

Supplementary Material

Optimal Active Control of Structures Using a Screw Jack Device and Open-Loop Linear Quadratic Gaussian Controller

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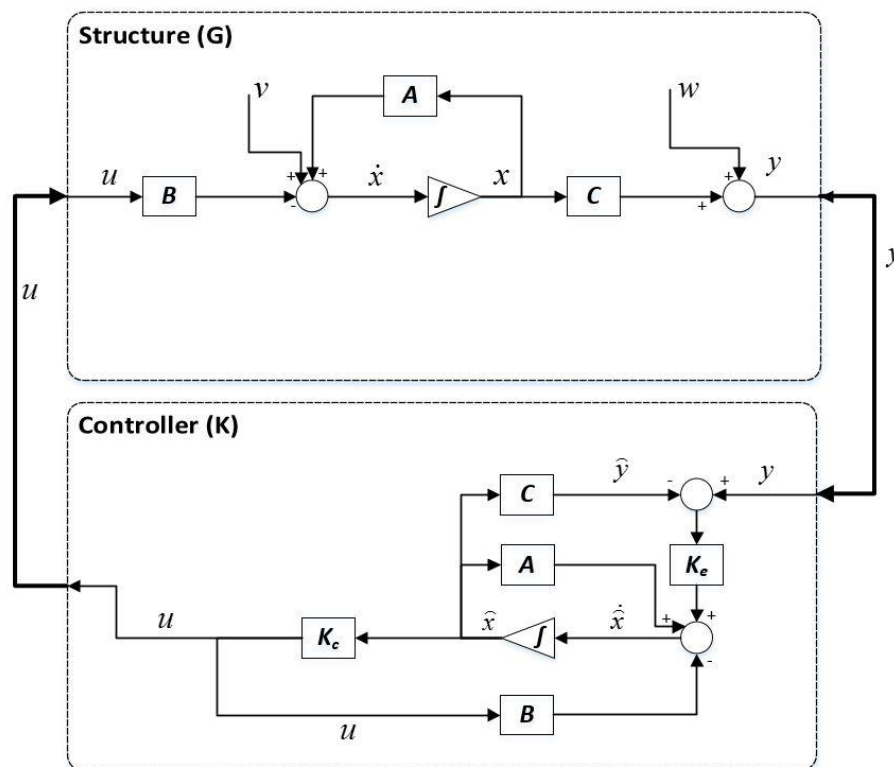
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Ali Noormohamed

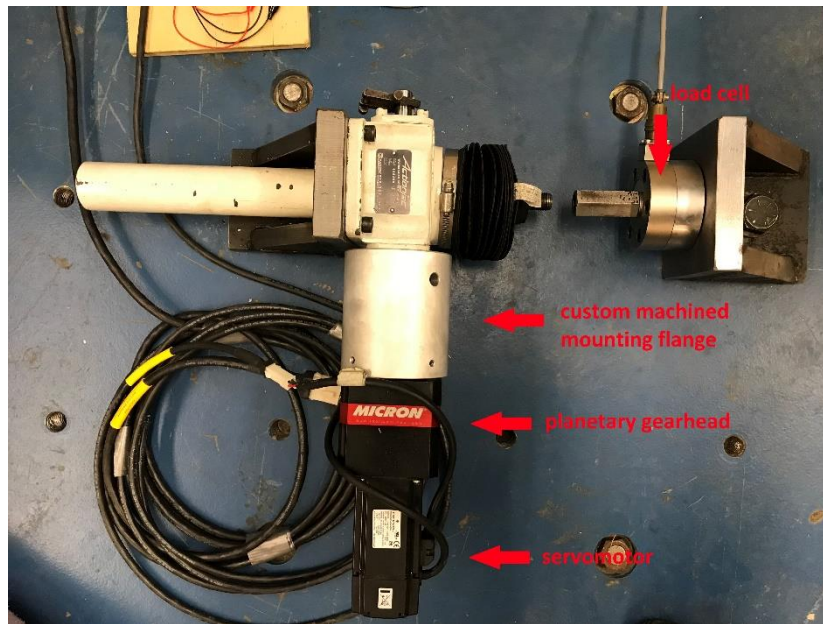
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1 Supplementary Figures and Tables

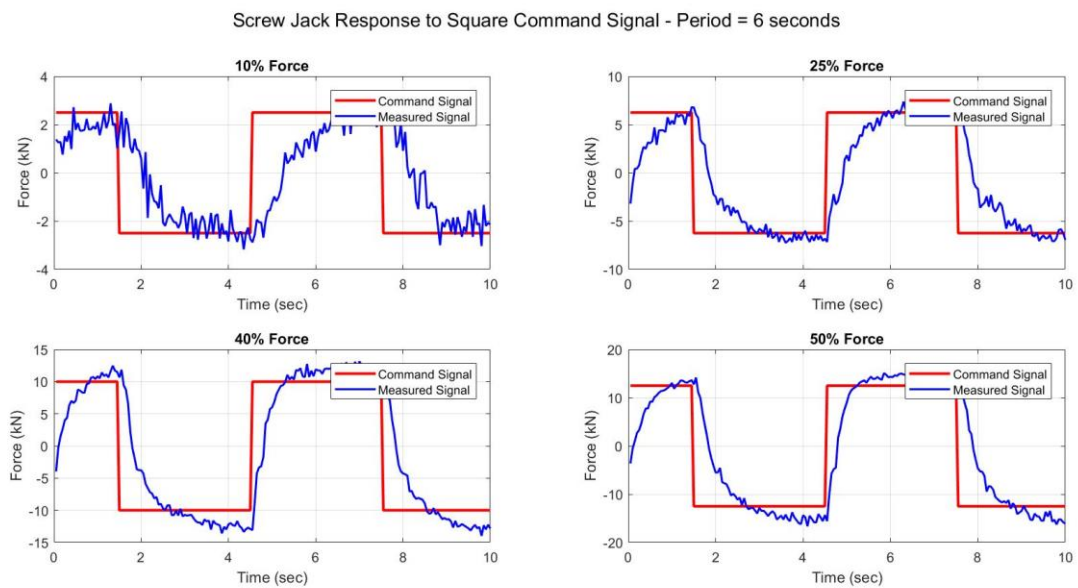
1.1 Supplementary Figures



Supplementary - Figure S1. Schematic representation of LQG controller used in experiments.

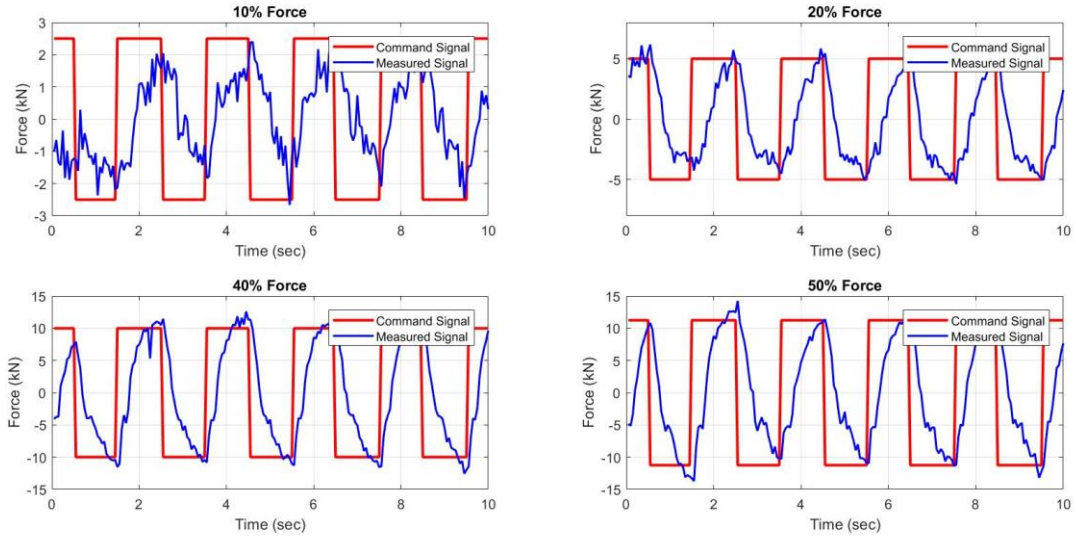


Supplementary - Figure S2: Screw jack experimental setup at the University of Toronto.



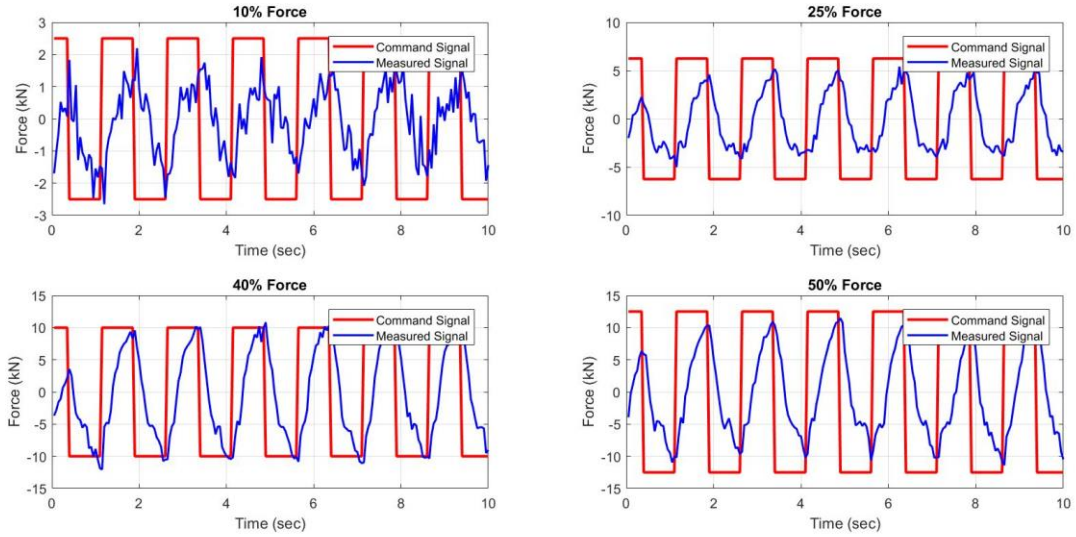
Supplementary - Figure S3. Screw jack characterization tests: square wave force command, period = 6.0 sec.

Screw Jack Response to Square Command Signal - Period = 2 seconds

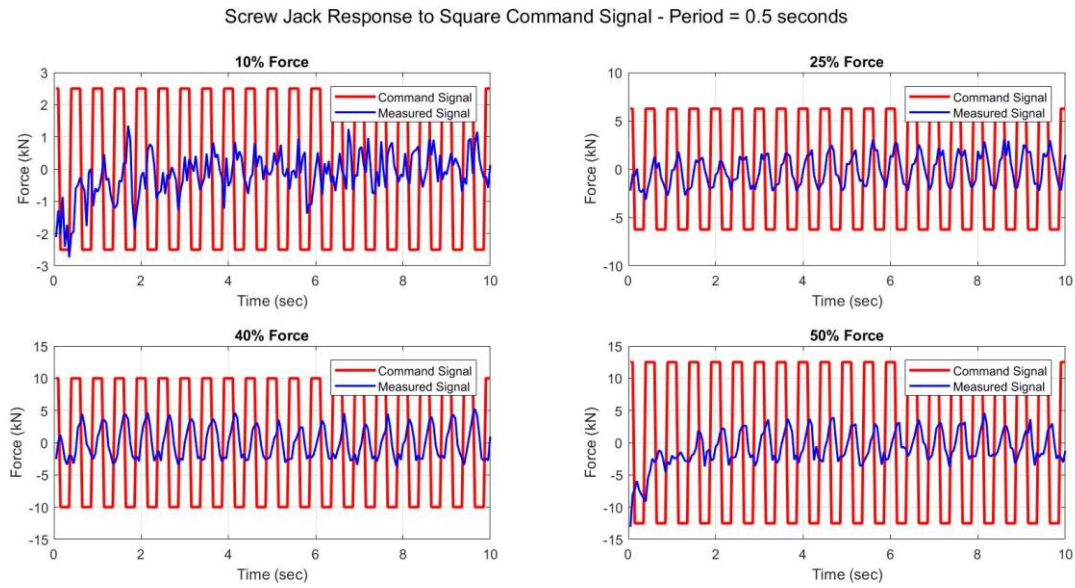


Supplementary - Figure S4. Screw jack characterization tests: square wave force command, period = 2.0 sec.

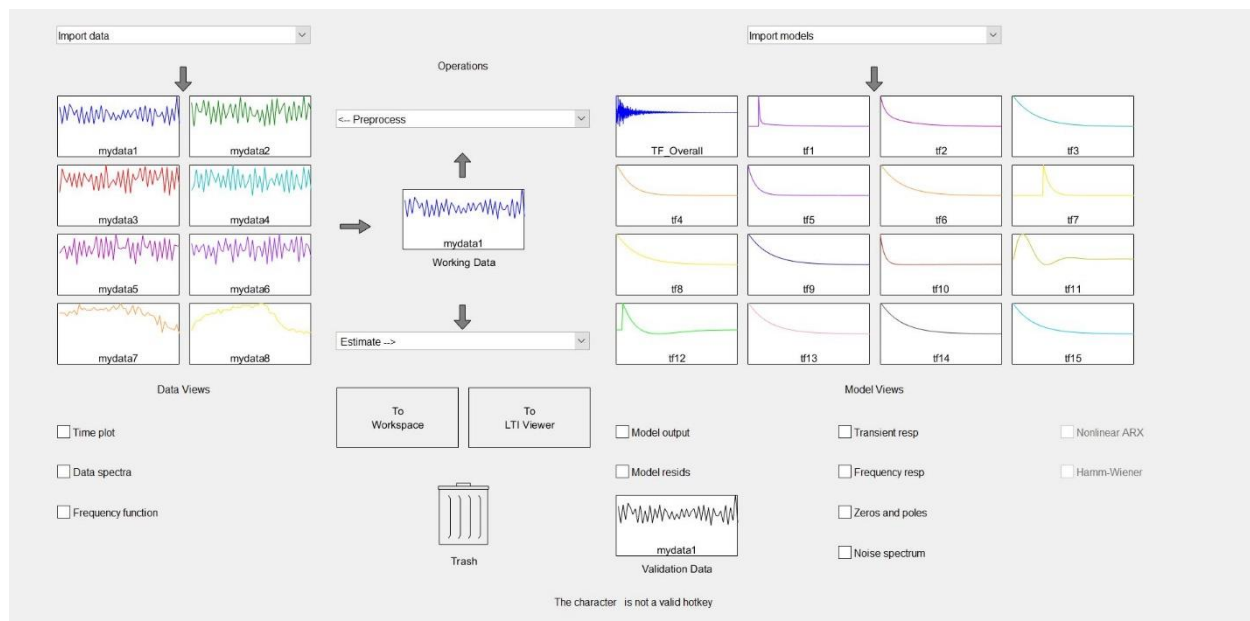
Screw Jack Response to Square Command Signal - Period = 1.5 seconds



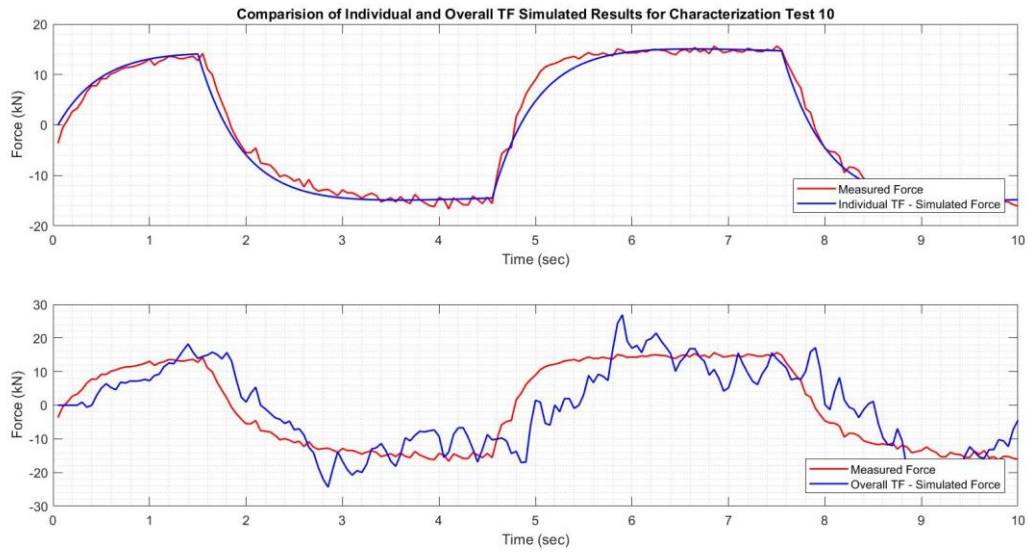
Supplementary - Figure S5. Screw jack characterization tests: square wave force command, period = 1.5 sec.



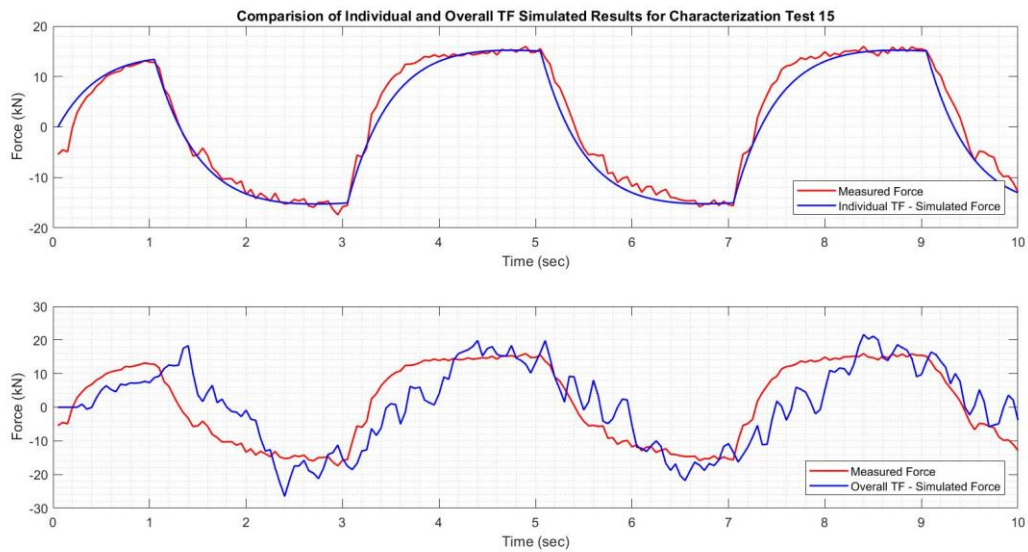
Supplementary - Figure S6. Screw jack characterization tests: square wave force command, period = 0.5 sec.



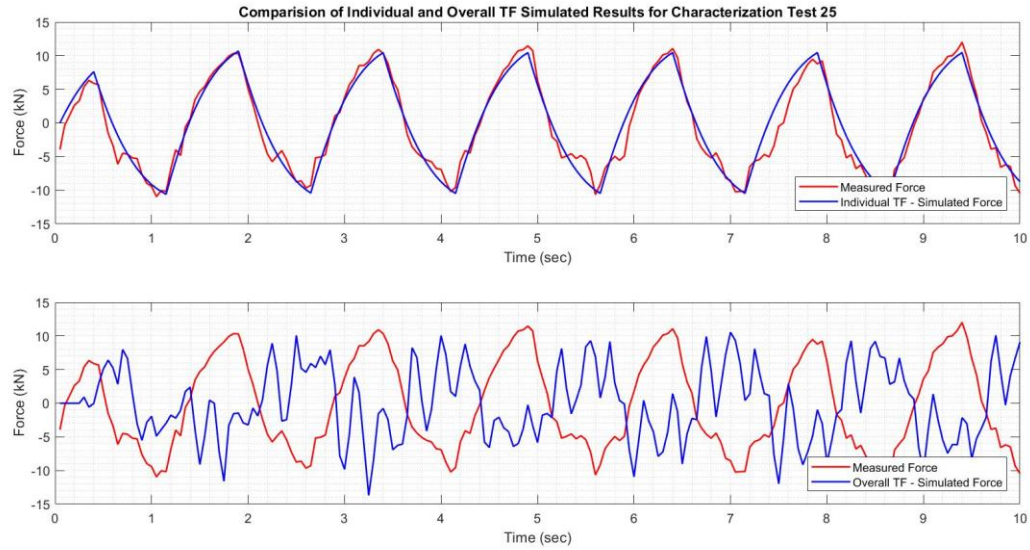
Supplementary - Figure S7. Screenshot of Matlab's System Identification app being used to calculate transfer functions for various input-output datasets.



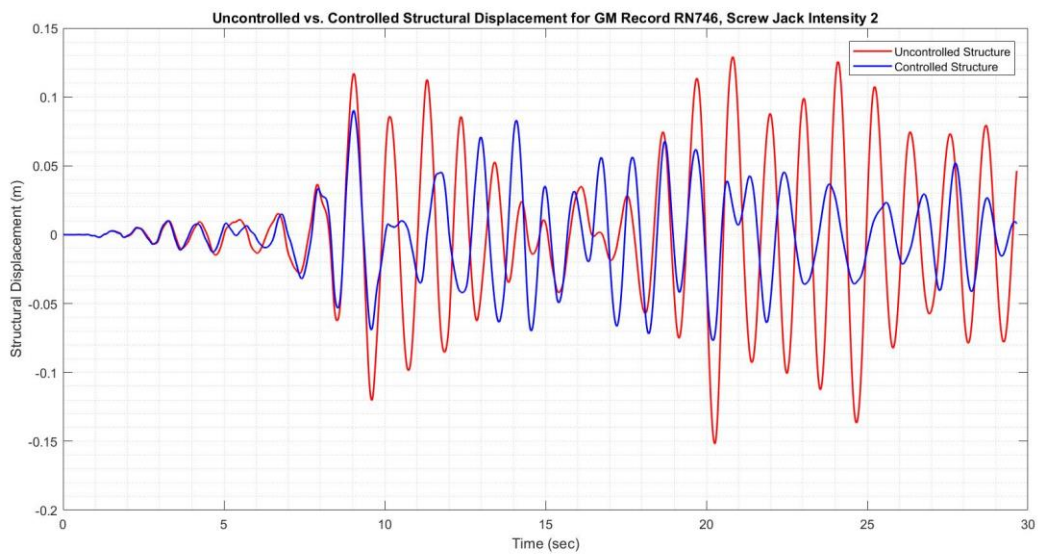
Supplementary - Figure S8. Screenshot of Matlab's System Identification app being used to calculate transfer functions for various input-output datasets.



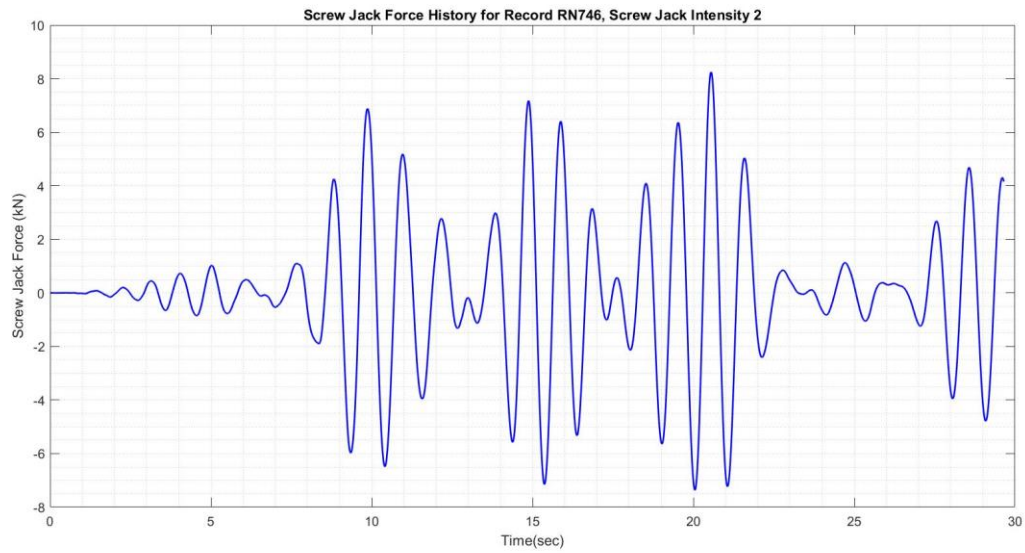
Supplementary - Figure S9. Screenshot of Matlab's System Identification app being used to calculate transfer functions for various input-output datasets.



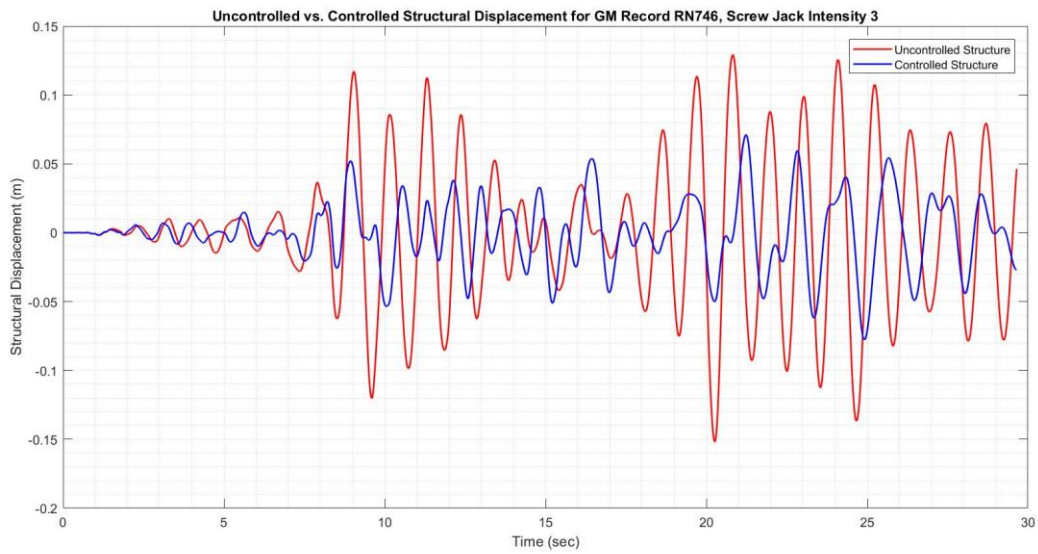
Supplementary - Figure S10. Screenshot of Matlab's System Identification app being used to calculate transfer functions for various input-output datasets.



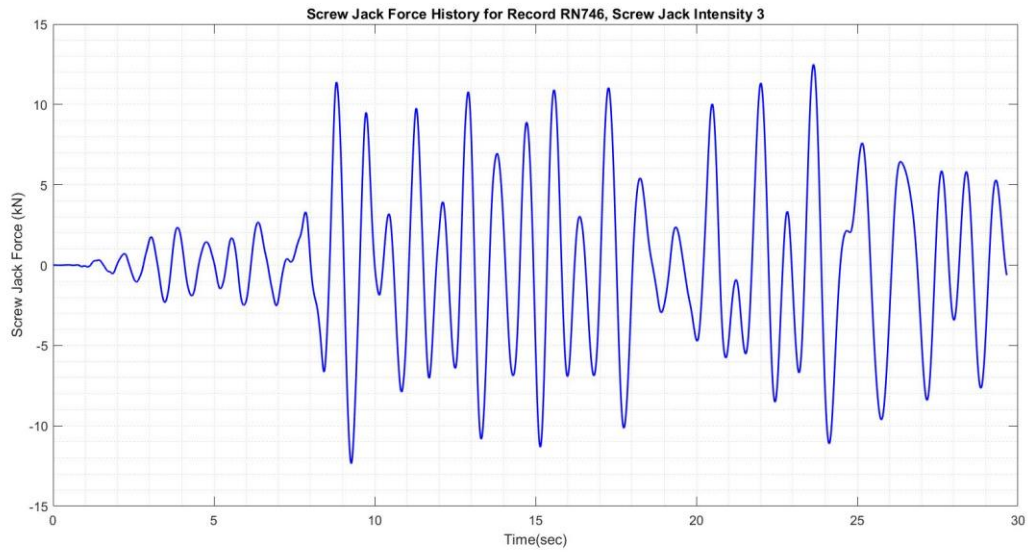
Supplementary - Figure S11. Structural displacement of SDOF structure subjected to ground motion record # 746 with and without screw jack (scenario 2), calculated using numerical methods.



Supplementary - Figure S12. Screw jack force history required for control of SDOF structure subjected to ground motion record # 746 (scenario 2).



Supplementary - Figure S13. Structural displacement of SDOF structure subjected to ground motion record # 746 with and without screw jack (scenario 3), calculated using numerical methods.



Supplementary - Figure S14. Screw jack force history required for control of SDOF structure subjected to ground motion record # 746 (scenario 3).

1.2 Supplementary Tables

Table S1: Summary of ground motion records.

Record #	Earthquake Name & Year	Station Name	PGA (g)	Total Time (sec)	Scale Factor
746	Loma Prieta 1989	Bear Valley #5	0.286	29.655	4.2
774	Loma Prieta 1989	Hayward City Hall – North	0.328	39.455	6.7
975	Northridge 1994	Glendora – N Oakbank	0.301	30.00	6.5
3202	Chi Chi 1999	TCU102	0.316	79.00	7.5
3859	Chi Chi 1999	CHY006	0.383	98.00	4.0
6949	Darfield 2010	PEEC	0.366	59.55	3.0
6963	Darfield 2010	RPZ	0.310	150.00	6.5

Table S2: Summary of LQG cost scenarios.

Case Name	Structural Response Cost	Control Effort Cost
Optimal	High	Low
1	Low	High
2	Low	Medium
3	Medium	Medium

Table S3: Summary of rise time, settling time, for impulse characterization tests.

Test Number	Loading Type	Magnitude (% SJ capacity)	Rise Time (sec)	Settling Time (sec)
1	Impulse	15	0.47	0.75
2	Impulse	25	0.89	1.0
3	Impulse	35	0.71	0.94
4	Impulse	60	0.69	1.0
5	Impulse	70	0.68	1.2
6	Impulse	80	0.42	0.7

Table S4: Transfer function simulation error for characterization tests.

Test Number	Loading Type	Loading Frequency (Hz)	Loading Amplitude (% SJ capacity)	Individual TF RMS % Error	Overall TF RMS % Error
1	Step load	N/A	15%	6.12%	7.40%
2	Step load	N/A	25%	2.83%	4.83%
3	Step load	N/A	35%	2.14%	4.33%
4	Step load	N/A	60%	1.15%	3.98%
5	Step load	N/A	70%	0.99%	4.11%
6	Step load	N/A	80%	0.93%	4.68%
7	Square wave	0.1667	10%	12.08%	13.04%
8	Square wave	0.1667	25%	2.73%	12.19%
9	Square wave	0.1667	40%	2.70%	14.65%
10	Square wave	0.1667	50%	3.06%	14.10%
11	Square wave	0.25	10%	30.04%	130.82%
12	Square wave	0.25	25%	2.34%	5.23%
13	Square wave	0.25	40%	2.43%	7.97%
14	Square wave	0.25	50%	2.51%	12.65%

15	Square wave	0.50	10%	21.58%	73.74%
16	Square wave	0.50	20%	13.87%	61.35%
17	Square wave	0.50	40%	1.70%	6.85%
18	Square wave	0.50	50%	2.19%	12.48%
19	Square wave	0.667	10%	16.22%	140.83%
20	Square wave	0.667	25%	7.10%	58.61%
21	Square wave	0.667	40%	9.24%	43.19%
22	Square wave	0.667	50%	1.05%	3.72%
23	Square wave	1.0	10%	9.74%	51.75%
24	Square wave	1.0	25%	5.82%	41.34%
25	Square wave	1.0	40%	3.94%	27.30%
26	Square wave	1.0	50%	5.49%	15.64%
27	Square wave	2.0	10%	4.94%	11.91%
28	Square wave	2.0	25%	3.74%	11.89%
29	Square wave	2.0	40%	4.11%	12.10%
30	Square wave	2.0	50%	4.17%	11.73%