



**EN 1177:2018**
**IMPACT ATTENUATING PLAYGROUND SURFACING – DETERMINATION OF CRITICAL FALL HEIGHT**
**FIBRE FREE RUBBER PLAY CHIPPINGS**

CLIENT	Nationwide Bark & Play Surfacing LLP
CLIENT ADDRESS	The Manor Suite, Lulworth House, 51 High Street, Cheadle, Stoke-On-Trent, Staffordshire, ST10 1AR
CLIENT CONTACT	Matt Burrows (Director)

REPORT NUMBER	LSUK.22-0279-A1	
REPORT STATUS	Final	
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REPORTED BY		David Rigby Technical Director
APPROVED BY		Professor David James Managing Director

SUMMARY OF REPORT / FINDINGS	<p>In accordance with EN 1177:2018 test specimen(s) of impact attenuating material were struck by an instrumented headform in a defined series of impacts from different drop heights. The signals emitted by an accelerometer in the headform during each impact were processed to yield a severity from the measured impact energy, defined as head injury criterion (HIC) and peak acceleration (<math>g_{max}</math>).</p> <p>The HIC and <math>g_{max}</math> of each impact was plotted and the critical fall height was determined as the lowest drop height producing a HIC value of 1,000 or a <math>g_{max}</math> value of 200.</p> <p>The test specimen(s) submitted met the requirements of EN 1177:2018 when tested under laboratory conditions on the 20/04/2022.</p>
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SCOPE OF TESTING / PROJECT

EN 1177:2018 specifies a method for determining the impact attenuation of playground surfacing. It defines a "Critical Fall Height" for surfacing, which represents the upper limit of its effectiveness in reducing injury when using playground equipment conforming to EN 1176. It is based on the safety principles given in EN 1176-1 for playground equipment and provides a method for the assessment of impact attenuation of surfaces intended for use in the impact area as defined in EN 1176-1.

Surfaces fulfilling the test requirements of EN 1177:2018 are considered to be in compliance with the requirements for impact attenuation in EN 1176-1.

Injuries arise during the use of playground equipment for a variety of reasons and the great majority are minor. Even the presence of protection features like impact attenuating surfacing is known to affect the behaviour of children, as well as carers and play providers, which in turn can affect the risk. The majority of more serious injuries are attributable to falls and there are many factors that influence injury mechanisms during a fall that are independent of the surfacing, e.g. body orientation, awkwardness of fall, bone density, etc.

The most severe injuries are likely to be injuries to the head. Recent research has indicated that arm and leg injuries are more frequent and could be influenced by the duration of the acceleration pulse. The committee responsible for EN 1177 maintains a constant review of research in this area for possible use in a future revision of the standard. The committee recognizes that there is a relationship between the risk of arm and leg injuries and surface type but takes the view that such injuries are not usually in the most severe category. At present the available injury data can be taken into account by limitation of the maximum (peak) acceleration.

Consequently, the committee has chosen to make its priority the reduction of the likelihood of serious head injuries caused by a fall from playground equipment, because even though such injuries are relatively uncommon, they can have the most severe consequences. The severity of injury resulting from an impact to the head can be quantified in terms of Head Injury Criterion (HIC) and the level of HIC = 1,000 together with the upper limit of the peak acceleration of  $g_{max} = 200g$  have been chosen as the upper limits for surfacing when assessed in accordance with EN 1177.

Limiting the HIC value at a maximum of 1,000 is equivalent to a 3% chance of a critical head injury (MAIS 5), an 18% probability of a severe head injury (MAIS 4), a 55% probability of a serious head injury (MAIS 3), a 89% probability of a moderate head injury (MAIS 2), and a 99.5% chance of a minor head injury (MAIS 1), to an average male adult. Limiting  $g_{max}$  to a maximum of 200g as well as limiting HIC to a maximum of 1,000 takes account of impacts of very short duration and follows the current research on arm injuries as a means of improvement to EN 1177.

The Maximum Abbreviated Injury Scale (MAIS), was first developed by the Association for the Advancement of Automotive Medicine and is used extensively in the automotive industry as an indicator of the severity of head related injuries.

TEST PROCEDURE / STANDARDS	<p>EN 1177:2018 – Impact attenuating playground surfacing – Determination of critical fall height</p> <p>EN 1176-1:2017 – Playground equipment and surfacing – Part 1: General safety requirements and test methods</p> <p>EN 933-1:2012 – Tests for geometrical properties of aggregates – Part 1: Determination of particle size distribution – Sieving method</p> <p>EN ISO/IEC 17025:2017 – General requirements for the competence of testing and calibration laboratories</p>
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PRODUCT (DETAILS / DESCRIPTION)	<p>Impact attenuating surfacing referred to as “Fibre Free Rubber Play Chippings” at depths of 50mm, 75mm and 100mm.</p> <p>Pure rubber chip derived from recycled agricultural tyres with a nominal particle size of 10-30mm.</p> <p>This information was supplied by the client.</p>
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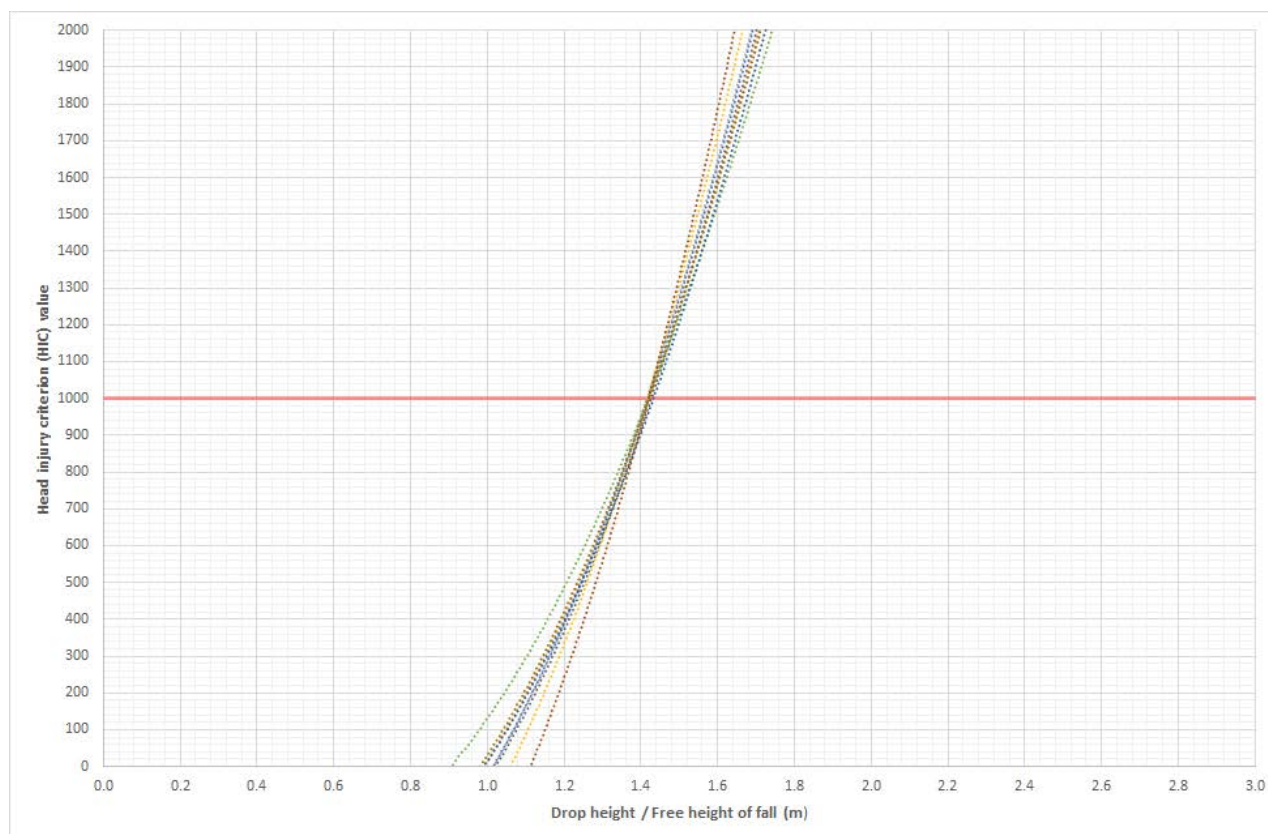
TEST CONDITIONS	<p>The test specimen(s) were tested at <math>23 \pm 2^{\circ}\text{C}</math> and <math>50 \pm 10\%</math> relative humidity and conditioned for a minimum of 24 hours prior to testing commencement.</p> <p>The test specimen(s) had a surface temperature of <math>21.6^{\circ}\text{C}</math> at the commencement of testing.</p> <p>All tests were carried out loose laid on a flat, rigid concrete, or equivalent substrate of sufficient mass, density and thickness that its deformation during the test made no significant contribution to the test result.</p> <p>For testing of particulate material, a test frame without a base was used, with internal dimensions of 1m x 1m.</p> <p>For products intended to be laid over another layer, the entire system, surfacing with under layer(s) was tested. This is classed as a composite product.</p>
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TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES									
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## Fibre Free Rubber Play Chippings at 50mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	1.41
0.00	0	0	0	0	0	0	0	0	0		
1.30	685	681	694	669	756	652	621	688	668	Yes	
1.40	856	858	806	915	853	870	785	779	930	Yes	
1.45	1134	1181	1122	1077	1088	1058	1159	1110	1085	Yes	
1.50	1248	1271	1374	1301	1266	1218	1365	1276	1249	Yes	
CFH (m)	1.42	1.41	1.41	1.42	1.42	1.43	1.42	1.42	1.42	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.

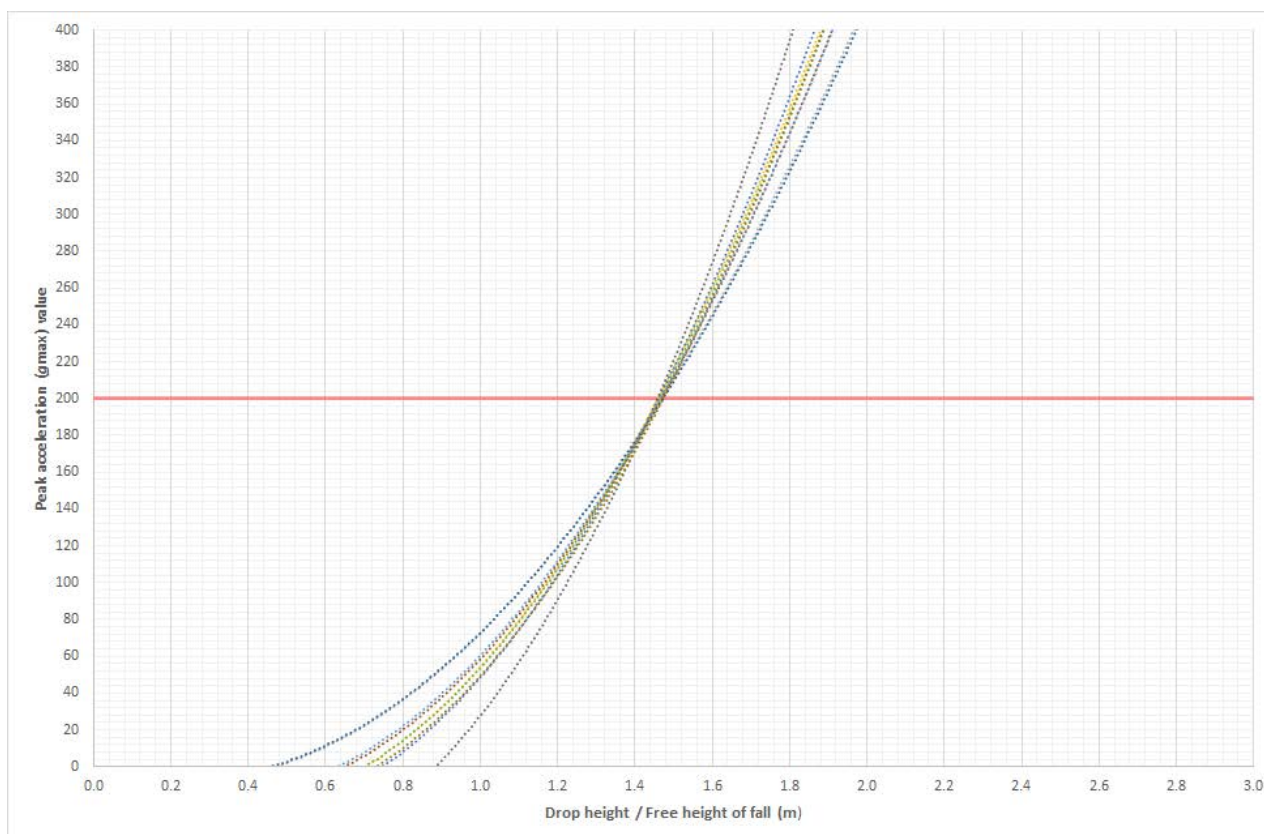


TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES									
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## Fibre Free Rubber Play Chippings at 50mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	1.45
0.00	0	0	0	0	0	0	0	0	0		
1.30	151	144	145	140	140	153	143	135	141	Yes	
1.40	164	163	157	171	160	165	156	155	173	Yes	
1.45	206	212	206	201	203	204	209	204	205	Yes	
1.50	208	212	218	212	210	209	220	210	207	Yes	
CFH (m)	1.46	1.45	1.45	1.46	1.46	1.46	1.45	1.46	1.46	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.



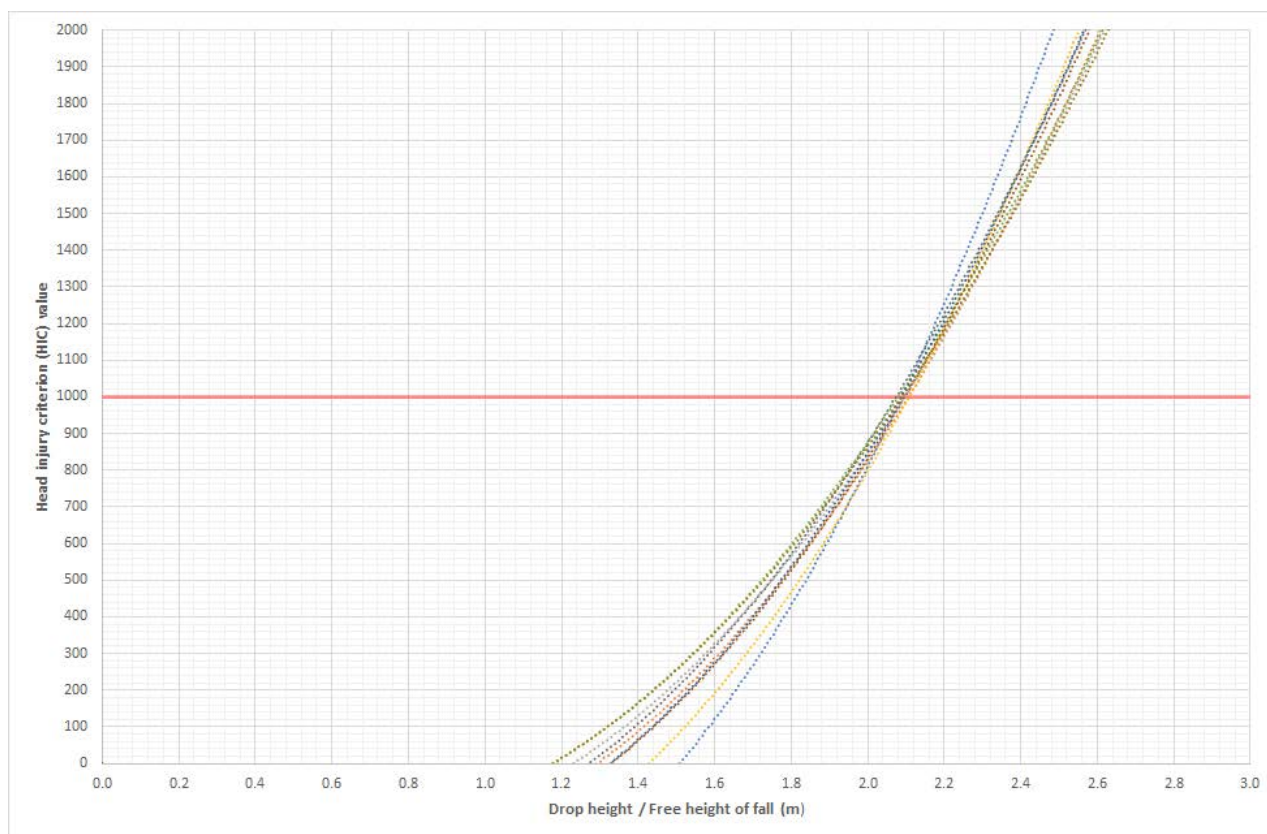
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TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND HEAD INJURY CRITERION (HIC) VALUES									
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## Fibre Free Rubber Play Chippings at 75mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	<b>2.07</b>
0.00	0	0	0	0	0	0	0	0	0		
1.90	687	753	672	640	760	696	703	736	729	Yes	
2.05	883	823	804	903	894	939	878	928	926	Yes	
2.15	1065	1102	1086	1033	1134	1049	1058	1124	1095	Yes	
2.20	1183	1211	1223	1346	1211	1261	1240	1250	1189	Yes	
CFH (m)	2.10	2.09	2.10	2.08	2.08	2.08	2.09	2.07	2.08	Yes	

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.



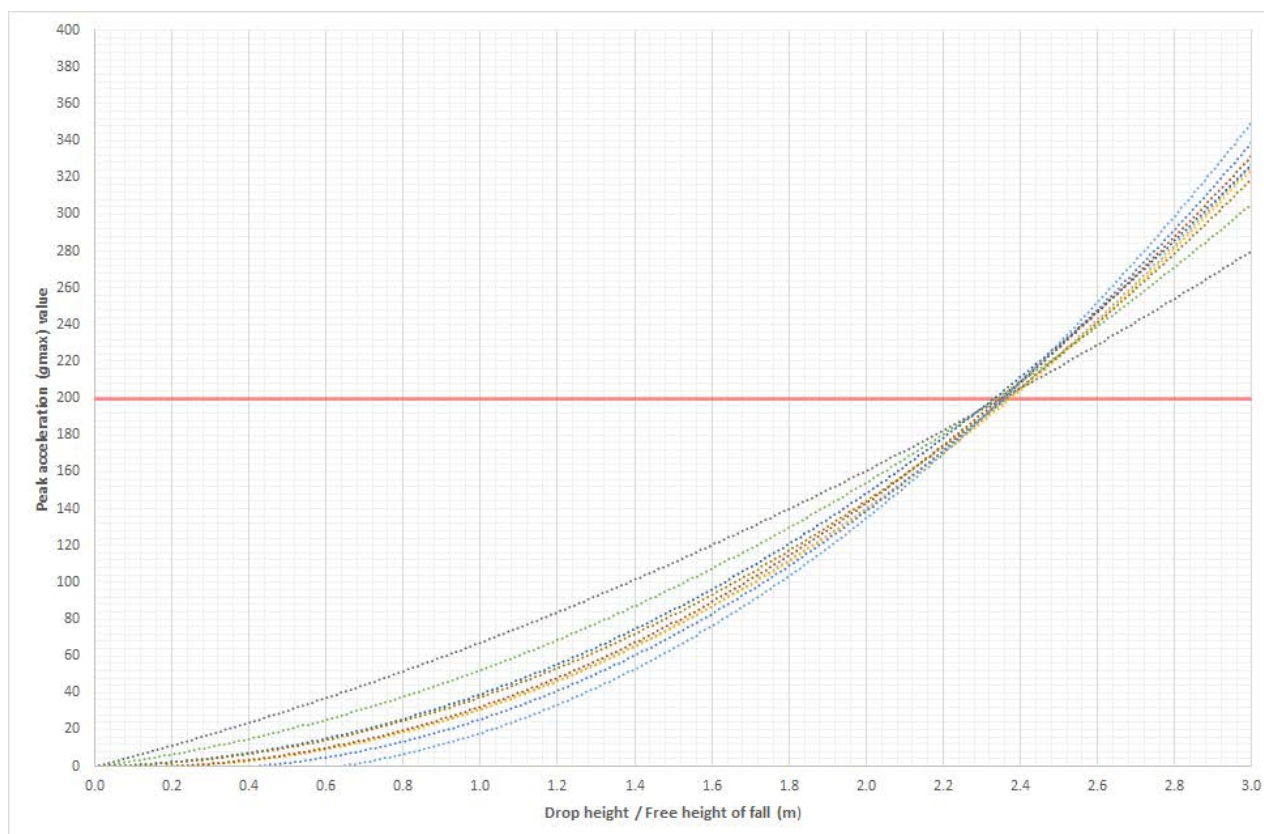


TEST RESULTS	CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES									
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## Fibre Free Rubber Play Chippings at 75mm

Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	<b>2.33</b>
0.00	0	0	0	0	0	0	0	0	0		
2.15	157	151	162	165	163	166	170	158	155	Yes	
2.20	179	183	172	192	188	173	192	184	177	Yes	
2.40	204	204	211	205	210	215	201	203	208	Yes	
2.50	224	221	226	225	229	224	219	224	230	Yes	
CFH (m)	2.36	2.37	2.35	2.33	2.33	2.34	2.35	2.36	2.35	Yes	

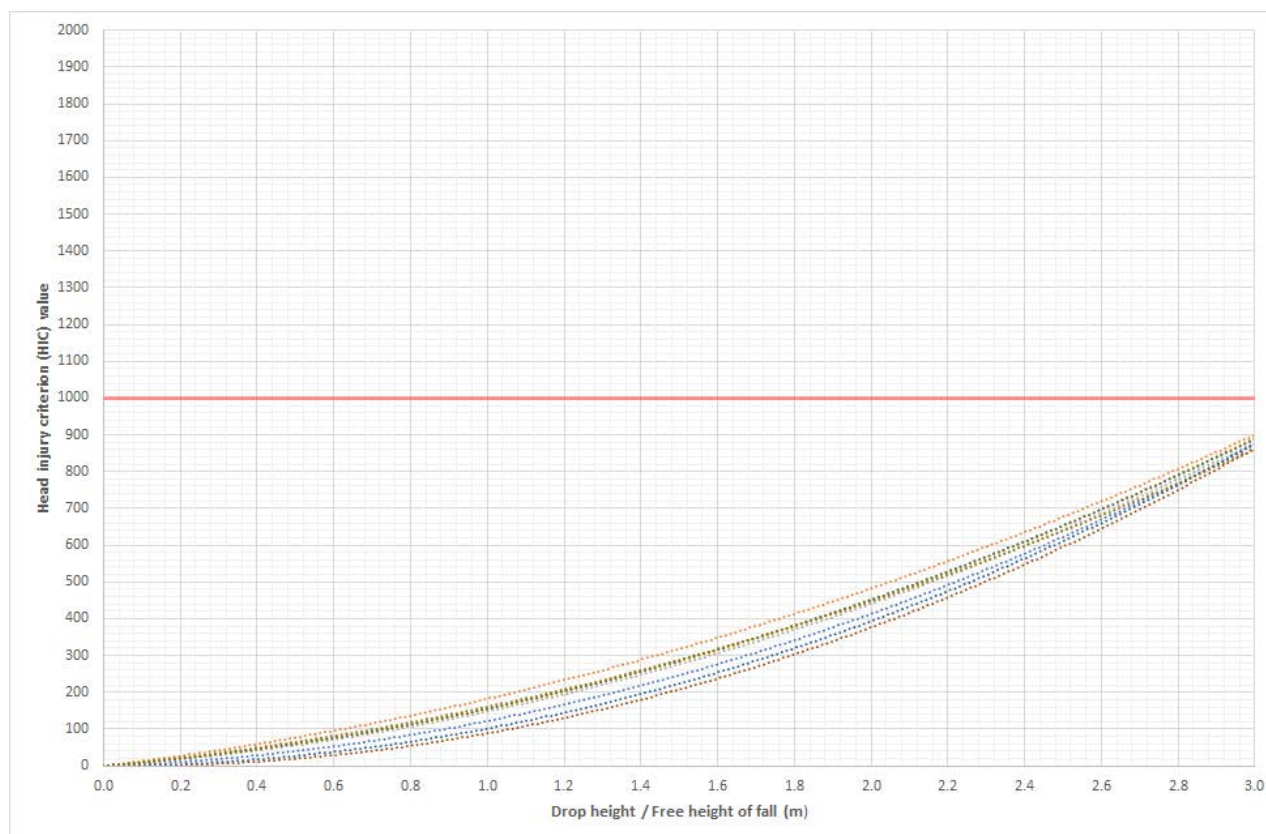
These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.



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Test Results	Critical Fall Height (CFH) and Head Injury Criterion (HIC) Values										
Fibre Free Rubber Play Chippings at 100mm											
Drop height (m)	Test position									Delta T	Lowest CFH (m)
	1	2	3	4	5	6	7	8	9	≥3ms	>3.00
0.00	0	0	0	0	0	0	0	0	0		
2.20	570	493	497	486	538	483	459	502	508	Yes	
2.40	617	645	651	616	591	554	547	649	575	Yes	
2.70	769	703	738	664	755	714	698	734	794	Yes	
3.00	901	886	887	897	886	878	864	888	827	Yes	
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes	

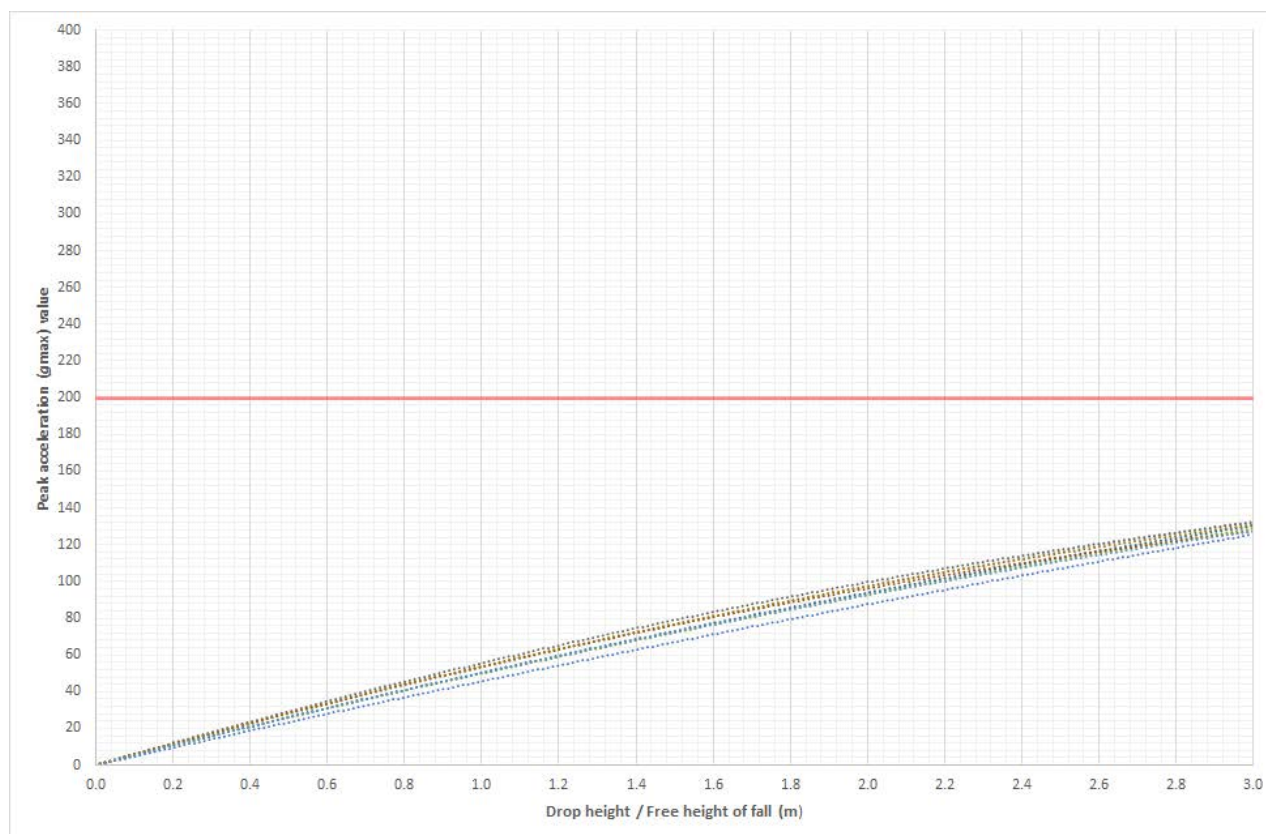
These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.





TEST RESULTS		CRITICAL FALL HEIGHT (CFH) AND PEAK ACCELERATION (GMAX) VALUES										
Fibre Free Rubber Play Chippings at 100mm												
Drop height (m)	Test position									Delta T	Lowest CFH (m)	
	1	2	3	4	5	6	7	8	9	≥3ms	>3.00	
0.00	0	0	0	0	0	0	0	0	0			
2.20	107	102	94	100	104	99	17	101	101			Yes
2.40	113	105	106	112	108	115	114	117	107			Yes
2.70	119	120	113	114	118	120	124	122	117			Yes
3.00	135	128	126	131	132	126	132	130	128	Yes		
CFH (m)	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	>3.00	Yes		

These results are only valid for impact events with a HIC duration (Delta T) of more than 3 ms, i.e.  $(t_2 - t_1) \geq 3$  ms.



## DISCUSSION

The test specimen(s) submitted were found to have critical fall height values of:

**Fibre Free Rubber Play Chippings at 50mm**      **1.41m**  
**Fibre Free Rubber Play Chippings at 75mm**      **2.07m**  
**Fibre Free Rubber Play Chippings at 100mm**      **>3.00m**

The maximum Free Height of Fall (FHF) on playground equipment conforming with EN 1176-1 is 3m (see EN 1176-1:2017, 4.2.8.1).

## CONCLUSIONS

The test specimen(s) submitted met the requirements of EN 1177:2018 when tested under laboratory conditions.

All measurements were conducted with an uncertainty of  $\pm 7\%$ . This uncertainty is based on the findings of a round robin test conducted by CEN in 2011.

The results relate only to the test specimen(s) received and tested.

## APPENDIX A

Diagram showing all test positions

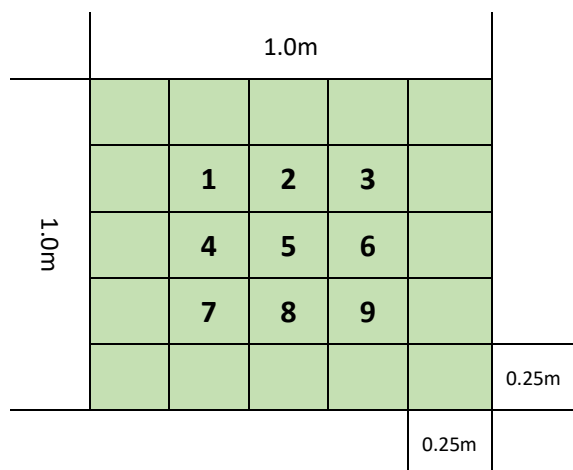
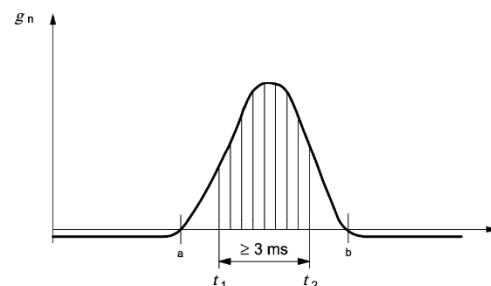


Diagram not to scale

Example of time / acceleration curve



**Key**  
 $g_n$  acceleration  
 $t$  time  
 $a$   $t_{start}$   
 $b$   $t_{end}$

Product photograph

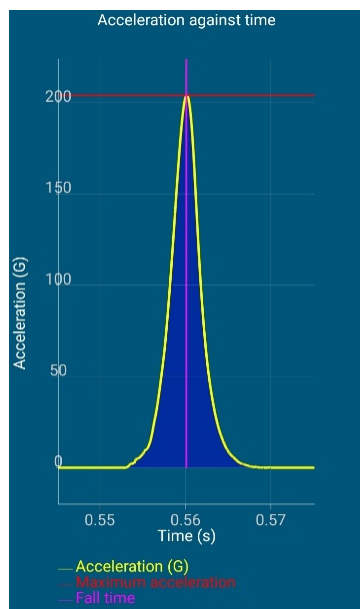


Product photograph

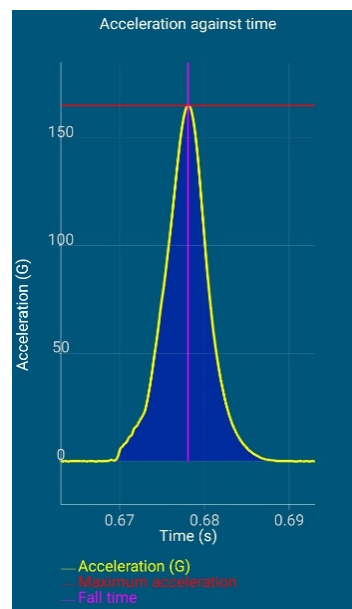


## APPENDIX B

Time / acceleration curve – At 50mm depth



Time / acceleration curve – At 75mm depth



Time / acceleration curve – At 100mm depth

