5
50002,    steelsheeting.65,     conclsab.65
50003,    steelsheeting.125,    conclsab.125
50004,    steelsheeting.185,    conclsab.185
50005,    steelsheeting.245,    conclsab.245
50006,    steelsheeting.305,    conclsab.305
50007,    steelsheeting.365,    conclsab.365
50008,    steelsheeting.425,    conclsab.425
50009,    steelsheeting.485,    conclsab.485
50010,    steelsheeting.545,    conclsab.545
50011,    steelsheeting.605,    conclsab.605
50012,    steelsheeting.665,    conclsab.665
50013,    steelsheeting.725,    conclsab.725
50014,    steelsheeting.785,    conclsab.785
50015,    steelsheeting.845,    conclsab.845
50016,    steelsheeting.905,    conclsab.905
50017,    steelsheeting.965,    conclsab.965
50018,    steelsheeting.1025,   conclsab.1025
50019,    steelsheeting.1085,   conclsab.1085
50020,    steelsheeting.1145,   conclsab.1145
50021,    steelsheeting.1205,   conclsab.1205
50022,    steelsheeting.1265,   conclsab.1265
50023,    steelsheeting.1325,   conclsab.1325
50024,    steelsheeting.1385,   conclsab.1385
50025,    steelsheeting.1445,   conclsab.1445
*ORIENTATION, NAME=connector-CS
0., 0., 1.0, 1.0, 0., 0.
1, 0.
*CONNECTOR SECTION, ELSET=at-edges, BEHAVIOR=edges
Radial Thrust,
connector-CS,
*CONNECTOR SECTION, ELSET=at-foldlines, BEHAVIOR=foldlines
Radial Thrust,
connector-CS,
*end assembly

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```

*****
**ELEMENT CONTROLS
*section controls, name=EC-1, hourglass=enhanced, second order
accuracy=yes
1., 1., 1.
*section controls, name=EC-2, hourglass=enhanced, second order
accuracy=yes
1., 1., 1.
*****
**MATERIALS PROPERTIES
*MATERIAL, NAME=ElasticConcrete
*DENSITY
0.0002293
*ELASTIC
3.6E6, 0.2
*MATERIAL, NAME=BrittleConcrete
*DENSITY
0.0002293
*ELASTIC
3.6E6, 0.2
*BRITTLE CRACKING, TYPE=displacement
300.0, 0.
90.0, 0.00088
0., .0055
*BRITTLE SHEAR, TYPE=POWER LAW
0.004, 2.0
*BRITTLE FAILURE, CRACKS=1
0.0005
*MATERIAL, NAME=steel-1
*DENSITY
0.0007299
*ELASTIC
2.95E7, 0.3
*PLASTIC
50000., 0.0
*MATERIAL, NAME=steel-3
*DENSITY
0.0007299
*ELASTIC
2.95E7, 0.3
*PLASTIC
15000., 0.0
*MATERIAL, NAME=steel-2
*DENSITY
0.0007299
*ELASTIC
**For embossed web, consider half of the stiffness
1.3275E7, 0.3
*PLASTIC
25000., 0.0
*****
*CONNECTOR BEHAVIOR, NAME=edges

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*CONNECTOR ELASTICITY, COMPONENT=3
1e6
*CONNECTOR ELASTICITY, NONLINEAR, COMPONENT=1
0.000,      0.000
78.500,     0.007
92.000,     0.014
103.800,    0.028
103.313,    0.099
101.400,    0.198
54.863,     0.411
0.000,      0.650
*CONNECTOR BEHAVIOR, NAME=foldlines
*CONNECTOR ELASTICITY, COMPONENT=3
1.00E+06
*CONNECTOR ELASTICITY, NONLINEAR, COMPONENT=1
0.00,       0.000
185.92,     0.007
217.89,     0.014
245.84,     0.028
244.69,     0.099
240.16,     0.198
129.94,     0.411
0.00,       0.650
*****
*AMPLITUDE, NAME=Amp-1, DEFINITION=SMOOTH STEP
0., 0., 0.15, 1.
*****
** BOUNDARY CONDITIONS
**
*Boundary
conc-left-face, 1
conc-right-face, 1
conc-right-end, 3
steelsheeting-left-edge, 1
steelsheeting-left-edge, 5, 6
steelsheeting-right-edge, 1
steelsheeting-right-edge, 5, 6
steelsheeting-right-end, 3, 5
support, 2
*****
** STEP: Step-1
**
*Step, name=Step-1
displacement loading at 32" from left
Natural frequency 51.342 => Natural period 0.01947
*Dynamic, Explicit
, 0.15
*Bulk Viscosity
0.06, 1.2
** BOUNDARY CONDITIONS
*Boundary, amplitude=Amp-1, type=displacement
loading-node, 2, 2, -1.0

```

```
**
** OUTPUT REQUESTS
*Restart, write, number interval=1, time marks=NO
*Output, field, variable=PRESELECT
*Output, history, variable=PRESELECT
*OUTPUT,HISTORY
*Node Output, nset=mid-defln
U2,
*Node Output, nset=slip
U3,
*Node Output, nset=support
RF2,
*End Step
```

VITA

Redzuan Abdullah was born on 7 February, 1961 in Kelantan, Malaysia. He graduated from the Universiti Teknologi Malaysia (UTM) with a Diploma in Civil Engineering in 1982. He worked for Petroleum Nasional Bhd (PETRONAS) for 3 ½ years as a site supervisor for a couple of company's staff housing projects in Terengganu, Malaysia. He then continued his study for a BS degree in Civil Engineering at the University of Hartford, CT. After graduation in 1987 he worked for Mardec Engineering Sdn Bhd in Kuala Lumpur, Malaysia for 2 years as a project engineer. Redzuan pursued his career as an assistant lecturer at the UTM for four years. In 1993 he continued his education at Cornell University, Ithaca, NY for an ME in Structural Engineering and graduated in 1995. Then he returned to work as a lecturer in UTM for 5 years. Redzuan began studying for his doctorate at Virginia Tech in 2000. He is currently a lecturer at the Faculty of Civil Engineering, UTM. He is married to Habibah Draman and is blessed with five children: Aainaa, Syauqi, Amir, Hafiy and Alif.