APPENDIX E: CORRELATION RESULTS

E.1 Workspace characterisations

For the workspace characterisations, the strut was subjected to a series of compression and extension displacements, while opening and closing the spring valve. During this stage of testing the suspension unit was not yet equipped with a damper and these tests were carried out in order to determine the workspace of the adjustable spring. Table E-1 indicates the spring and damper state, as well as the excitation speed.

Table E-1: Spring/damper configuration for workspace characterisations

Figure number	Input	Spring state	Damper state	Excitation speed [*m/s*]
Figure E-2 and Figure E-3	Figure E-1	Figure E-1	OFF	0.001
Figure E-4 and Figure E-5	Figure E-1	Figure E-1	OFF	0.01
Figure E-6 and Figure E-7	Figure E-1	Figure E-1	OFF	0.1

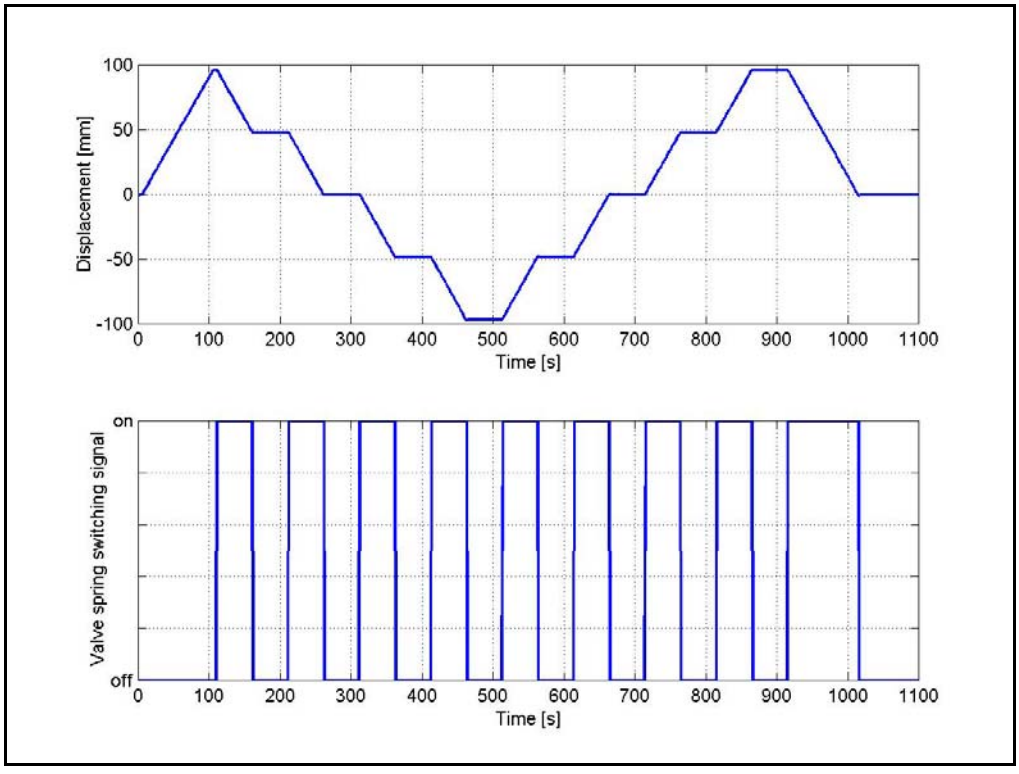

Figure E-1: Input signal

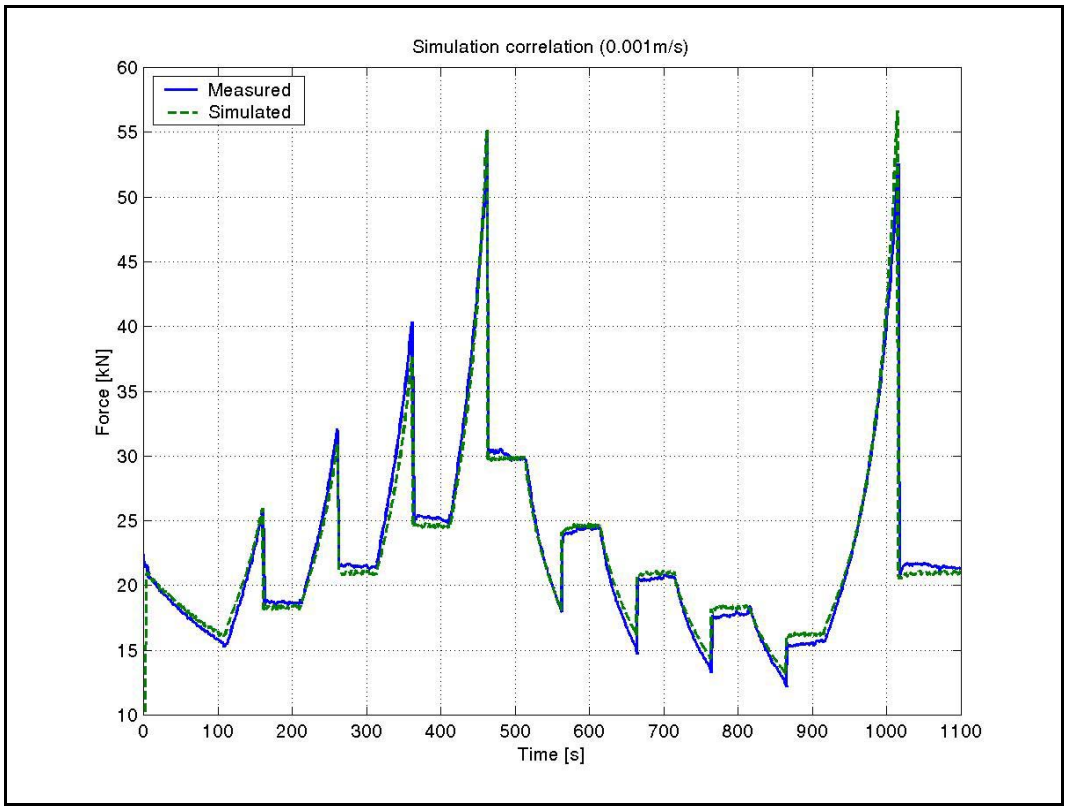

Figure E-2: Simulation correlation at 0.001*m/s*

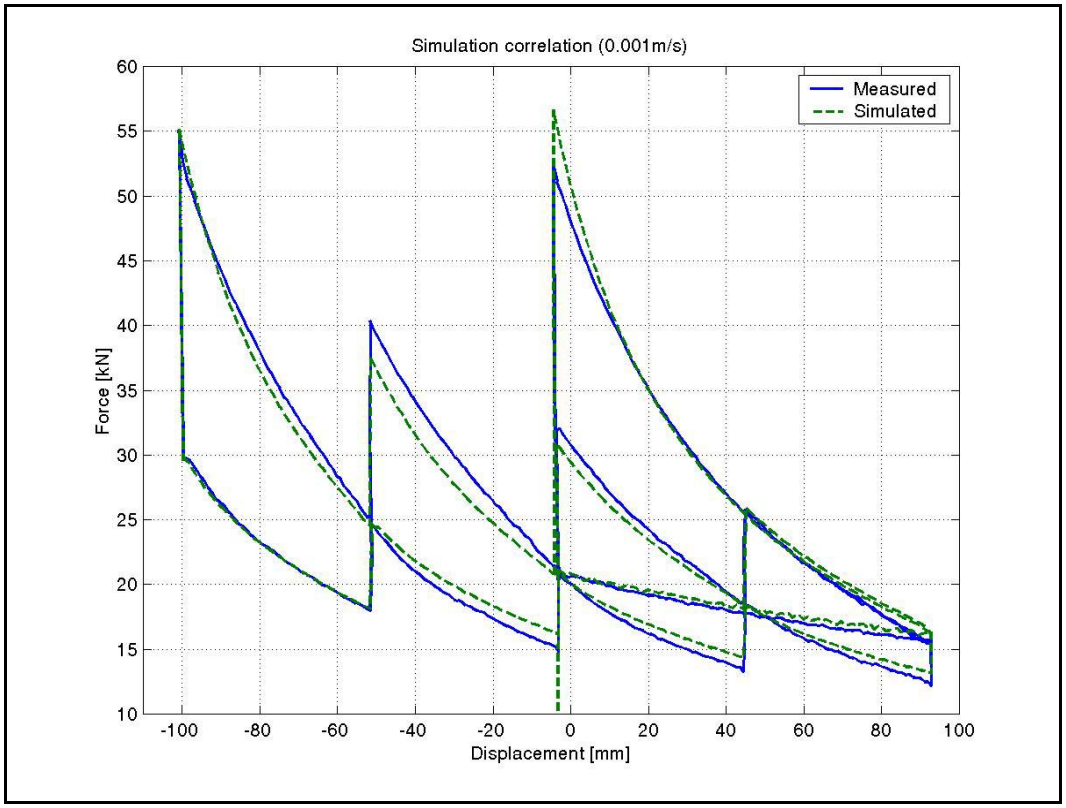

Figure E-3: Simulation correlation at 0.001*m/s*

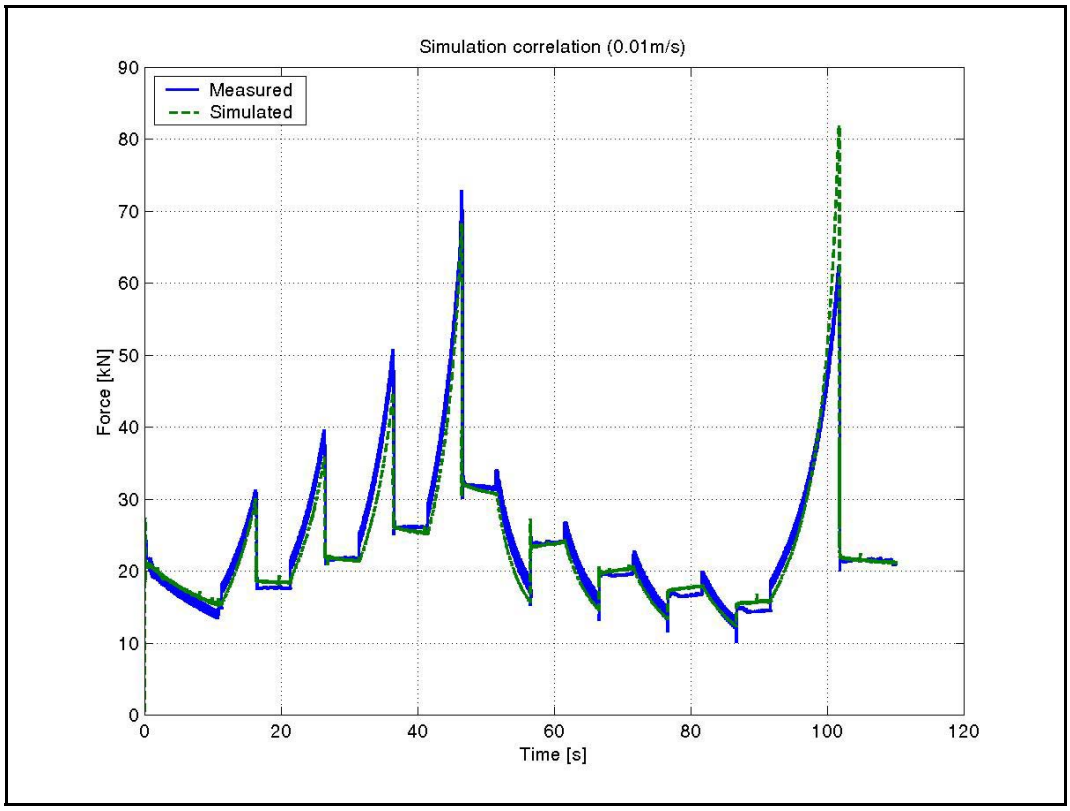

Figure E-4: Simulation correlation at 0.01*m/s*

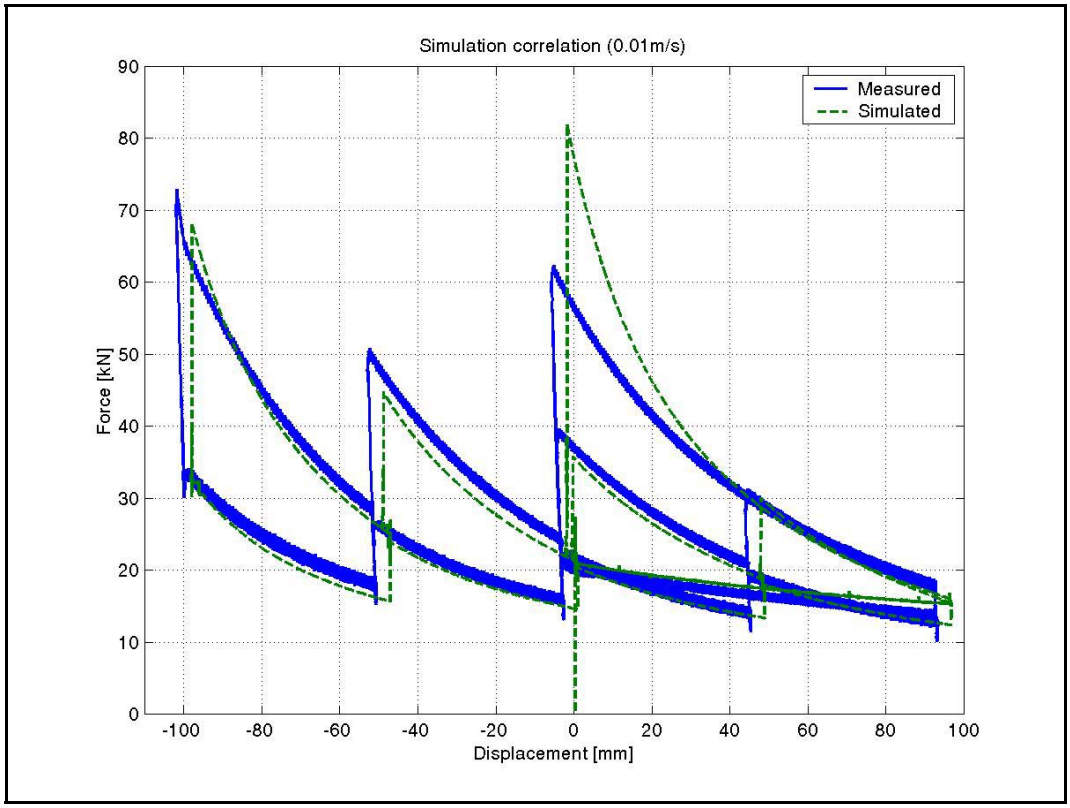

Figure E-5: Simulation correlation at 0.01*m/s*

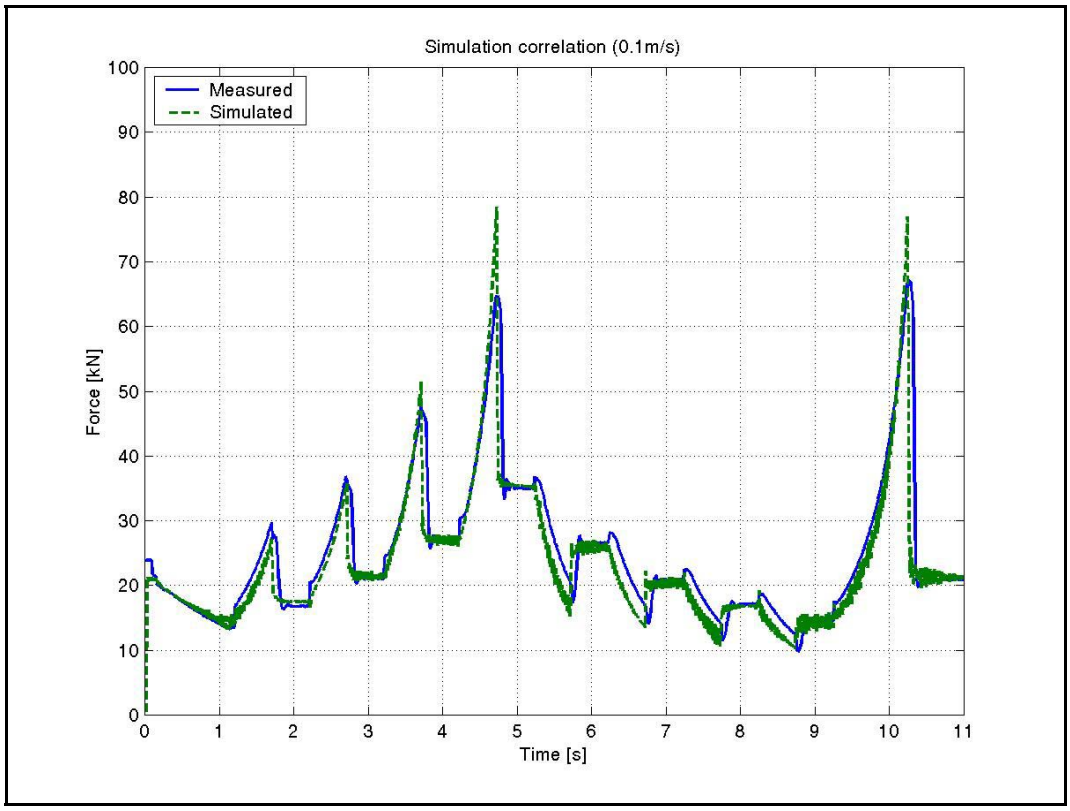

Figure E-6: Simulation correlation at 0.1*m/s*

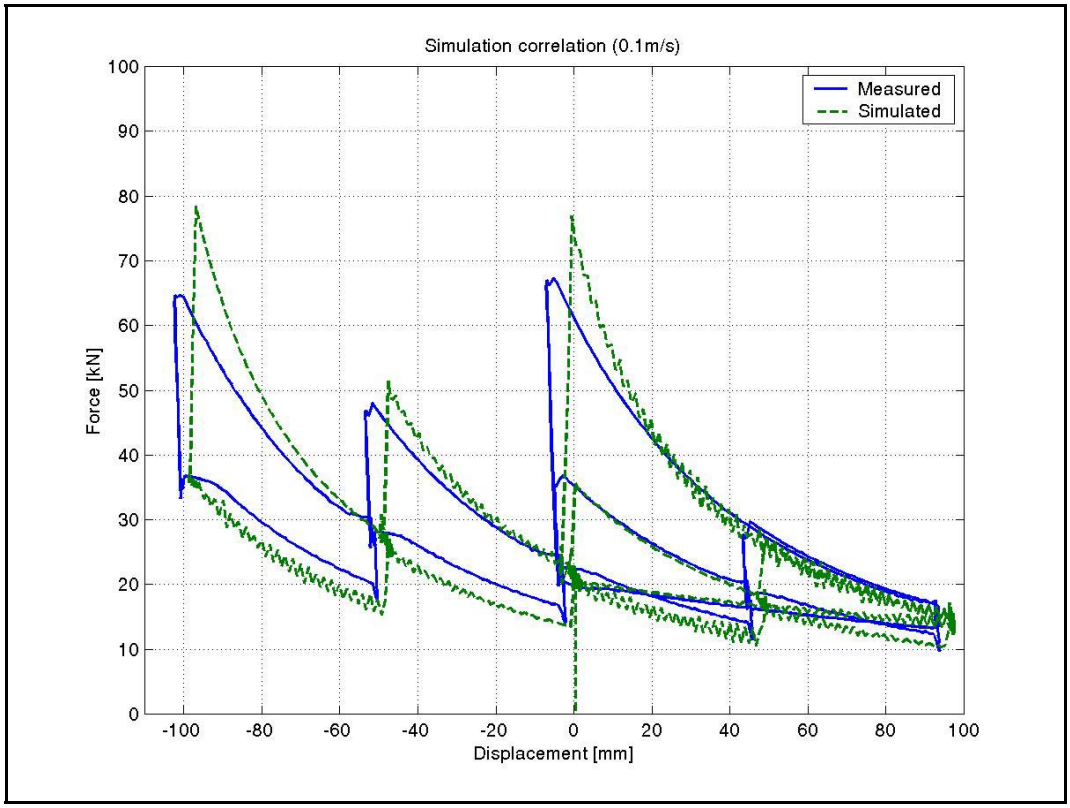

Figure E-7: Simulation correlation at 0.1*m/s*

E.2 Step response correlation

Three types of tests were performed on the SDOF setup, namely step response, random input response and sine sweep. This section contains the correlation between measured and simulated results for the step response tests. All the correlation graphs are of relative displacement.

Table E-2: Spring/damper configuration for step response tests

Figure number	Input	Spring state	Damper state
Figure E-8	30*mm* step	OFF	OFF
Figure E-9	30*mm* step	ON	OFF
Figure E-10	30*mm* step	OFF	ON
Figure E-11	30*mm* step	ON	ON
Figure E-12	30*mm* step	ON	Karnopp
Figure E-13	30*mm* step	OFF	Karnopp
Figure E-14	30*mm* step	ON	Hölscher & Huang
Figure E-15	30*mm* step	OFF	Hölscher & Huang
Figure E-16	60*mm* step	OFF	OFF

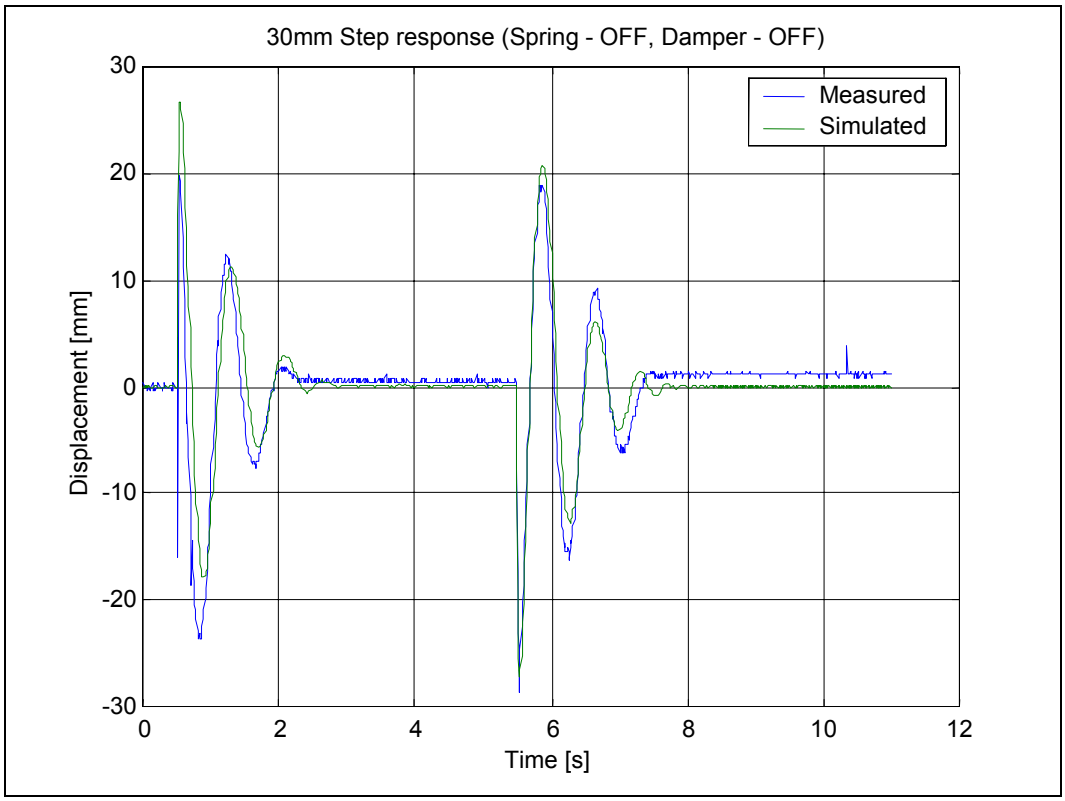

Figure E-8: 30*mm* step response (Spring – OFF, Damper - OFF)

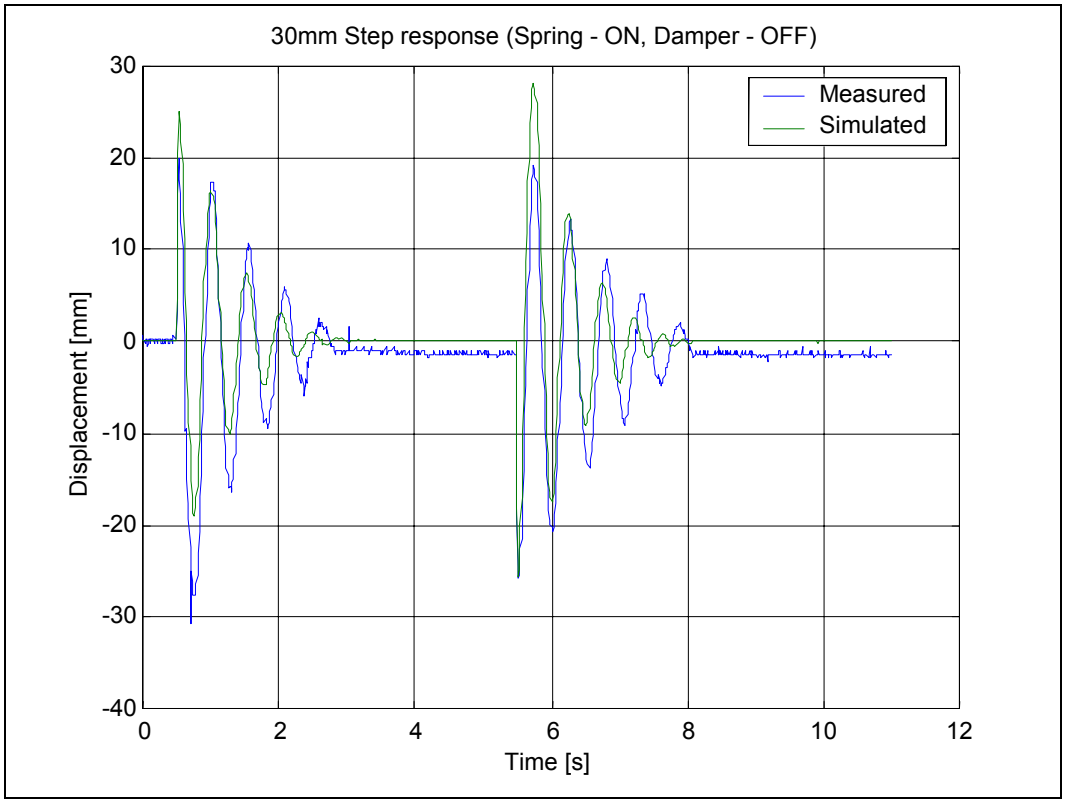

Figure E-9: 30*mm* step response (Spring – ON, Damper - OFF)

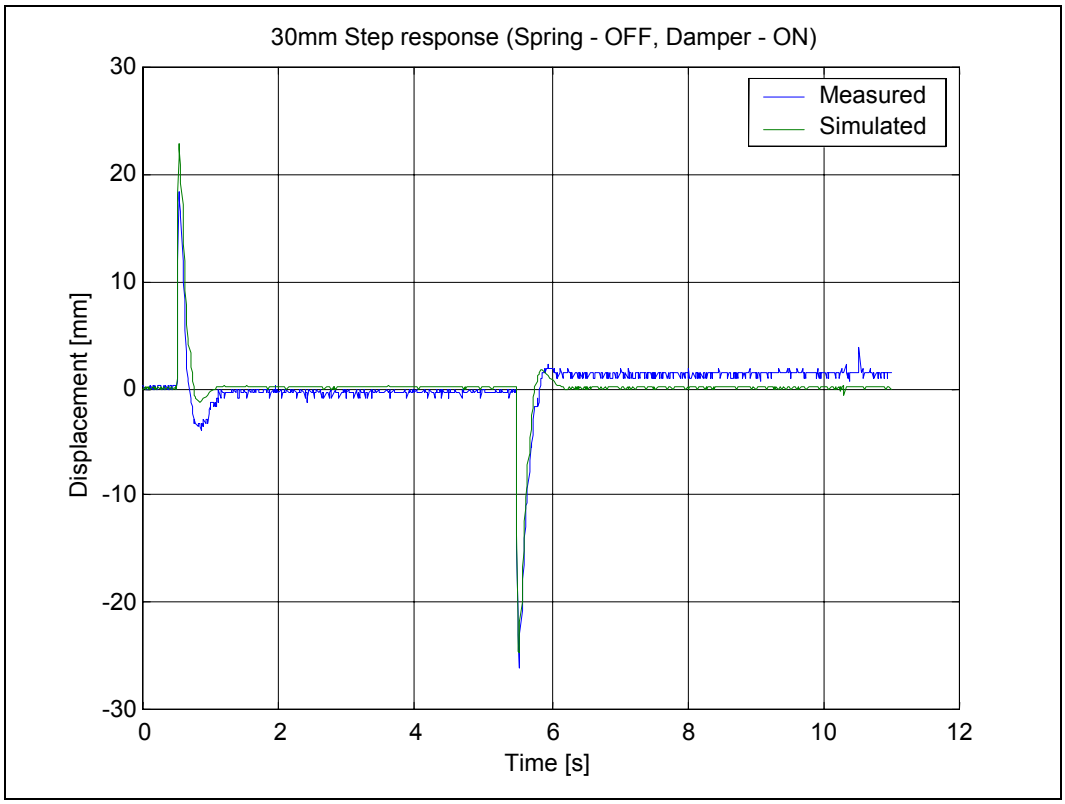

Figure E-10: 30*mm* step response (Spring – OFF, Damper - ON)

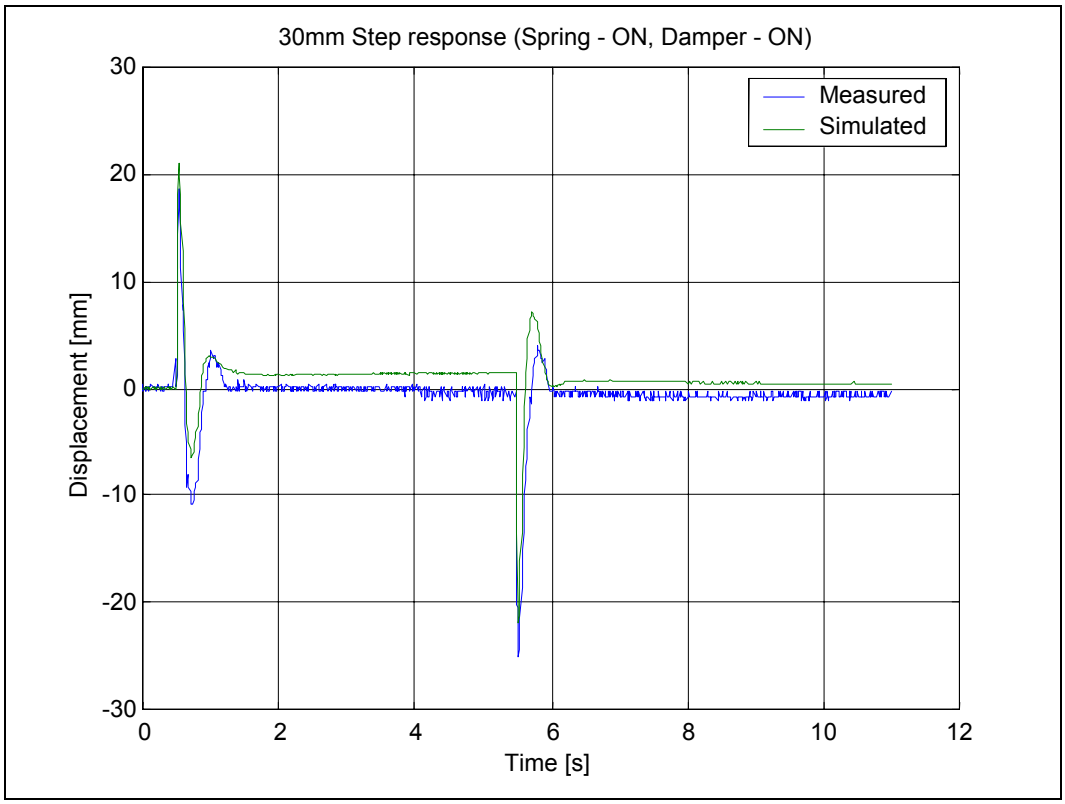

Figure E-11: 30*mm* step response (Spring – ON, Damper - ON)

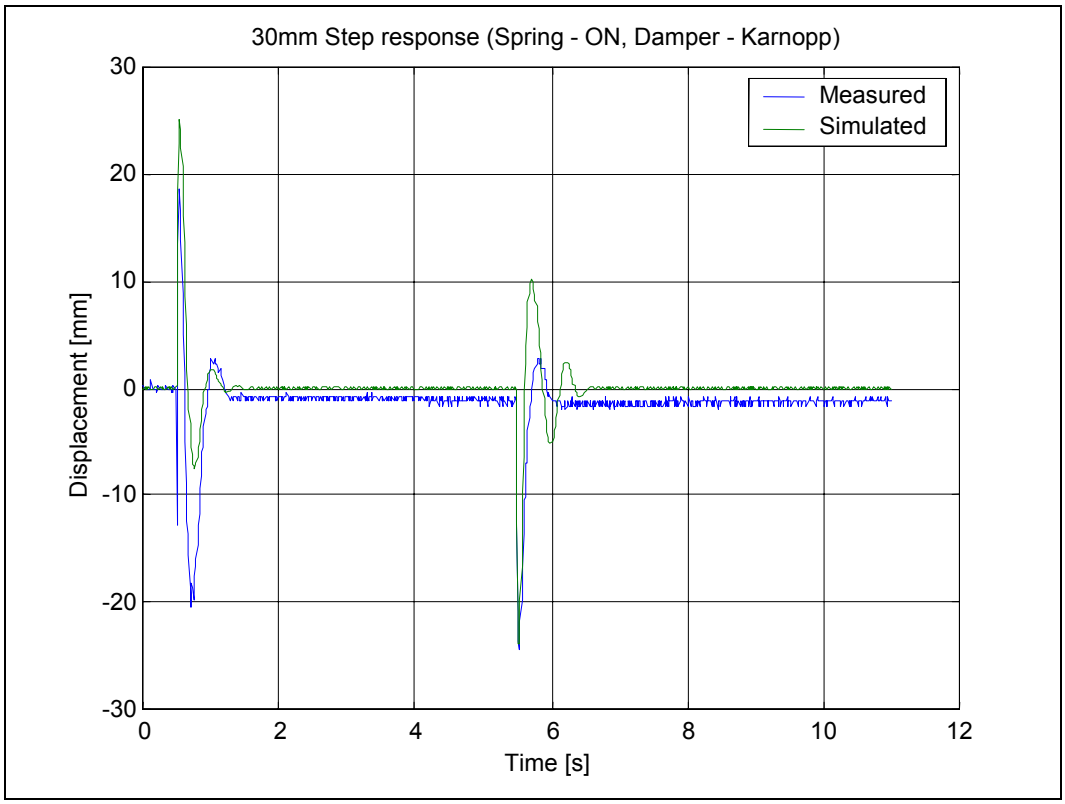

Figure E-12: 30*mm* step response (Spring – ON, Damper - Karnopp)

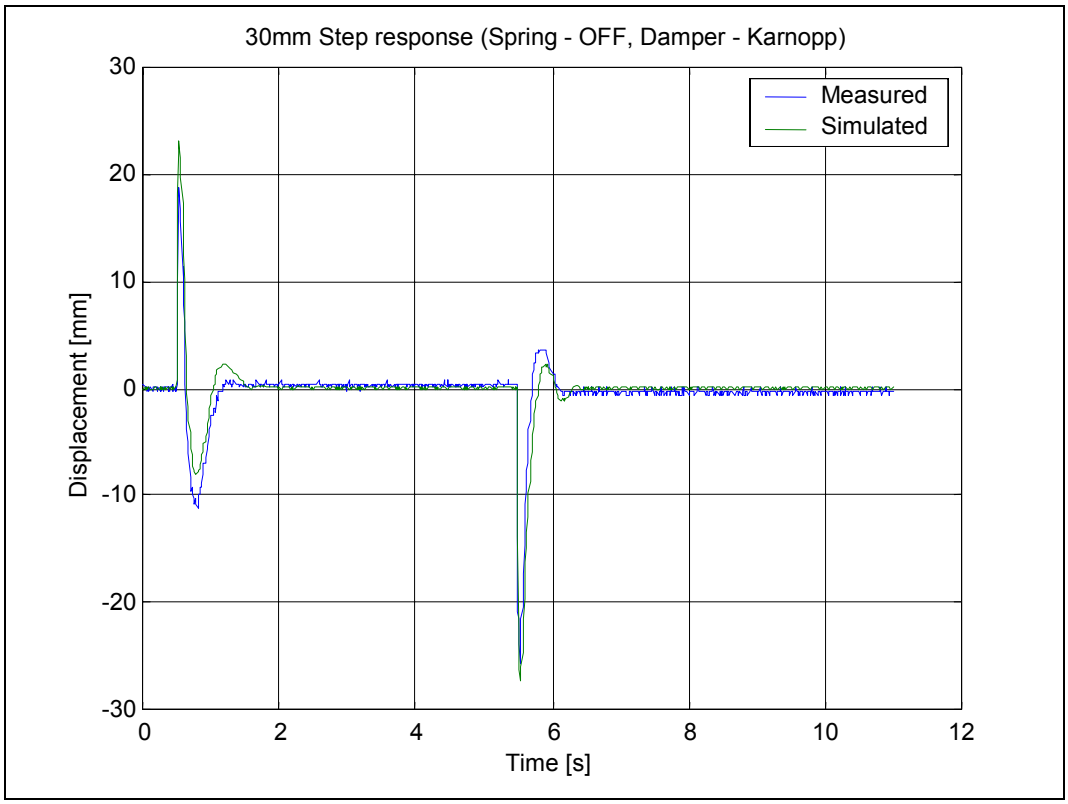

Figure E-13: 30*mm* step response (Spring – OFF, Damper - Karnopp)

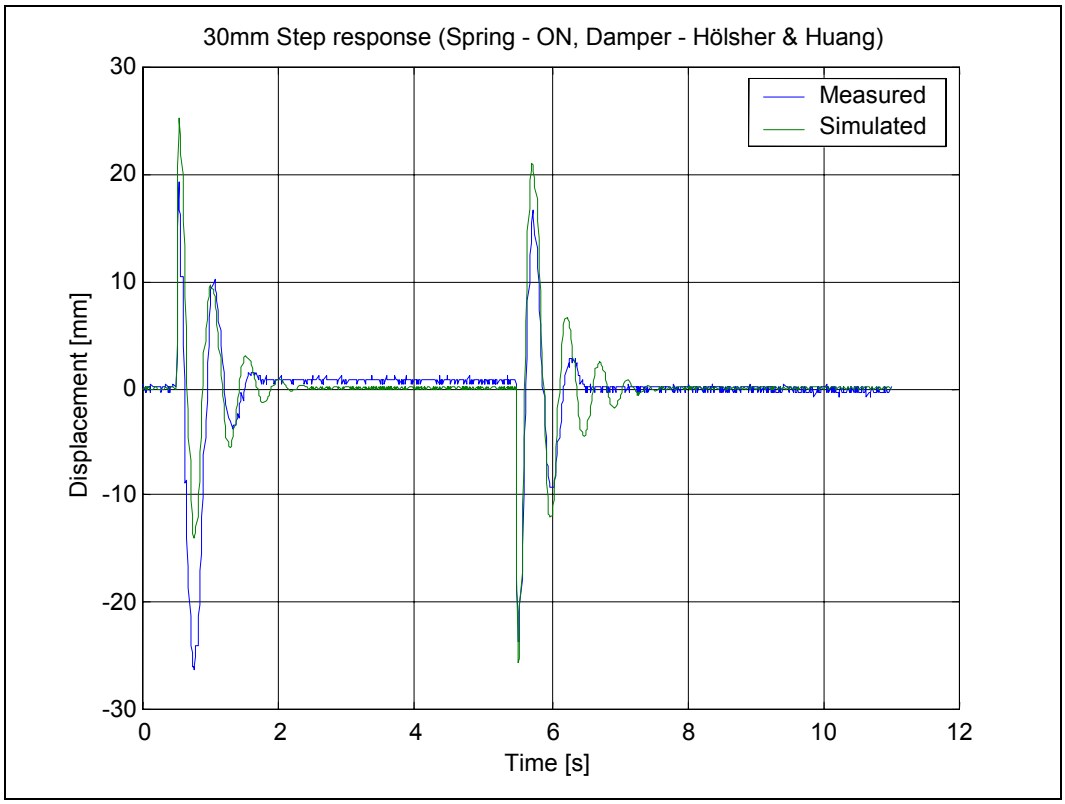

Figure E-14: 30*mm* step response (Spring – ON, Damper – Hölscher & Huang)

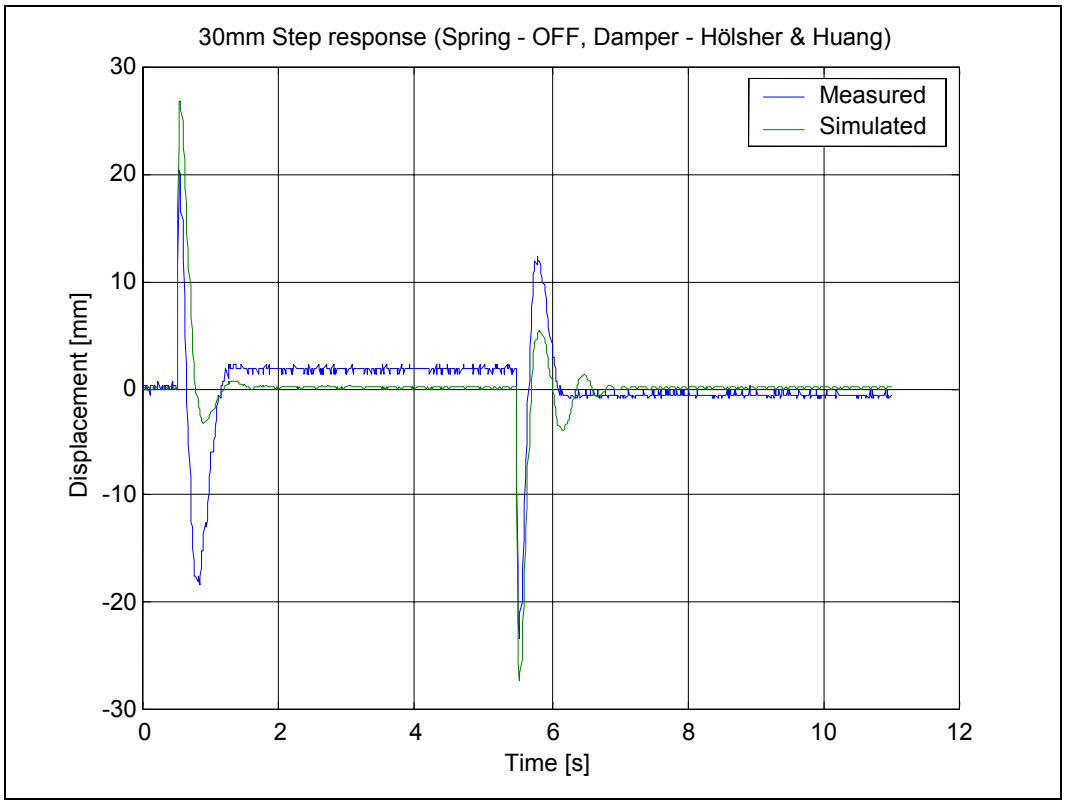

Figure E-15: 30*mm* step response (Spring – OFF, Damper – Hölscher & Huang)

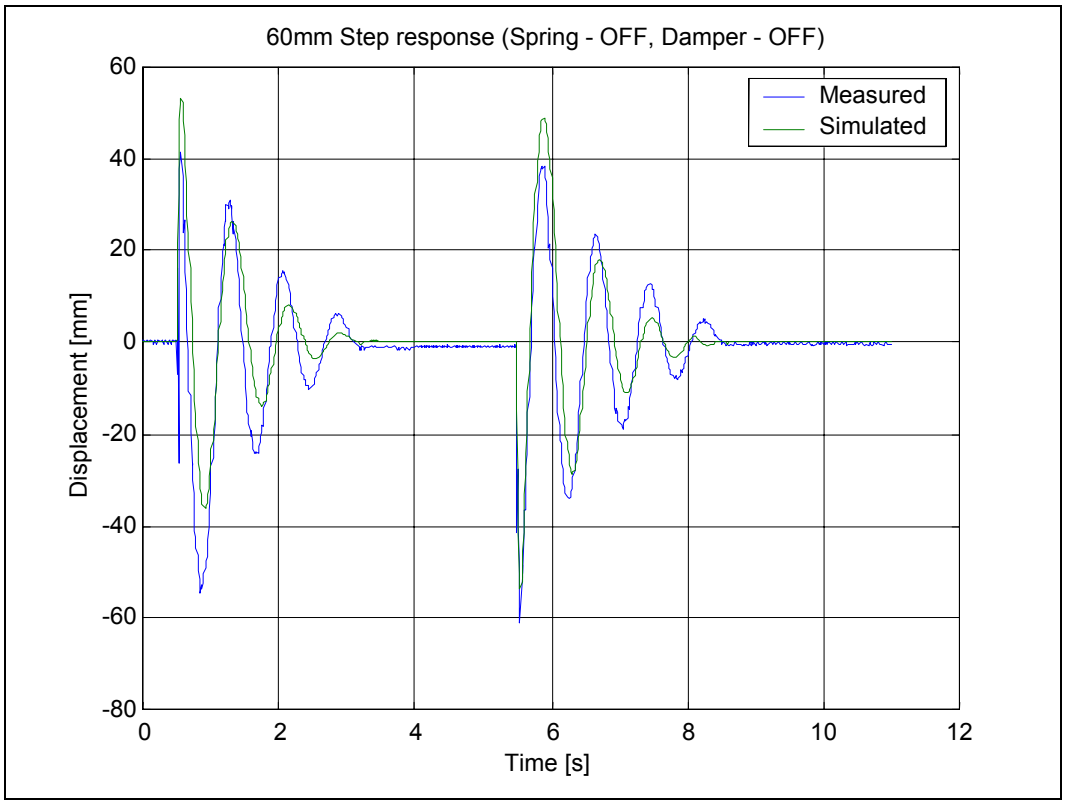

Figure E-16: 60*mm* step response (Spring – OFF, Damper - OFF)

E.3 Random input response correlation

For the random input response tests, the left-hand lane of the Belgian paving track at the Gerotek Vehicle Testing Facility was used. Different spring and damper settings were tested and the figures in this section indicate the correlation obtained between measured and simulated results. Table E-3 indicates the spring and damper setting for each of the graphs presented in this section.

Table E-3: Spring/damper configuration for random input tests

Configuration no.	Figure number	Input	Spring state	Damper state
1	Figure E-17	Belgian paving	OFF	OFF
2	Figure E-18	Belgian paving	ON	OFF
3	Figure E-19	Belgian paving	OFF	ON
4	Figure E-20	Belgian paving	ON	ON
5	Figure E-21	Belgian paving	ON	Karnopp
6	Figure E-22	Belgian paving	OFF	Karnopp
7	Figure E-23	Belgian paving	ON	Hölscher & Huang
8	Figure E-24	Belgian paving	OFF	Hölscher & Huang
9	Figure E-25	Belgian paving	Karnopp	Karnopp
10	Figure E-26	Belgian paving	Height adjustment	OFF
-	Figure E-27	Belgian paving	Minimum and maximum results summary	
-	Figure E-28	Belgian paving	RMS results summary	

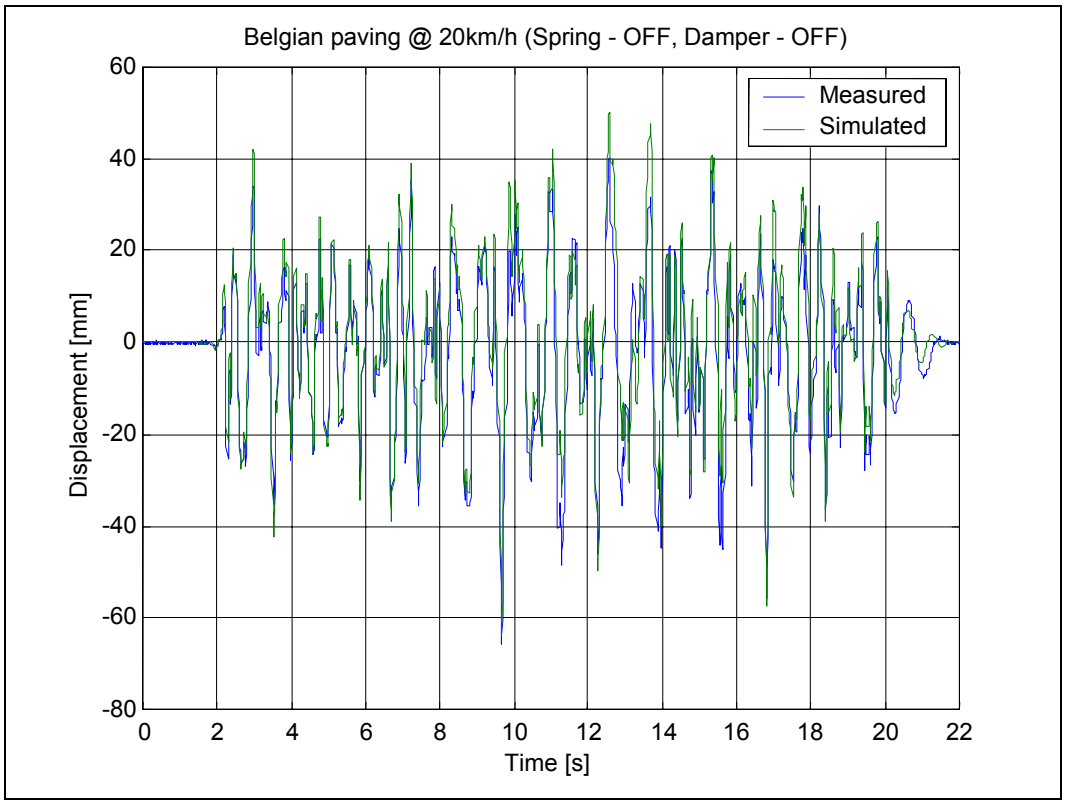

Figure E-17: Random input correlation (Spring – OFF, Damper – ON)

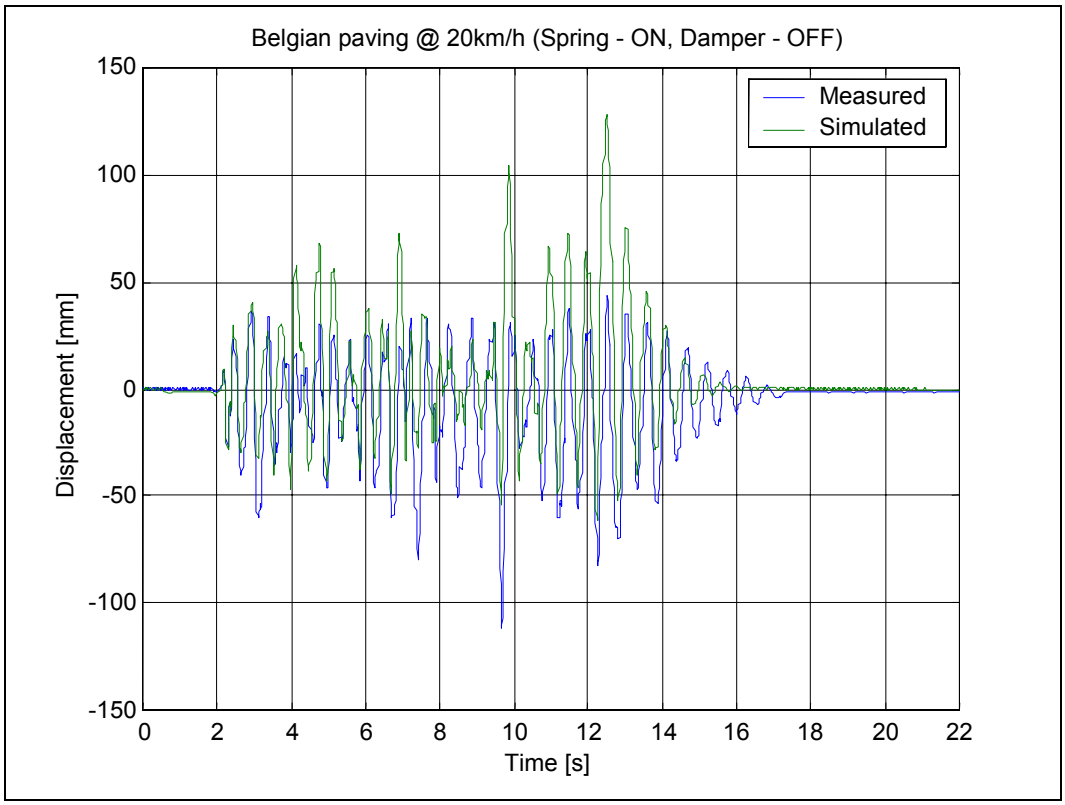

Figure E-18: Random input correlation (Spring – ON, Damper – OFF)

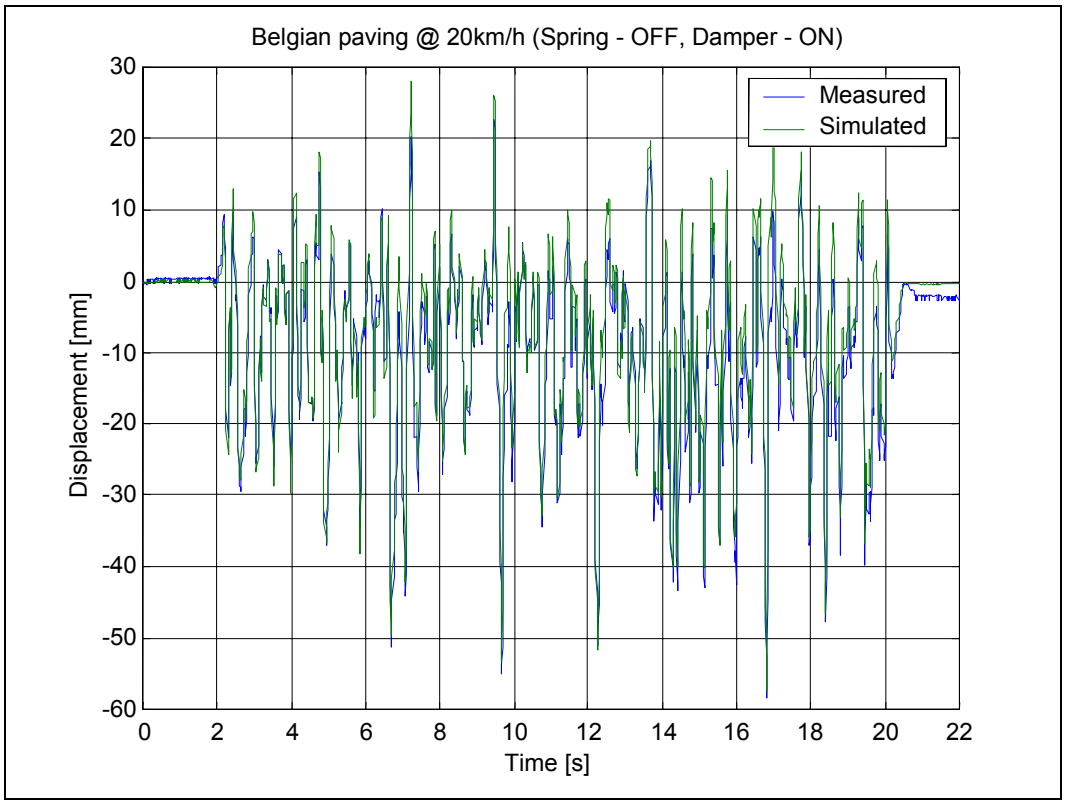

Figure E-19: Random input correlation (Spring – OFF, Damper – ON)

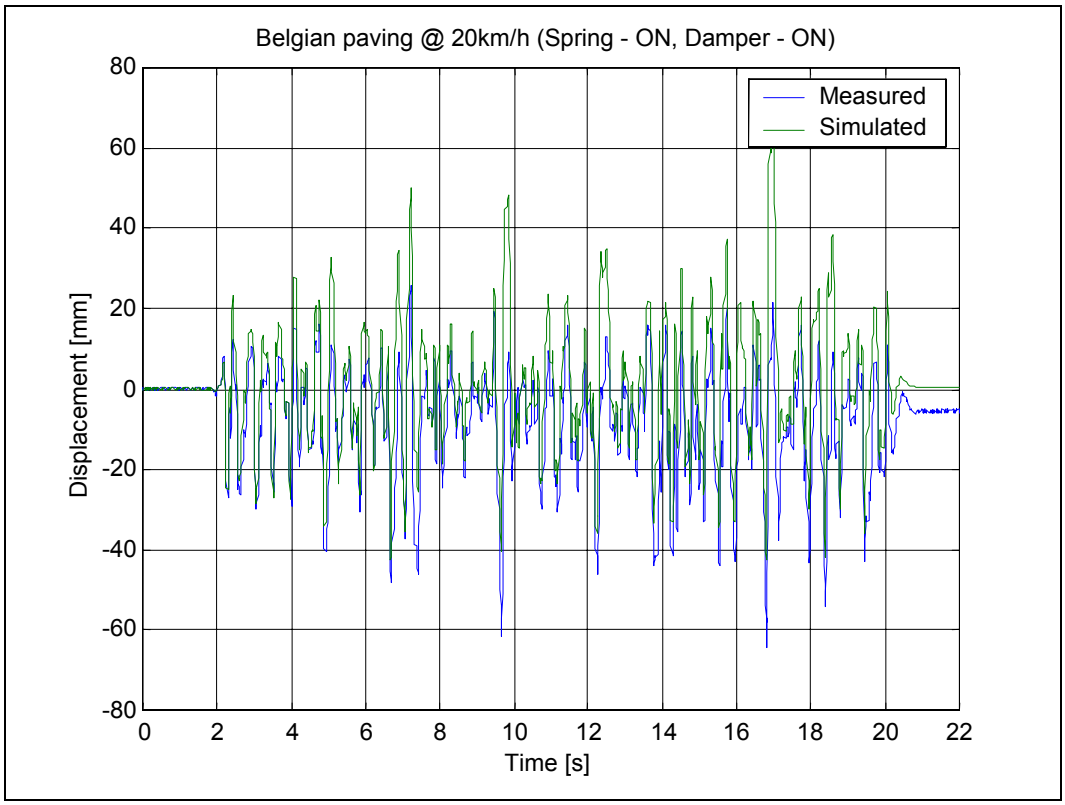

Figure E-20: Random input correlation (Spring – ON, Damper – ON)

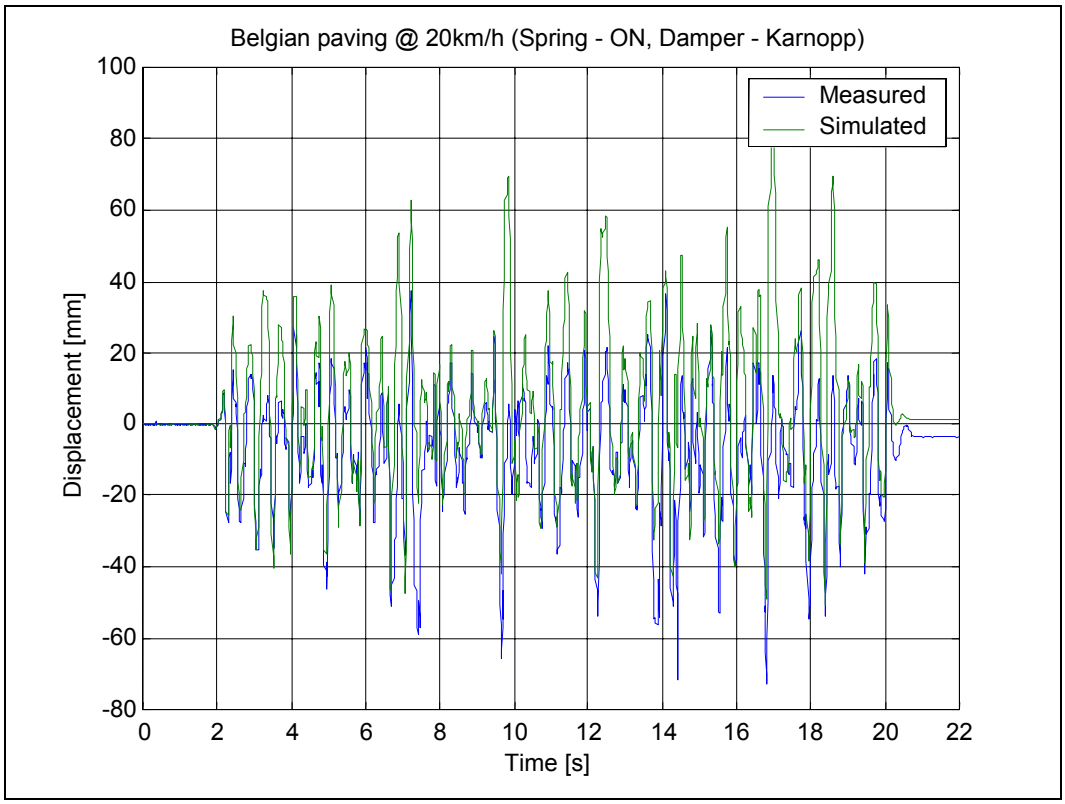

Figure E-21: Random input correlation (Spring – ON, Damper – Karnopp)

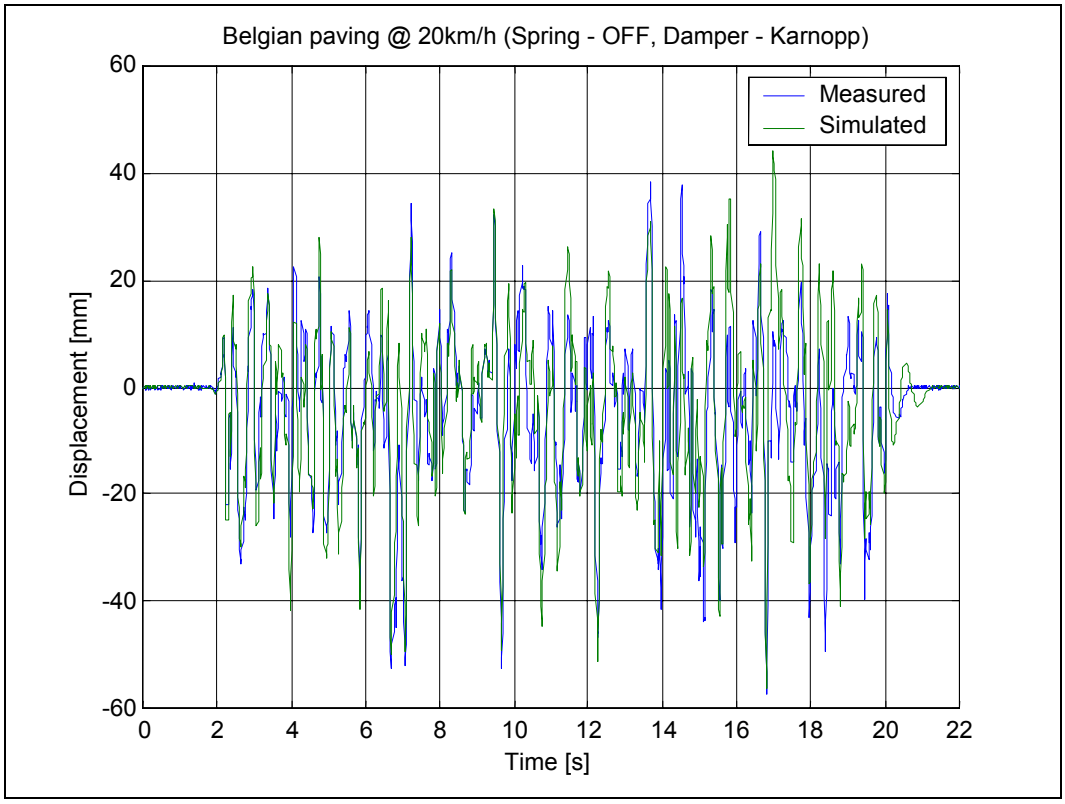

Figure E-22: Random input correlation (Spring – OFF, Damper – Karnopp)

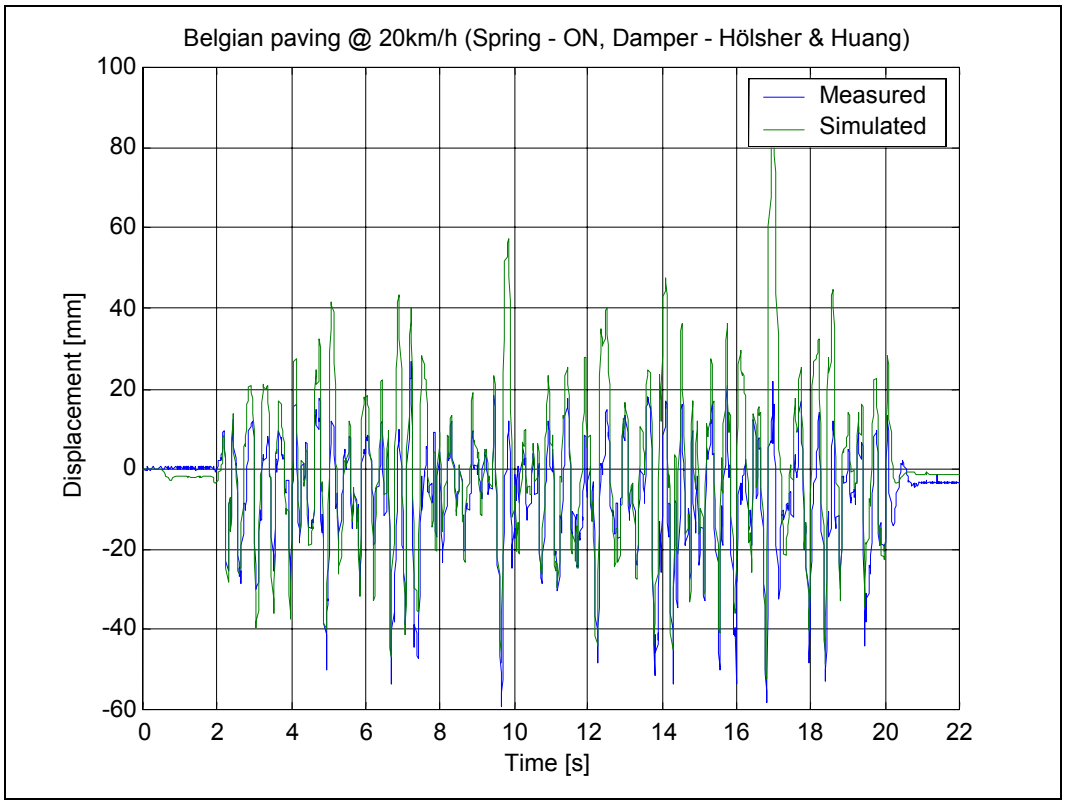

Figure E-23: Random input correlation (Spring – ON, Damper – Hölscher & Huang)

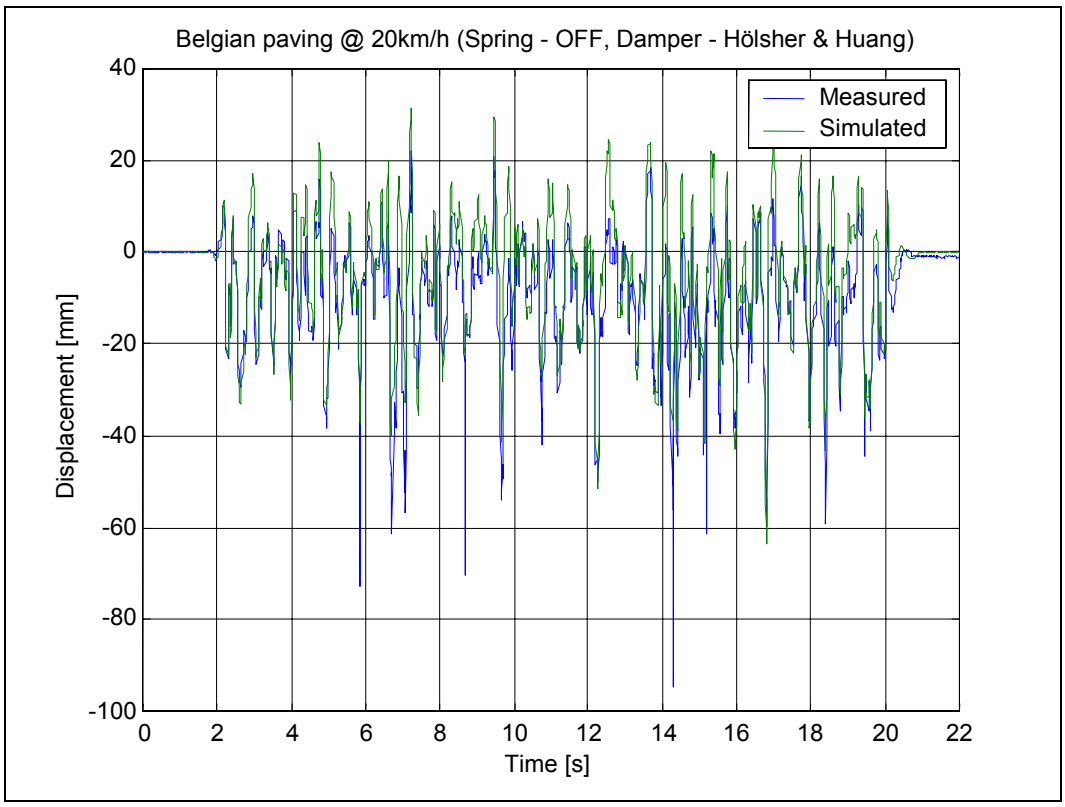

Figure E-24: Random input correlation (Spring – OFF, Damper – Hölscher & Huang)

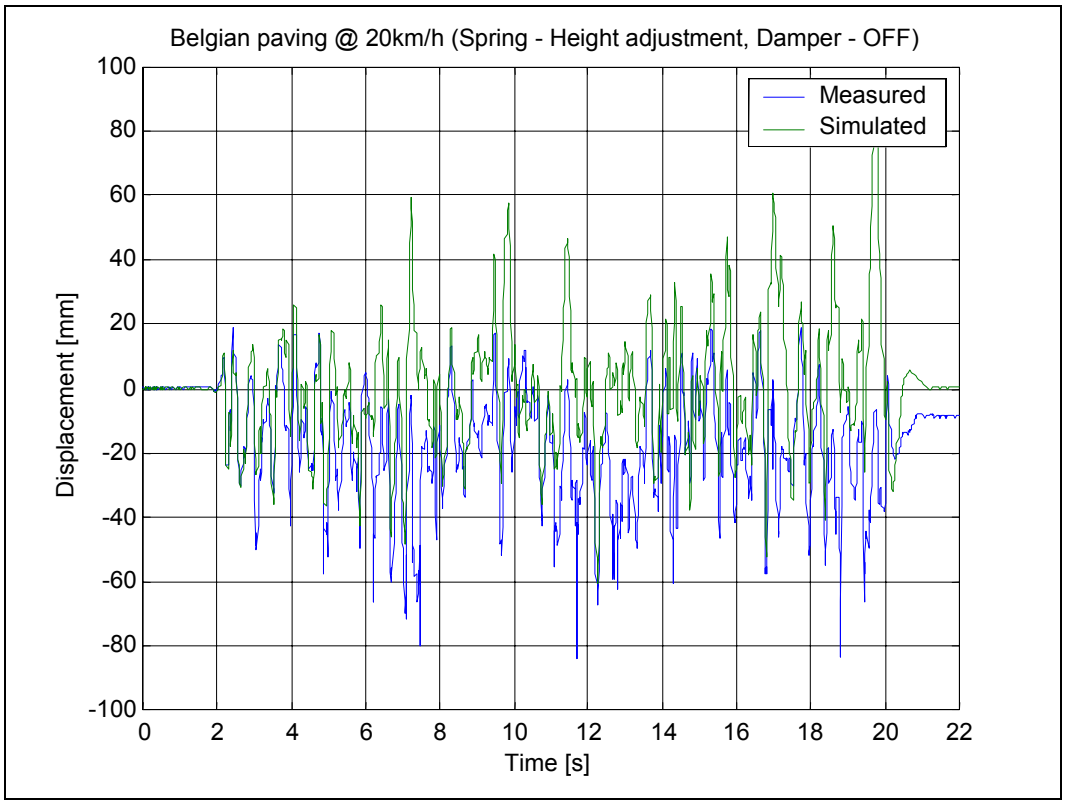

Figure E-25: Random input correlation (Spring – Height adjustment, Damper – OFF)

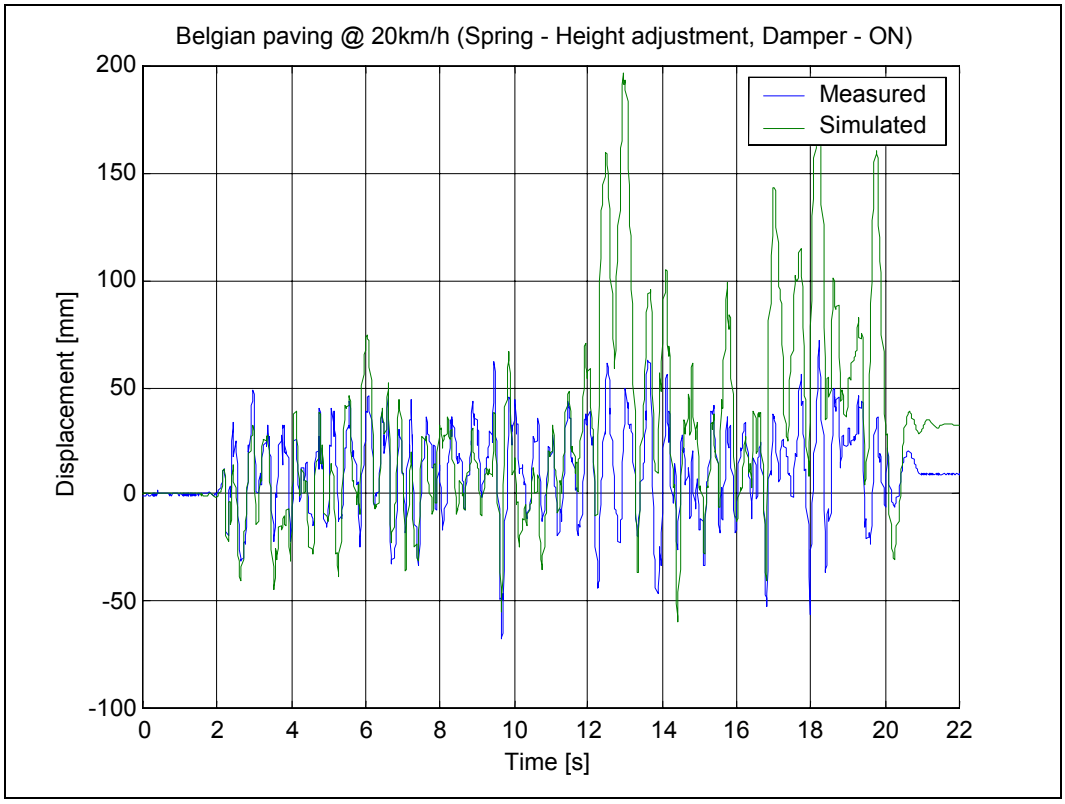

Figure E-26: Random input correlation (Spring – Height adjustment, Damper – ON)

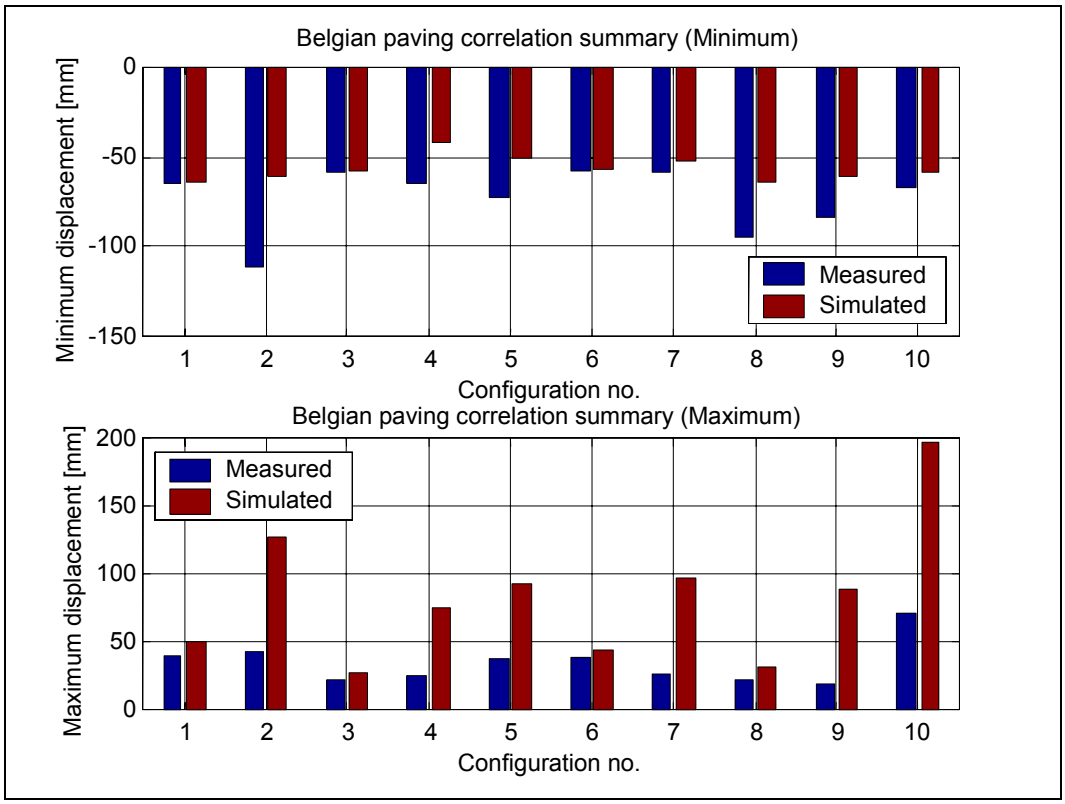

Figure E-27: Belgian paving correlation summary (Minimum and maximum)

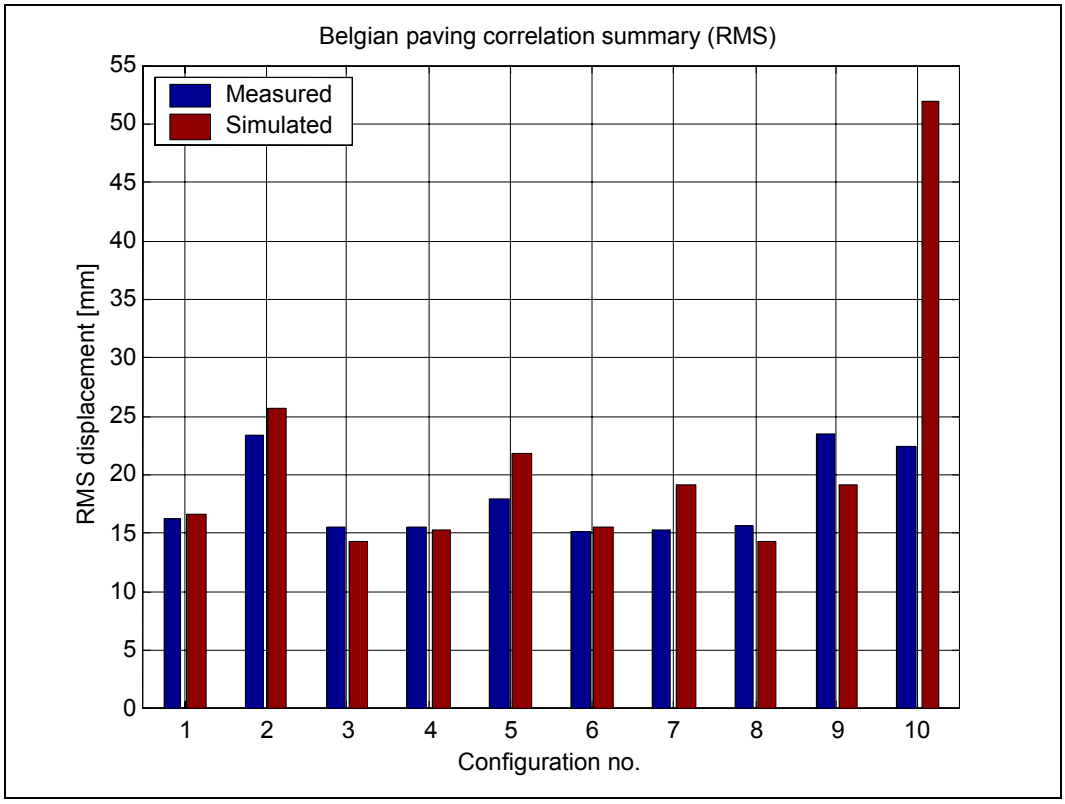

Figure E-28: Belgian paving correlation summary (RMS)

E.4 Sine sweep correlation

For the sine sweep tests, a sine displacement input was supplied to the actuator. The sine wave had a constant amplitude of 15*mm*, while the frequency was linearly adjusted from 0.1*Hz* to 15*Hz* in 78*s*. Figure E-29 indicates the recorded actuator signal for the sine sweep tests. From this figure, it is clear that the frequency response of the actuator is not sufficient to follow the input signal at the higher frequencies. Table E-4 supplies a list of figures and the corresponding spring and damper settings for different correlation graphs.

Table E-4: Spring/damper configuration for sine sweep tests

Figure number	Input	Spring state	Damper state
Figure E-30	Sine sweep (15*mm* amplitude)	OFF	OFF
Figure E-31	Sine sweep (15*mm* amplitude)	ON	OFF
Figure E-32	Sine sweep (15*mm* amplitude)	OFF	ON
Figure E-33	Sine sweep (15*mm* amplitude)	ON	ON
Figure E-34	Sine sweep (15*mm* amplitude)	ON	Karnopp
Figure E-35	Sine sweep (15*mm* amplitude)	OFF	Karnopp
Figure E-36	Sine sweep (15*mm* amplitude)	ON	Holsher & Huang
Figure E-37	Sine sweep (15*mm* amplitude)	OFF	Holsher & Huang

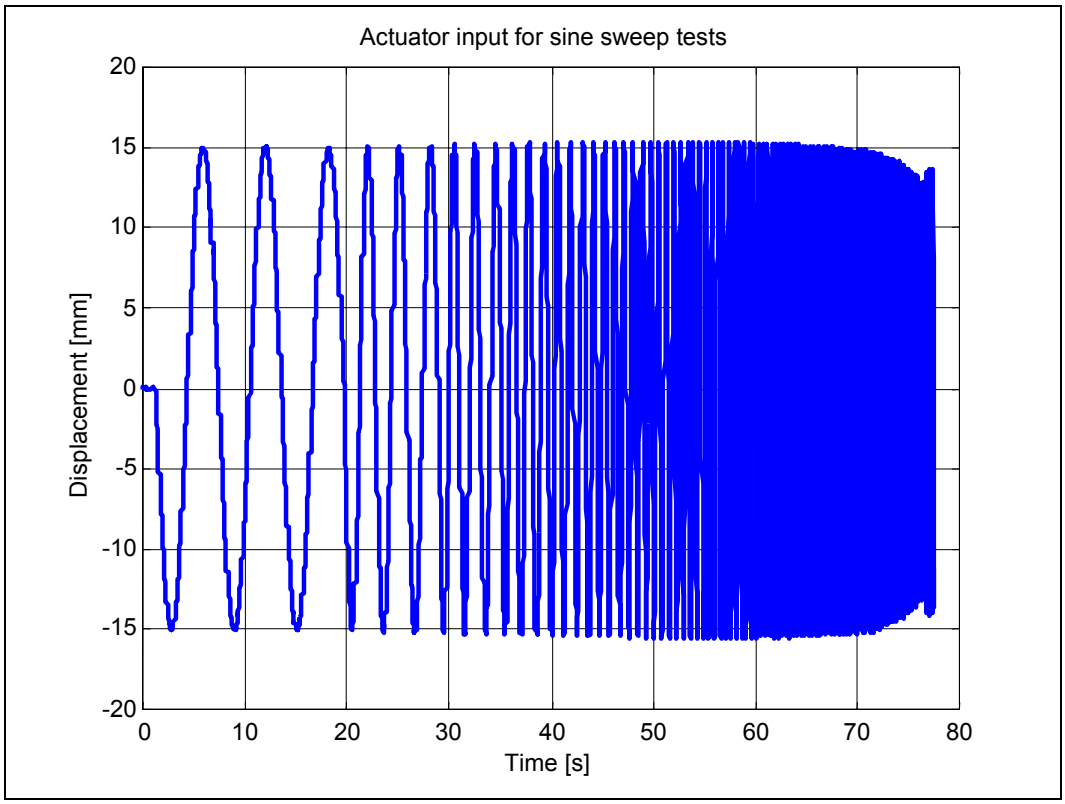

Figure E-29: Sine sweep actuator input

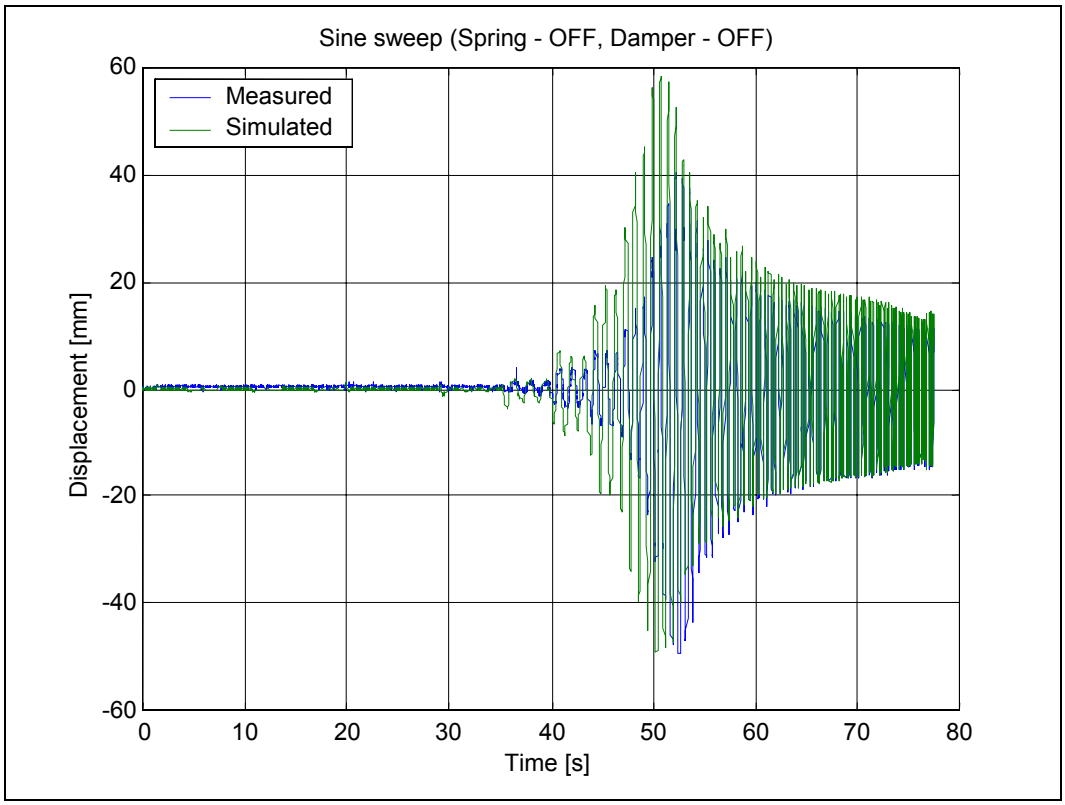

Figure E-30: Sine sweep (Spring - OFF, Damper - OFF)

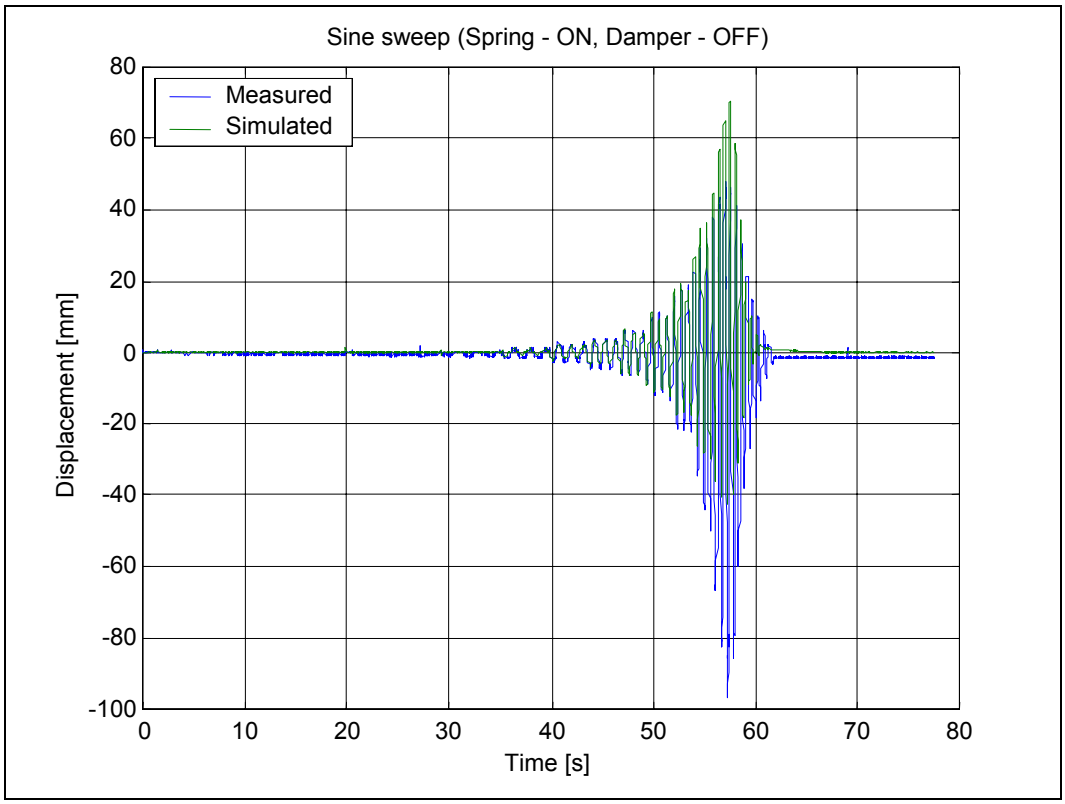

Figure E-31: Sine sweep (Spring - ON, Damper - OFF)

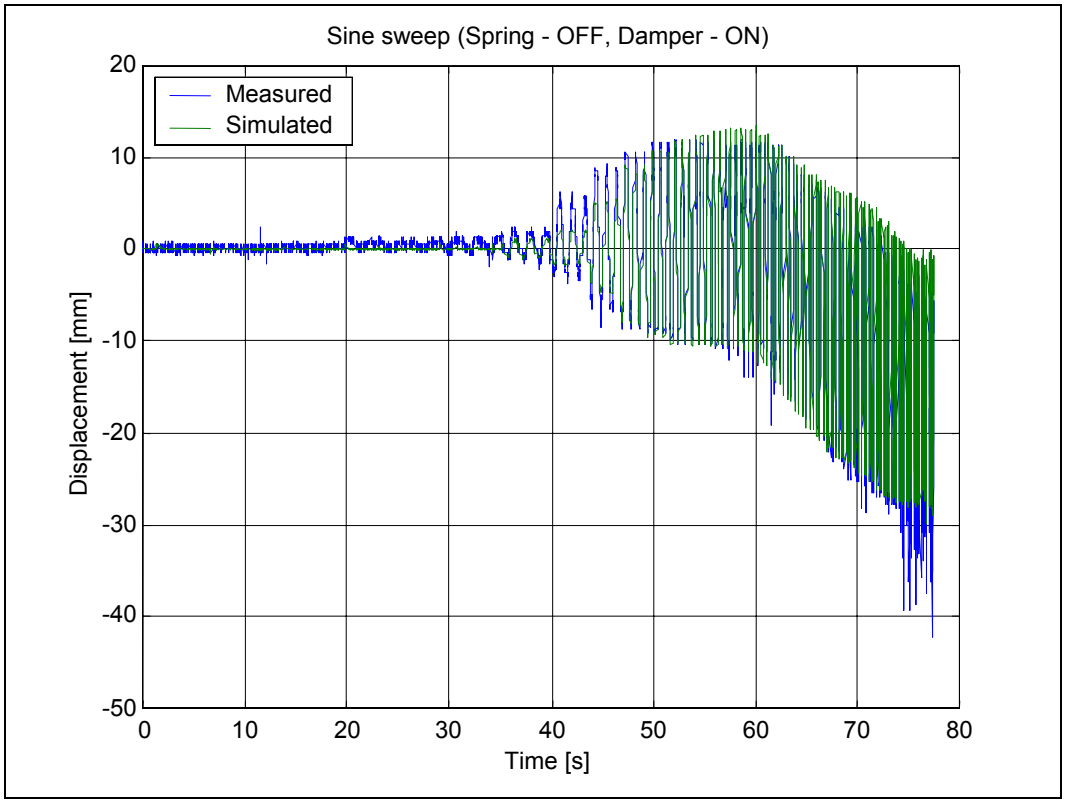

Figure E-32: Sine sweep (Spring - OFF, Damper - ON)

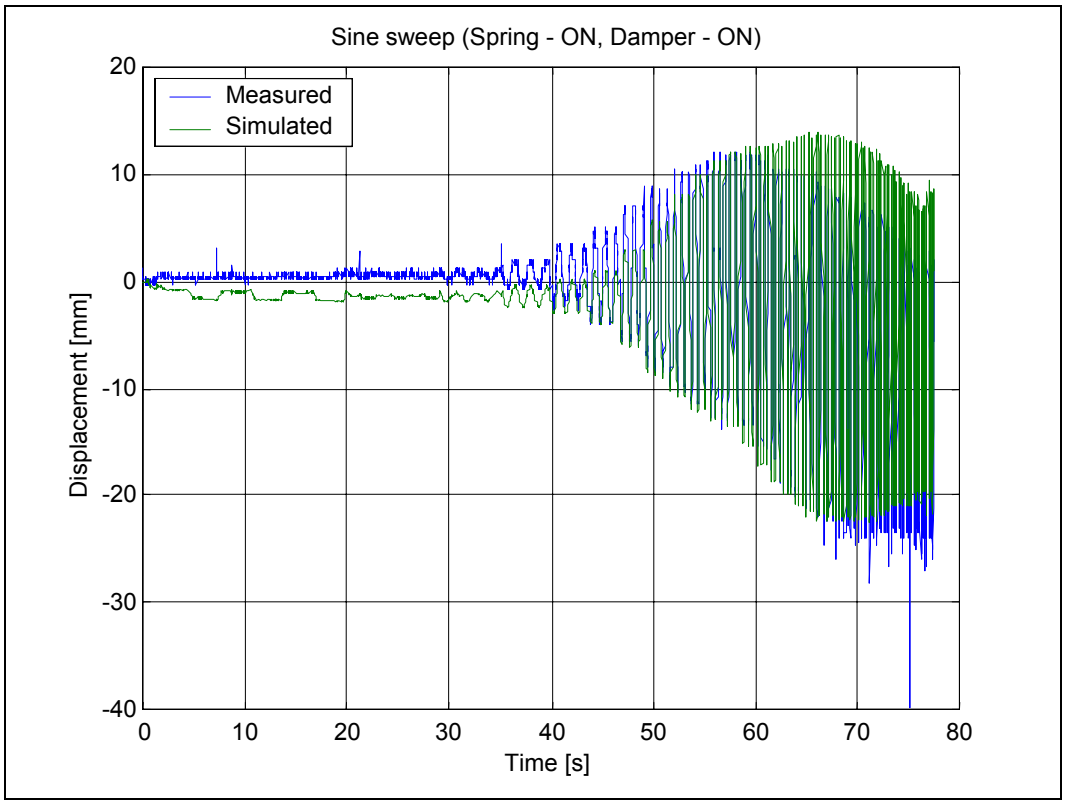

Figure E-33: Sine sweep (Spring - ON, Damper - ON)

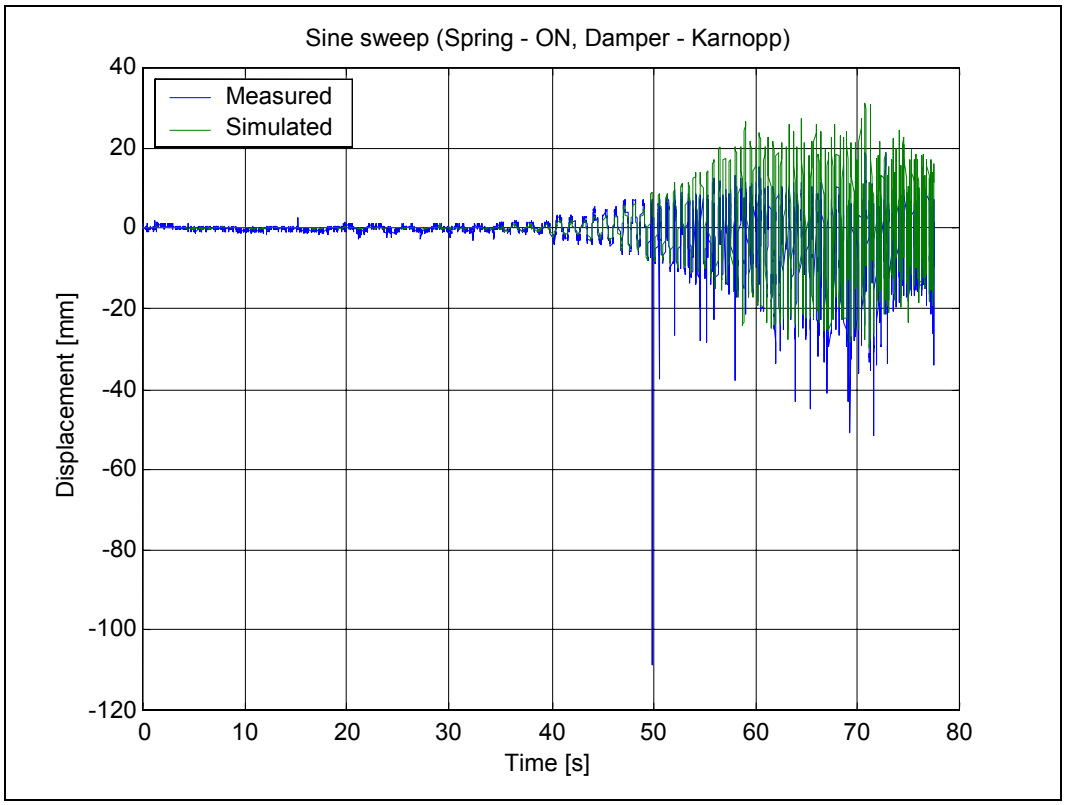

Figure E-34: Sine sweep (Spring - ON, Damper - Karnopp)

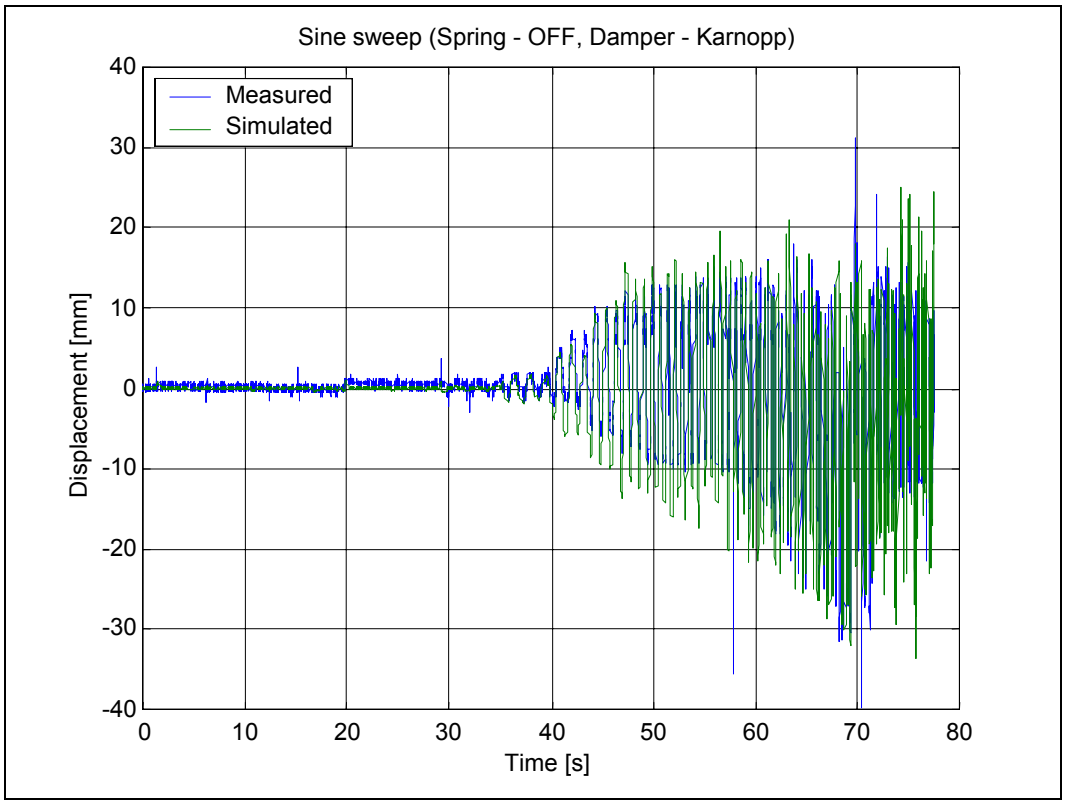

Figure E-35: Sine sweep (Spring - OFF, Damper - Karnopp)

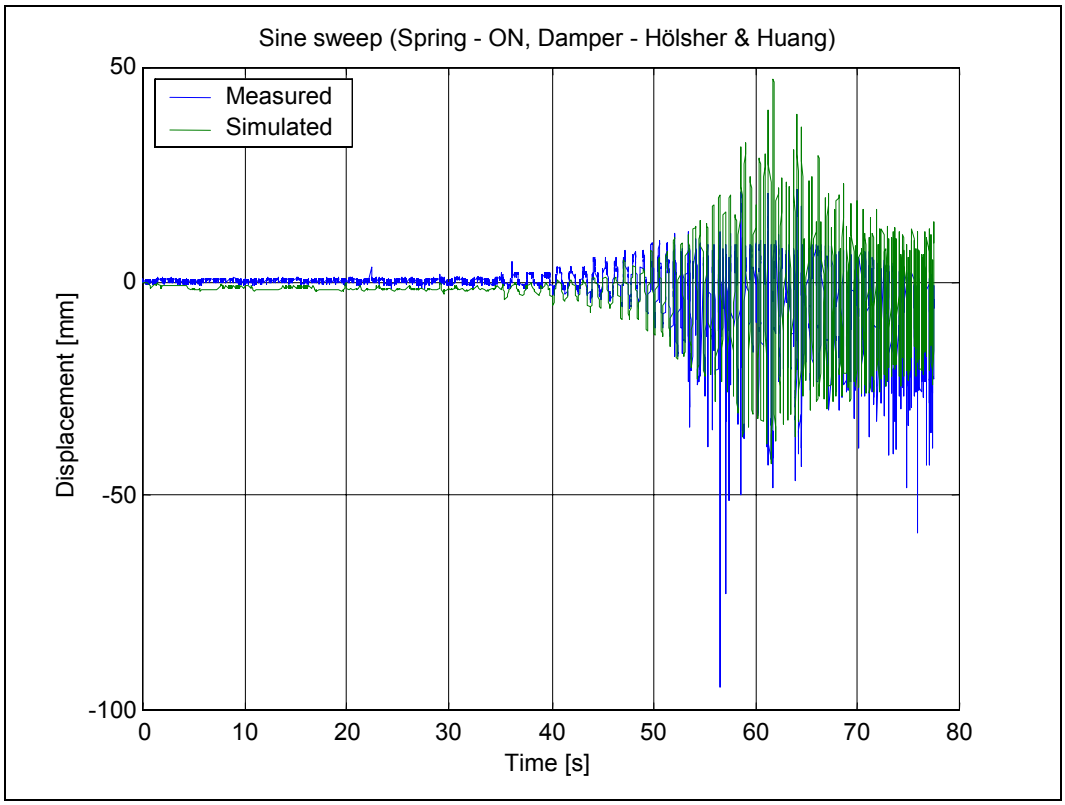

Figure E-36: Sine sweep (Spring - ON, Damper - Hölscher & Huang)

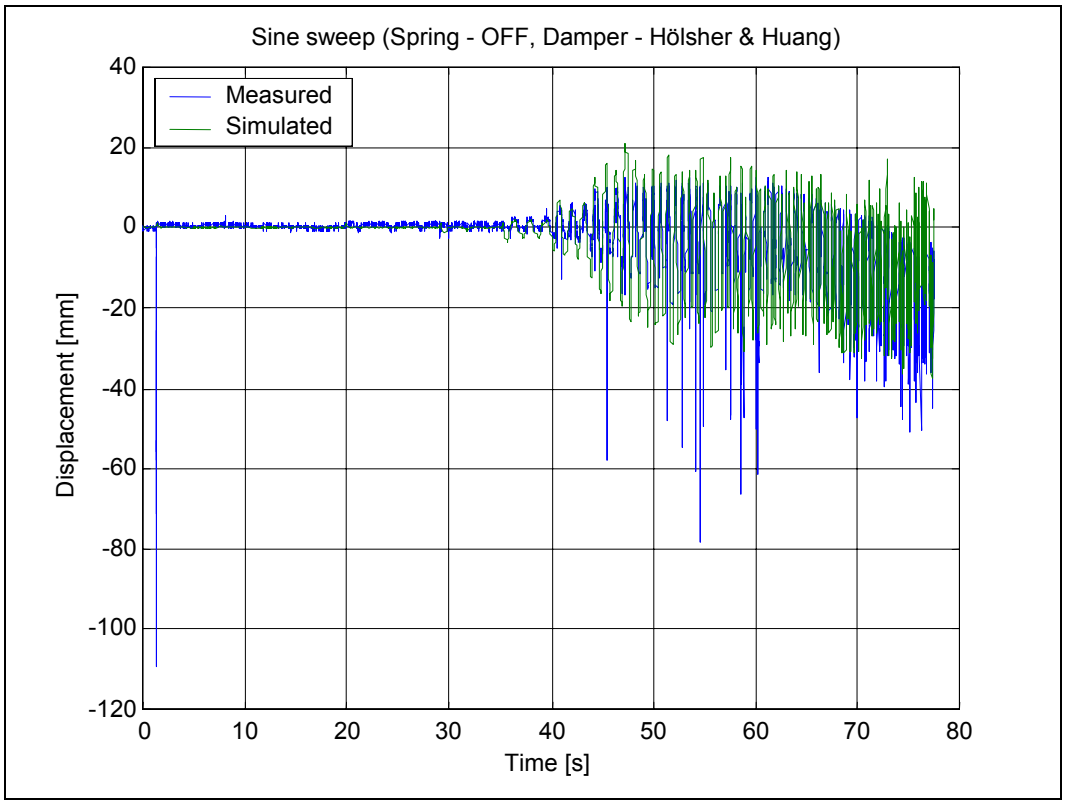

Figure E-37: Sine sweep (Spring - OFF, Damper - Hölscher & Huang)

The transmissibility between the input signal (Schenck displacement) and the sprung mass displacement was determined for the measured, as well as the simulated data. Table E-5 supplies a list of figures and the corresponding spring and damper settings for the transmissibility graphs.

Table E-5: Spring/damper configuration for transmissibility graphs

Figure number	Input	Spring state	Damper state
Figure E-38	Sine sweep (15mm amplitude)	OFF	OFF
Figure E-39	Sine sweep (15mm amplitude)	ON	OFF
Figure E-40	Sine sweep (15mm amplitude)	OFF	ON
Figure E-41	Sine sweep (15mm amplitude)	ON	ON
Figure E-42	Sine sweep (15mm amplitude)	ON	Karnopp
Figure E-43	Sine sweep (15mm amplitude)	OFF	Karnopp
Figure E-44	Sine sweep (15mm amplitude)	ON	Holsher & Huang
Figure E-45	Sine sweep (15mm amplitude)	OFF	Holsher & Huang

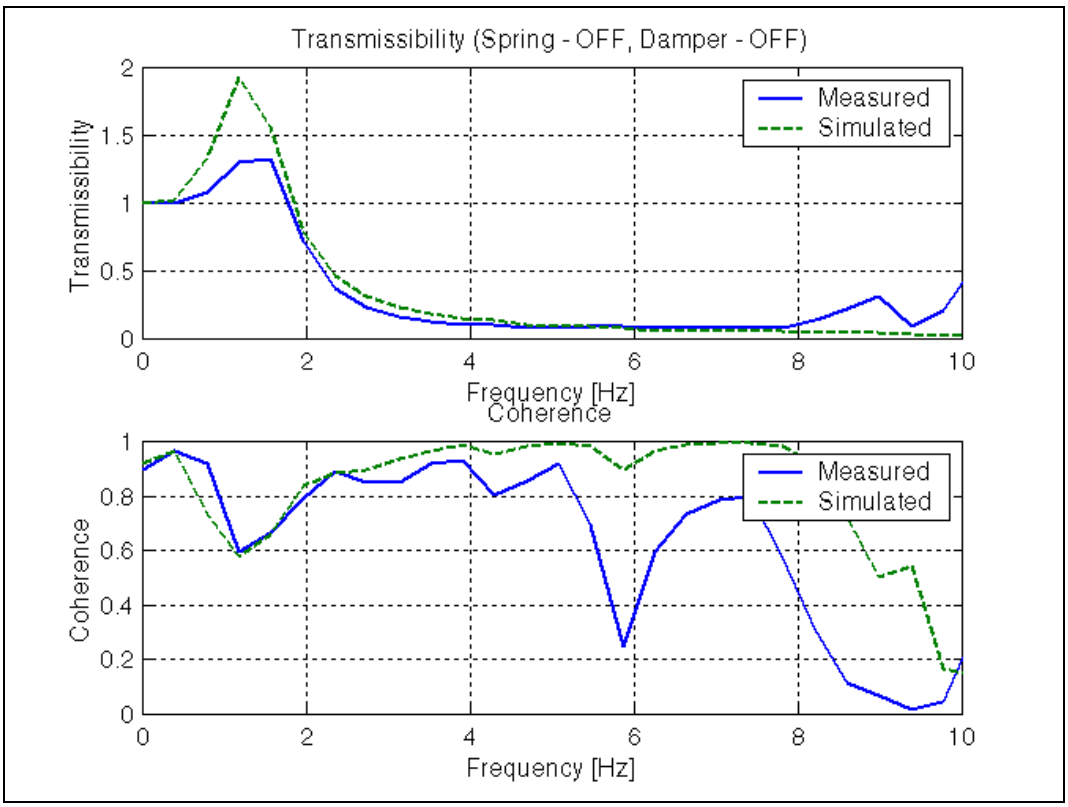

Figure E-38: Transmissibility plot (Spring - OFF, Damper - OFF)

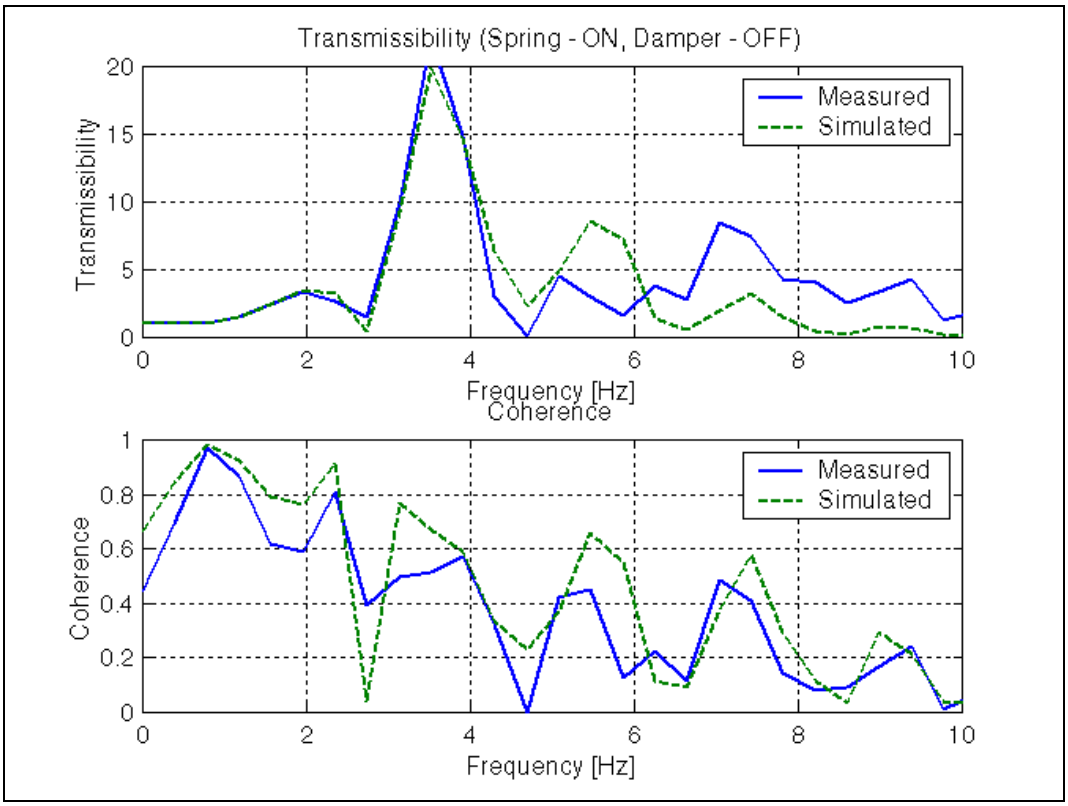

Figure E-39: Transmissibility plot (Spring - ON, Damper - OFF)

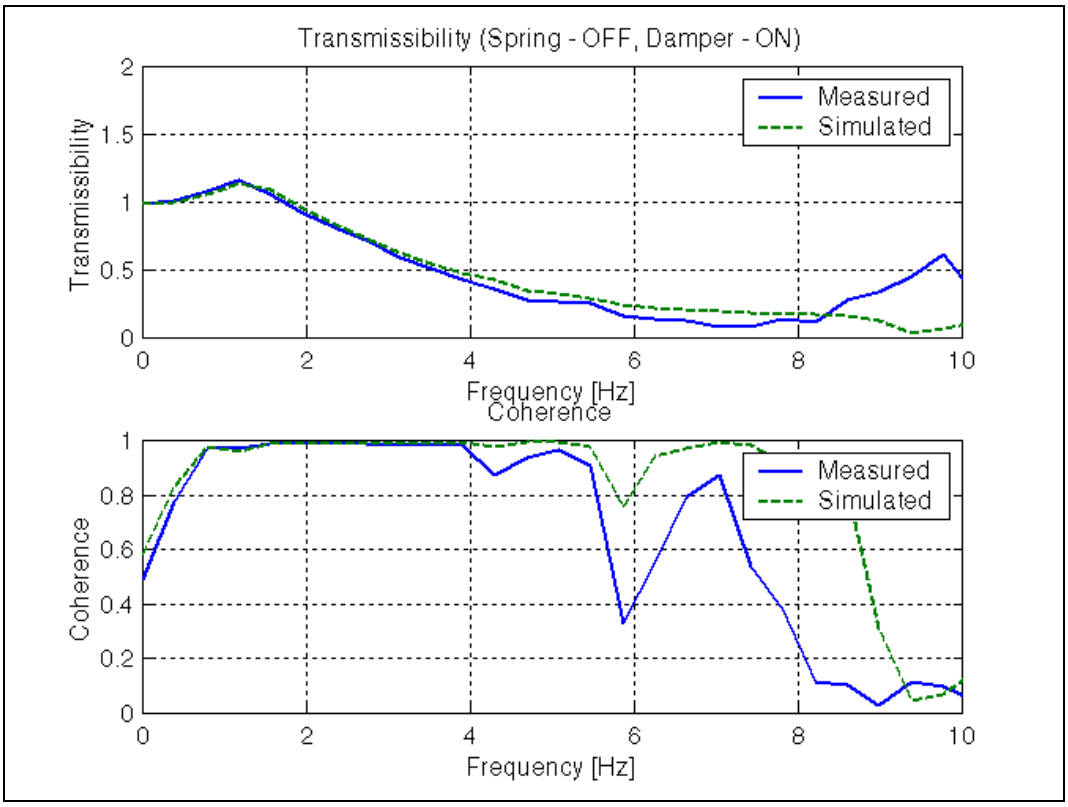

Figure E-40: Transmissibility plot (Spring - OFF, Damper - ON)

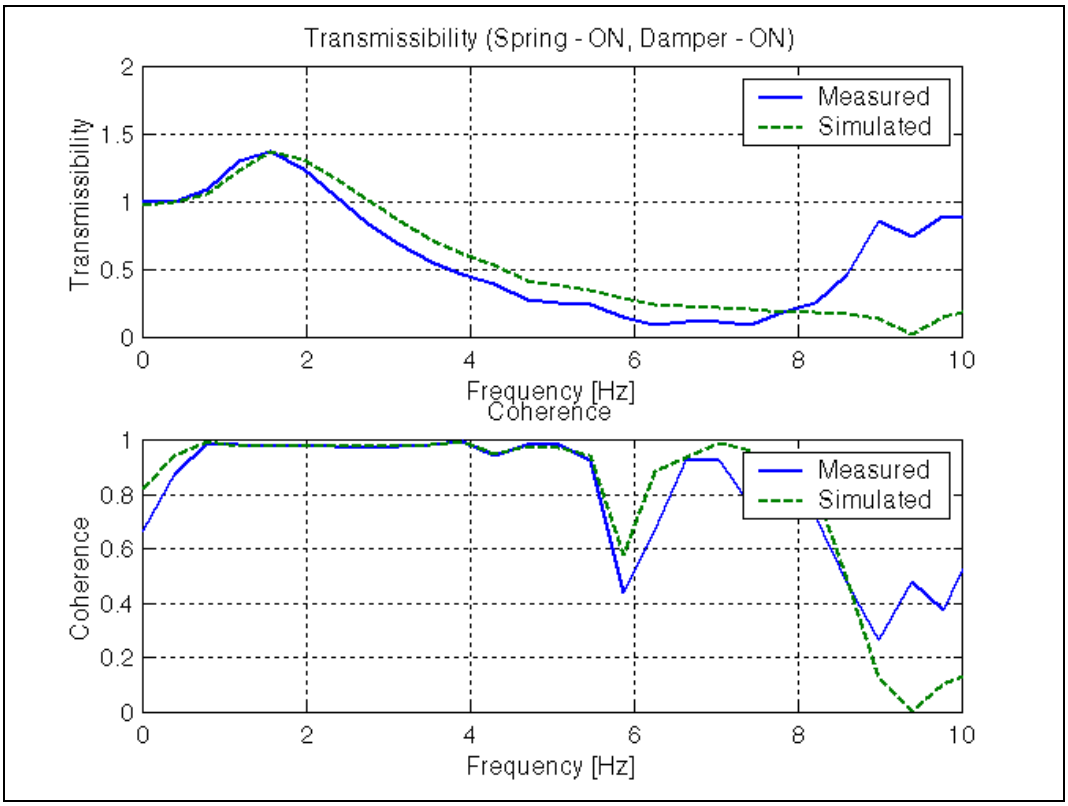

Figure E-41: Transmissibility plot (Spring - ON, Damper - ON)

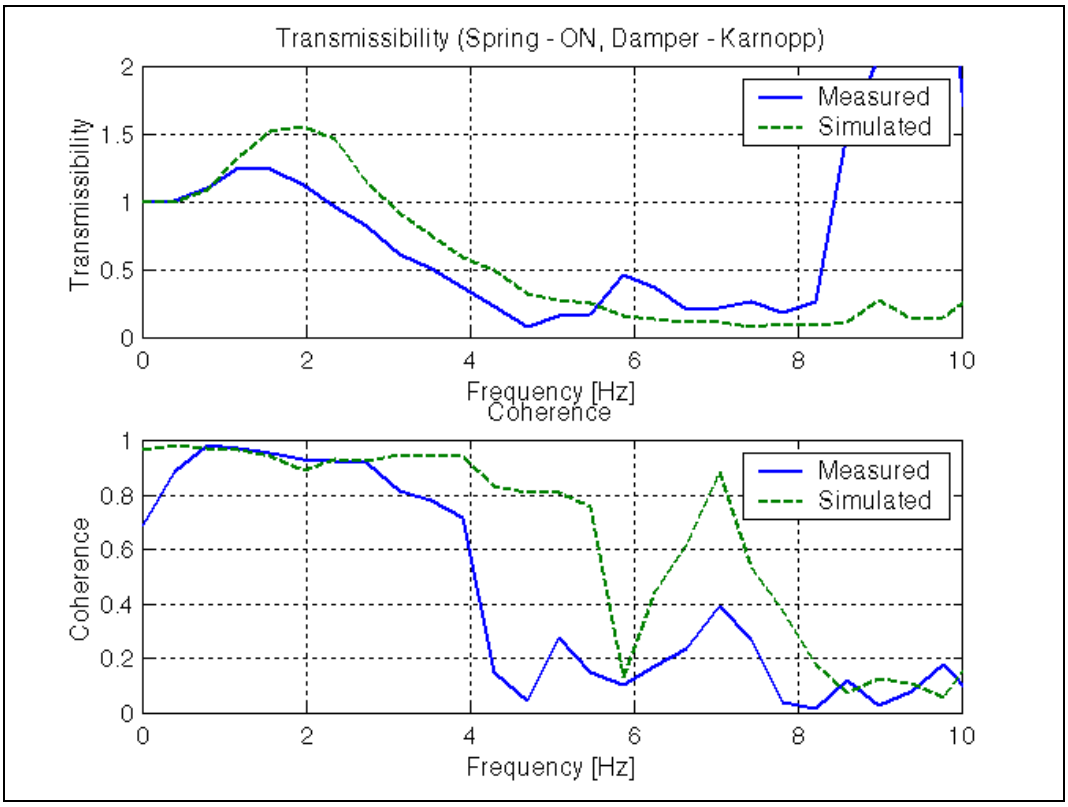

Figure E-42: Transmissibility plot (Spring - ON, Damper - Karnopp)

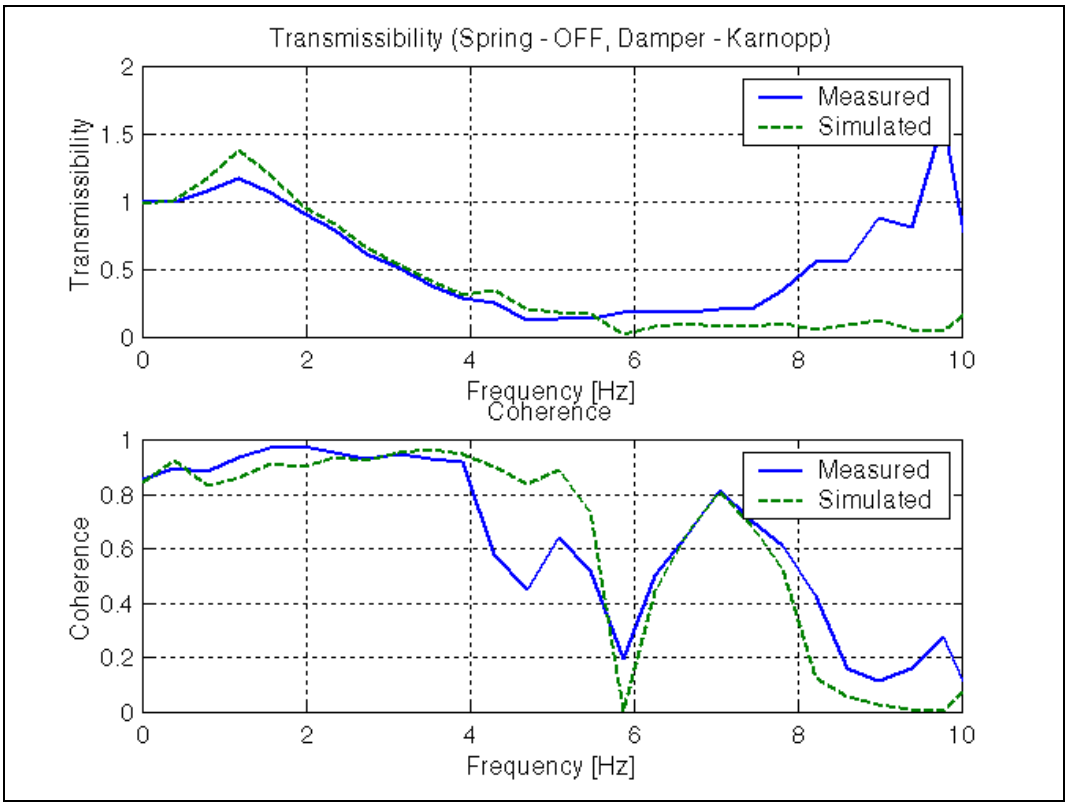

Figure E-43: Transmissibility plot (Spring - OFF, Damper - Karnopp)

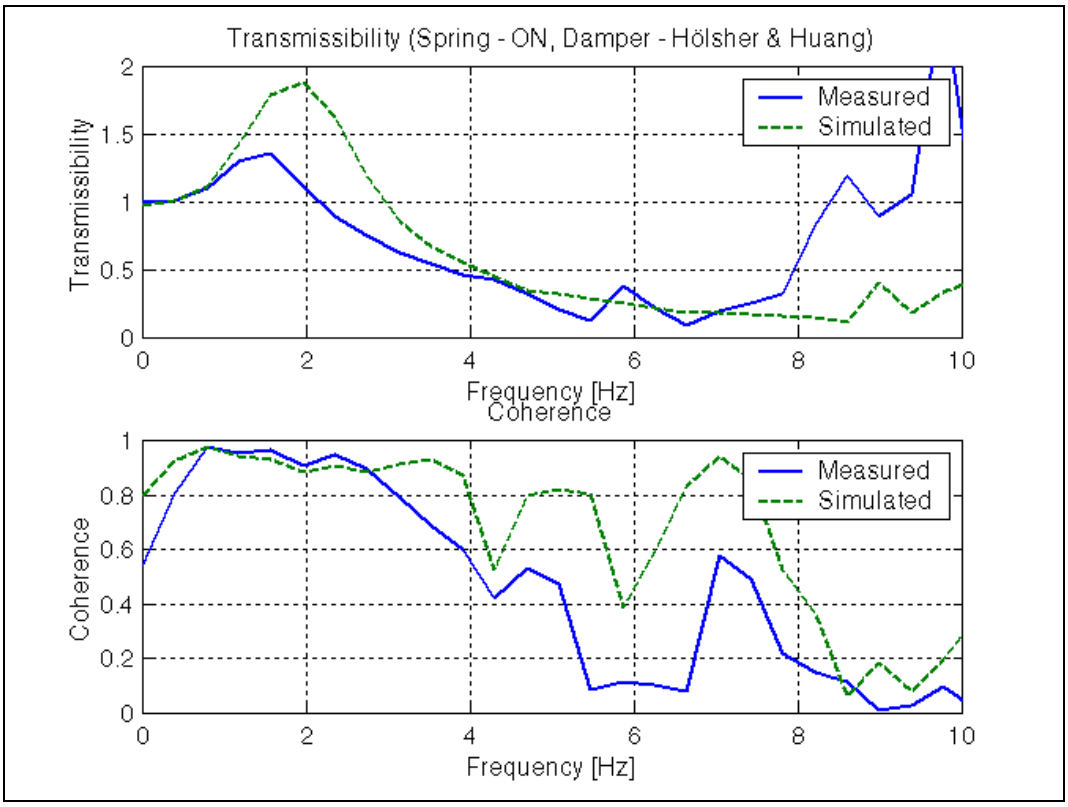

Figure E-44: Transmissibility plot (Spring - ON, Damper - Hölscher & Huang)

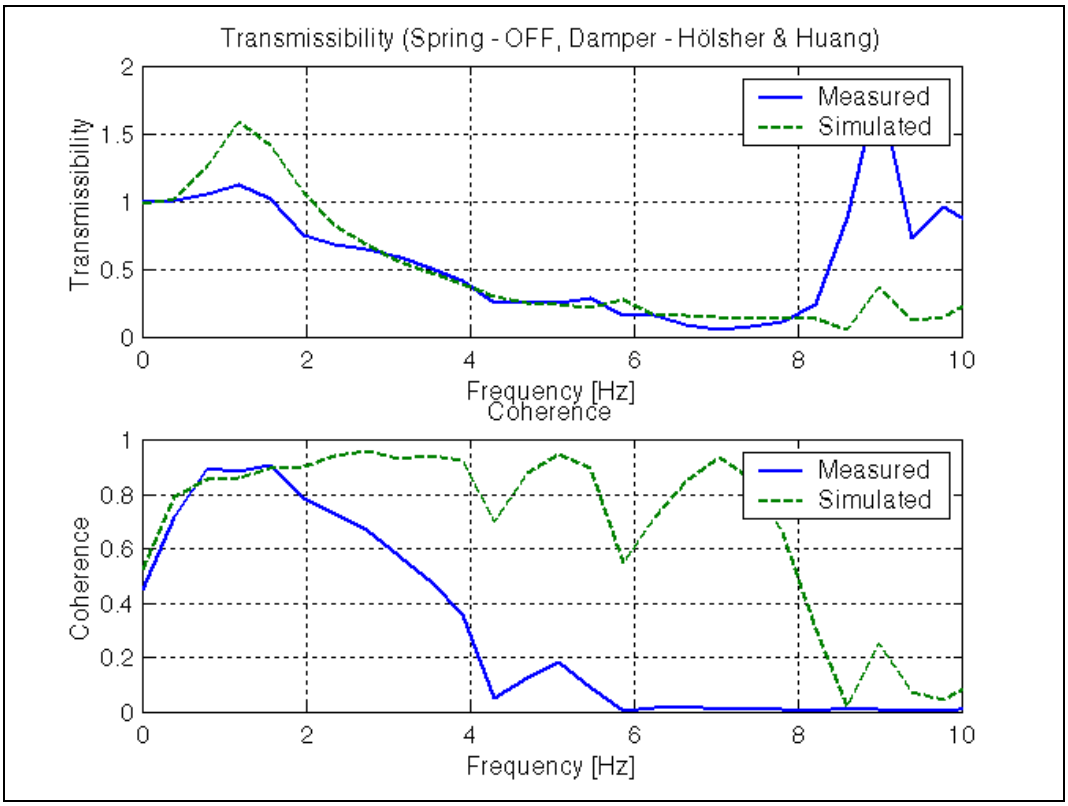

Figure E-45: Transmissibility plot (Spring - OFF, Damper - Hölscher & Huang)