Appendix C: Cyclic Test Data

Results from cyclic regimes previously described provided load and deflection data for timber frame and SIP roof assemblies that were used to generate values for cyclic stiffness, strain energy, damped hysteretic energy and equivalent viscous damping for each of the five tested assemblies. Load versus deflection plots for cyclic testing resulted in a series of hysteresis loops, rather than single lines obtained from monotonic tests. This appendix contains tabulated data for all cyclic tests conducted on roof panel assemblies and plots comparing different testing configurations. Chapter 4 contains explanations and describes methods utilized to obtain various cyclic parameters.

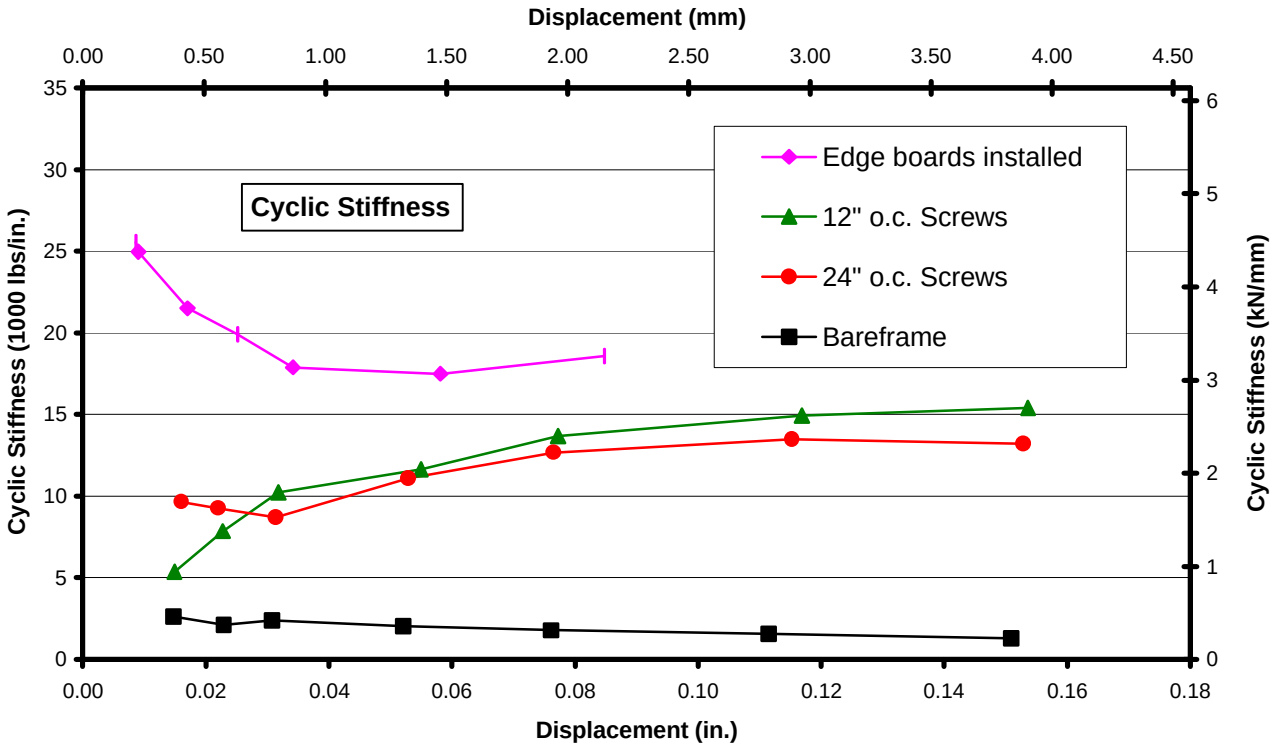

Figure C.1. Cyclic stiffness as a function of displacement for Assembly 1 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. Displacements shown were adjusted to coincide with wall mounted string potentiometer. Displacements were smaller for the tests with edge boards installed due to the change in waveform after hydraulic controller replacement.

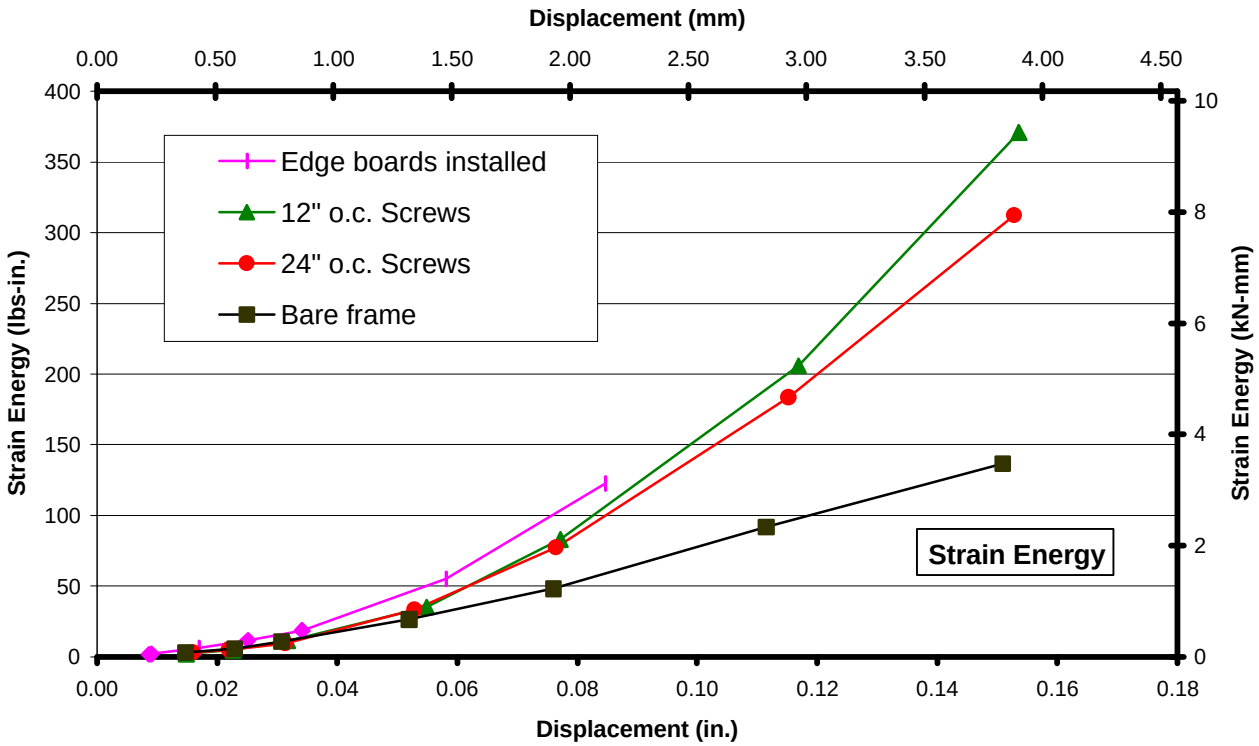

Figure C.2. Strain energy as a function of displacement for Assembly 1 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. Displacements shown were adjusted to coincide with wall mounted string potentiometer. Displacements were smaller for the tests with edge boards installed due to the change in waveform after hydraulic controller replacement.

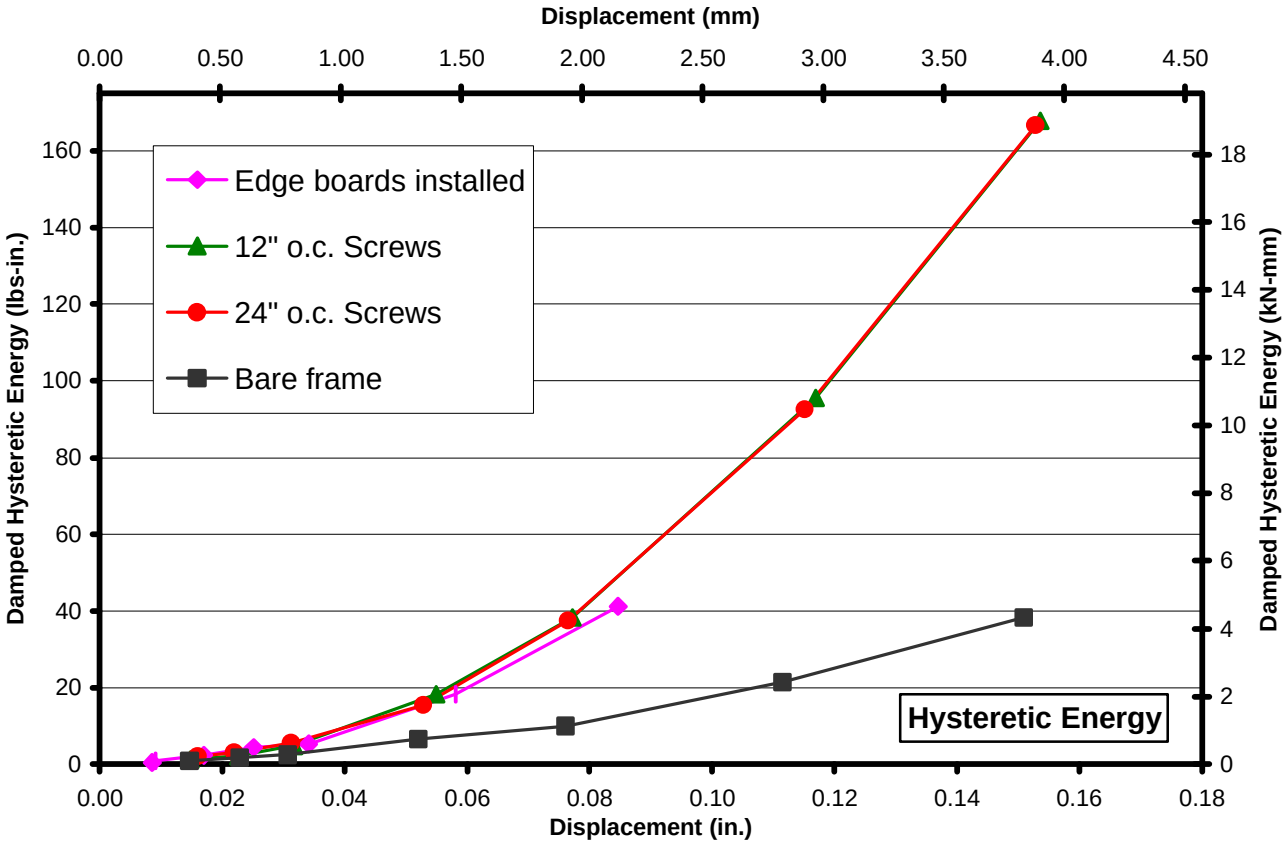

Figure C.3. Hysteretic energy as a function of displacement for Assembly 1 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. Displacements shown were adjusted to coincide with wall mounted string potentiometer. Displacements were smaller for the tests with edge boards installed due to the change in waveform after hydraulic controller replacement.

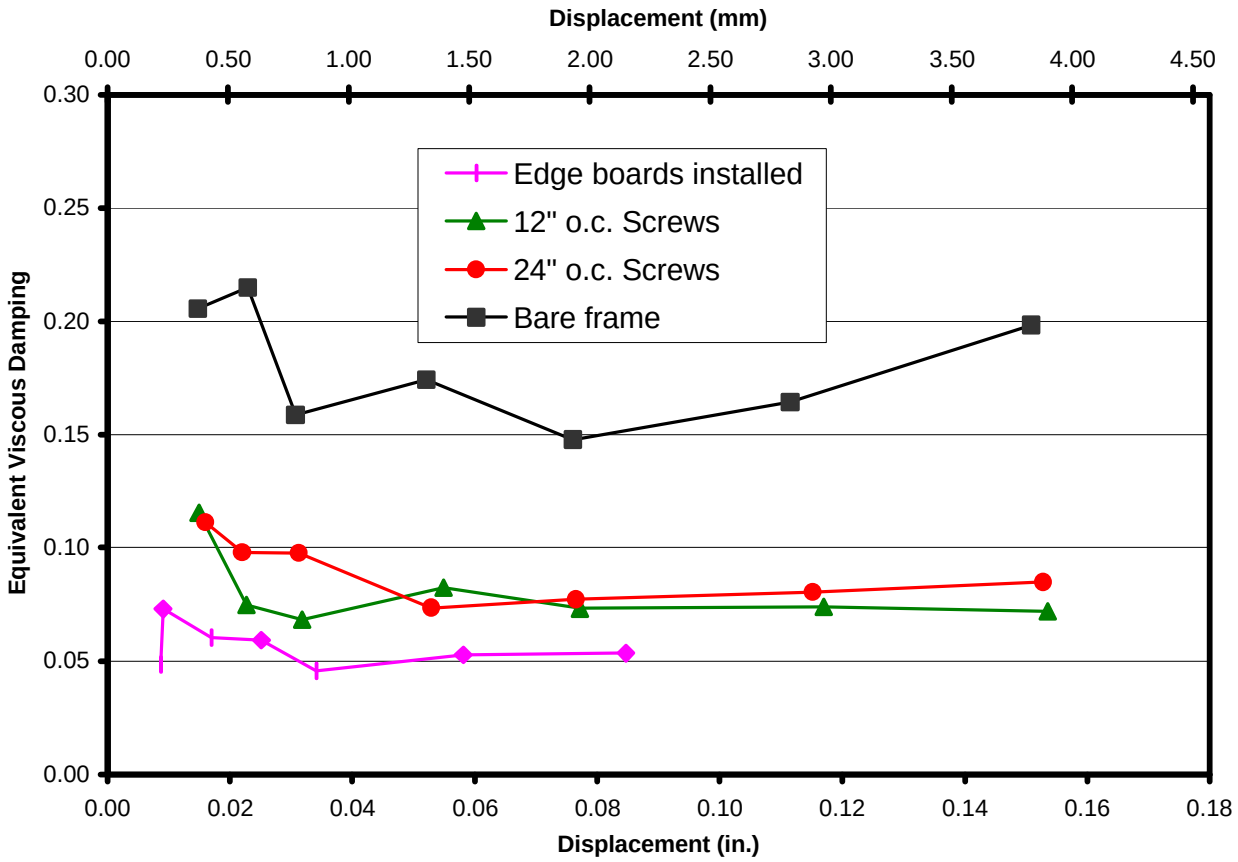

Figure C.4. Equivalent viscous damping as a function of displacement for Assembly 1 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. Displacements shown were adjusted to coincide with wall mounted string potentiometer. Displacements were smaller for the tests with edge boards installed due to the change in waveform after hydraulic controller replacement.

Table B.1. Cyclic test parameters for various testing configurations of Assembly 1 at maximum displacements.

Test configuration	Maximum displacement	Cyclic stiffness	Strain energy	Hysteretic energy	Equivalent viscous damping
Bare timber frame	0.151 in. (3.8 mm)	1,320 lbs/in. (231 N/mm)	30.7 lbs-in. (3.47 kN-mm)	38.3 lbs-in. (4.33 kN-mm)	0.20
SIPs installed; screws 24” o.c.	0.153 in. (3.9 mm)	13,200 lbs/in. (2.31 kN/mm)	312 lbs-in. (35.3 kN-mm)	83.6 lbs-in. (9.45 kN-mm)	0.043
SIPs installed; screws 12” o.c.	0.154 in. (3.9 mm)	15,400 lbs/in. (2.70 kN/mm)	369 lbs-in. (41.7 kN-mm)	83.9 lbs-in. (9.48 kN-mm)	0.036
SIPs installed; screws 12” o.c., edge boards installed	0.085 in. (2.2 mm)	18,600 lbs/in. (3.26 kN/mm)	123 lbs-in. (13.9 kN-mm)	41.2 lbs-in. (4.66 kN-mm)	0.054

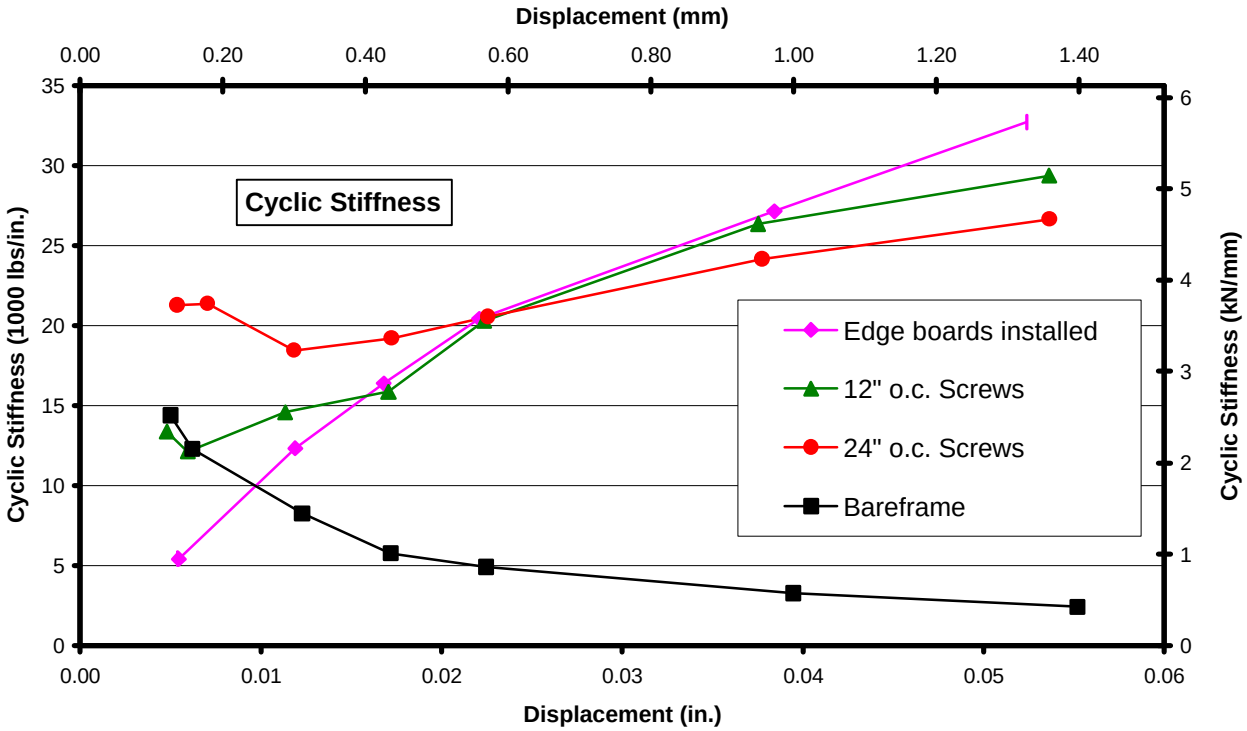

Figure C.5. Cyclic stiffness as a function of displacement for Assembly 2 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

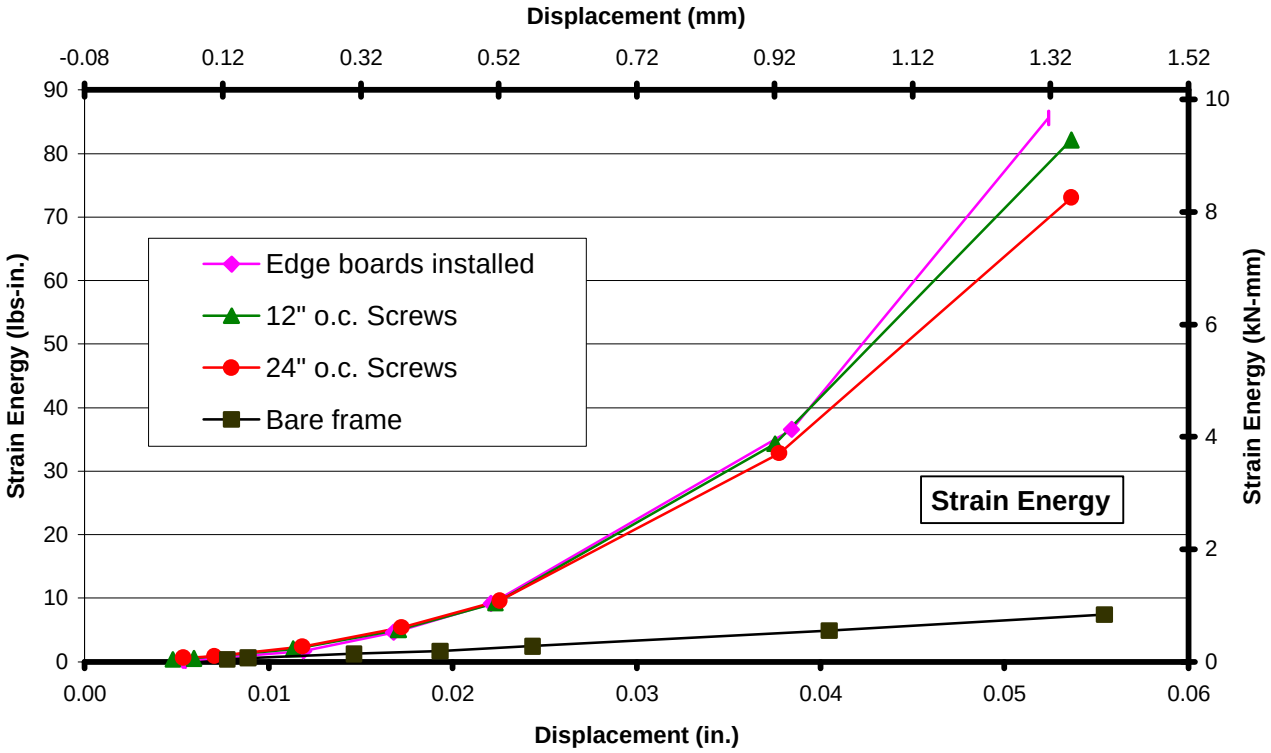

Figure C.6. Strain energy as a function of displacement for Assembly 2 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

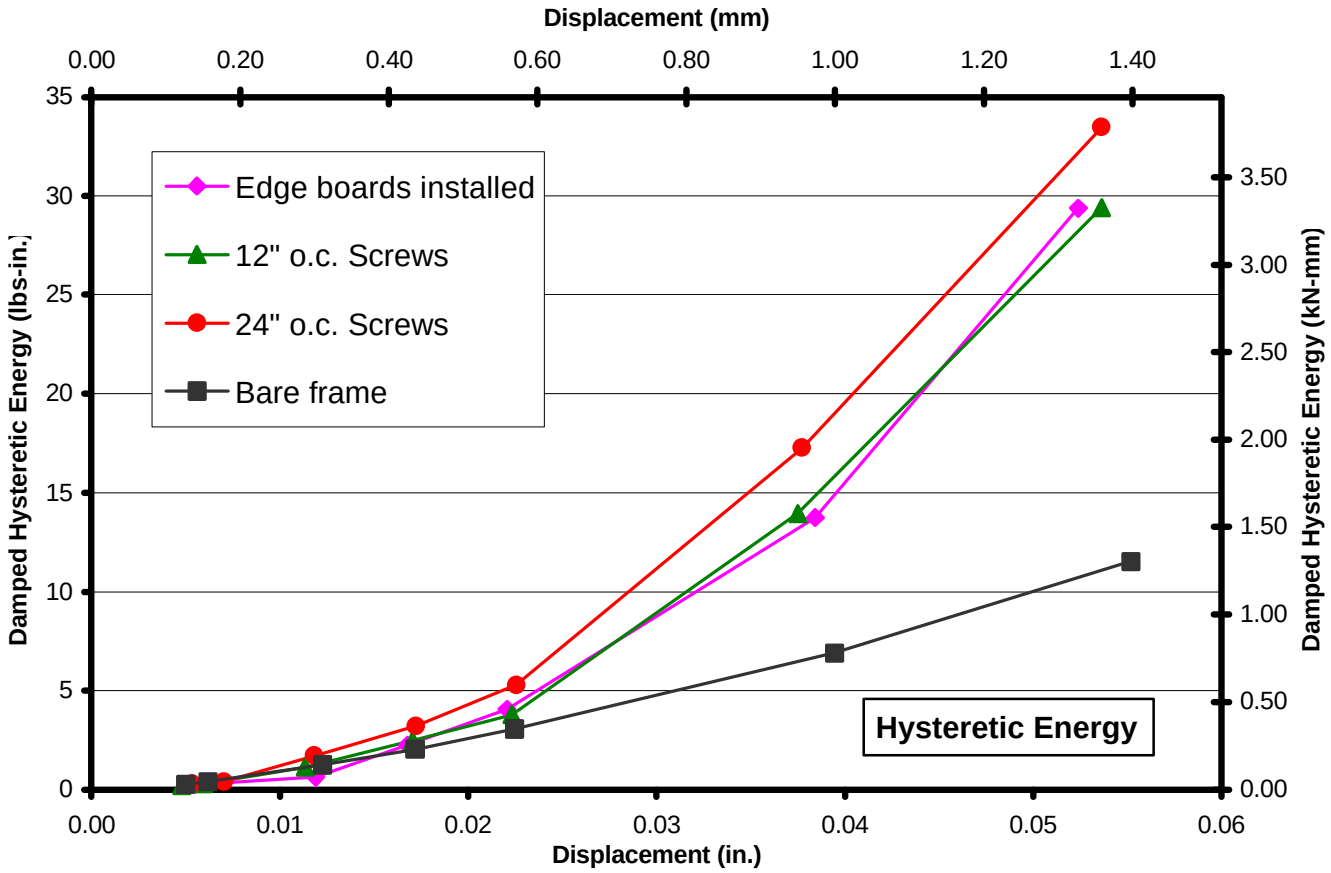

Figure C.7. Hysteretic energy as a function of displacement for Assembly 2 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

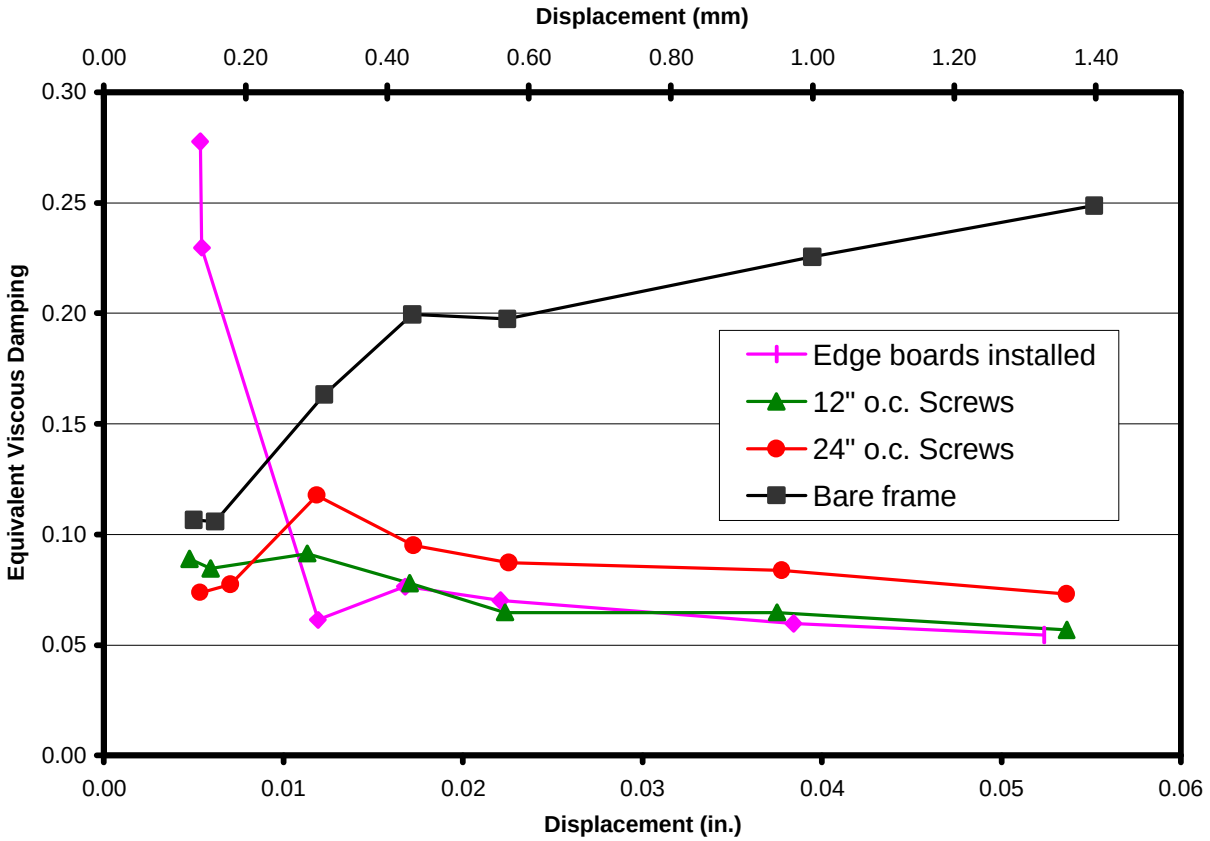

Figure C.8. Equivalent viscous damping as a function of displacement for Assembly 2 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

Table C.2. Cyclic test parameters for various testing configurations of Assembly 2 at maximum displacements.

Test configuration	Maximum displacement	Cyclic stiffness	Strain energy	Hysteretic energy	Equivalent viscous damping
Bare timber frame	0.055 in. (1.4 mm)	2,430 lbs/in. (426 N/mm)	7.39 lbs-in. (835 N-mm)	11.5 lbs-in. (1.30 kN-mm)	0.25
SIPs installed; screws 24” o.c.	0.054 in. (1.4 mm)	26,600 lbs/in. (4.66 kN/mm)	73.1 lbs-in. (8.26 kN-mm)	33.5 lbs-in. (3.79 kN-mm)	0.073
SIPs installed; screws 12” o.c.	0.054 in. (1.4 mm)	29,400 lbs/in. (5.15 kN/mm)	82.2 lbs-in. (9.39 kN-mm)	29.4 lbs-in. (3.32 kN-mm)	0.057
SIPs installed; screws 12” o.c., edge boards installed	0.052 in. (1.3 mm)	32,700 lbs/in. (5.73 kN/mm)	85.6 lbs-in. (9.67 kN-mm)	29.4 lbs-in. (3.32 kN-mm)	0.055
SIPs installed; screws 12” o.c., edge boards installed	0.134 in. (3.4 mm)	32,500 lbs/in. (5.69 kN/mm)	567 lbs-in. (64.1 kN-mm)	258 lbs-in. (29.2 kN-mm)	0.072

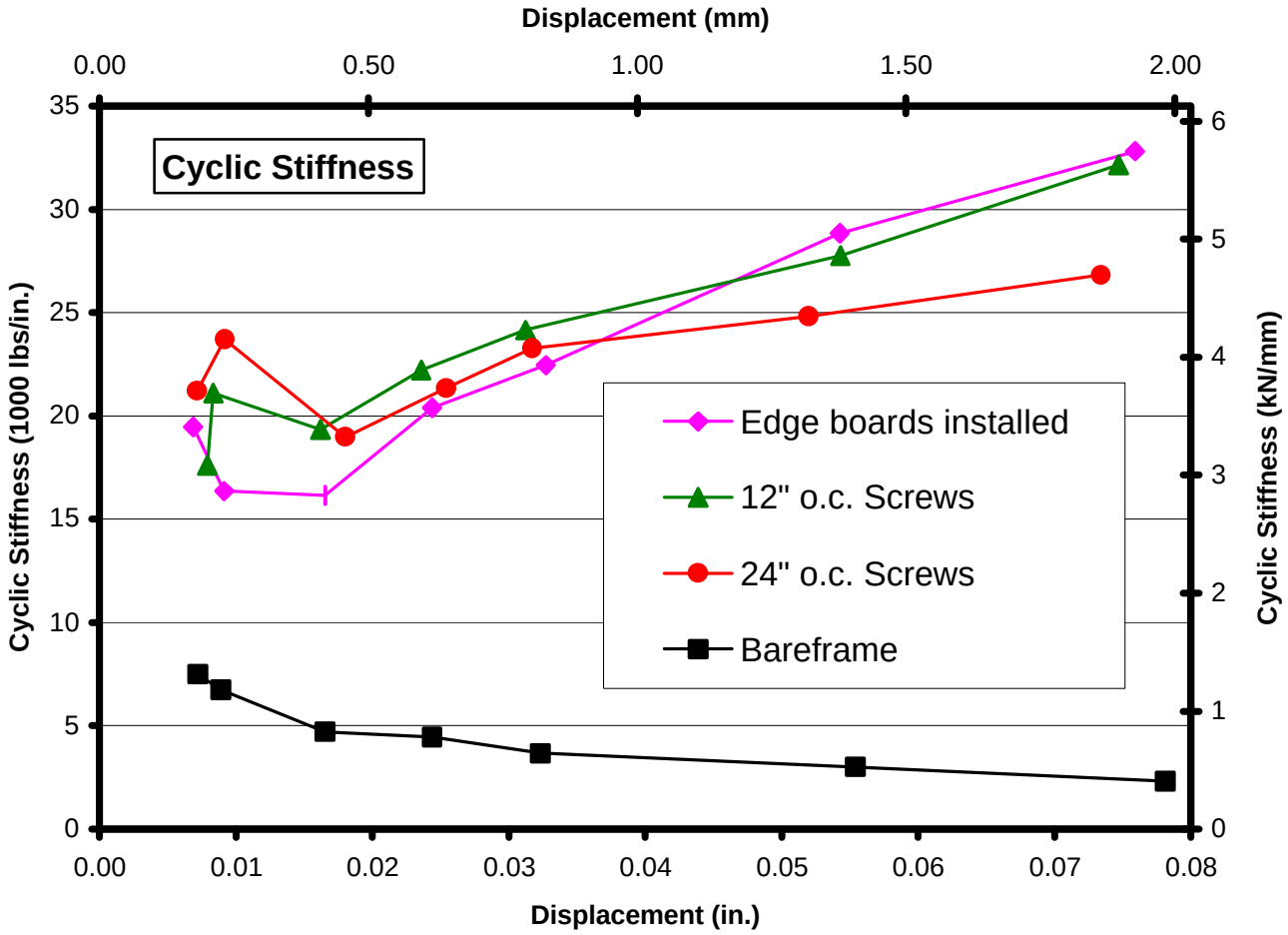

Figure C.9. Cyclic stiffness as a function of displacement for Assembly 3 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

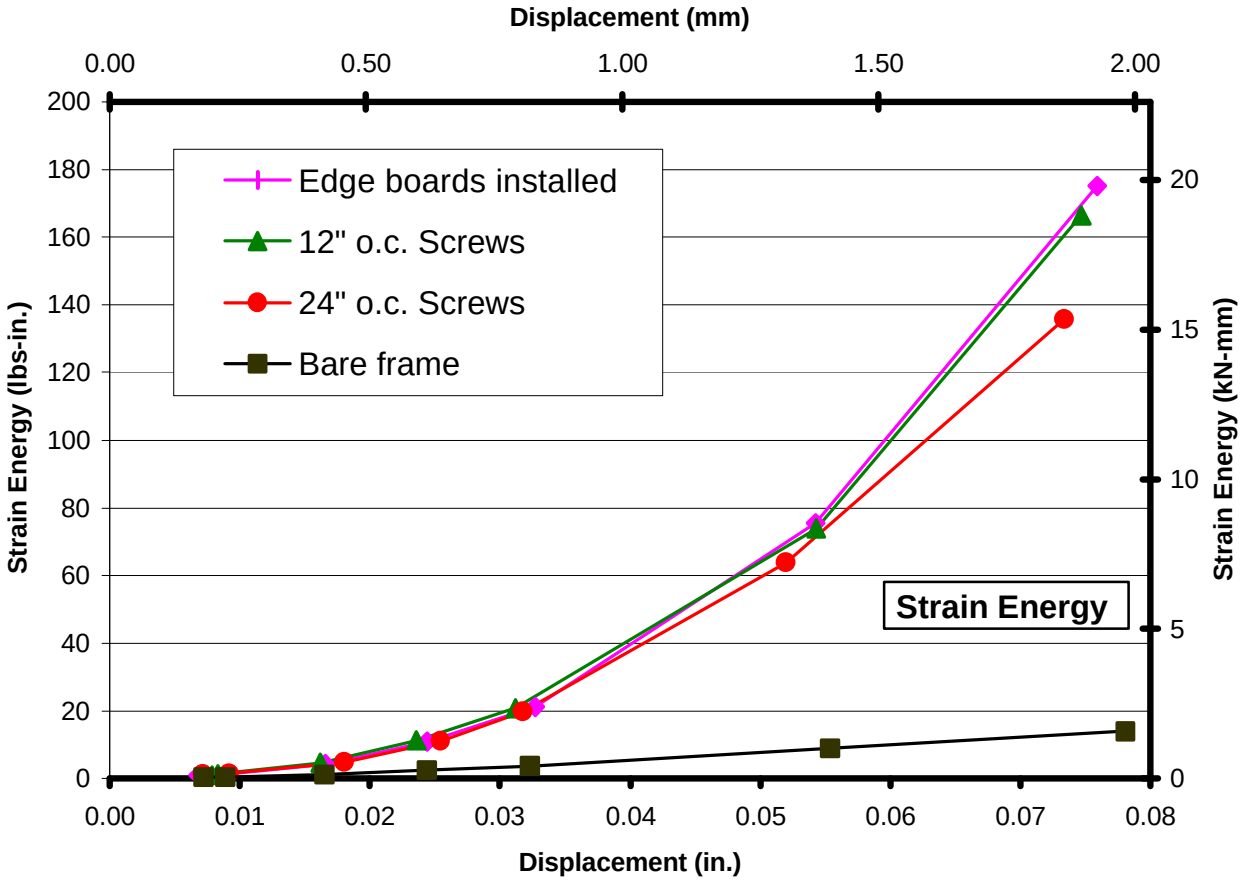

Figure C.10. Strain energy as a function of displacement for Assembly 3 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

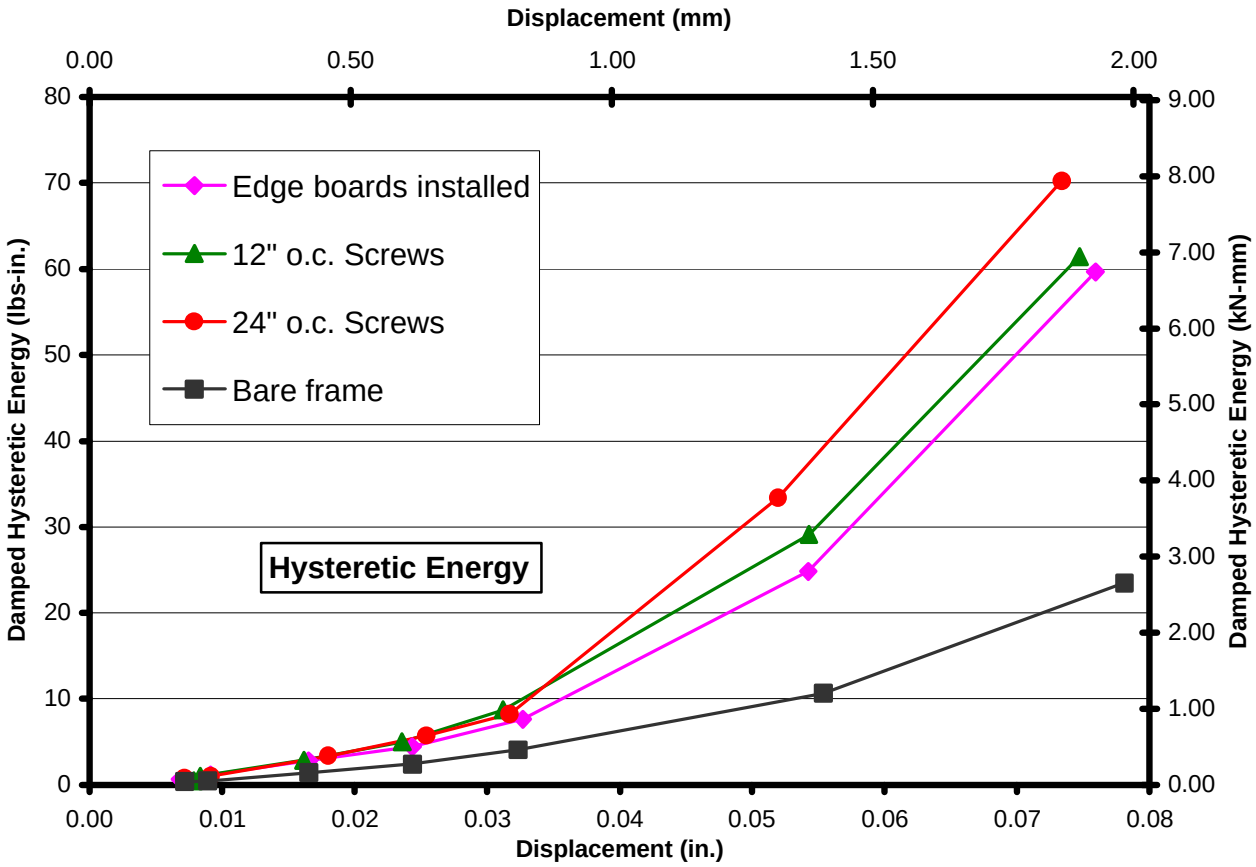

Figure C.11. Hysteretic energy as a function of displacement for Assembly 3 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

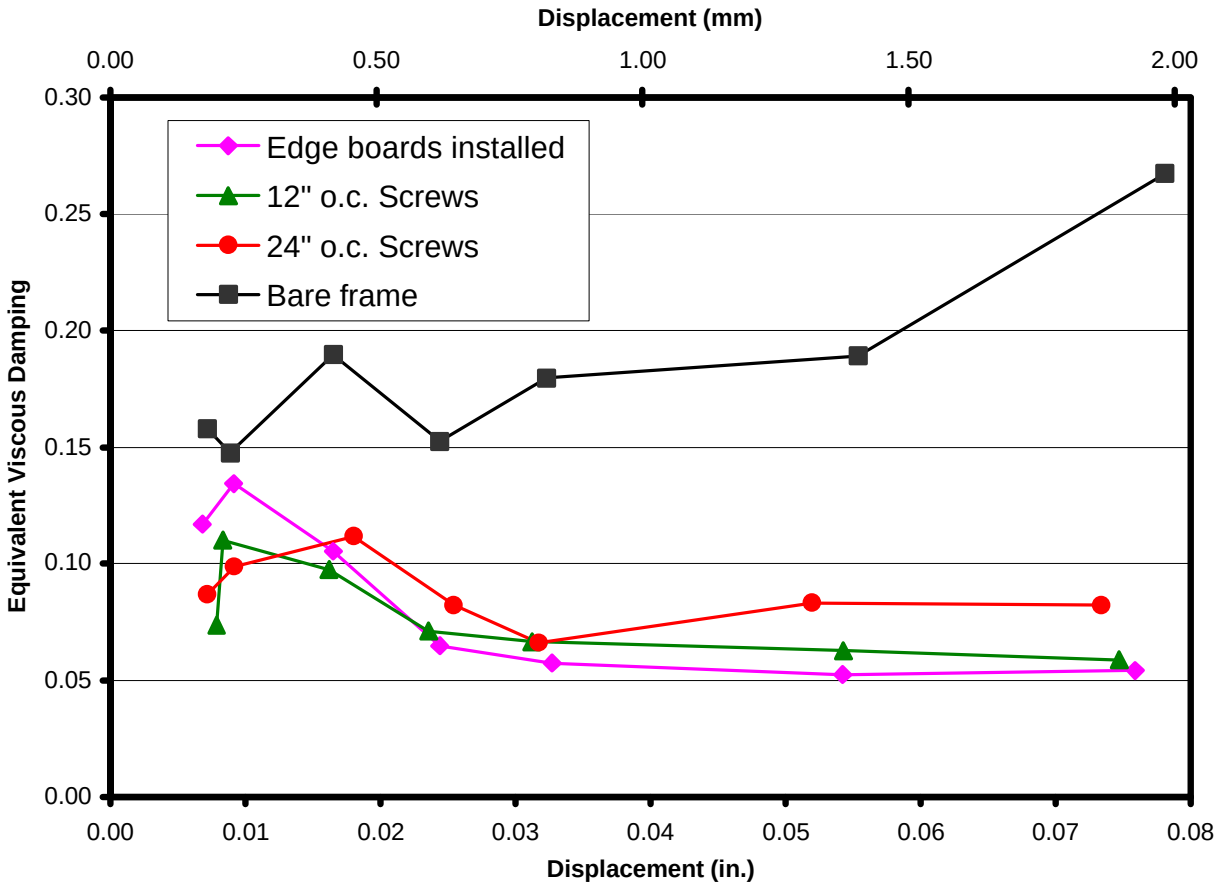

Figure C.12. Equivalent viscous damping as a function of displacement for Assembly 3 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

Table C.3. Cyclic test parameters for various testing configurations of Assembly 3 at maximum displacements.

Test configuration	Maximum displacement	Cyclic stiffness	Strain energy	Hysteretic energy	Equivalent viscous damping
Bare timber frame	0.078 in. (2.0 mm)	2,320 lbs/in. (407 N/mm)	14.0 lbs-in. (1.58 kN-mm)	23.5 lbs-in. (2.66 kN-mm)	0.27
SIPs installed; screws 24” o.c.	0.073 in. (1.9 mm)	26,800 lbs/in. (4.70 kN/mm)	136 lbs-in. (15.4 kN-mm)	70.2 lbs-in. (7.93 kN-mm)	0.082
SIPs installed; screws 12” o.c.	0.075 in. (1.9 mm)	32,200 lbs/in. (5.64 kN/mm)	166 lbs-in. (18.8 kN-mm)	61.5 lbs-in. (6.95 kN-mm)	0.058
SIPs installed; screws 12” o.c., edge boards installed	0.076 in. (1.9 mm)	32,800 lbs/in. (5.75 kN/mm)	175 lbs-in. (19.8 kN-mm)	59.7 lbs-in. (6.75 kN-mm)	0.054
SIPs installed; screws 12” o.c., edge boards installed	0.196 in. (5.0 mm)	32,400 lbs/in. (5.68 kN/mm)	1,110 lbs-in. (125 kN-mm)	539 lbs-in. (60.9 kN-mm)	0.078

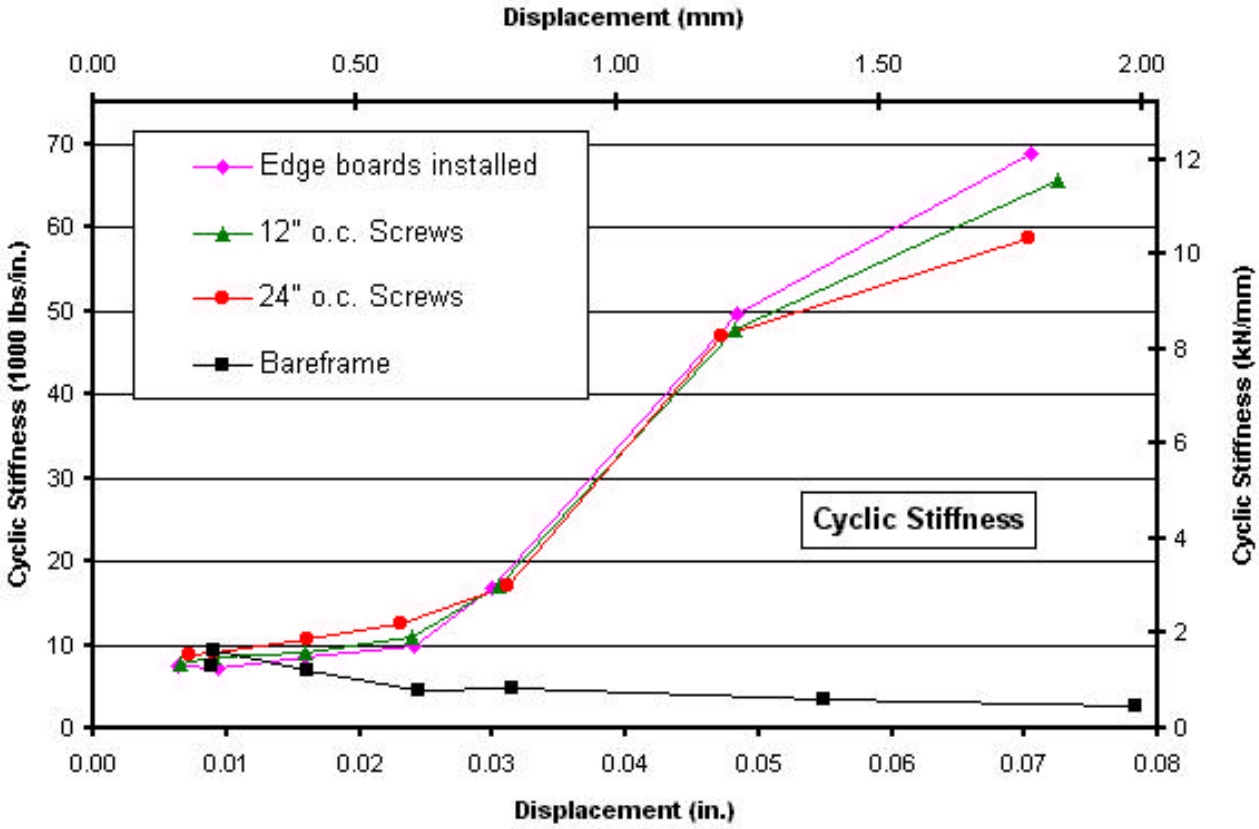

Figure C.13. Cyclic stiffness as a function of displacement for Assembly 4 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

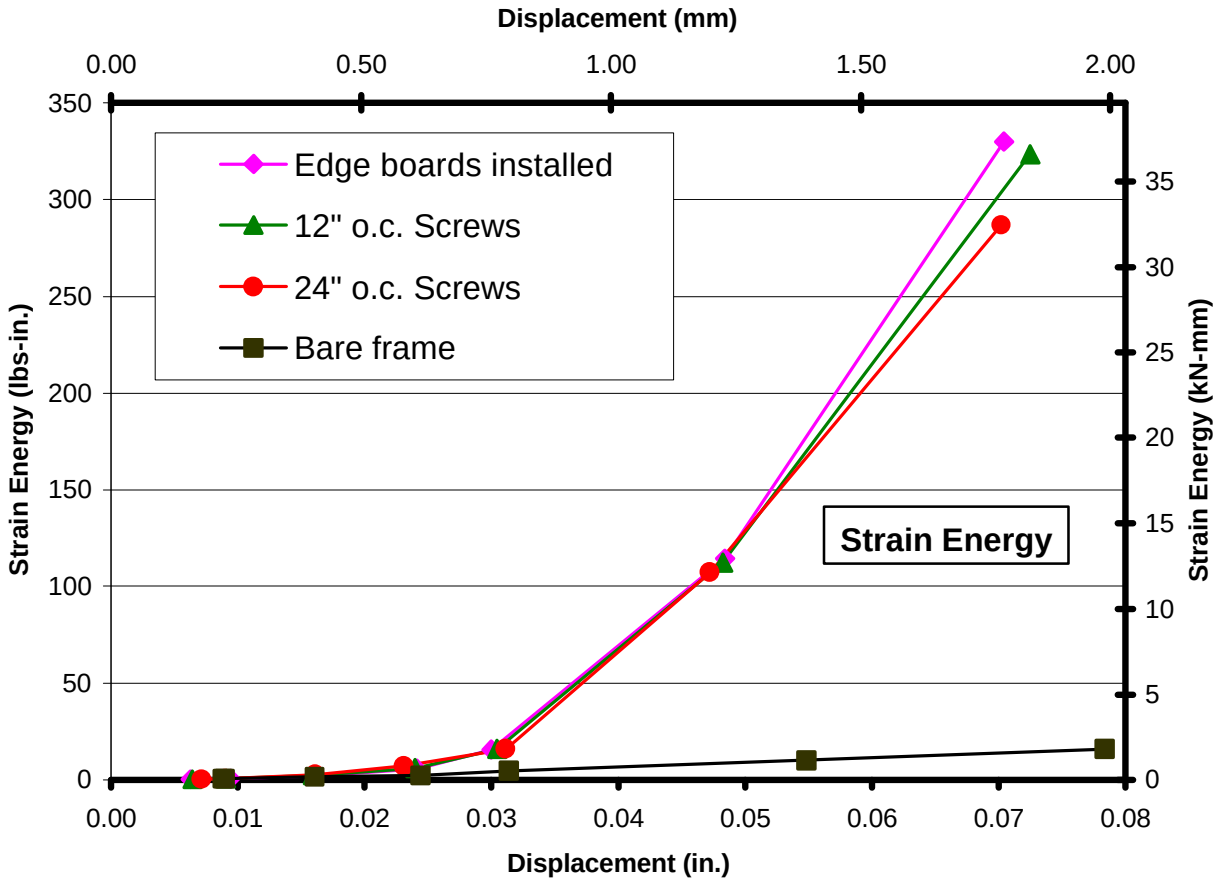

Figure C.14. Strain energy as a function of displacement for Assembly 4 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

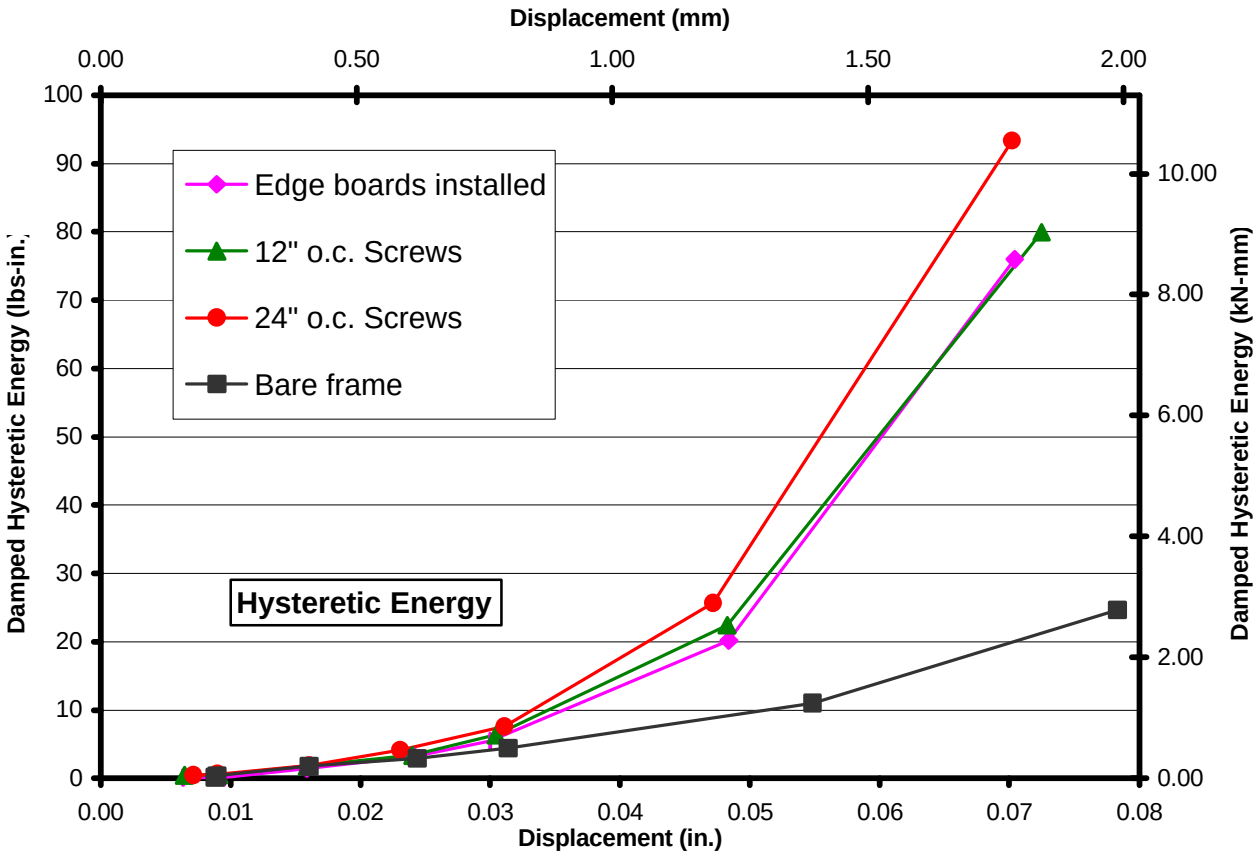

Figure C.15. Hysteretic energy as a function of displacement for Assembly 4 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

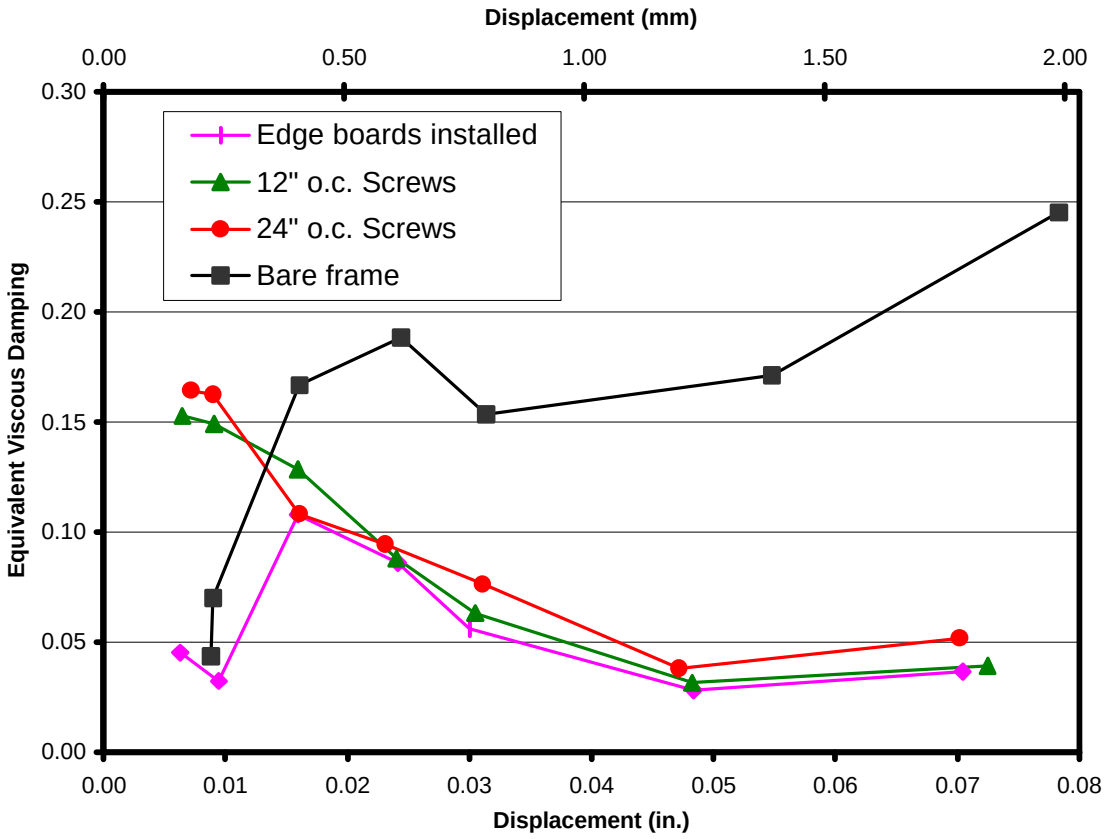

Figure C.16. Equivalent viscous damping as a function of displacement for Assembly 4 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

Table C.4. Cyclic test parameters for various testing configurations of Assembly 4 at maximum displacements.

Test configuration	Maximum displacement	Cyclic stiffness	Strain energy	Hysteretic energy	Equivalent viscous damping
Bare timber frame	0.078 in. (2.0 mm)	2,750 lbs/in. (482 N/mm)	16.0 lbs-in. (1.81 kN-mm)	24.6 lbs-in. (2.78 kN-mm)	0.25
SIPs installed; screws 24” o.c.	0.070 in. (1.8 mm)	58,900 lbs/in. (10.3 kN/mm)	287lbs-in. (32.4 kN-mm)	93.3 lbs-in. (10.5 kN-mm)	0.052
SIPs installed; screws 12” o.c.	0.073 in. (1.9 mm)	65,700 lbs/in. (11.5 kN/mm)	324 lbs-in. (36.6 kN-mm)	79.9 lbs-in. (9.03 kN-mm)	0.039
SIPs installed; screws 12” o.c., edge boards installed	0.070 in. (1.8 mm)	68,800 lbs/in. (12.1 kN/mm)	330 lbs-in. (37.3 kN-mm)	76.0 lbs-in. (8.59 kN-mm)	0.037
SIPs installed; screws 12” o.c., edge boards installed	0.193 in. (4.9 mm)	70,400 lbs/in. (12.3 kN/mm)	2,610 lbs-in. (295 kN-mm)	1,080 lbs-in. (122 kN-mm)	0.066

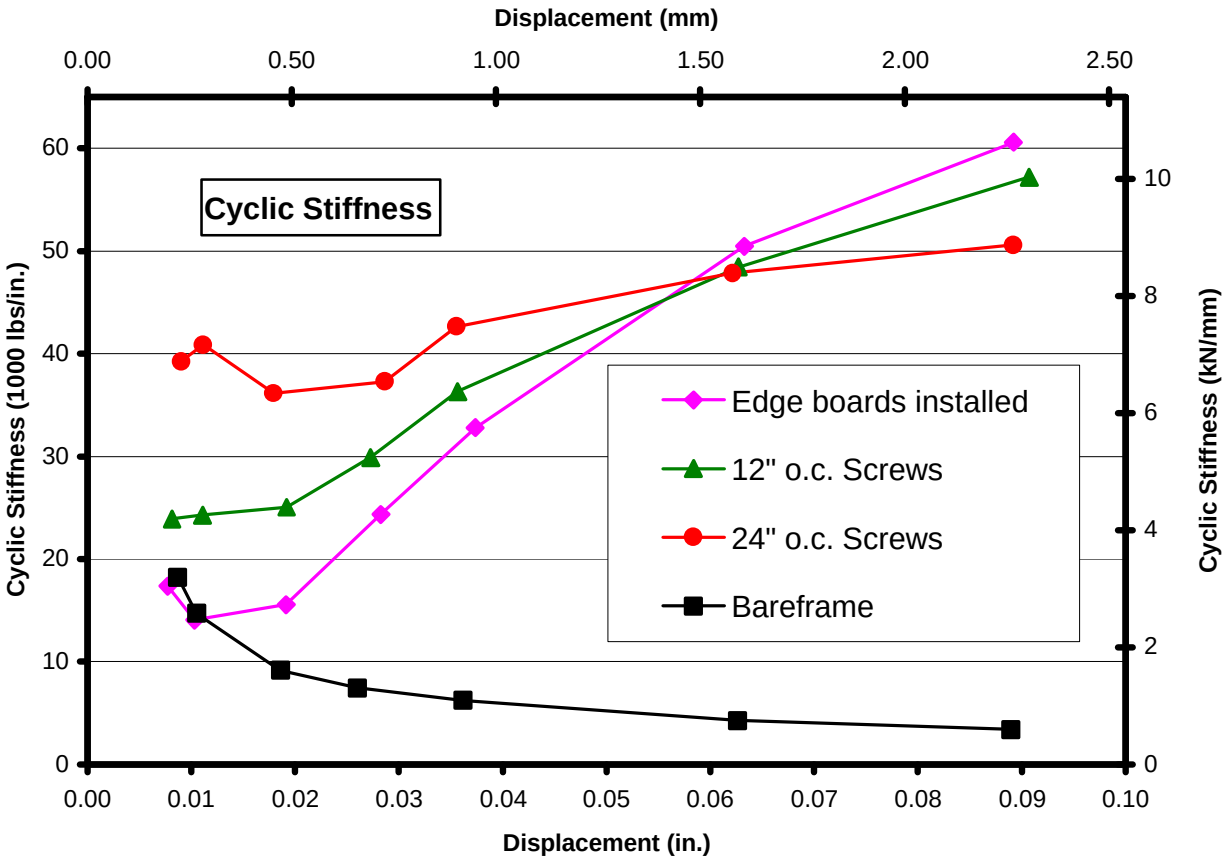

Figure C.17. Cyclic stiffness as a function of displacement for Assembly 5 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

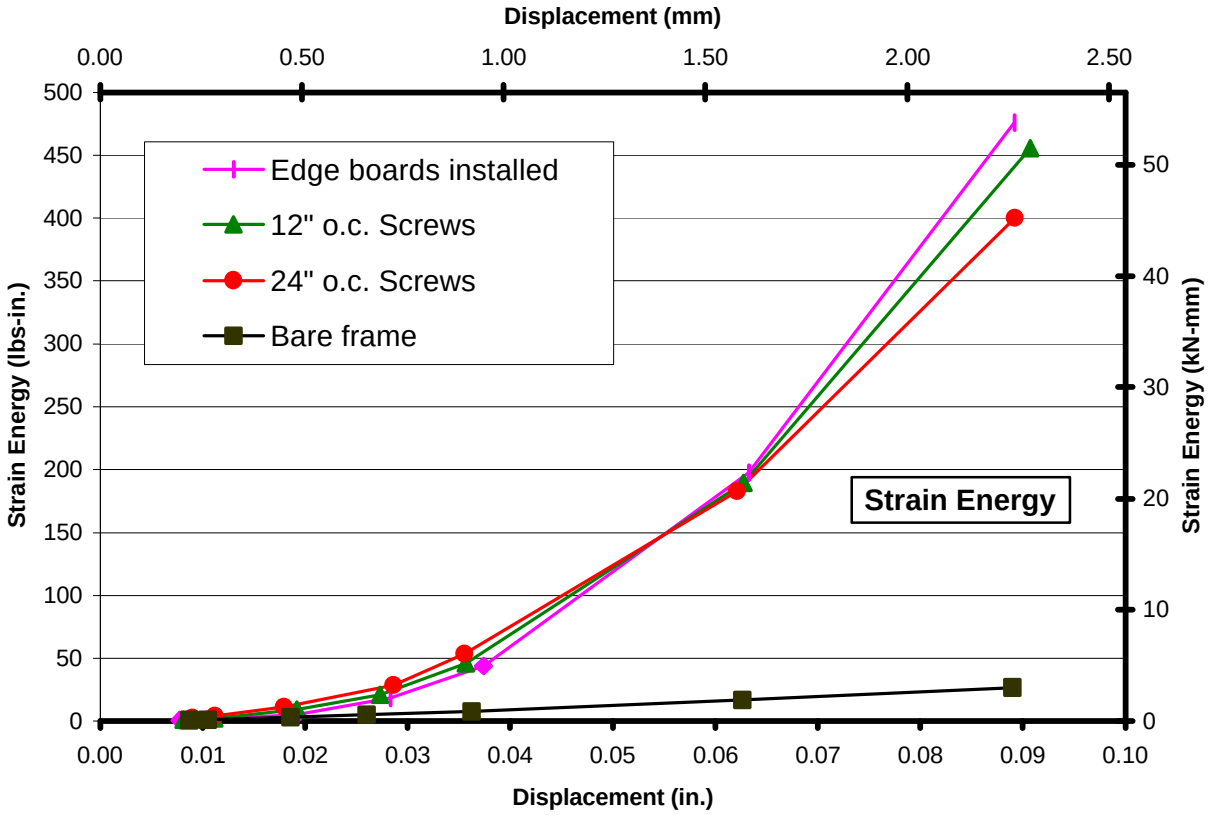

Figure C.18. Strain energy as a function of displacement for Assembly 5 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

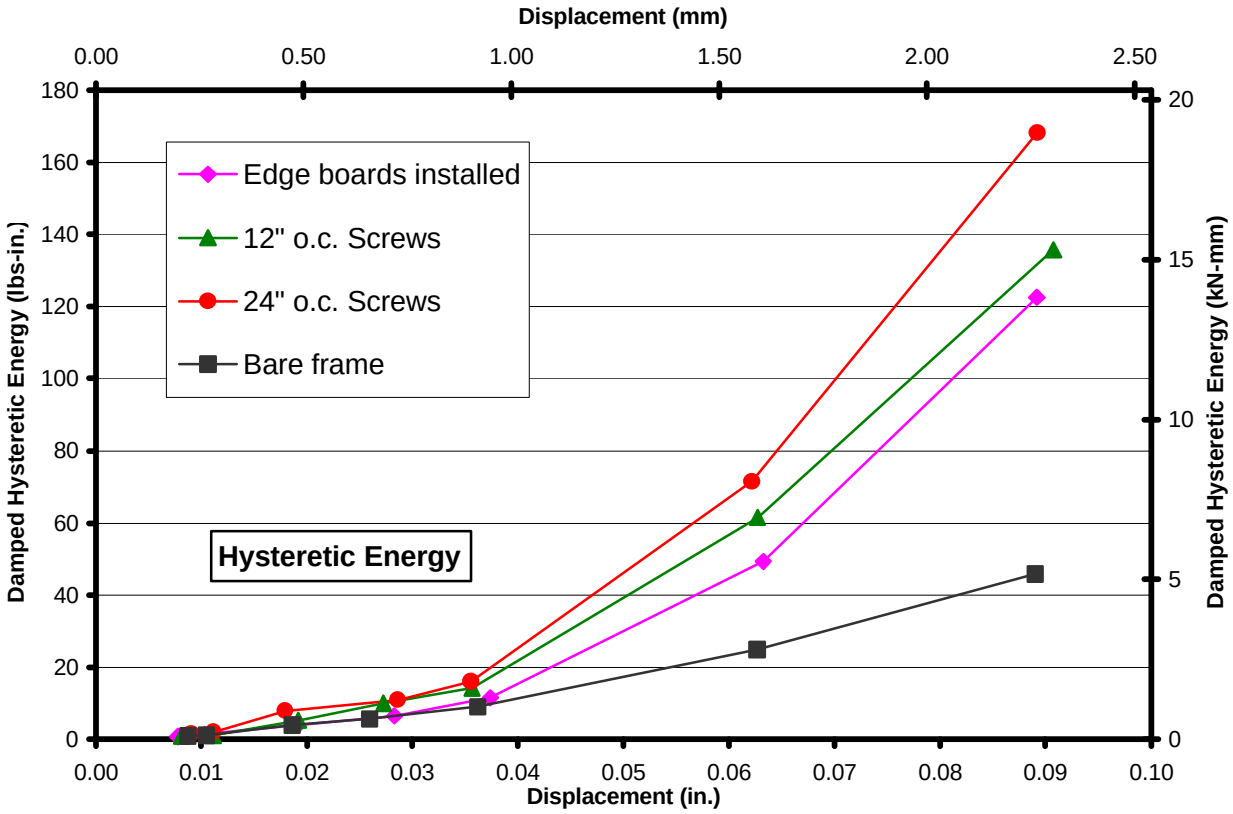

Figure C.19. Hysteretic energy as a function of displacement for Assembly 5 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

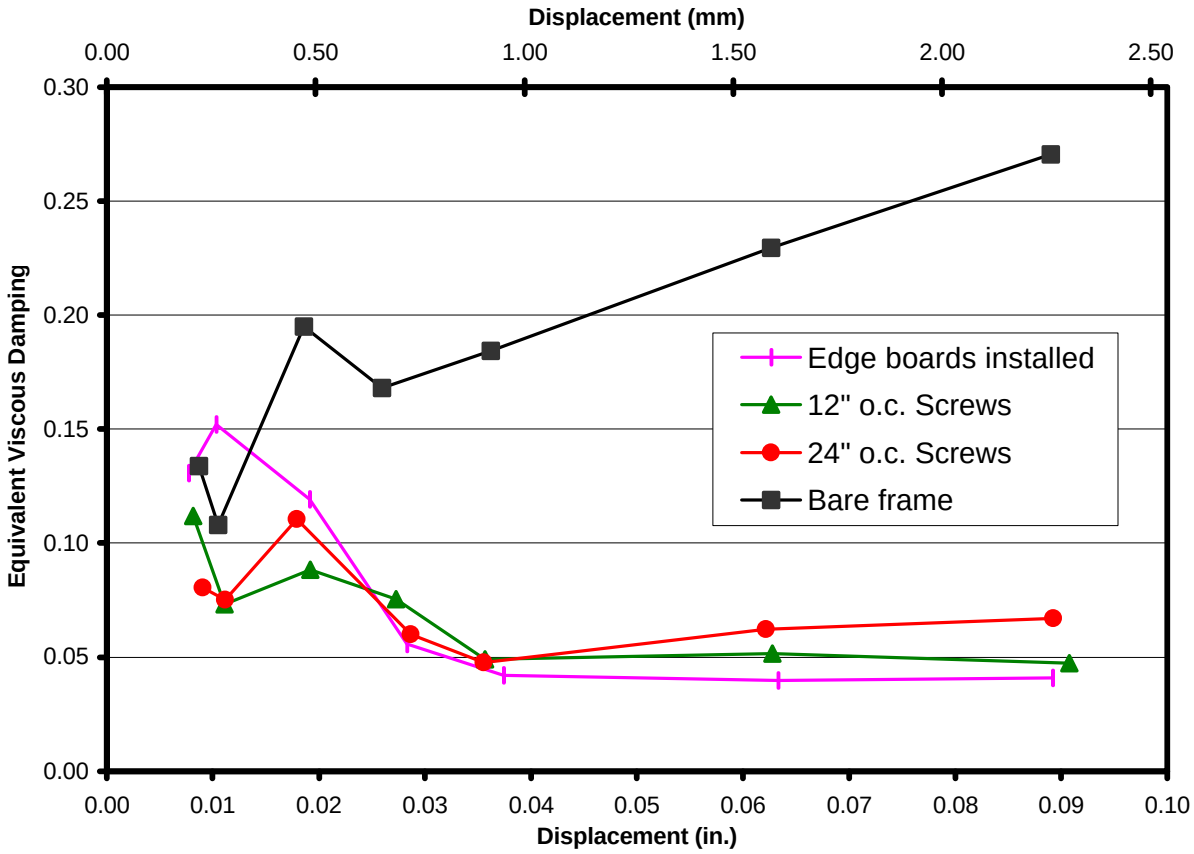

Figure C.20. Equivalent viscous damping as a function of displacement for Assembly 5 for configurations including the bare timber frame, timber frame with SIPs installed with screws at 24" (610 mm) o.c., timber frame with SIPs installed with screws at 12" (305 mm) o.c. and timber frame with SIPs installed with screws at 12" (305 mm) o.c. and edge boards installed. All tests performed with maximum actuator displacements of 0.1" (2.5 mm). Displacements shown were adjusted to coincide with wall mounted string potentiometer.

Table C.5. Cyclic test parameters for various testing configurations of Assembly 5 at maximum displacements.

Test configuration	Maximum displacement	Cyclic stiffness	Strain energy	Hysteretic energy	Equivalent viscous damping
Bare timber frame	0.089 in. (2.3 mm)	3,400 lbs/in. (596 N/mm)	26.9 lbs-in. (3.04 kN-mm)	45.7 lbs-in. (5.16 kN-mm)	0.27
SIPs installed; screws 24” o.c.	0.089 in. (2.3 mm)	50,600 lbs/in. (8.87 kN/mm)	400 lbs-in. (45.2 kN-mm)	168 lbs-in. (19.0 kN-mm)	0.067
SIPs installed; screws 12” o.c.	0.091 in. (2.3 mm)	57,200 lbs/in. (10.0 kN/mm)	456 lbs-in. (51.5 kN-mm)	136 lbs-in. (15.4 kN-mm)	0.047
SIPs installed; screws 12” o.c., edge boards installed	0.089 in. (2.3 mm)	60,600 lbs/in. (10.6 kN/mm)	476 lbs-in. (53.8 kN-mm)	123 lbs-in. (13.9 kN-mm)	0.041
SIPs installed; screws 12” o.c., edge boards installed	0.225 in. (5.7 mm)	68,600 lbs/in. (12.0 kN/mm)	3,390 lbs-in. (383 kN-mm)	1,440 lbs-in. (163 kN-mm)	0.068