

Conceptual and quantitative categorization of wave-induced flooding impacts for pedestrians and assets in urban beaches

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Supplementary material

Table S1. Oceanic conditions used on the XBeach simulations.

Costa de Caparica				
Storm	Hs (m)	Tp (s)	Direction (°N)	Water level (m)
Hercules	4.53	20.0	270	2.05
Emma	4.15	10.9	270	2.22
Feb2017	4.69	16.5	270	1.21
Praia de Faro				
Storm	Hs (m)	Tp (s)	Direction (°N)	Water level (m)
Hercules, 6 th	1.37	20.5	240	0.95
Hercules, 7 th	1.8	18.6	240	1.08
Emma	5.57	11.9	220	1.75
Elsa	4.35	9.8	230	1.1
Barbara	3.14	8.3	216	1.46
Lola, 24 th , 11:00	2.95	14.7	225	0.51
Lola, 24 th , 12:00	2.96	14.7	225	0.94
Lola, 24 th , 13:00	2.97	14.7	224	1.19
Lola, 24 th , 14:00	2.97	14.7	223	1.2
Lola, 24 th , 15:00	2.95	14.7	223	0.97
Lola, 24 th , 16:00	2.91	14.7	224	0.56
Lola, 25 th , 02:00	2.30	14.7	229	1.46
Lola, 25 th , 12:00	1.97	13.3	228	0.76
Lola, 25 th , 13:00	1.93	13.3	228	1.23
Lola, 25 th , 14:00	1.88	13.3	228	1.47
Lola, 25 th , 15:00	1.83	13.3	228	1.39
Lola, 25 th , 16:00	1.79	13.3	228	1.04

Table S2. Minimum, maximum and mean overtopping discharges and depth velocities at CC and PdF.

Costa de Caparica										
Storm	Profile	Assessment location	q (l/s per m)			Depth velocity (m³/s per m)				
			[Mix – Max]		Mean	[Mix – Max]		Mean		
Hercules	CC1	Crest	3.510	-	5.721	4.549	3.870	-	7.222	4.922
		Buildings at crest	1.893	-	3.820	2.499	1.412	-	3.536	2.057
		Behind seawall	2.734	-	4.955	3.527	1.229	-	4.479	2.308
Hercules	CC2	Crest	0.803	-	3.028	1.460	1.753	-	3.803	2.817
		Buildings at crest	0.464	-	2.114	0.857	0.641	-	2.159	1.356
Emma	CC1	Crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000
		Buildings at crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000
		Behind seawall	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Emma	CC2	Crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000
		Buildings at crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Feb2017	CC1	Crest	0.000	-	0.037	0.010	0.000	-	0.402	0.114
		Buildings at crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000
		Behind seawall	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Feb2017	CC2	Crest	0.000	-	0.007	0.001	0.000	-	0.083	0.017
		Buildings at crest	0.000	-	0.000	0.000	0.000	-	0.000	0.000

Praia de Faro

Storm	Assessment location	q (l/s per m)			Depth velocity (m³/s per m)				
		[Mix – Max]		Mean	[Mix – Max]		Mean		
Hercules, 6 th	Promenade	0.000	-	0.200	0.054	0.010	-	0.490	0.136
	Park/Buildings	0.000	-	0.170	0.036	0.000	-	0.280	0.062
Hercules, 7 th	Promenade	0.010	-	0.710	0.324	0.040	-	0.700	0.466
	Park/Buildings	0.000	-	0.600	0.272	0.000	-	0.410	0.260
Emma	Promenade	12.632	-	16.431	14.765	2.698	-	4.132	3.596
	Park/Buildings	11.449	-	15.140	13.610	2.637	-	4.321	3.554
Elsa	Promenade	0.078	-	0.405	0.199	0.207	-	0.721	0.431
	Park/Buildings	0.051	-	0.349	0.160	0.081	-	0.400	0.229
Barbara	Promenade	0.000	-	0.000	0.000	0.000	-	0.000	0.000
	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Lola, 24 th , 11:00	Promenade	0.000	-	0.000	0.000	0.000	-	0.000	0.000
	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Lola, 24 th , 12:00	Promenade	0.060	-	0.201	0.141	0.156	-	0.586	0.342
	Park/Buildings	0.009	-	0.157	0.101	0.022	-	0.352	0.164
Lola, 24 th , 13:00	Promenade	0.069	-	1.524	0.770	0.176	-	1.633	0.964
	Park/Buildings	0.539	-	1.333	0.844	0.055	-	1.044	0.585
Lola, 24 th , 14:00	Promenade	0.244	-	1.209	0.625	0.341	-	1.149	0.754
	Park/Buildings	0.136	-	1.076	0.486	0.146	-	0.805	0.409
Lola, 24 th , 15:00	Promenade	0.000	-	0.225	0.066	0.000	-	0.352	0.122
	Park/Buildings	0.000	-	0.173	0.045	0.000	-	0.195	0.053
Lola, 24 th , 16:00	Promenade	0.000	-	0.000	0.000	0.000	-	0.000	0.000
	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Lola, 25 th , 02:00	Promenade	1.031	-	1.934	1.553	0.649	-	2.339	1.163
	Park/Buildings	0.842	-	1.665	1.323	0.374	-	1.850	0.798
Lola, 25 th , 12:00	Promenade	0.000	-	0.000	0.000	0.000	-	0.000	0.000

	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Lola, 25 th , 13:00	Promenade	0.000	-	0.067	0.013	0.000	-	0.116	0.023
	Park/Buildings	0.000	-	0.033	0.007	0.000	-	0.028	0.006
Lola, 25 th , 14:00	Promenade	0.038	-	0.365	0.153	0.111	-	0.435	0.285
	Park/Buildings	0.016	-	0.275	0.104	0.028	-	0.229	0.135
Lola, 25 th , 15:00	Promenade	0.000	-	0.002	0.000	0.000	-	0.007	0.001
	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000
Lola, 25 th , 16:00	Promenade	0.000	-	0.000	0.000	0.000	-	0.000	0.000
	Park/Buildings	0.000	-	0.000	0.000	0.000	-	0.000	0.000

Table S3. Adapted from CEM, HIDRALERTA and EurOtop 2018. Mean discharge limits in l/s per m.

Aware pedestrians at the seawall crest/promenade								
CEM				HIDRALERTA (based on EurOtop 2007)				EurOtop 2018
<i>Not uncomfortable</i>	<i>Uncomfortable</i>	<i>Dangerous</i>	<i>Very dangerous</i>	<i>No injuries</i>	<i>Single minor injury</i>	<i>Multiple minor injuries</i>	<i>Serious injuries or fatalities</i>	<i>Not tolerable</i>
<0.004	[0.004 - 0.03[	[0.03 - 1[	≥ 1	<0.1	[0.1 - 0.3[	[0.3 - 1.0[	≥ 1	> 0.3 / 1 / 10*
Urban components & buildings								
CEM			HIDRALERTA (based on EurOtop 2007)				EurOtop 2018	
No damage	Minor damage	Structural damage	<i>No damage</i>	<i>Minor damage</i>	<i>Non-structural moderate damage</i>	<i>Serious structural damage</i>	<i>Non-tolerable</i>	
<0.001	[0.001 - 0.03[	≥ 0.03	<0.1	[0.1 - 0.4[	[0.4 - 1.0[	≥ 1	≥ 1	
Unaware pedestrians behind the seawall crest/promenade								
CEM				HIDRALERTA				EurOtop 2018
<i>Not uncomfortable</i>	<i>Uncomfortable</i>	<i>Dangerous</i>	<i>Very dangerous</i>	<i>No injuries</i>	<i>Single minor injury</i>	<i>Multiple minor injuries</i>	<i>Serious injuries or fatalities</i>	<i>Not tolerable</i>
<0.004	[0.004 - 0.03[	[0.03 - 1[	≥1	<0.03	[0.03 - 0.09[	[0.09 - 0.3[	≥0.3	> 0.3 / 1 / 10*
Vehicles (low speed)								
CEM			HIDRALERTA (low speed)				EurOtop 2018	
Safe at all speeds	Unsafe at any speed and when parked		<i>No damage</i>	<i>Minor damage</i>	Serius damage	Extreme damage	<i>Non-tolerable</i>	
<0.001	≥0.02		< 10	[10 - 25 [	[25 - 50 [	≥50	≥ 5 / 10 / 75*	

* Values corresponding to sea states with $H_{m0} \geq 3 \text{ m} / 2 \text{ m} \leq H_{m0} < 3 \text{ m} / 1 \text{ m} \leq H_{m0} < 2 \text{ m}$

Table S4. Depth velocity in m³/s per m adapted from FLOODsite

Pedestrians			
Low caution	Vulnerable people (e.g. children and the elderly)	Highly dangerous for most	Extremely dangerous for all
<0.25	[0.25 - 0.50[	[0.5 - 1.1[	≥1.1
Vehicles			
Low caution	Unstable		Stall and unstable
<0.25	[0.25 - 0.50[		≥0.5
Buildings			
Unlikely structural damage	Possible structural damage		Serious structural damage/Building collapsing
<1.1	[1.1 - 7[		≥7

