Appendix A

Figure A-1 plots monotonic shear load ratios determined at capacity for each of the five shear walls examined with shear load ratios determined at capacity by Rose and Keith (1995). Equation 4.6 is include in Figure A-1 to show that Sugiyama's prediction equation is conservative for all test data presented at capacity.

Figure A-2 plots monotonic shear load ratios determined at a shear deformation angle of 1/100 for each of the five shear walls examined with shear load ratios determined from one-third scale shear wall tests performed by Wakatsuki and Uchida (data presented in Sugiyama and Matsumoto, 1994). Equation 4.6 is include in Figure A-2 for reference. As shown, the majority of test data is conservative.

Figure A-3 plots the natural log method and Equation 4.6 with shear load ratios determined from this study and from Rose and Keith (1995) when the design capacity is used as the reference capacity.

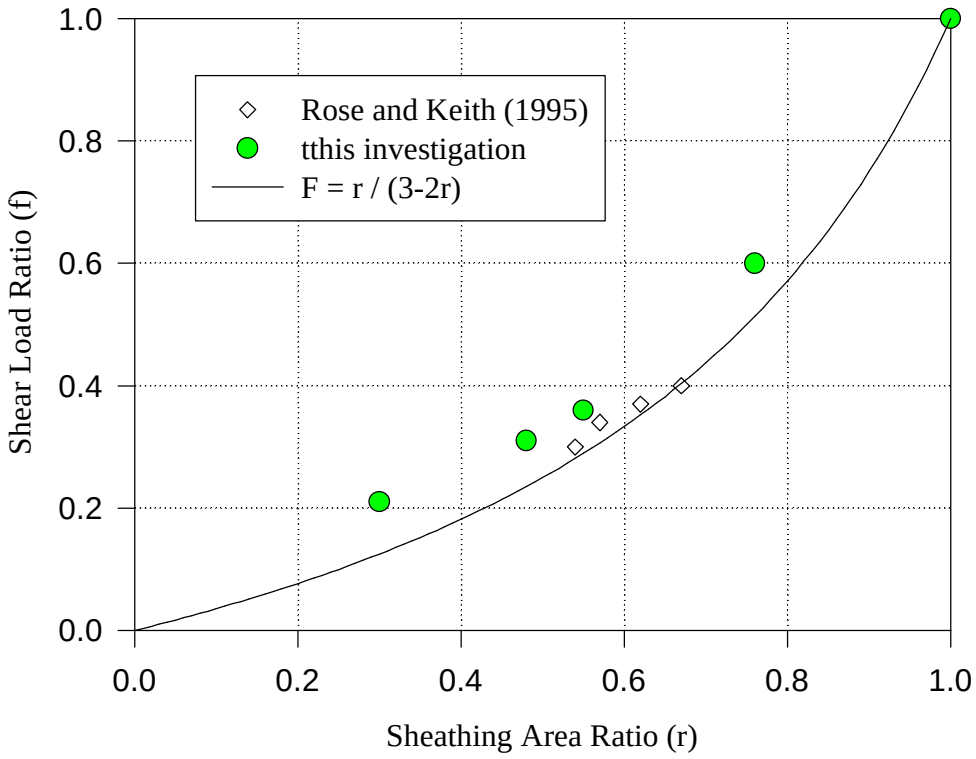

Figure A-1: Shear load ratios at capacity from this investigation and Rose and Keith (1995) plotted against sheathing area ratio

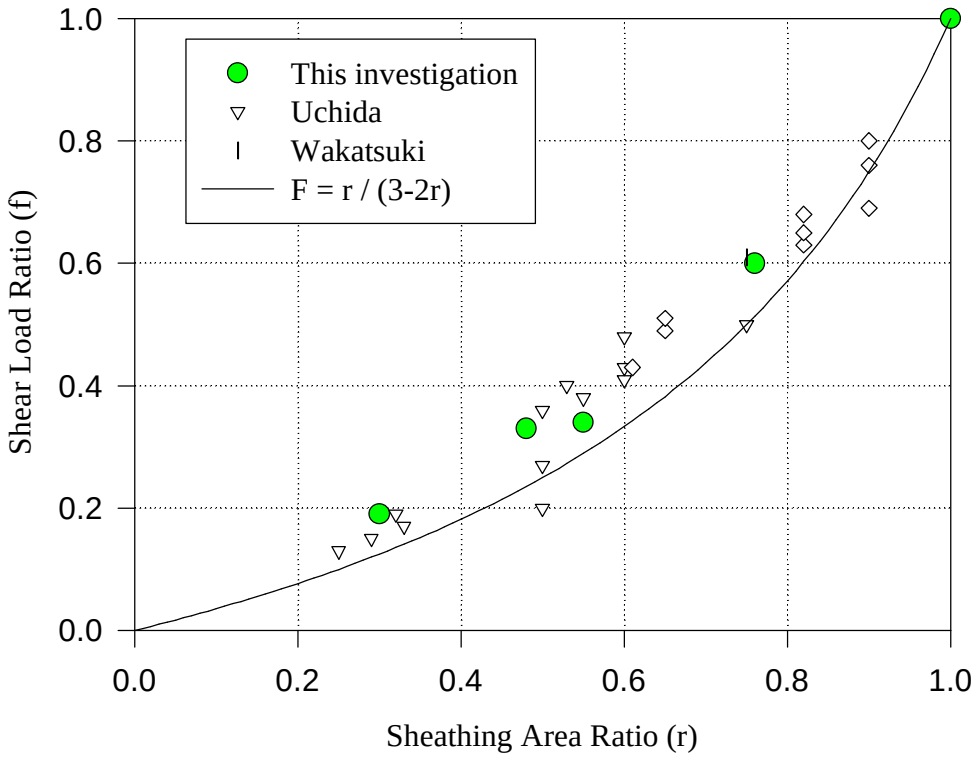

Figure A-2: Shear load ratios at a shear deformation angle of 1/100 from this investigation and Wakatsuki and Uchida plotted against sheathing area ratio

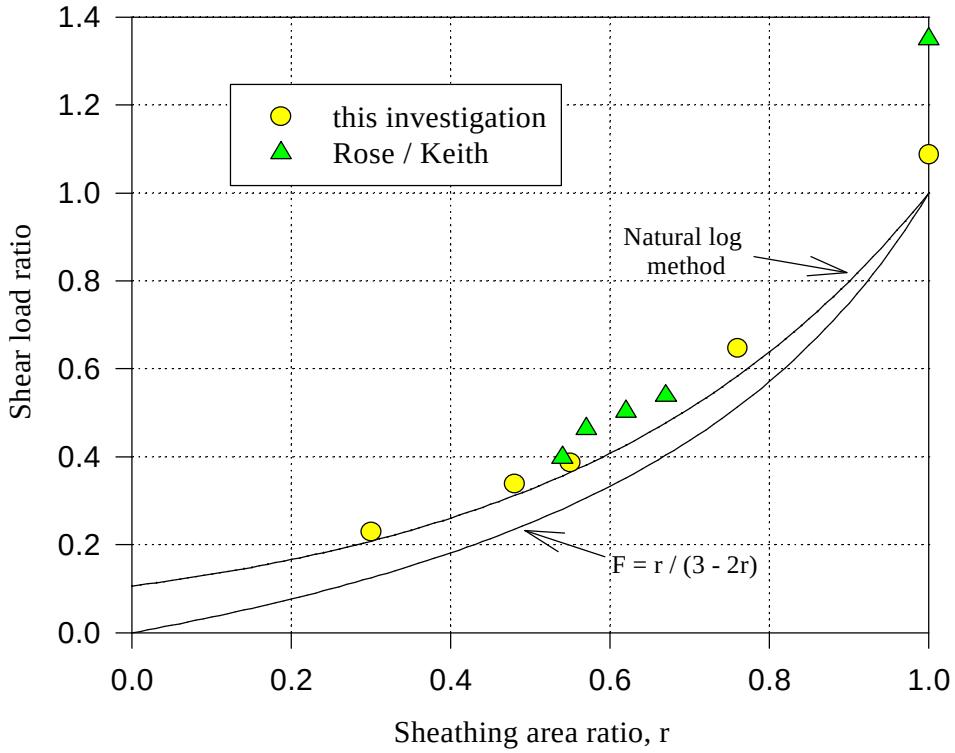

Figure A-3: Shear load ratios from this investigation and Rose and Keith (1995) plotted with the natural log method and Sugiyama's prediction equation

Appendix B

Tables B-1 through B-5 present cyclic data determined in each phase of SPD loading for Walls A - E, respectively. The tables included interstory drift calculation, average peak load, average cyclic stiffness, hysteretic energy (HE), potential energy (PE), and equivalent viscous damping ratio (EVDR) determined from the initial and stabilized load envelope curves until failure.

Displacement, load and stiffness data from both the positive and negative cycles are presented and then averaged to determine appropriate value for each phase.

Table B-1: Cyclic data of Wall A (r = 1.0)

Initial

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.182	-0.001	0.183		12.8	70.2				
0.196	-0.000	0.196	**0.190**	13.6	69.5	**69.8**	1.91	2.51	**0.121**
0.401	0.035	0.366		22.9	62.5				
0.401	0.034	0.367	**0.367**	20.7	56.4	**59.4**	6.35	7.98	**0.127**
0.601	0.065	0.536		28.5	53.1				
0.606	0.042	0.565	**0.550**	26.4	46.8	**49.9**	11.94	15.09	**0.126**
0.800	0.078	0.722		31.0	43.0				
0.806	0.060	0.746	**0.734**	29.6	39.6	**41.3**	17.69	22.22	**0.127**
1.017	0.087	0.930		32.6	35.1				
1.014	0.069	0.944	**0.937**	30.7	32.5	**33.8**	23.47	29.64	**0.126**
1.216	**0.100**	**1.116**		**32.8**	**29.4**				
1.210	**0.071**	**1.139**	**1.127**	**30.9**	**27.1**	**28.2**	**27.02**	**35.89**	**0.120**
1.412	0.110	1.302		32.3	24.8				
1.409	0.071	1.339	**1.320**	31.3	23.3	**24.1**	31.57	41.96	**0.120**
1.544	0.111	1.433		30.9	21.6				
1.538	0.073	1.465	**1.449**	29.8	20.3	**20.9**	31.14	43.96	**0.113**
1.816	0.114	1.702		31.1	18.3				
1.793	0.074	1.719	**1.711**	30.6	17.8	**18.0**	39.08	52.71	**0.118**
2.027	**0.116**	**1.911**		**29.2**	**15.3**				
2.024	**0.073**	**1.952**	**1.931**	**29.0**	**14.9**	**15.1**	**41.35**	**56.25**	**0.117**

Table B-1 (cont.): Cyclic data of Wall A (r = 1.0)

Stabilized

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.196	0.004	0.192		13.6	70.5				
0.196	0.003	0.193	**0.193**	13.1	67.8	**69.2**	1.68	2.57	**0.104**
0.401	0.054	0.348		21.2	60.9				
0.404	0.040	0.364	**0.356**	19.6	53.8	**57.4**	4.88	7.25	**0.107**
0.606	0.069	0.537		25.6	47.6				
0.606	0.049	0.557	**0.547**	24.2	43.5	**45.5**	9.21	13.62	**0.108**
0.806	0.079	0.726		27.6	38.0				
0.809	0.064	0.745	**0.736**	26.3	35.3	**36.7**	13.41	19.81	**0.108**
1.011	0.092	0.919		28.1	30.5				
1.008	0.067	0.940	**0.930**	26.1	27.8	**29.2**	16.83	25.17	**0.106**
1.210	**0.103**	**1.107**		**28.2**	**25.5**				
1.204	**0.068**	**1.136**	**1.122**	**26.8**	**23.5**	**24.5**	**21.05**	**30.8**	**0.109**
1.412	0.107	1.305		27.5	21.1				
1.400	0.072	1.329	**1.317**	26.7	20.1	**20.6**	24.96	35.69	**0.111**
1.614	0.110	1.505		27.3	18.2				
1.585	0.073	1.512	**1.508**	26.5	17.5	**17.8**	28.36	40.57	**0.111**
1.819	0.112	1.707		26.1	15.3				
1.825	0.072	1.753	**1.730**	26.0	14.8	**15.1**	31.92	45.06	**0.113**
2.024	**0.111**	**1.913**		**23.3**	**12.2**				
2.027	**0.072**	**1.956**	**1.934**	**23.9**	**12.2**	**12.2**	**32.41**	**45.57**	**0.113**

Table B-2: Cyclic data of Wall B (r = 0.76)

Initial

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.100	-0.001	0.101		4.7	46.9				
0.105	-0.000	0.106	**0.103**	6.1	57.4	**52.2**	0.36	0.56	**0.101**
0.299	-0.011	0.310		11.8	38.0				
0.293	-0.020	0.313	**0.311**	10.1	32.1	**35.1**	0.28	3.40	**0.013**
0.398	0.003	0.396		12.0	30.4				
0.416	0.005	0.411	**0.403**	13.9	33.7	**32.0**	3.68	5.23	**0.112**
0.592	0.004	0.587		15.6	26.5				
0.601	0.009	0.592	**0.589**	17.2	29.0	**27.7**	7.34	9.65	**0.121**
0.791	0.007	0.784		17.2	21.9				
0.806	0.012	0.794	**0.789**	19.1	24.1	**23.0**	10.60	14.30	**0.118**
1.005	0.011	0.994		18.5	18.6				
1.014	0.012	1.002	**0.998**	19.7	19.7	**19.1**	13.80	19.00	**0.116**
1.175	**0.013**	**1.162**		**19.7**	**16.9**				
1.204	**0.012**	**1.192**	**1.177**	**20.5**	**17.2**	**17.1**	**16.40**	**23.70**	**0.110**
1.409	0.015	1.394		20.0	14.3				
1.397	0.022	1.375	**1.384**	19.0	13.8	**14.1**	19.00	27.00	**0.112**
1.538	0.021	1.517		19.5	12.8				
1.559	0.014	1.545	**1.531**	18.9	12.2	**12.5**	19.10	29.40	**0.103**
1.781	0.026	1.755		20.0	11.4				
1.778	0.014	1.765	**1.760**	18.9	10.7	**11.1**	23.50	34.30	**0.109**
2.013	**0.023**	**1.990**		**19.0**	**9.5**				
2.022	**0.018**	**2.004**	**1.997**	**16.3**	**8.1**	**8.8**	**24.8**	**35.6**	**0.111**

Table B-2 (cont.): Cyclic data of Wall B (r = 0.76)

Stabilized

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.105	0.000	0.105		4.7	44.5				
0.100	-0.001	0.101	**0.103**	5.7	56.3	**50.4**	0.29	0.54	**0.087**
0.305	0.002	0.303		11.2	37.0				
0.293	0.003	0.290	**0.296**	9.4	32.5	**34.8**	1.91	3.08	**0.099**
0.398	0.001	0.398		11.1	28.0				
0.407	0.004	0.403	**0.401**	12.5	30.9	**29.5**	3.06	4.73	**0.103**
0.601	0.003	0.598		14.0	23.5				
0.609	0.008	0.601	**0.599**	15.1	25.1	**24.3**	5.30	8.73	**0.097**
0.776	0.006	0.770		15.4	20.0				
0.806	0.008	0.797	**0.784**	17.0	21.3	**20.6**	7.99	12.69	**0.100**
1.005	0.013	0.992		16.3	16.4				
1.002	0.010	0.992	**0.992**	16.4	16.6	**16.5**	10.60	16.30	**0.103**
1.189	**0.013**	1.176		**17.2**	14.6				
1.213	**0.012**	1.201	**1.189**	**17.4**	14.4	**14.5**	**12.80**	**20.50**	**0.099**
1.389	0.009	1.380		17.0	12.3				
1.380	0.019	1.361	**1.370**	16.4	12.1	**12.2**	15.10	22.90	**0.105**
1.582	0.020	1.562		17.4	11.1				
1.608	0.012	1.596	**1.579**	15.7	9.8	**10.5**	17.40	26.40	**0.105**
1.784	0.017	1.767		17.3	9.8				
1.813	0.015	1.799	**1.783**	15.5	8.6	**9.2**	19.90	29.20	**0.108**
2.010	**0.025**	**1.985**		**15.0**	7.6				
1.983	**0.012**	**1.972**	**1.978**	**13.2**	6.7	**7.1**	**20.00**	**28.00**	**0.114**

Table B-3: Cyclic data of Wall C (r = 0.55)

Initial Cycle

Ch 6 (in)	Ch 3 (in)	Ch 6-Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.103	0.003	0.100		2.6	26.5				
0.105	0.002	0.104	**0.102**	2.8	27.0	**26.7**	0.16	0.28	**0.092**
0.293	0.010	0.283		5.9	20.9				
0.308	0.004	0.304	**0.293**	5.6	18.4	**19.6**	1.30	1.68	**0.123**
0.404	0.013	0.392		7.3	18.6				
0.404	0.005	0.400	**0.396**	6.9	17.2	**17.9**	1.91	2.80	**0.109**
0.601	0.015	0.586		9.4	16.0				
0.604	0.006	0.598	**0.592**	8.9	14.9	**15.5**	4.11	5.41	**0.121**
0.806	0.016	0.790		11.1	14.1				
0.809	0.008	0.800	**0.795**	10.4	13.0	**13.6**	6.11	8.57	**0.113**
1.008	0.017	0.990		12.4	12.6				
1.011	0.009	1.001	**0.996**	11.6	11.5	**12.1**	8.29	11.95	**0.110**
1.198	0.011	1.187		12.6	10.6				
1.207	0.019	1.188	**1.188**	13.4	11.2	**10.9**	10.50	15.41	**0.108**
1.395	**0.020**	**1.375**		**13.9**	**10.1**				
1.400	**0.011**	**1.389**	**1.382**	**13.4**	**9.6**	**9.9**	**12.71**	**18.85**	**0.107**
1.550	0.021	1.529		13.6	8.9				
1.547	0.010	1.536	**1.533**	13.1	8.5	**8.7**	13.31	20.48	**0.103**
1.805	0.010	1.795		13.3	7.4				
1.822	0.024	1.798	**1.797**	13.6	7.6	**7.5**	16.82	24.17	**0.111**
2.021	0.025	1.996		13.3	6.6				
2.036	0.010	2.026	**2.011**	12.7	6.3	**6.5**	18.43	26.11	**0.112**
2.206	**0.027**	**2.179**		**12.6**	**5.8**				
2.218	**0.008**	**2.210**	**2.194**	**11.9**	**5.4**	**5.6**	**19.4**	**26.83**	**0.115**

Table B-3 (cont): Cyclic data of Wall C (r = 0.55)

Stabilized Cycle

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.105	0.003	0.103		2.8	27.3				
0.103	0.002	0.101	**0.102**	2.5	25.1	**26.2**	0.18	0.27	**0.105**
0.293	0.011	0.282		5.7	20.2				
0.308	0.003	0.304	**0.293**	5.5	18.2	**19.2**	1.07	1.65	**0.103**
0.396	0.013	0.383		6.9	18.0				
0.413	0.005	0.408	**0.396**	6.4	15.7	**16.9**	1.69	2.63	**0.102**
0.601	0.013	0.587		8.5	14.4				
0.606	0.006	0.601	**0.594**	8.1	13.4	**13.9**	3.15	4.91	**0.102**
0.797	0.014	0.783		10.1	12.9				
0.809	0.007	0.802	**0.792**	9.5	11.9	**12.4**	5.10	7.74	**0.105**
0.990	0.015	0.975		11.4	11.6				
1.002	0.008	0.994	**0.985**	10.8	10.9	**11.3**	7.00	10.90	**0.102**
1.192	0.009	1.183		11.6	9.8				
1.202	0.017	1.185	**1.184**	12.0	10.1	**10.0**	8.55	13.96	**0.097**
1.389	**0.020**	**1.369**		**12.0**	**8.8**				
1.389	**0.009**	**1.380**	**1.374**	**11.5**	**8.3**	**8.6**	**10.60**	**16.19**	**0.104**
1.605	0.023	1.583		12.1	7.6				
1.588	0.009	1.579	**1.581**	11.5	7.3	**7.5**	12.59	18.64	**0.107**
1.819	0.009	1.810		11.8	6.5				
1.816	0.023	1.794	**1.802**	12.0	6.7	**6.6**	14.63	21.41	**0.109**
2.016	0.024	1.991		11.4	5.7				
2.021	0.007	2.015	**2.003**	10.7	5.3	**5.5**	15.78	22.14	**0.113**
2.186	**0.027**	**2.159**		**10.1**	**4.7**				
2.191	**0.006**	**2.185**	**2.172**	**9.5**	**4.3**	**4.5**	**16.71**	**21.26**	**0.125**

Table B-4: Cyclic data of Wall D (r = 0.48)

Initial

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.188	0.005	0.182		3.8	21.1				
0.196	0.006	0.191	**0.186**	3.4	17.7	**19.4**	0.41	0.67	**0.097**
0.396	0.024	0.372		6.5	17.4				
0.401	0.022	0.379	**0.376**	6.2	16.4	**16.9**	1.66	2.39	**0.111**
0.601	0.038	0.563		8.3	14.8				
0.604	0.038	0.565	**0.564**	8.5	15.0	**14.9**	3.30	4.74	**0.111**
0.800	0.045	0.755		9.7	12.8				
0.806	0.044	0.761	**0.758**	9.9	12.9	**12.9**	4.74	7.42	**0.102**
1.005	0.051	0.954		10.7	11.3				
1.011	0.048	0.963	**0.959**	10.9	11.3	**11.3**	6.65	10.37	**0.102**
1.201	0.058	1.144		11.1	9.7				
1.192	0.047	1.145	**1.144**	11.3	9.9	**9.8**	8.26	12.82	**0.103**
1.400	**0.051**	**1.349**		**11.5**	**8.6**				
1.412	**0.061**	**1.351**	**1.350**	**11.3**	**8.3**	**8.4**	**9.62**	**15.40**	**0.099**
1.556	0.064	1.492		10.7	7.2				
1.547	0.048	1.499	**1.495**	10.6	7.0	**7.1**	9.92	15.90	**0.099**
1.811	0.067	1.743		11.3	6.5				
1.802	0.048	1.754	**1.749**	10.7	6.1	**6.3**	12.59	19.24	**0.104**
1.995	**0.068**	**1.927**		**10.2**	**5.3**				
2.004	**0.048**	**1.956**	**1.941**	**9.4**	**4.8**	**5.0**	**13.38**	**18.95**	**0.112**

Table B-4 (cont.): Cyclic data of Wall D (r = 0.48)

Stabilized

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.199	0.005	0.195		3.8	19.4				
0.199	0.006	0.193	**0.194**	3.4	17.5	**18.5**	0.34	0.7	**0.077**
0.401	0.026	0.376		6.5	17.3				
0.404	0.026	0.378	**0.377**	6.2	16.3	**16.8**	1.30	2.39	**0.087**
0.604	0.037	0.566		7.8	13.8				
0.606	0.037	0.569	**0.568**	8.1	14.2	**14.0**	2.50	4.51	**0.088**
0.803	0.043	0.760		8.9	11.7				
0.806	0.043	0.763	**0.761**	9.2	12.1	**11.9**	3.73	6.89	**0.086**
0.996	0.046	0.950		9.3	9.8				
0.996	0.042	0.954	**0.952**	9.6	10.1	**10.0**	4.97	9.01	**0.088**
1.201	0.055	1.146		9.3	8.1				
1.198	0.048	1.151	**1.148**	9.6	8.4	**8.2**	6.37	10.86	**0.093**
1.403	0.047	1.357		9.7	7.1				
1.409	0.060	1.349	**1.353**	9.5	7.1	**7.1**	7.80	12.98	**0.096**
1.614	**0.064**	**1.550**		**10.0**	**6.5**				
1.588	**0.045**	**1.543**	**1.547**	**9.6**	**6.2**	**6.4**	**9.26**	**15.21**	**0.097**
1.805	0.064	1.741		9.5	5.4				
1.805	0.045	1.759	**1.750**	7.9	4.5	**5.0**	10.36	15.97	**0.103**
1.998	**0.063**	**1.935**		**6.5**	**3.4**				
2.004	**0.048**	**1.956**	**1.946**	**4.9**	**2.5**	**2.9**	**8.57**	**11.06**	**0.123**

Table B-5: Cyclic data of Wall E (r = 0.30)

Initial

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.069		0.069		1.7	25.1				
0.077	0.000	0.077	**0.073**	1.8	23.8	**24.4**	0.14	0.22	**0.100**
0.100	0.003	0.097		2.2	23.1				
0.103	0.005	0.098	**0.097**	2.2	23.0	**23.0**	1.04	1.22	**0.136**
0.287	0.014	0.273		4.2	15.5				
0.299	0.009	0.290	**0.281**	4.4	15.2	**15.3**	1.52	1.94	**0.125**
0.404	0.019	0.386		5.0	12.9				
0.407	0.015	0.393	**0.389**	5.0	12.8	**12.8**	3.05	3.47	**0.140**
0.589	0.028	0.560		6.1	10.9				
0.592	0.020	0.572	**0.566**	6.2	10.8	**10.8**	4.39	5.04	**0.139**
0.803	0.041	0.762		6.6	8.7				
0.800	0.023	0.777	**0.770**	6.5	8.4	**8.5**	5.72	6.95	**0.131**
1.011	0.049	0.962		7.2	7.5				
1.008	0.023	0.985	**0.973**	7.1	7.2	**7.3**	7.03	8.55	**0.131**
1.181	**0.057**	**1.124**		**7.6**	**6.8**				
1.201	**0.024**	**1.177**	**1.150**	**7.3**	**6.2**	**6.5**	**8.26**	**10.20**	**0.129**
1.409	0.063	1.346		7.4	5.5				
1.421	0.024	1.397	**1.371**	7.4	5.3	**5.4**	8.52	10.90	**0.124**
1.541	0.065	1.476		7.6	5.1				
1.515	0.023	1.492	**1.484**	7.1	4.8	**4.9**	10.20	12.50	**0.130**
1.796	0.072	1.724		7.4	4.3				
1.802	0.025	1.777	**1.750**	6.9	3.9	**4.1**	10.6	12.9	**0.131**
2.016	**0.071**	**1.945**		**6.8**	**3.5**				
2.027	**0.023**	**2.004**	**1.974**	**6.3**	**3.2**	**3.3**	**9.62**	**11.5**	**0.133**

Table B-5 (cont.): Cyclic data of Wall E (r = 0.30)

Stabilized

Ch 6 (in)	Ch 3 (in)	Ch 6 - Ch3 (in)	Avg. I.D. (in)	Load (kips)	Kc (kips/in)	Avg. Kc (kips/in)	HE (kips-in)	PE (kips-in)	EVDR
0.069		0.069		1.8	25.5				
0.077	0.000	0.077	**0.073**	1.8	23.2	**24.4**	0.14	0.225	**0.100**
0.114	0.003	0.111		2.3	20.5				
0.100	0.006	0.093	**0.102**	2.1	22.9	**21.7**	0.86	1.19	**0.115**
0.293	0.015	0.278		4.0	14.4				
0.316	0.012	0.305	**0.292**	4.0	13.2	**13.8**	1.30	1.76	**0.118**
0.401	0.019	0.382		4.4	11.6				
0.404	0.016	0.389	**0.385**	4.7	12.1	**11.8**	2.40	3.11	**0.123**
0.595	0.028	0.566		5.4	9.6				
0.595	0.019	0.576	**0.571**	5.5	9.5	**9.5**	3.49	4.39	**0.127**
0.779	0.040	0.739		5.9	7.9				
0.794	0.021	0.773	**0.756**	5.8	7.5	**7.7**	4.72	6.09	**0.123**
0.990	0.049	0.941		6.2	6.6				
1.005	0.015	0.990	**0.965**	6.4	6.5	**6.6**	5.88	7.48	**0.125**
1.192	**0.054**	**1.138**		**6.7**	**5.9**				
1.181	**0.020**	**1.161**	**1.149**	**6.3**	**5.4**	**5.7**	**7.01**	**8.57**	**0.130**
1.383	0.063	1.320		6.4	4.8				
1.400	0.022	1.378	**1.349**	6.3	4.6	**4.7**	7.90	10.1	**0.124**
1.605	0.064	1.541		6.7	4.3				
1.582	0.022	1.560	**1.550**	6.4	4.1	**4.2**	8.58	10.6	**0.129**
1.784	0.064	1.720		6.1	3.6				
1.793	0.022	1.771	**1.746**	6.0	3.4	**3.5**	8.28	9.36	**0.141**
2.007	**0.057**	**1.950**		**4.4**	**2.3**				
2.033	**0.020**	**2.013**	**1.982**	**5.0**	**2.5**	**2.4**	**8.44**	**10.1**	**0.133**