21 October 2024

WRL Ref: WRL2024007 LR20241021 JTC

SUBJECT TO LEGAL PRIVILEGE

UNSW Water Research Laboratory

Eskil Julliard, Northern Beaches Council
C/o- King & Wood Mallesons (Contact: Steven Adler)
Level 61, Governor Phillip Tower, 1 Farrer Place
Sydney NSW 2000

By email: steven.adler@au.kwm.com; Stella.Zhao@au.kwm.com; kate.dean@au.kwm.com

Dear Steven,

RE: Newport SLSC seawall physical model – wave pressures on SLSC wall and overtopping water through upper windows

1. Introduction

This letter provides additional commentary, additional tests and additional analysis undertaken on the same physical model reported in Carley and Doherty (2024), Newport SLSC stepped seawall physical modelling, WRL Technical Report 2024/20, UNSW Water Research Laboratory, and on WRL's letter report dated 5 September 2024.

It also documents the volume of wave overtopping water that would pass through a hypothetically broken upper storey window.

2. Levels

2.1 Building and load cell geometry

The following levels and geometry are from Carley and Doherty (2024), modified for additional clarity and additional tests:

- The promenade level is 5.5 m AHD and width tested is 4 m (the minimum width)
- Ground floor level is 5.66 m AHD = approximately 160 mm above promenade
- First floor level is 9.0 m AHD
- Eaves level is approximately 12.1 m AHD
- The ground floor bottom load cell (Figure 2.1) covered the vertical range: 5.66 m AHD to 7.16 m AHD (1.5 m), for 10 m width
- The ground floor top load cell (Figure 2.1) covered the vertical range: 7.16 m AHD to 8.66 m AHD (1.5 m), for 10 m width
- The upper floor bottom load cell (Figure 2.2) covered the vertical range: 8.66 m AHD to 10.16 m AHD (1.5 m), for 10 m width
- The upper floor top load cell (Figure 2.2) covered the vertical range: 10.16 m AHD to 11.66 m AHD (1.5 m), for 10 m width

- The SLSC building was represented as a fixed wall (4.0 m promenade width – the minimum width) up to the eaves (12.1 m AHD), leaving a 2.5 m (100 mm model scale) gap at the flume sides for drainage

2.2 Upper floor window geometry

Two upper floor windows were modelled (Figure 2.2). The following geometry was adopted in the model:

- Window sill level: 9.79 m AHD
- Window width: 880 mm
- Window height: 2020 mm
- Window head level (assumed semi-circular): 11.81 m AHD
- Window area approximately 1.7 m^2 per window

Figure 2.1 Ground floor top and ground floor bottom load cell panels

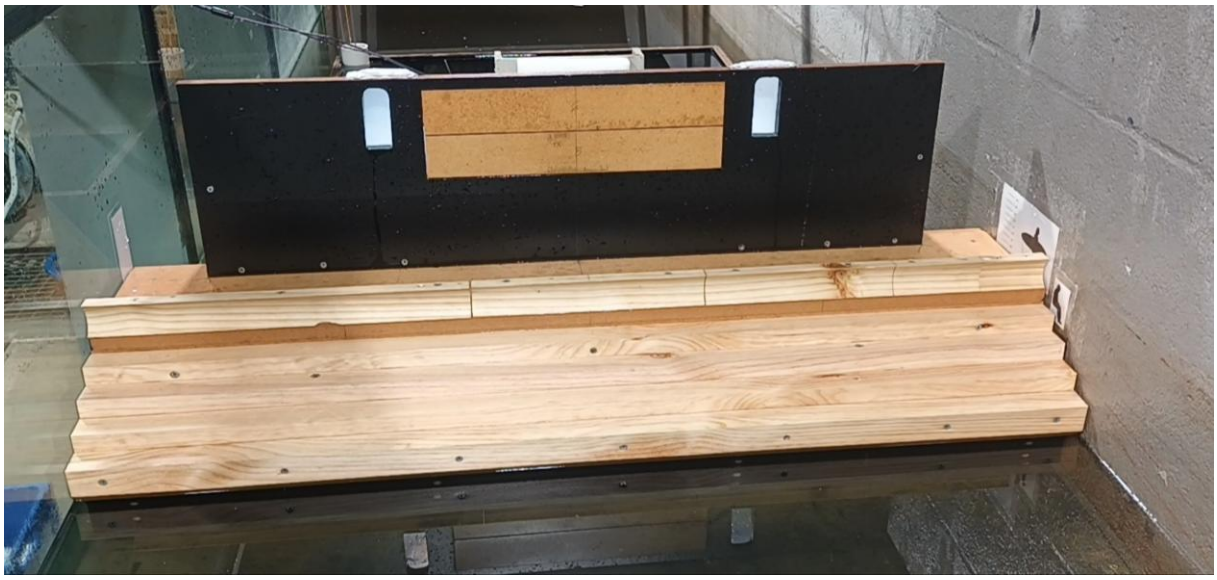


Figure 2.2 Upper floor top and upper floor bottom load cell panels and two window openings

3. Contributions to pressure

The following factors and comments contribute to wave/water pressure measured on the load cells:

- The hydrostatic pressure from ponded water
- The dynamic pressure from velocity (velocity head)
- Highly aerated water and splash will not exert as much pressure as “green water”
- The load cells average all three of the above, with the individual contributions of each component not known
- While the testing is 2D, for large individual wave overtopping events, short duration tendrils of water were observed to strike the upper floor wall
- The load cells sample at a rate of 1000 Hz model, 200 Hz prototype
- Individual readings could therefore be as short as 0.005 second
- Advice from an expert structural engineer was to present the force/pressure data using a 2 second moving average filter, as this is a more accurate representation of the response time for the structure (versus short duration spikes of less than 0.1 second)

4. Tests undertaken

Tests undertaken for the measurement of forces/pressures are shown in Table 4.1.

Figures and test permutations for the existing building (fronted by a wave return parapet) are shown in Table 5.1. A common Y axis was used for all plots to facilitate comparison between tests and various analyses.

Figures and test permutations for the new building (without a wave return parapet) are shown in Table 6.1.

Tests were generally undertaken with the following design conditions and an eroded beach condition:

- 100 year ARI 2024
- 100 year ARI 2084 (0.53 m sea level rise)
- 1000 year ARI 2024
- 1000 year ARI 2084 (0.53 m sea level rise)

Note that the short duration Pmax and the 2 second average Pmax may be associated with different individual waves, with the individual Pmax event and associated 1 s and 2 s average events shown in the figures below.

Table 4.1 Force test summary

ARI (years)	Year	SLR (m)	Existing building	New building	Parapet	Ground floor	Upper floor
Existing							
100	2024	0	✓		✓	✓	✓
100	2084	0.53	✓		✓	✓	✓
1000	2024	0	✓		✓	✓	✓
1000	2084	0.53	✓		✓	✓	✓
New							
100	2024	0		✓		✓	
100	2084	0.53		✓		✓	
1000	2024	0		✓		✓	
1000	2084	0.53		✓		✓	
Parapet							
100	2024	0			✓		
100	2084	0.53			✓		
1000	2024	0			✓		
1000	2084	0.53			✓		

5. Existing building force/pressure tests

The figures for each force/pressure test on the existing SLSC building (with a wave return parapet) are listed in Table 5.1. A common Y axis was used for all plots to facilitate comparison between tests and various analyses.

Table 5.1 Figure numbers for force tests on existing SLSC building – with wave return parapet

ARI (years)	Year	SLR (m)	ID	Panel	Entire time series	Pmax event*	2 second average time series	2 second average Pmax*
100	2024	0	0090	GF bottom	5.1	5.1	5.1	5.1
			0090	GF top	5.2	5.2	5.2	5.2
			0100	UF bottom	5.3	5.3	5.3	5.3
			0100	UF top	5.4	5.4	5.4	5.4
100	2084	0.53	0089	GF bottom	5.5	5.5	5.5	5.5
			0089	GF top	5.6	5.6	5.6	5.6
			0103	UF bottom	5.7	5.7	5.7	5.7
			0103	UF top	5.8	5.8	5.8	5.8
1000	2024	0	0093	GF bottom	5.9	5.9	5.9	5.9
			0093	GF top	5.10	5.10	5.10	5.10
			0101	UF bottom	5.11	5.11	5.11	5.11
			0101	UF top	5.12	5.12	5.12	5.12
1000	2084	0.53	0086	GF bottom	5.13	5.13	5.13	5.13
			0086	GF top	5.14	5.14	5.14	5.14
			0104	UF bottom	5.15	5.15	5.15	5.15
			0104	UF top	5.16	5.16	5.16	5.16

* Note that the short duration Pmax and the 2 second average Pmax may be associated with different individual waves, but the figure shown in for the short duration Pmax

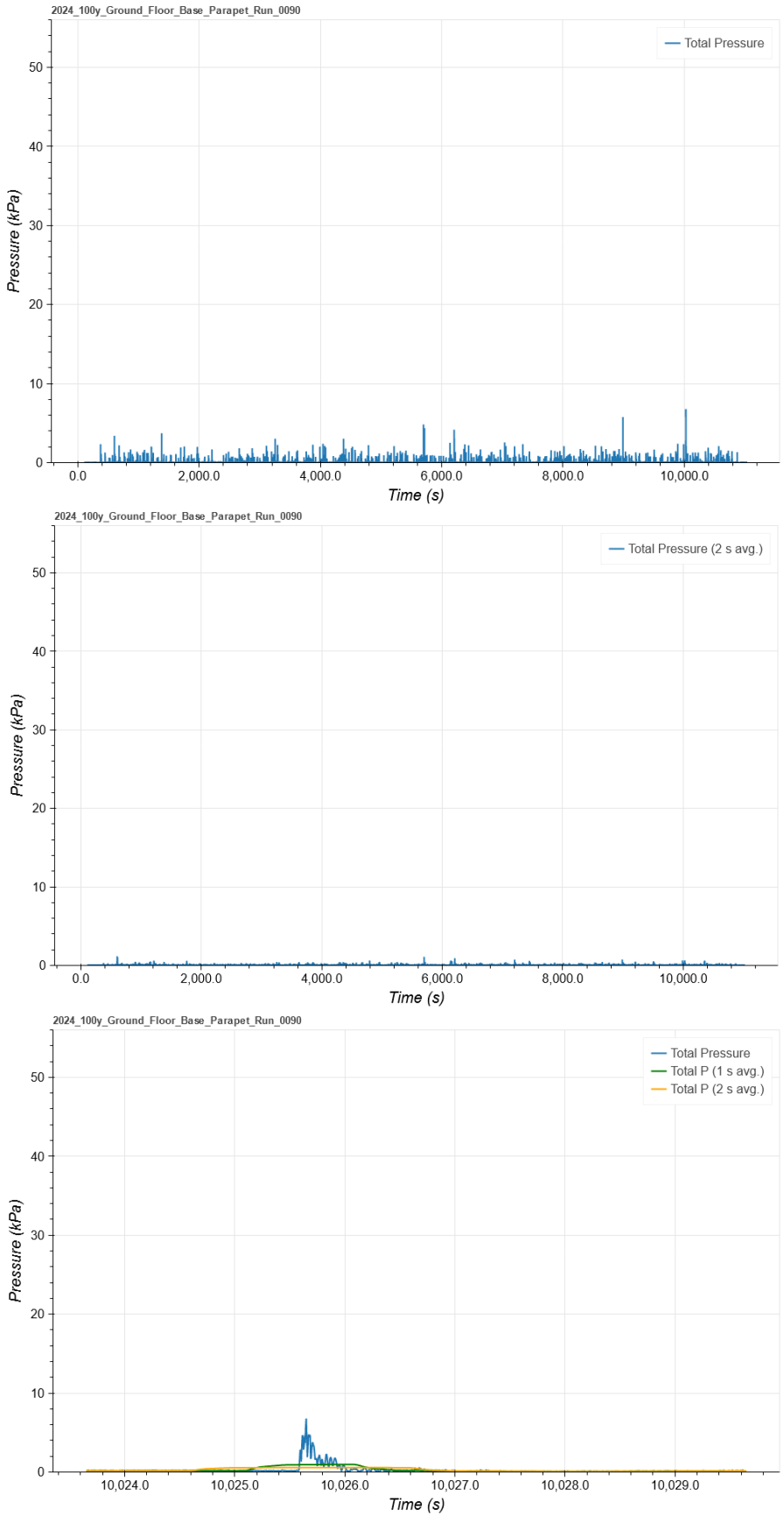


Figure 5.1 Existing building with parapet, 100 year ARI, 2024, ground floor bottom

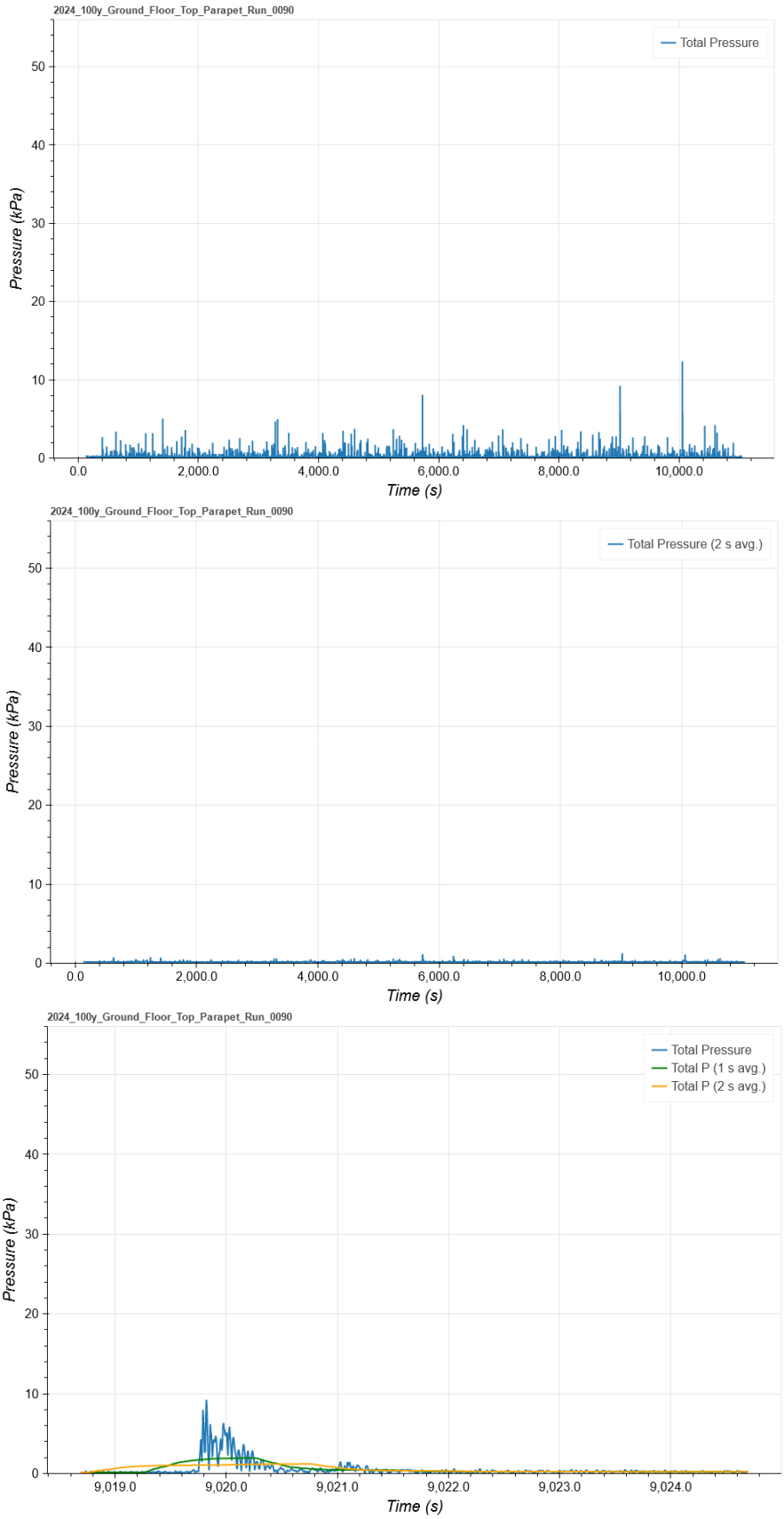


Figure 5.2 Existing building with parapet, 100 year ARI, 2024, ground floor top

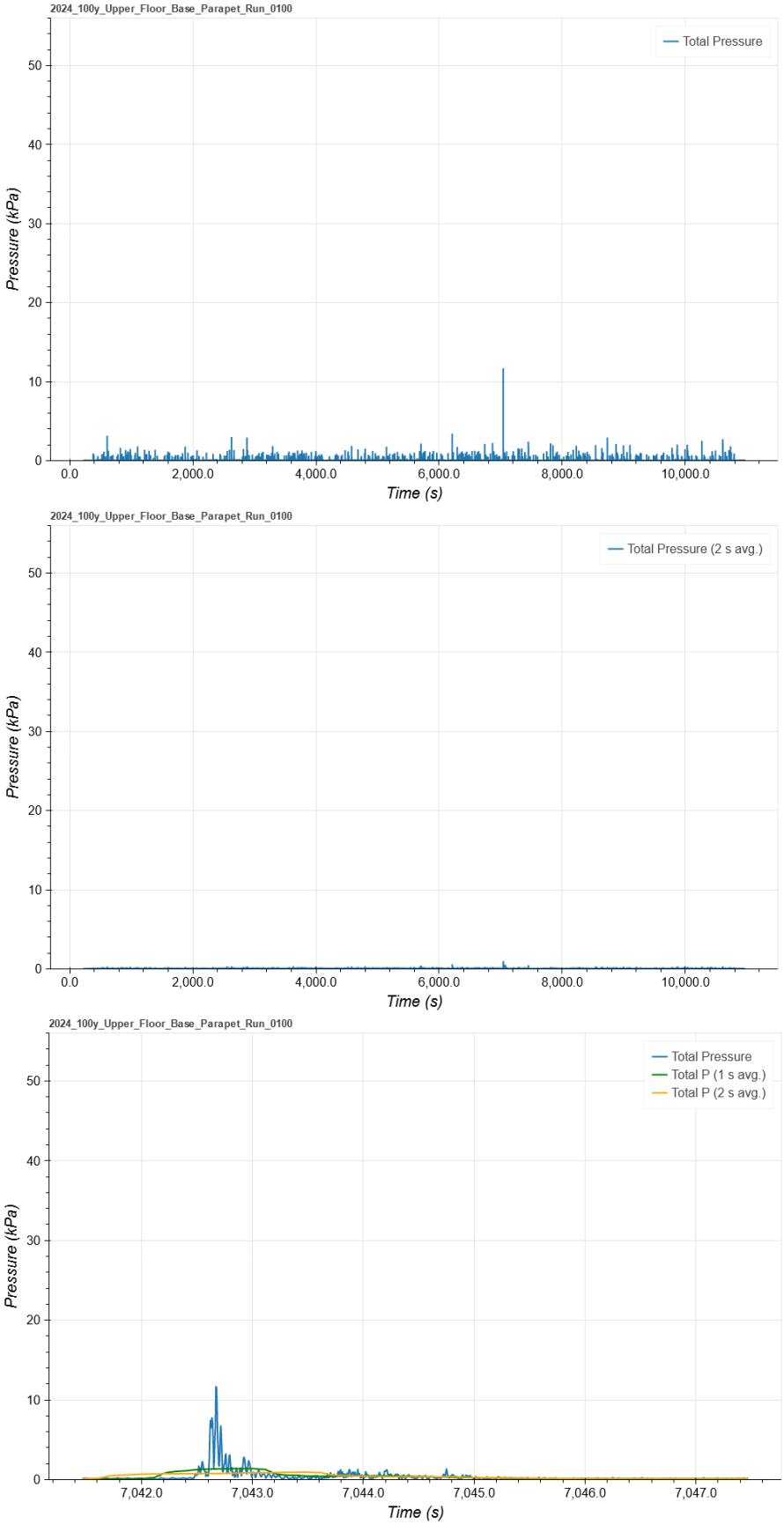


Figure 5.3 Existing building with parapet, 100 year ARI, 2024, upper floor bottom

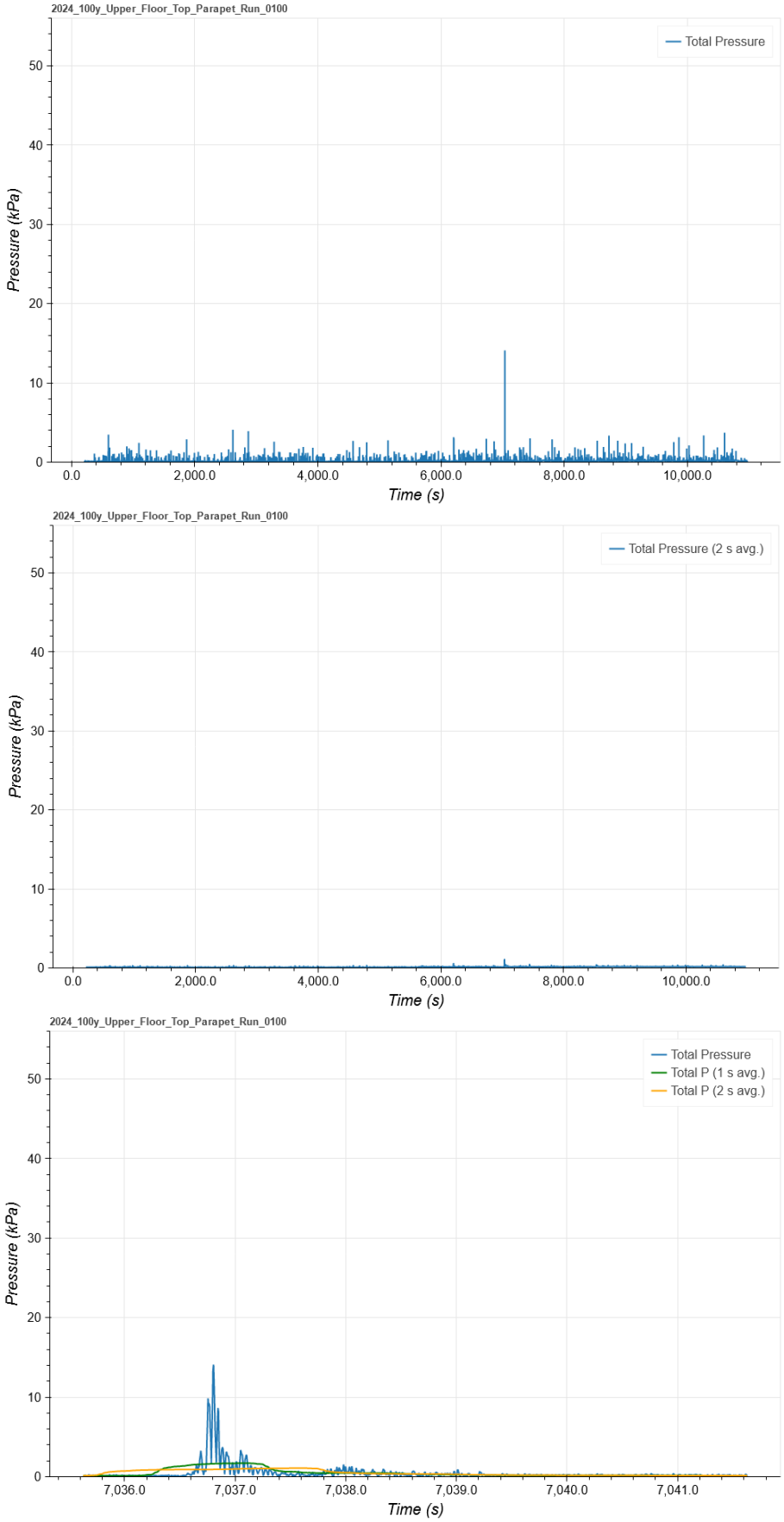


Figure 5.4 Existing building with parapet, 100 year ARI, 2024, upper floor top

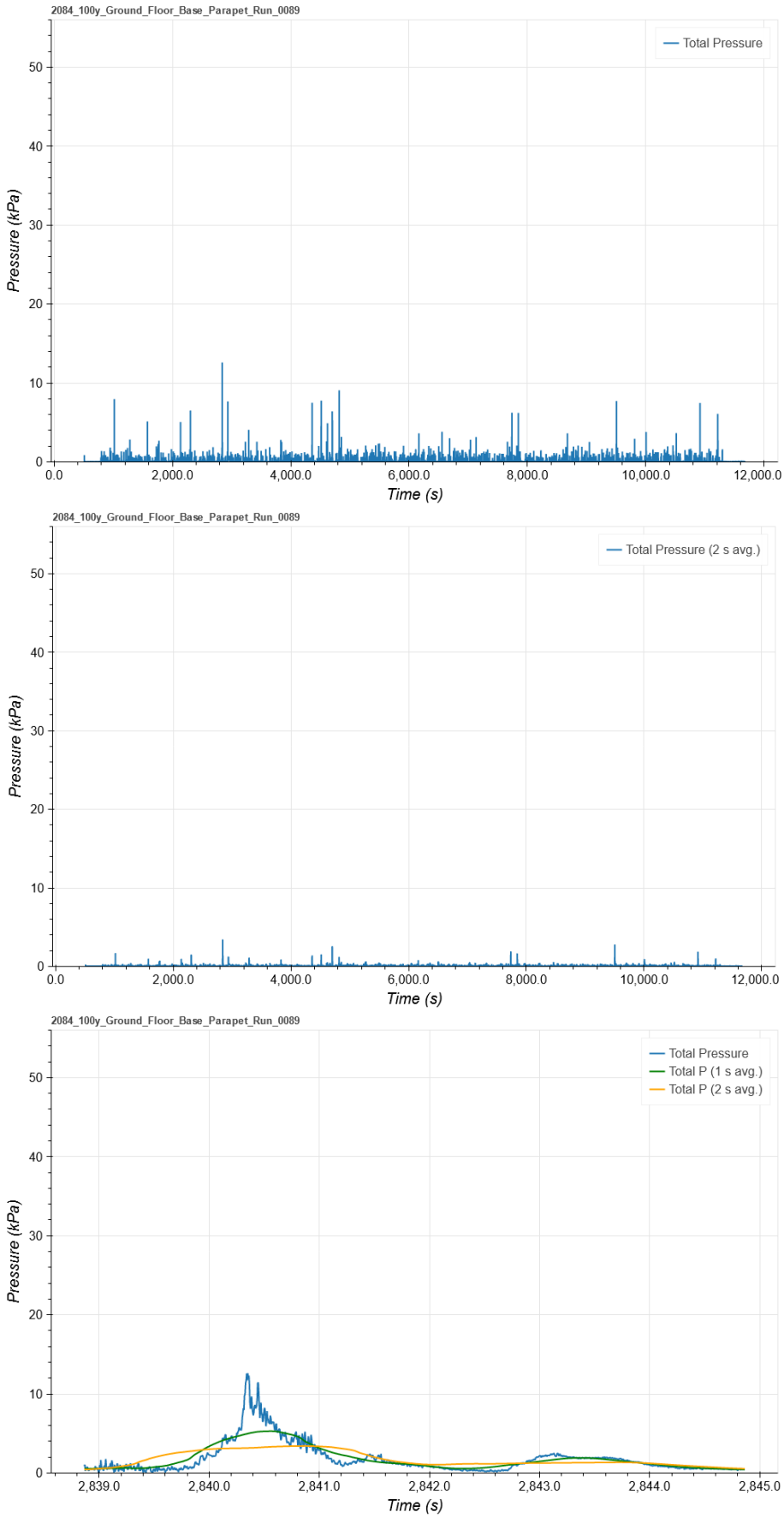


Figure 5.5 Existing building with parapet, 100 year ARI, 2084, ground floor bottom

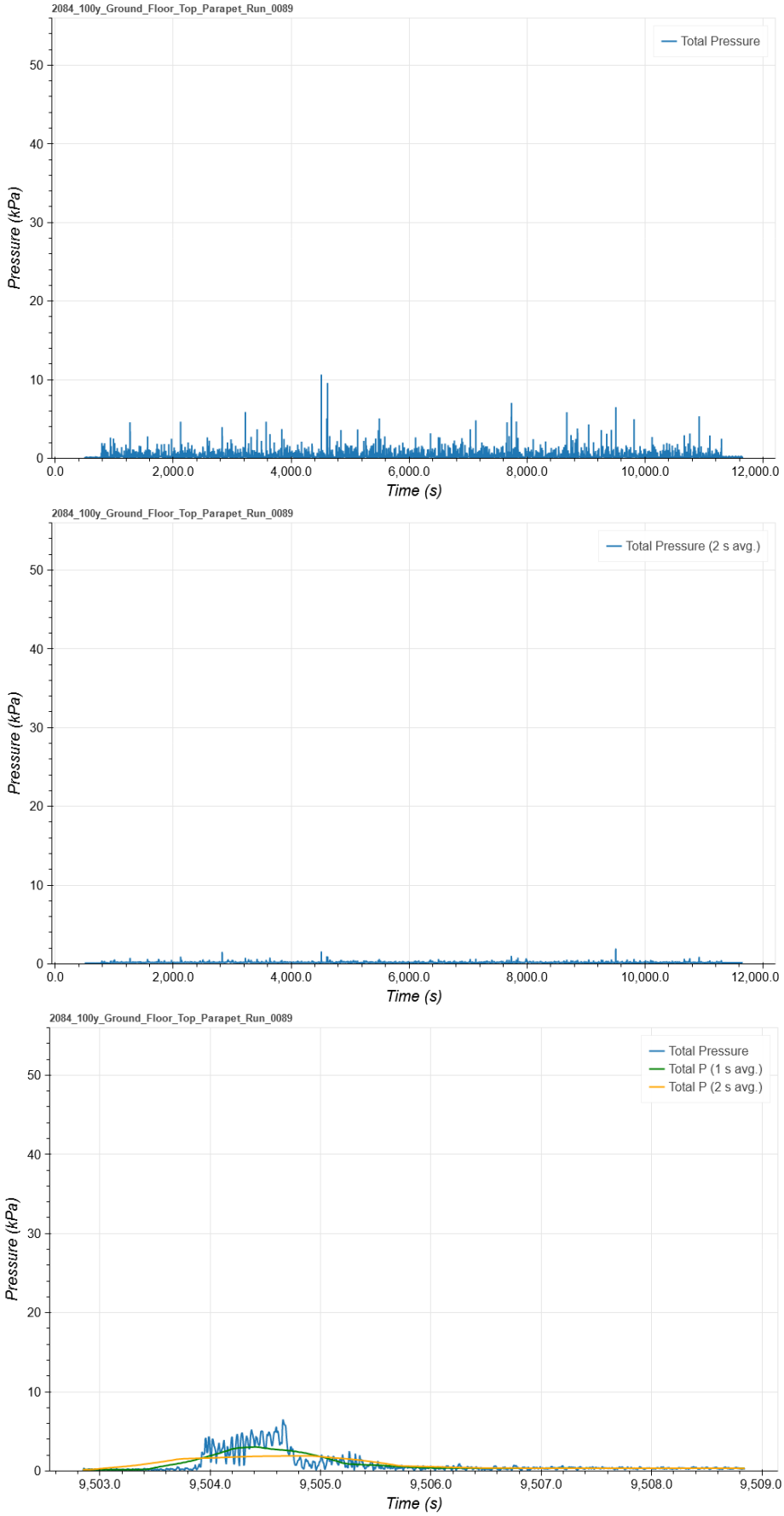


Figure 5.6 Existing building with parapet, 100 year ARI, 2084, ground floor top

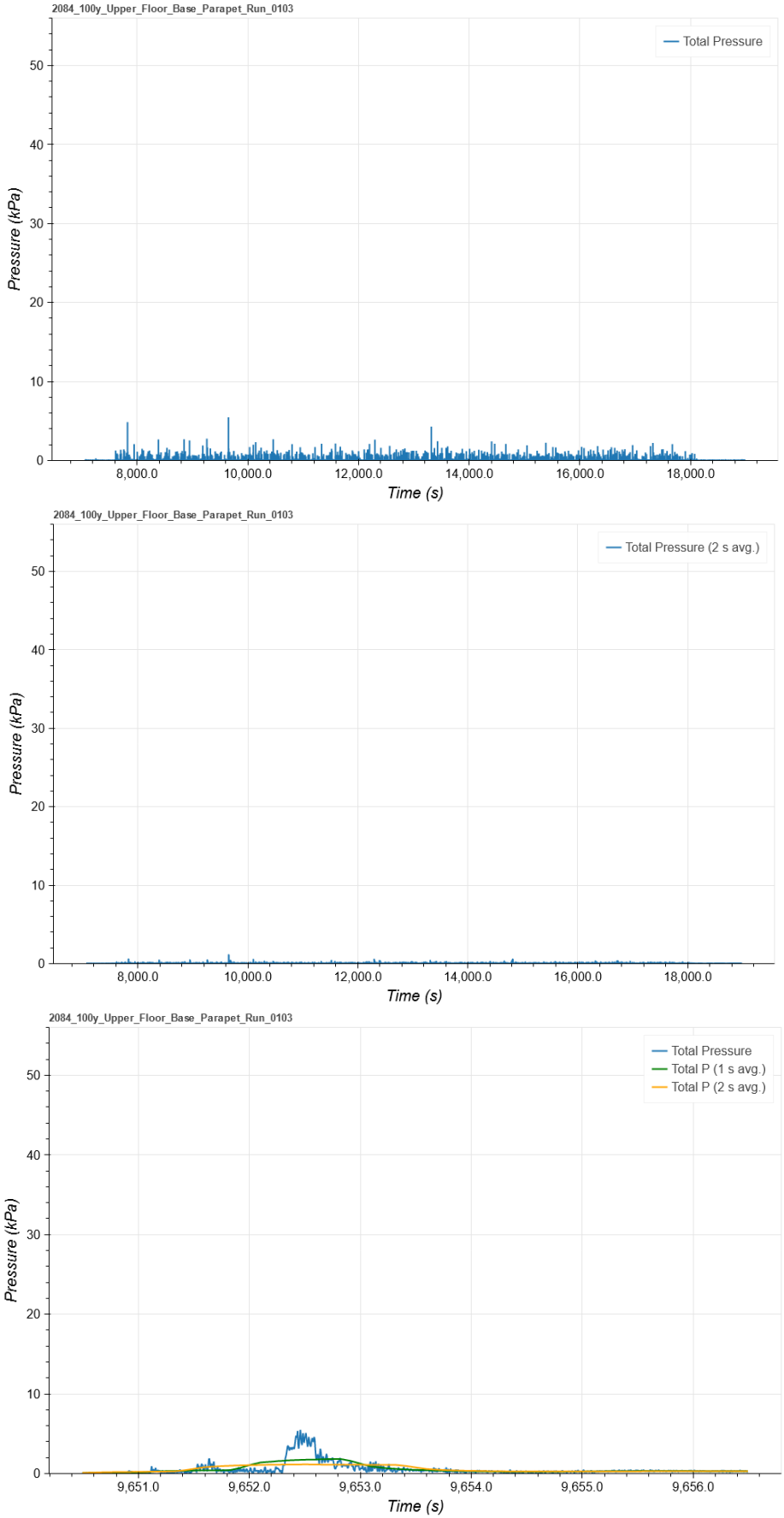


Figure 5.7 Existing building with parapet, 100 year ARI, 2084, upper floor bottom

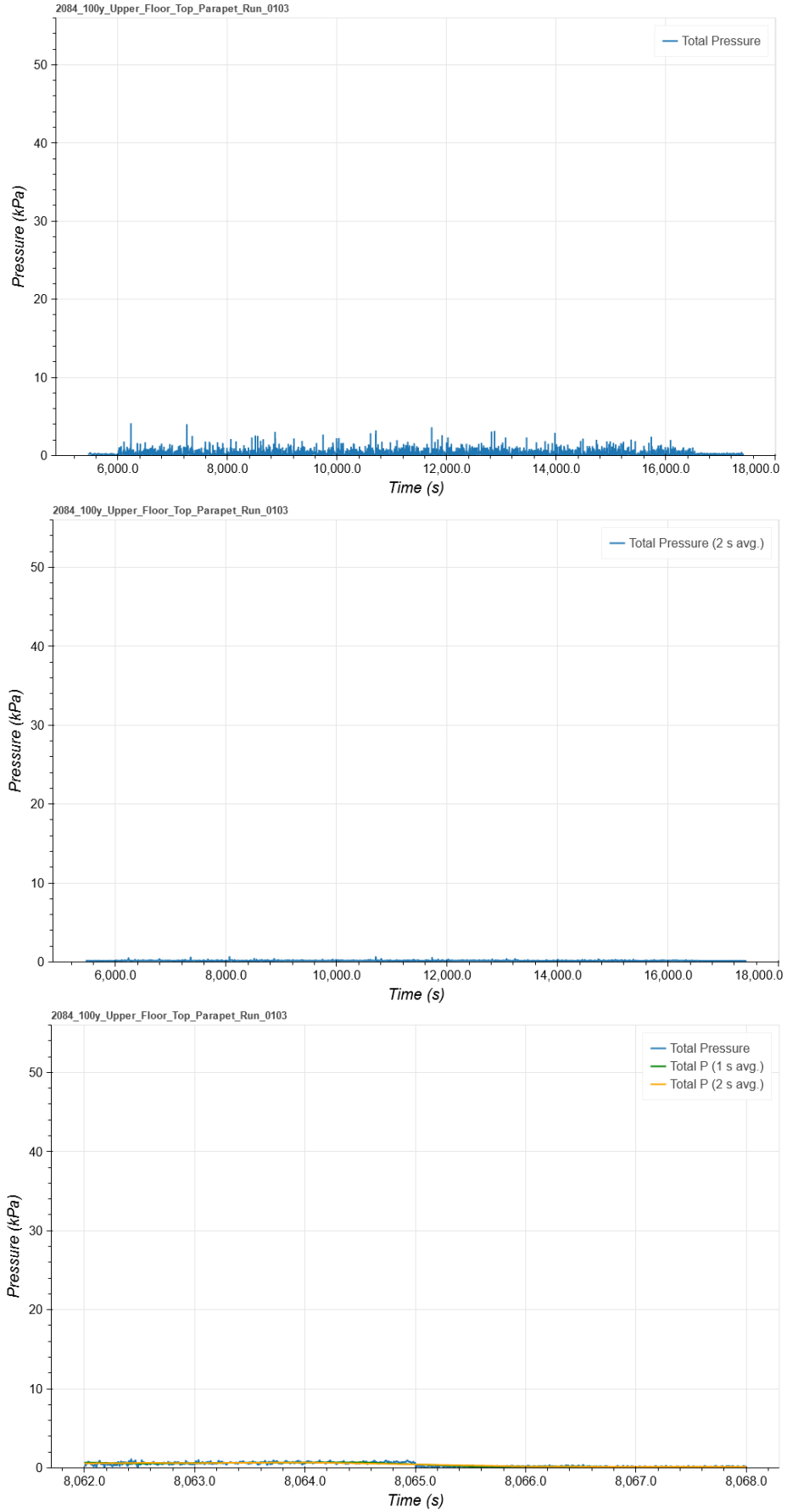


Figure 5.8 Existing building with parapet, 100 year ARI, 2084, upper floor top

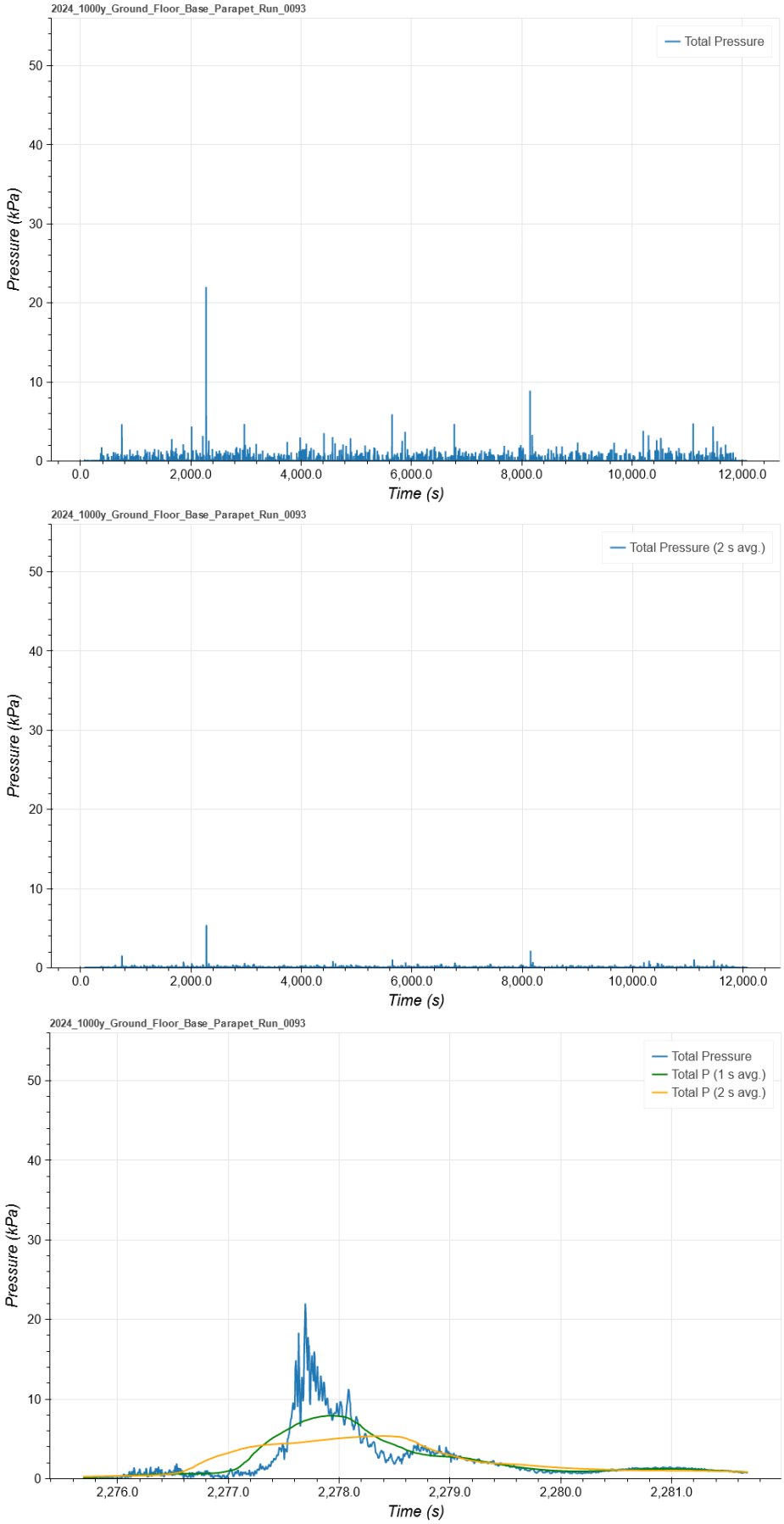


Figure 5.9 Existing building with parapet, 1000 year ARI, 2024, ground floor bottom

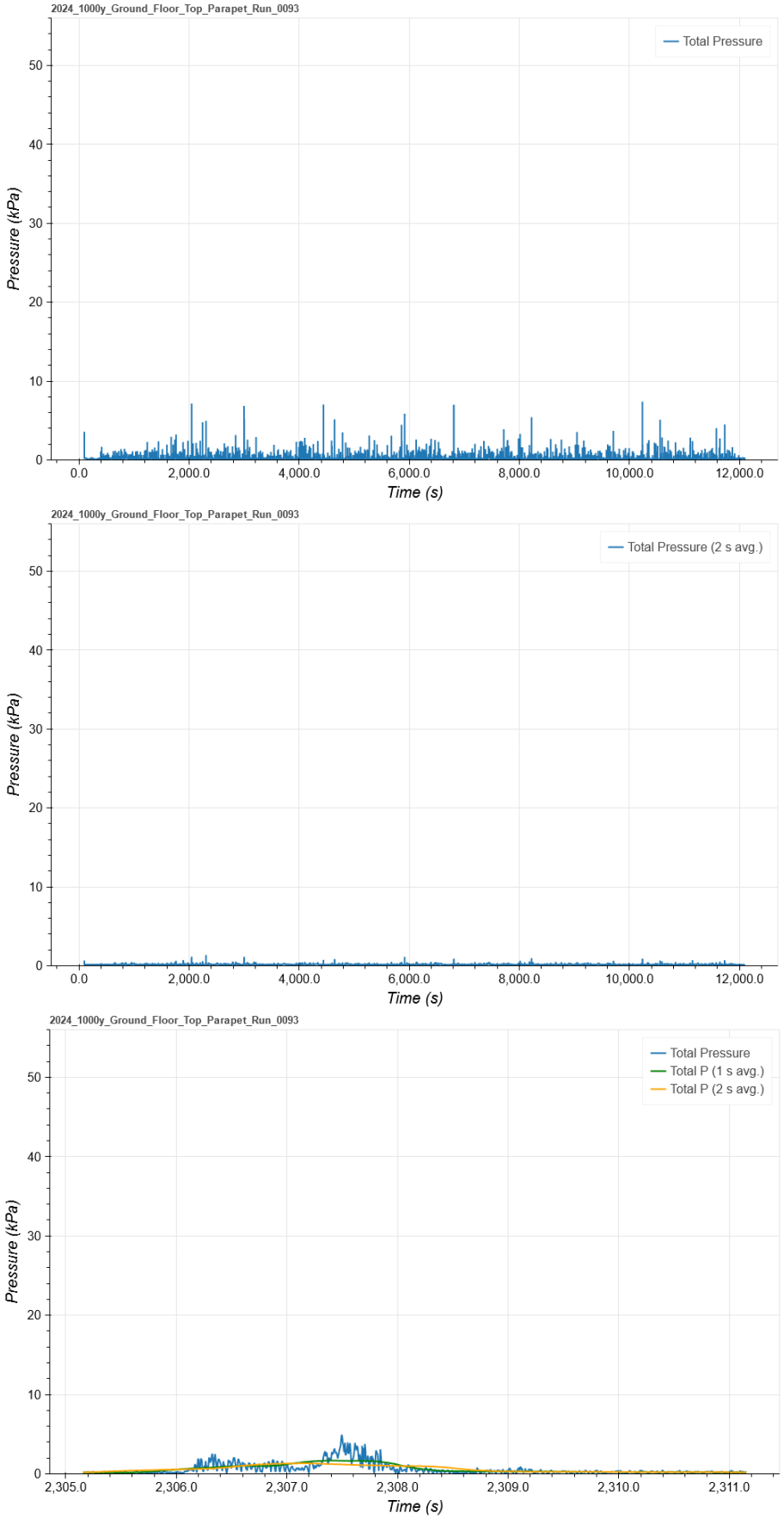


Figure 5.10 Existing building with parapet, 1000 year ARI, 2024, ground floor top

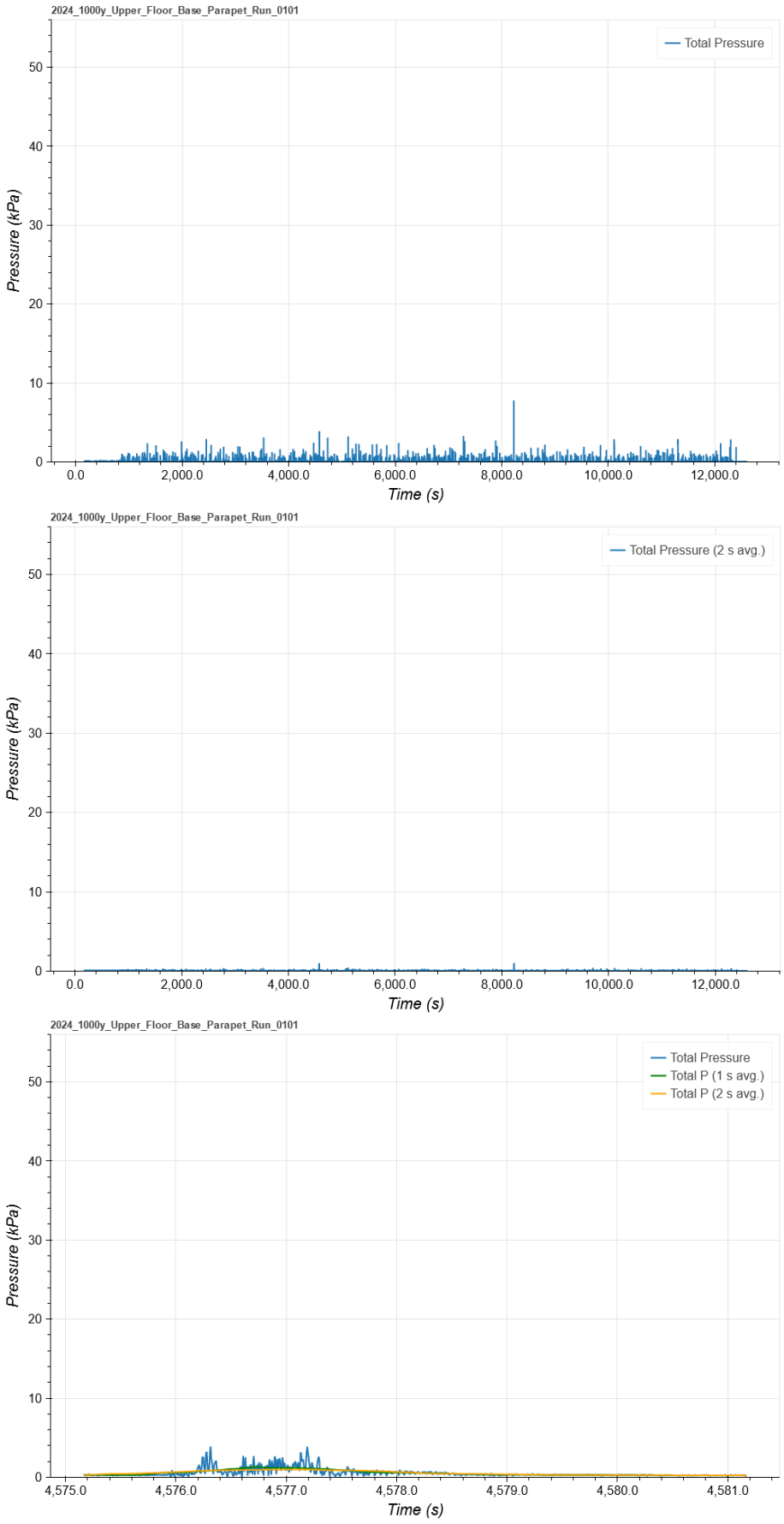


Figure 5.11 Existing building with parapet, 1000 year ARI, 2024, upper floor bottom

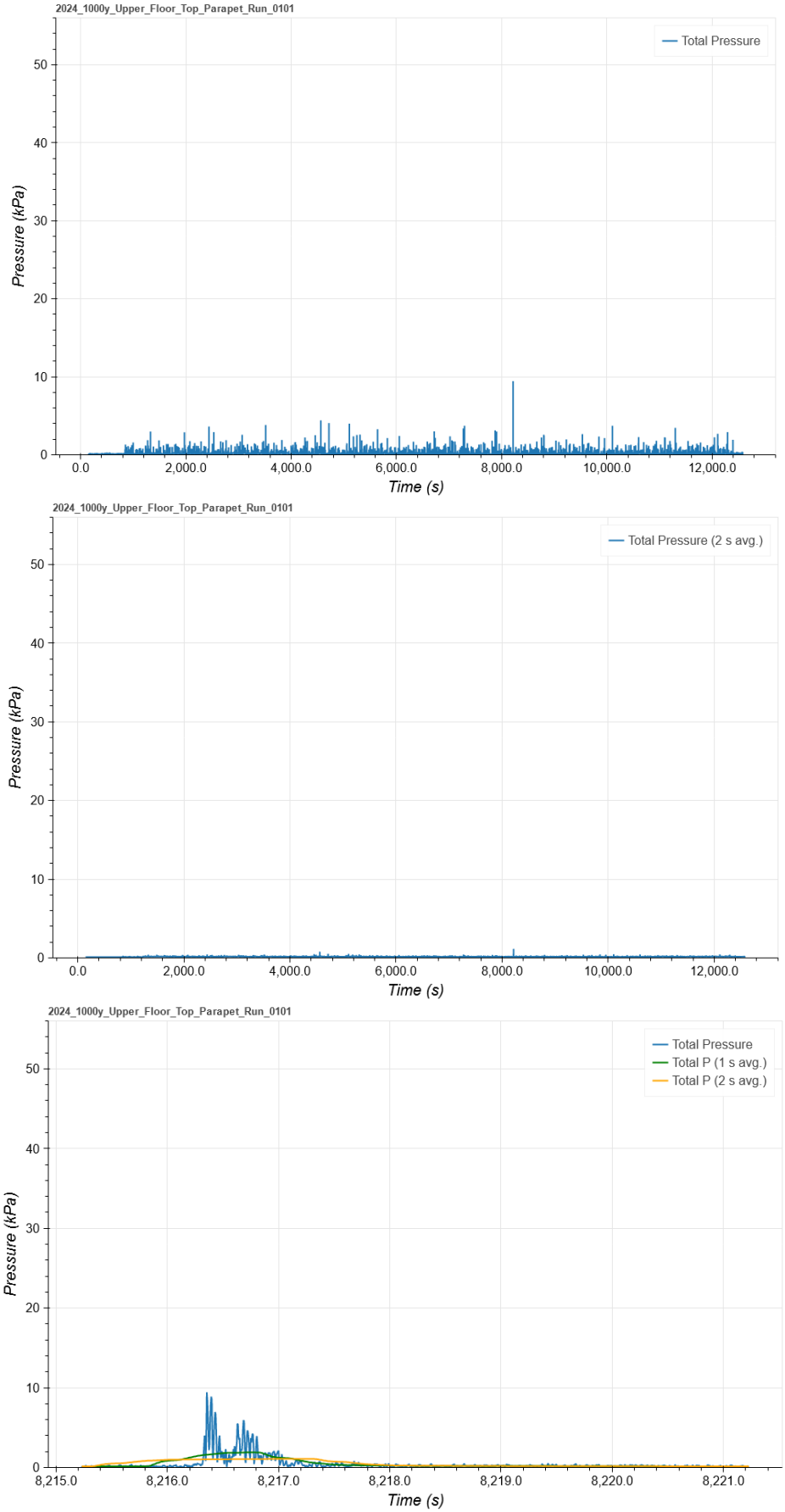


Figure 5.12 Existing building with parapet, 1000 year ARI, 2024, upper floor top

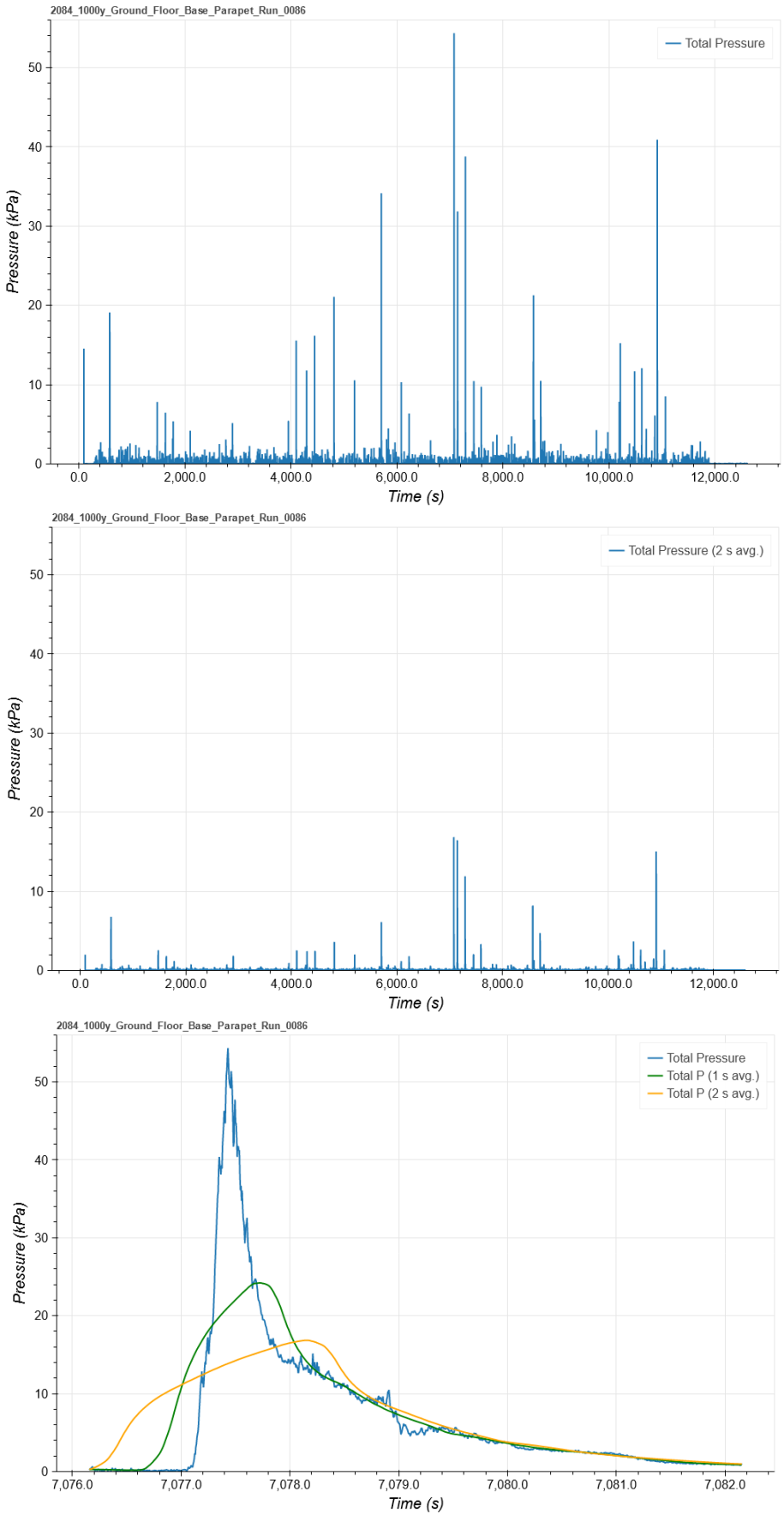


Figure 5.13 Existing building with parapet, 1000 year ARI, 2084, ground floor bottom

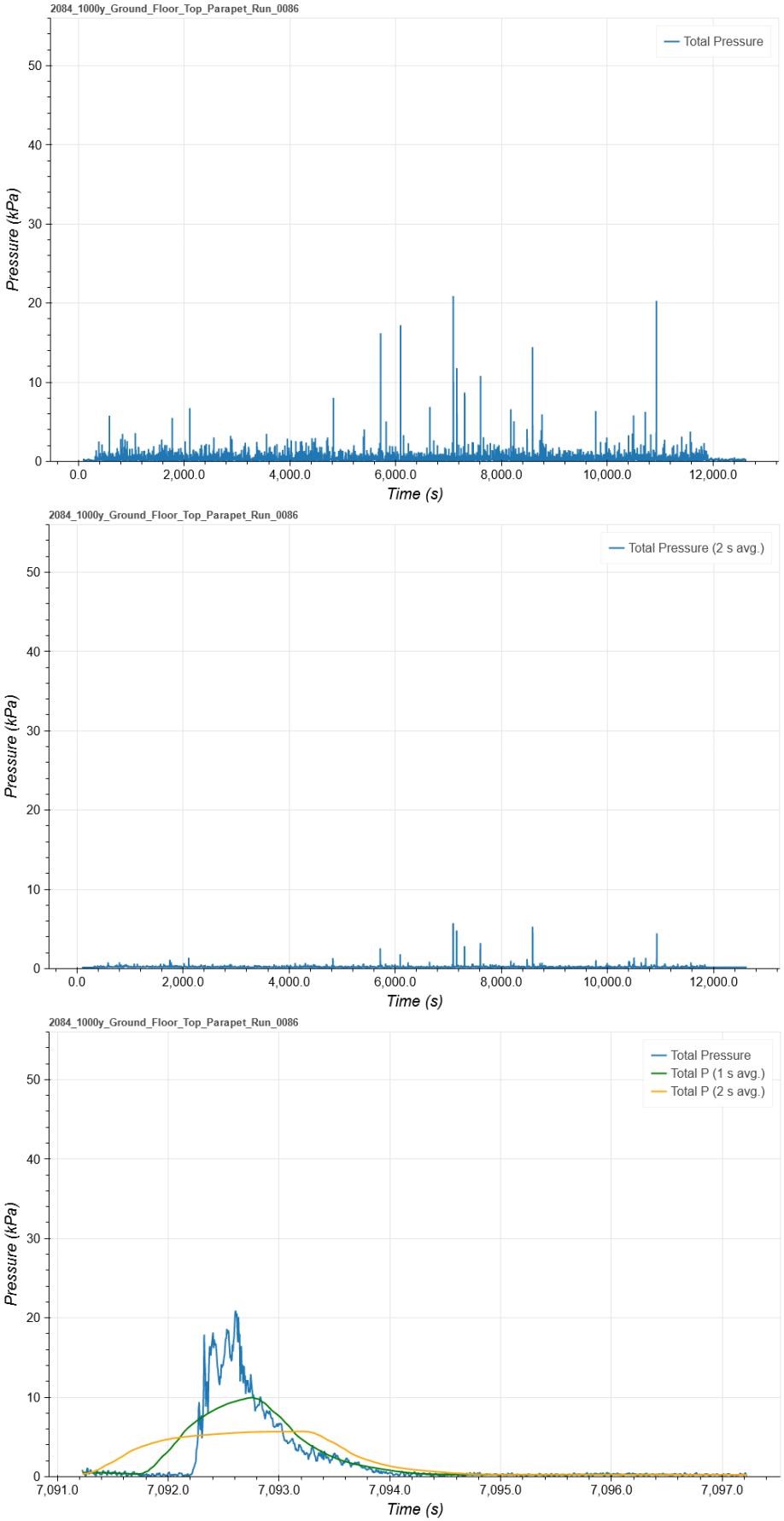


Figure 5.14 Existing building with parapet, 1000 year ARI, 2084, ground floor top

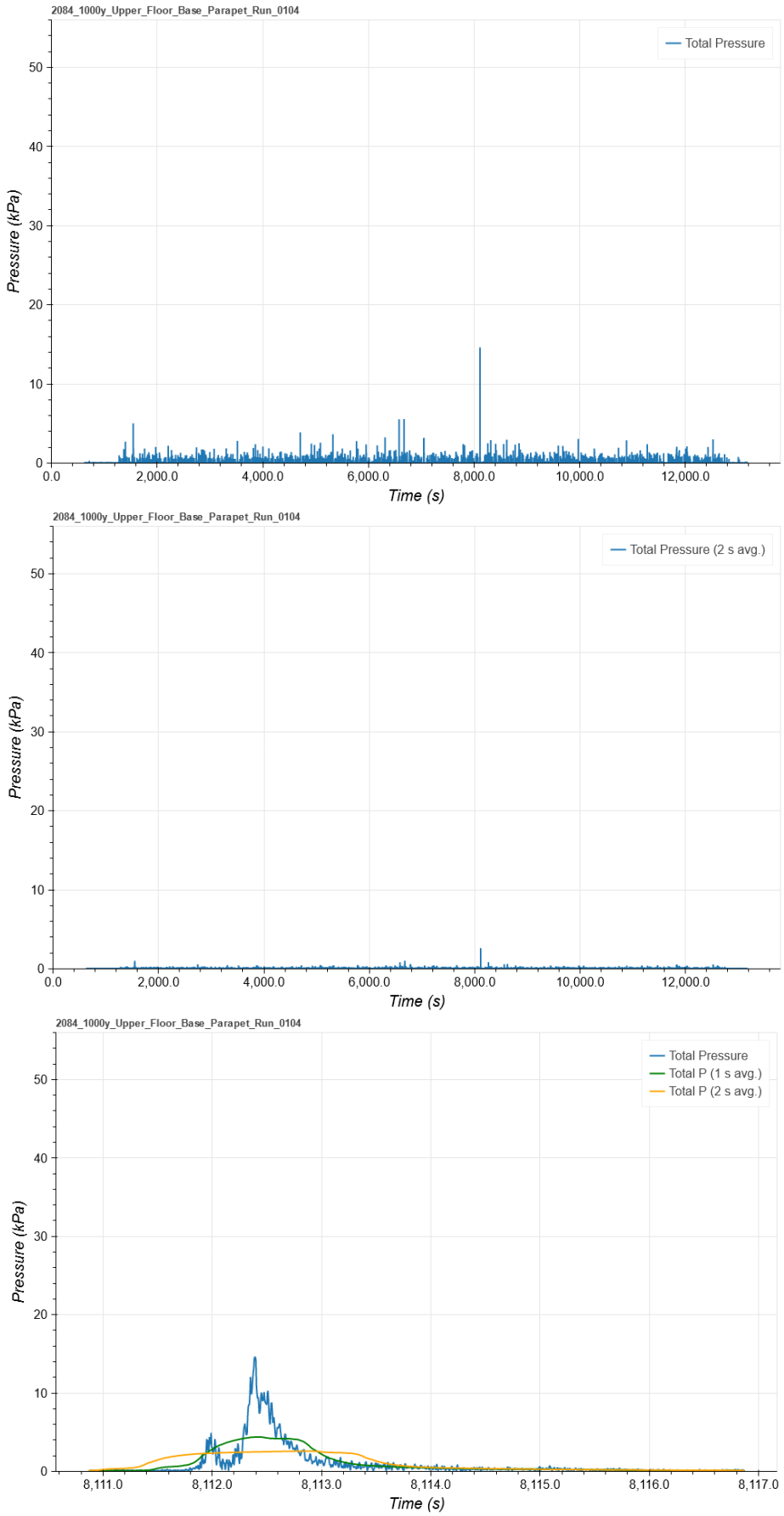


Figure 5.15 Existing building with parapet, 1000 year ARI, 2084, upper floor bottom

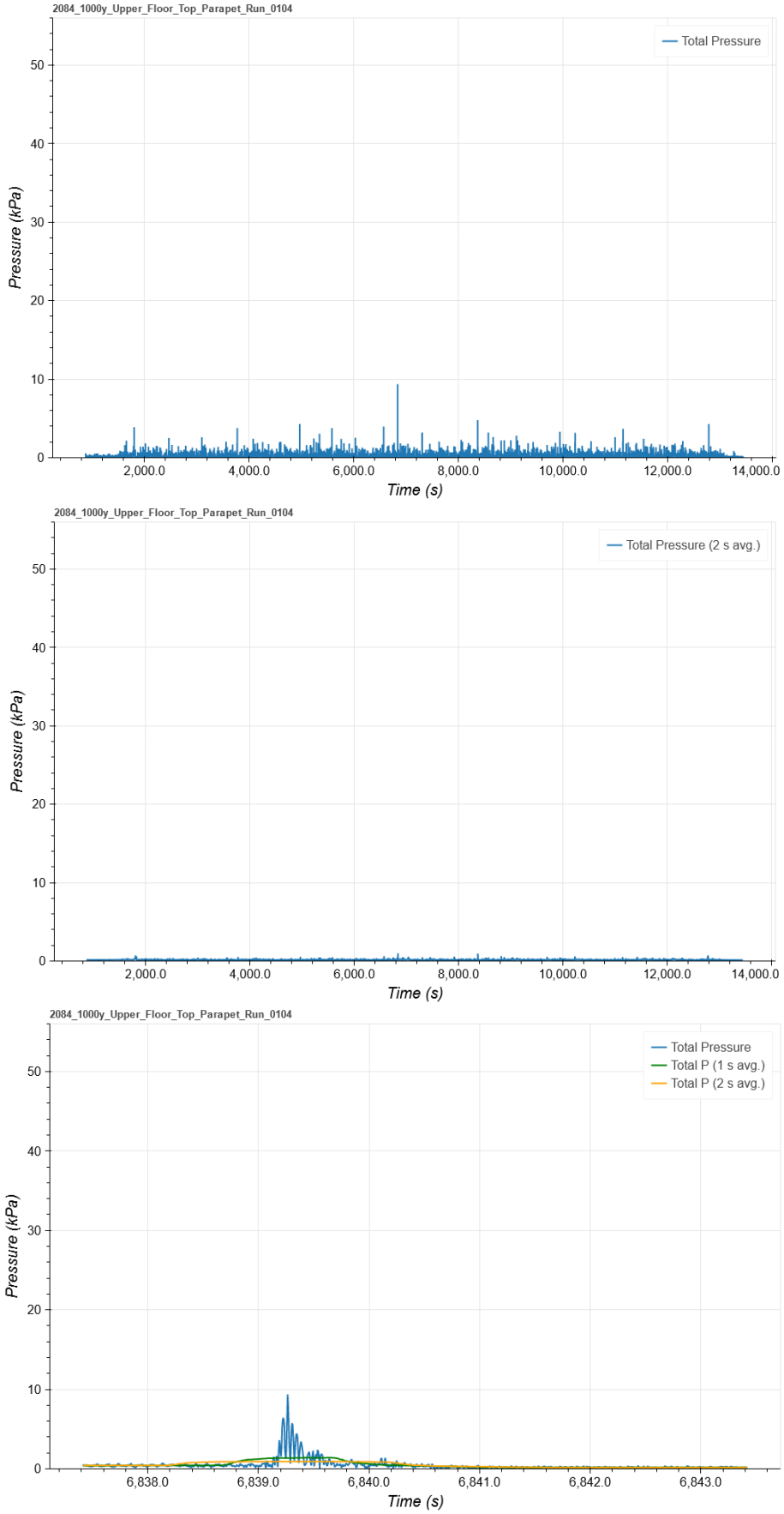


Figure 5.16 Existing building with parapet, 1000 year ARI, 2084, upper floor top

6. New building force/pressure tests

The figures for each force/pressure test on the new SLSC building (without a wave return parapet) are listed in Table 6.1. A common Y axis was used for all plots to facilitate comparison between tests and various analyses.

Table 6.1 Figures for force tests on new SLSC building – without wave return parapet

ARI (years)	Year	SLR (m)	ID	Panel	Entire time series	Pmax event	2 second average time series	2 second average Pmax
100	2024	0	0091	GF bottom	6.1	6.1	6.1	6.1
			0091	GF top	6.2	6.2	6.2	6.2
100	2084	0.53	0088	GF bottom	6.3	6.3	6.3	6.3
			0088	GF top	6.4	6.4	6.4	6.4
1000	2024	0	0092	GF bottom	6.5	6.5	6.5	6.5
			0092	GF top	6.6	6.6	6.6	6.6
1000	2084	0.53	0087	GF bottom	6.7	6.7	6.7	6.7
			0087	GF top	6.8	6.8	6.8	6.8

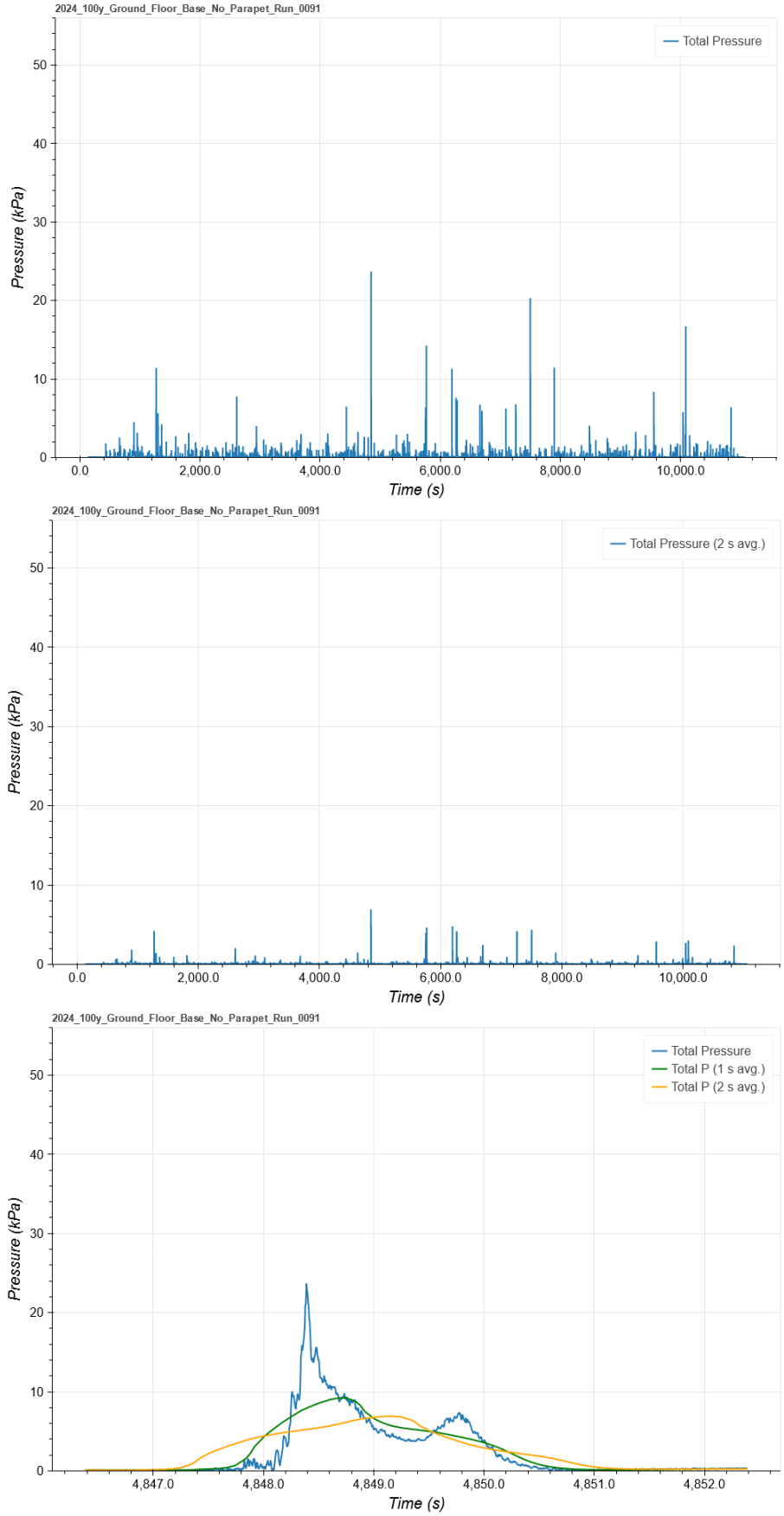


Figure 6.1 New building without parapet, 100 year ARI, 2024, lower floor bottom

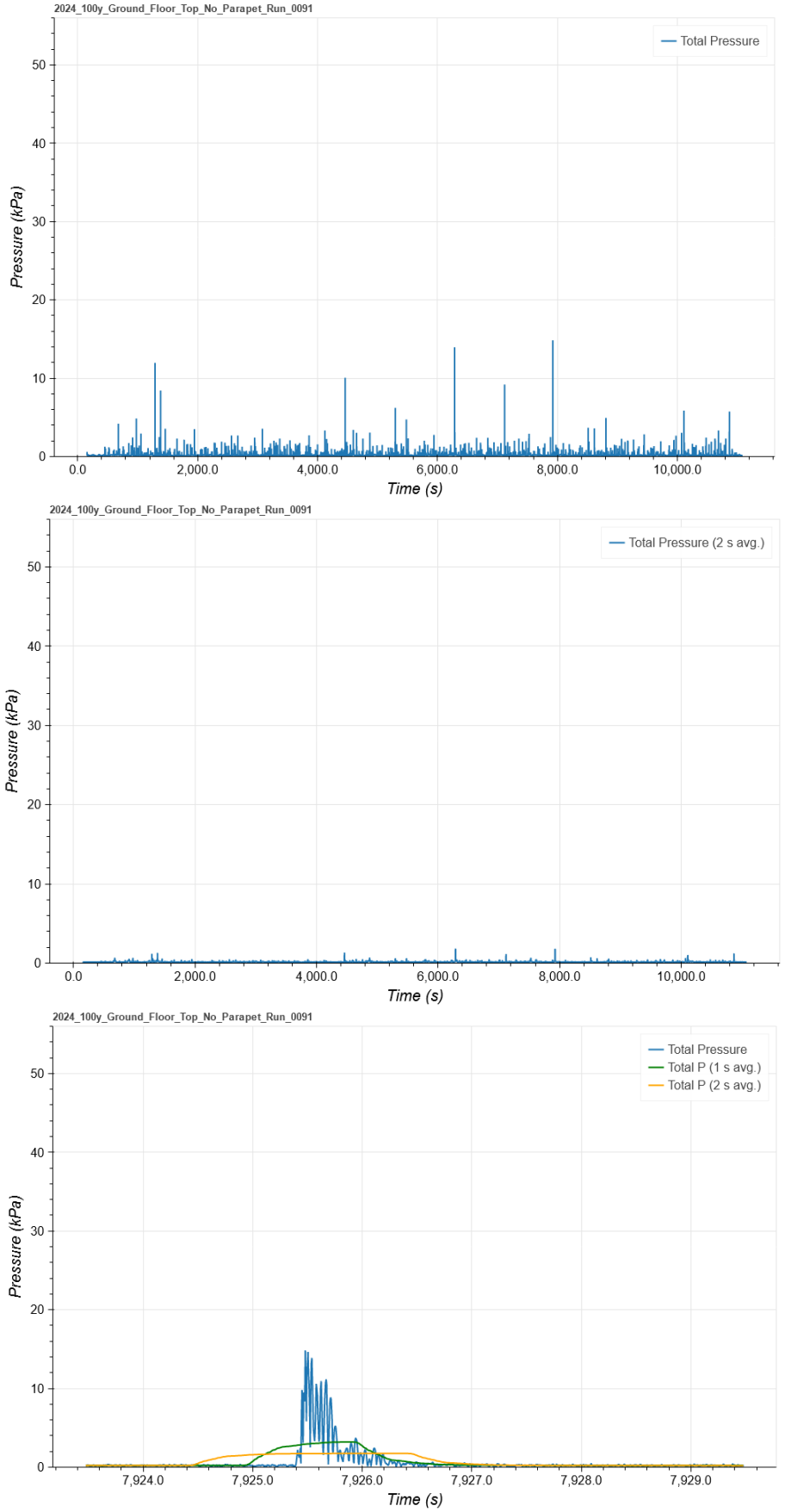


Figure 6.2 New building without parapet, 100 year ARI, 2024, lower floor top

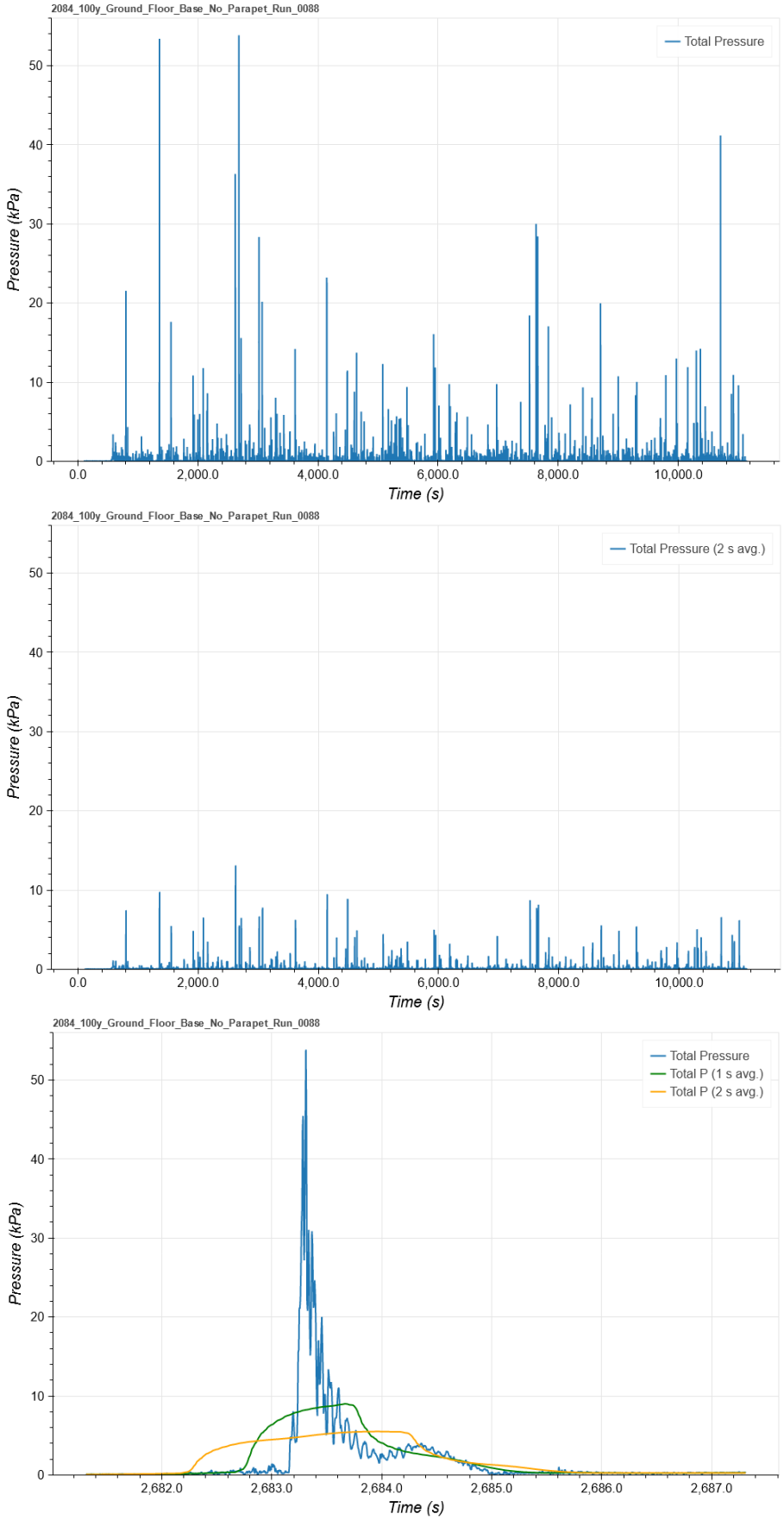


Figure 6.3 New building without parapet, 100 year ARI, 2084, lower floor bottom

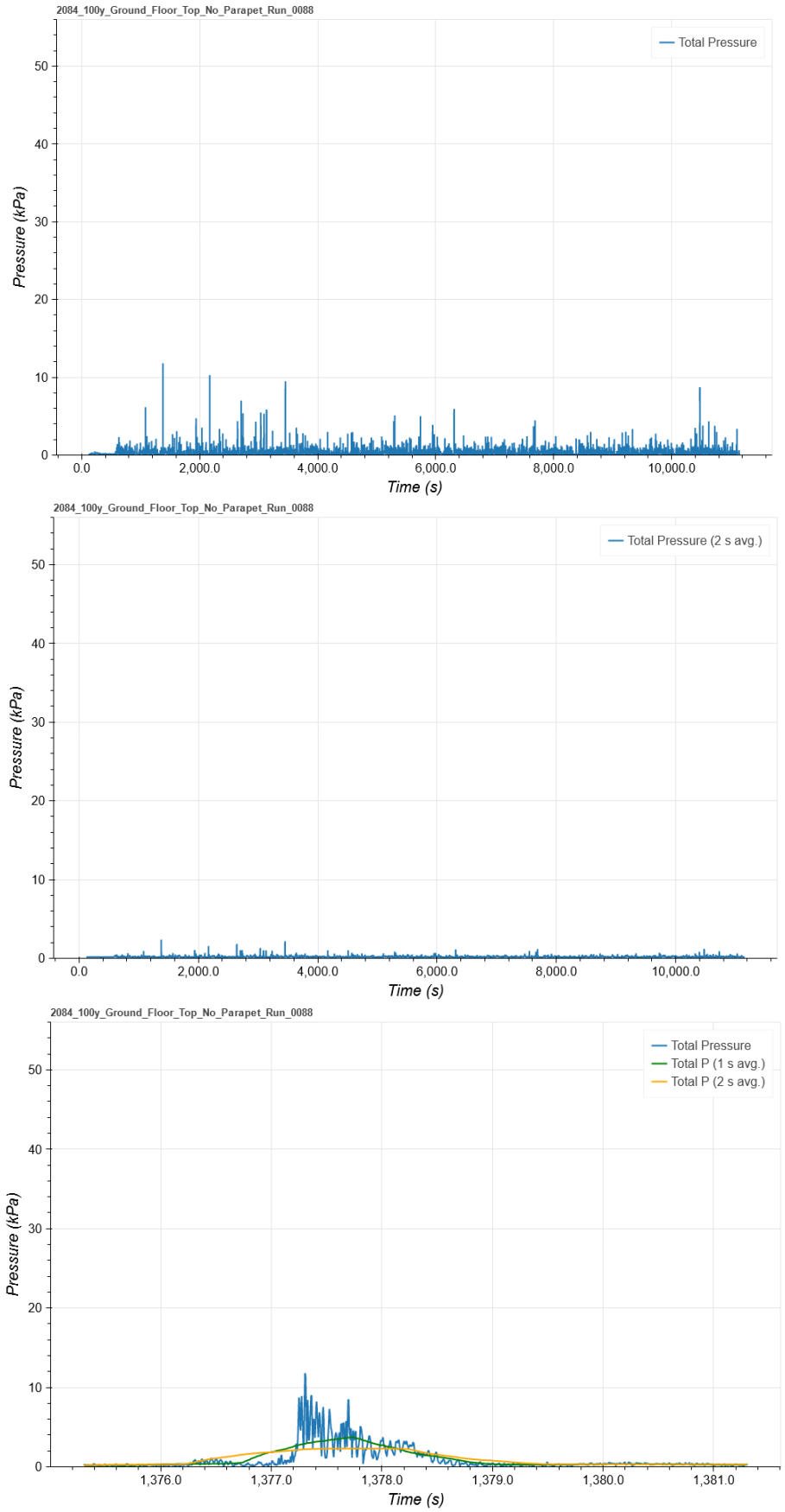


Figure 6.4 New building without parapet, 100 year ARI, 2084, lower floor top

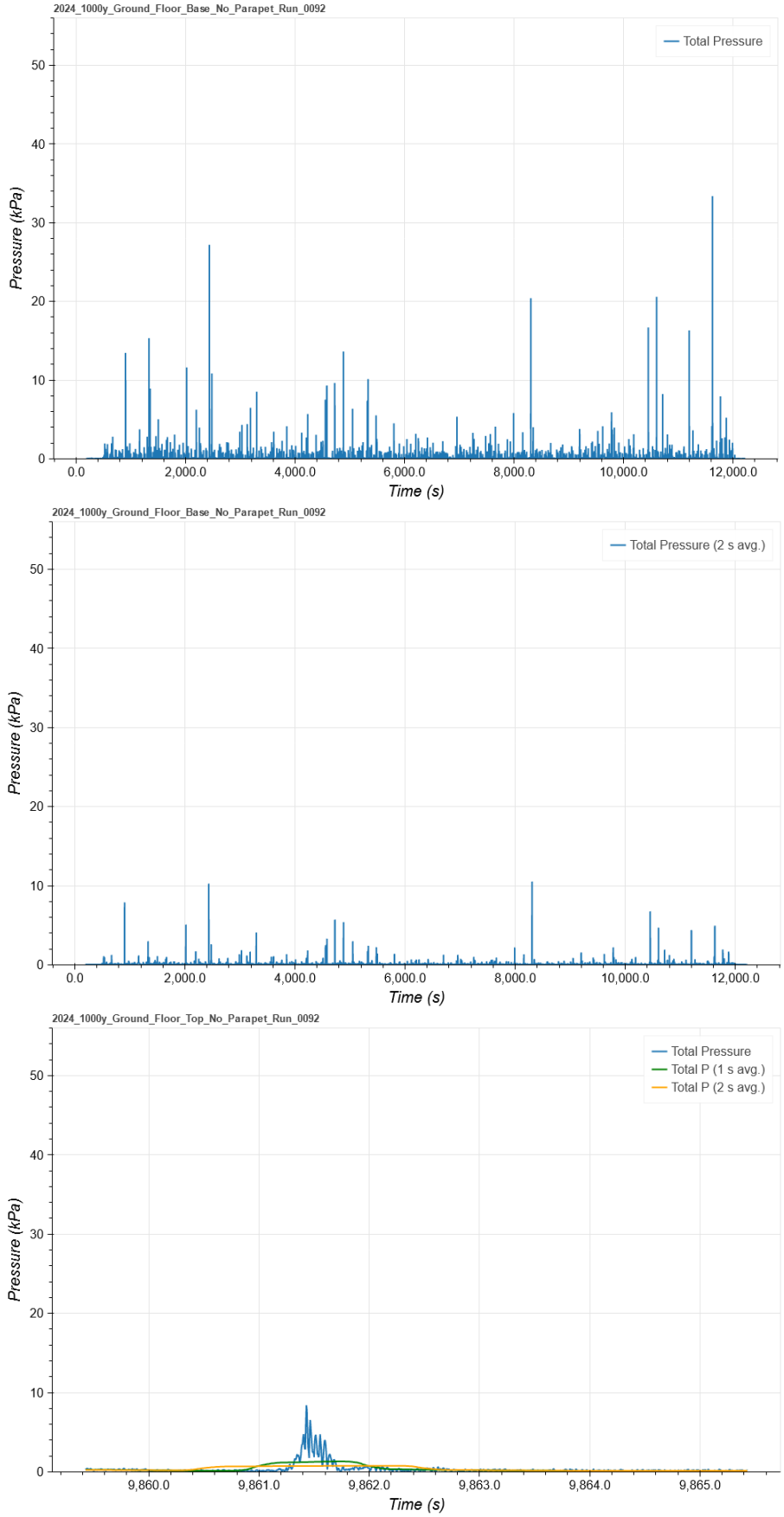


Figure 6.5 New building without parapet, 1000 year ARI, 2024, lower floor bottom

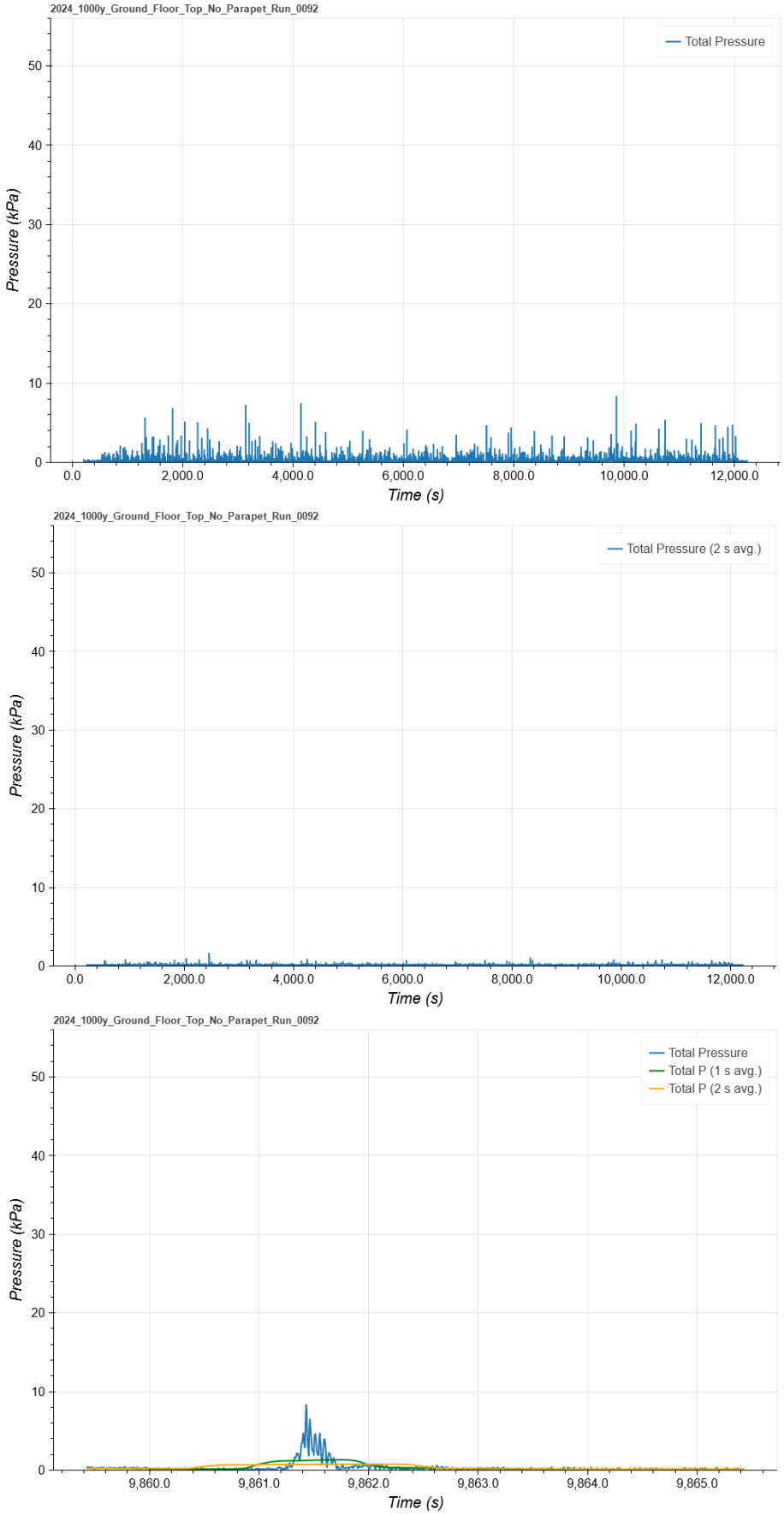


Figure 6.6 New building without parapet, 1000 year ARI, 2024, lower floor top

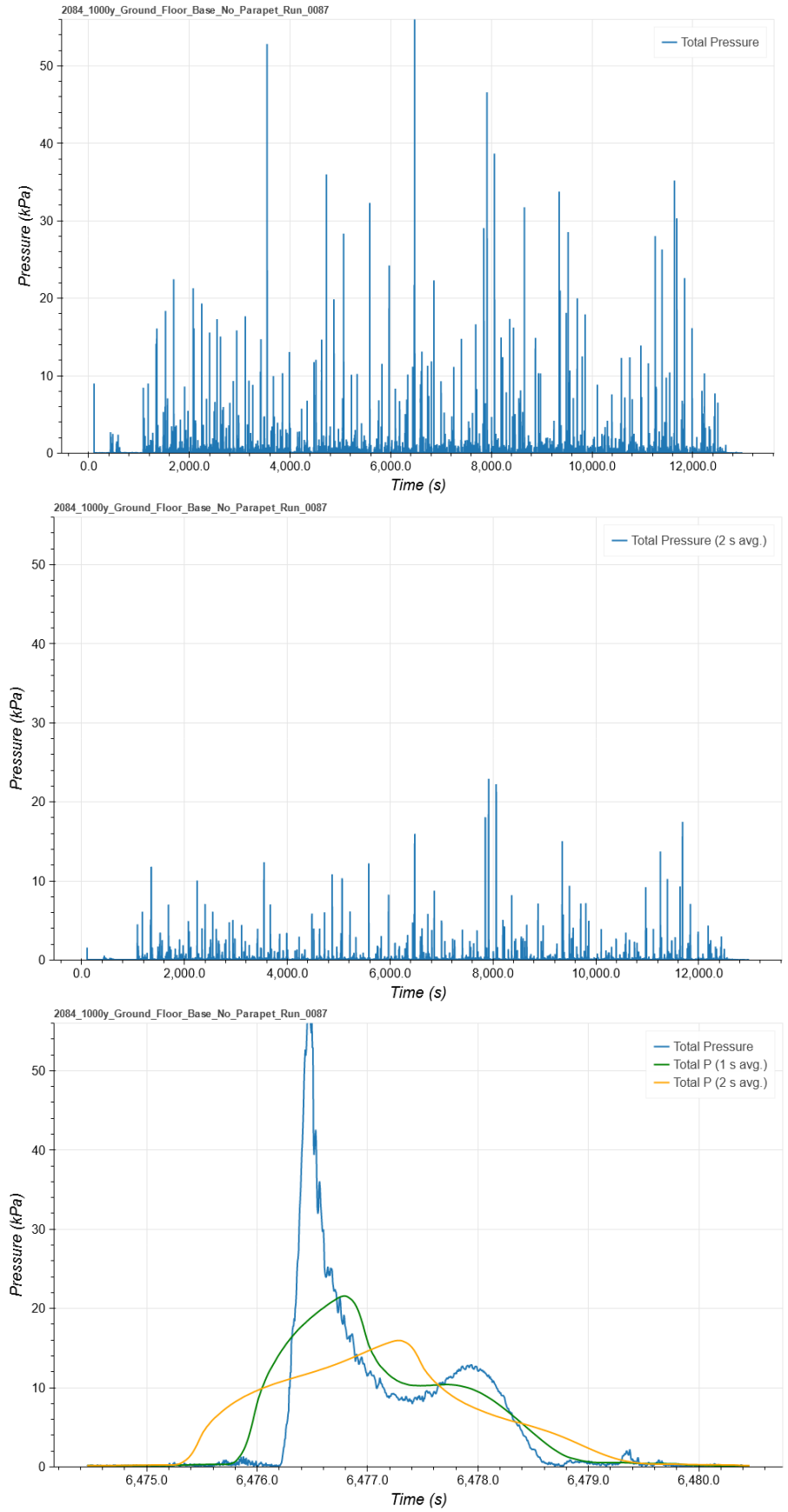


Figure 6.7 New building without parapet, 1000 year ARI, 2084, lower floor bottom

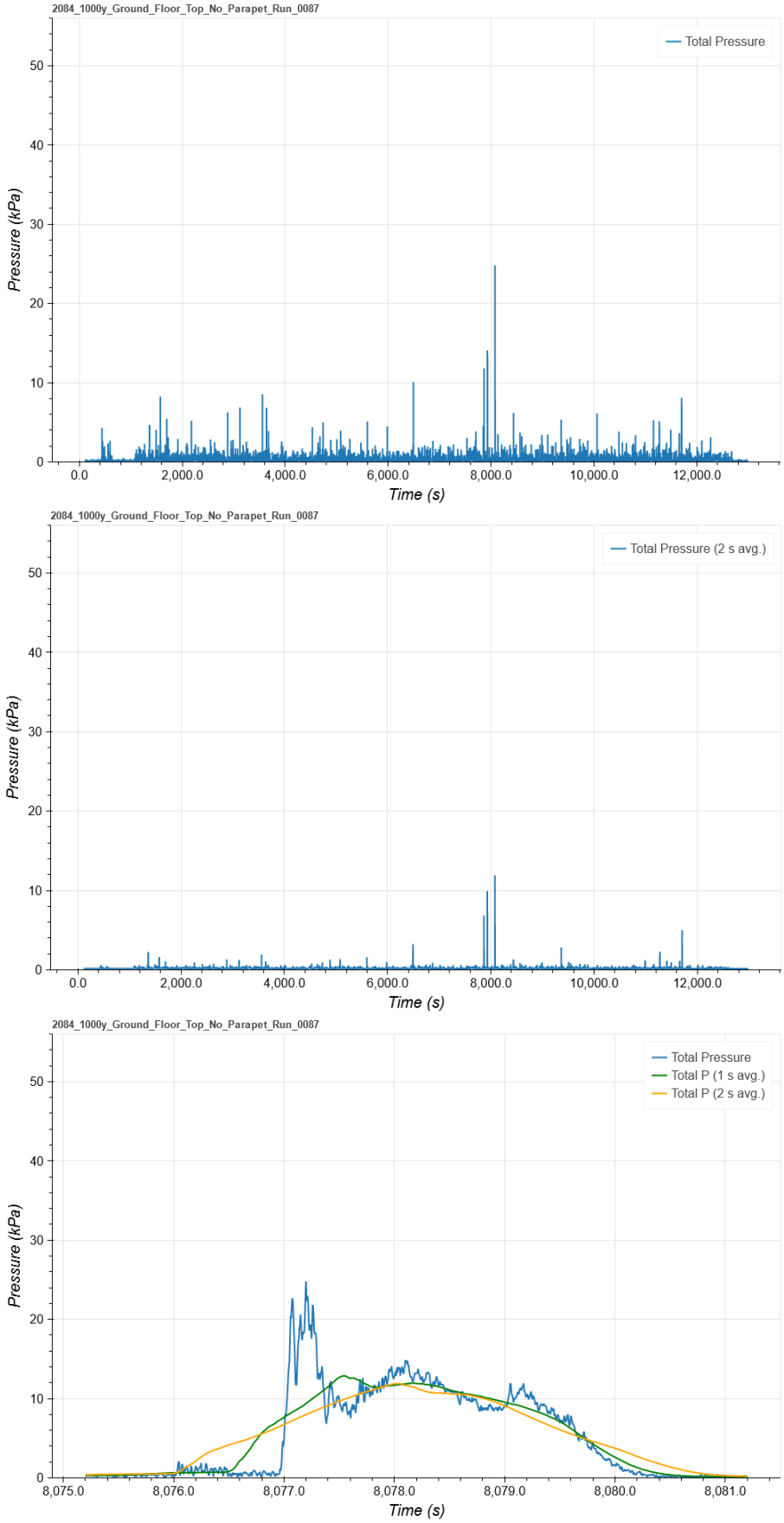


Figure 6.8 New building without parapet, 1000 year ARI, 2084, lower floor top

7. Tabulation of pressures

The maximum measured pressures (Pmax) for the existing SLSC building (fronted by a wave parapet) for extremely short duration (as little as 0.005 s) and for 2 s average are shown in Table 7.1. Due to the signal to noise ratio within the load cell, the 2 s average Pmax was limited to a minimum value of 1.0 kPa.

The maximum measured pressures (Pmax) for the new SLSC building (without a wave parapet) for extremely short duration (as little as 0.005 s) and for 2 s average are shown in Table 7.2.

Table 7.1 Pmax on existing SLSC building – with wave return parapet

ARI	Year	SLR	ID	Panel	Pmax event (kPa)	2 second average Pmax (kPa)
100	2024	0	0090	GF bottom	6.8	1.1
			0090	GF top	12.3	1.2
			0100	UF bottom	11.7	<1.0
			0100	UF top	14.1	<1.0
100	2084	0.53	0089	GF bottom	12.6	3.4
			0089	GF top	10.6	1.9
			0103	UF bottom	5.5	1.1
			0103	UF top	4.1	<1.0
1000	2024	0	0093	GF bottom	25.6	5.9
			0093	GF top	7.4	2.6
			0101	UF bottom	7.8	<1.0
			0101	UF top	9.4	<1.0
1000	2084	0.53	0086	GF bottom	54.3	16.8
			0086	GF top	20.9	5.7
			0104	UF bottom	14.6	2.6
			0104	UF top	9.4	<1.0

Table 7.2 Pmax on new SLSC building – without wave return parapet (no upper floor measurements)

ARI	Year	SLR	ID	Panel	Pmax event (kPa)	2 second average Pmax (kPa)
100	2024	0	0091	GF bottom	23.7	6.9
			0091	GF top	14.8	1.8
100	2084	0.53	0088	GF bottom	53.8	13.1
			0088	GF top	11.8	2.3
1000	2024	0	0092	GF bottom	33.4	10.5
			0092	GF top	8.4	1.7
1000	2084	0.53	0087	GF bottom	62.9	22.9
			0087	GF top	24.8	11.9

8. Overtopping water volume through upper storey window

The following window geometry was adopted:

- Window sill level: 9.79 m AHD
- Window width: 880 mm
- Window height: 2020 mm
- Window head level (assumed semi-circular): 11.81 m AHD
- Window area approximately 1.7 m^2 per window

The volume of water measured through each window (averaged between the two) is shown in Table 8.1.

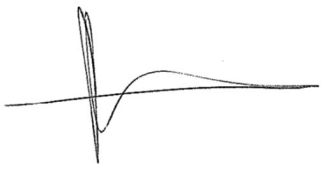
Table 8.1 Overtopping water volume through upper storey window

ARI	Year	SLR (m)	ID	Q (L per window ~3 hour test)	q (L/s per window)	q (L/minute per window)	q (L/hour per window)
100	2024	0	0100	203	0.019	1.2	70
100	2084	0.53	0103	273	0.024	1.4	86
1000	2024	0	0101	1344	0.126	7.7	461
1000	2084	0.53	0104	1625	0.141	8.5	509

9. Summary

Please contact James Carley (james.carley@unsw.edu.au ; 0414 385 053) should you require further information.

Yours sincerely,



Dr Francois Flocard
Director, Industry Research