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Playground Safety Surface Test Report for The Hills Bark Blower

“Playbark” Playground Undersurfacing Products

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1.0 Executive Summary

The Hills Bark Blower supply two pine bark products for use as a loose-fill material for playground undersurfacing. In each case, the “*Playbark*” pine bark materials are produced from raw pine bark pieces (stripped from slash pine logs) that are passed through a tub grinder. The resulting material is then screened through a trommel process into consistent size gradings. The average pine bark particle size for the “*15mm Playbark*” product (sourced from Queensland) is observed to be approximately between 20mm×15mm×2mm and 15mm×15mm×2mm. The average pine bark particle size for the “*10mm Playbark*” product (sourced from Tumut, NSW) is observed to be approximately between 15mm×10mm×4mm and 10mm×10mm×3mm.

Impact absorption testing was performed on the two loose-fill material samples when in both in a dry condition and when they had been completely wet with water. The assessment of the supplied materials to the impact testing procedure detailed in AS/NZS 4422:1996 resulted with the critical fall heights outlined in Table 1.

Product	Material Condition	Critical Fall Height (m)
“Playbark - 15mm”	Dry	3.1
	Wet	3.6
“Playbark - 10mm”	Dry	3.2
	Wet	3.8

Table 1: Critical Fall Heights for the product tested.

The critical fall heights for the materials tested at a test depth of 200mm were each determined to be lower for the dry test than for the wet test. The lesser critical fall height value between both the dry and wet test cases are to be quoted for each material, as the products are most likely to be used outdoors with no protection from drying due to variations in weather conditions.

The critical fall height for the “*Playbark - 15mm*” product is 3.1m.

The critical fall height for the “*Playbark - 10mm*” product is 3.2m.

The testing of the samples to AS/NZS 4422:1996 yielded the recommendations for installation depths shown in Table 2.

Product	Property	Dry Condition (Uncompressed) (mm)	Wet Condition (Uncompressed) (mm)
“Playbark - 15mm”	Test Depth	200	200
	Material Allowance	115	105
	Depth to be Installed: +20% for Heavy Traffic Areas	315 380	305 365
“Playbark - 10mm”	Test Depth	200	200
	Material Allowance	125	95
	Depth to be Installed: +20% for Heavy Traffic Areas	325 390	295 355

Table 2: Material depths to be installed (in mm) for the product tested.

If either “*Playbark*” product is to be used in a dry and wet condition (i.e. installed outdoors) then each product shall be installed according to the depths shown in the unshaded “*Dry Condition*” column of Table 2.

The material allowance was determined to be greater for the dry condition cases than it was for the wet condition cases. Therefore, **the recommended installation depth for the “*Playbark - 15mm*” material is 315mm.** However, a depth of 380mm is to be used in heavy traffic areas.

The recommended installation depth for the “*Playbark - 10mm*” material is 325mm. However, a depth of 390mm is to be used in heavy traffic areas.

Important Notes:

Slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the present "*Playbark - 15mm*" test sample, the occasional presence of sharp-tipped long slender wood particles (up to an approximate size of: 135mm×9mm×3mm) were observed at the time of testing. For the "*Playbark - 10mm*" test sample, similar particles of approximate size: 72mm×4mm×2mm were observed.

Small amounts of fine wood dust particles present in the dry samples for both materials tested, and were observed to become momentarily airborne when disturbed during handling in each case. People who use or handle this product when it is in a dry condition risk inhaling these airborne fine wood dust particles.

2.0 Introduction

The impact absorption properties of both the “*Playbark – 15mm*” and the “*Playbark - 10mm*” materials supplied by The Hills Bark Blower were measured according to the impact testing procedure specified in the Australian Standard AS/NZS 4422:1996.

The testing procedures involved dropping an aluminium headform from a measured height and recording the deceleration of the headform as it struck the test sample. The severity of the impact was then measured and ranked in terms of the Head Injury Criterion (HIC).

The material samples were tested in both a “dry” and a “wet” test condition. The “dry” condition pine bark sample was obtained by placing the sample onto a series of flat trays inside a heated enclosure (approximately 40°C+) for a period of 24 hours or more. The “wet” condition sample was obtained by thoroughly soaking the test material, then allowing it to drain for a period of one hour. The impact testing was then carried out on the wet sample within eight hours of it being drained. If testing was not completed within this time, then the soaking procedure was repeated.

The Australian Standard AS/NZS 4422:1996 concentrates on a method for the measurement of HIC, which indicates the deceleration impact on the brain. It does not indicate injury potential to other parts of the body. The HIC values set in the standard are those, which if exceeded, are *likely* to result in injury to the brain. It should be noted that although the standard stipulates that the HIC value of 1000 will determine the critical fall height; this does not have widespread agreement. Common sense should always be used in the interpretation and implementation of the results.

3.0 Referenced Documents

The documents that are pertinent to this report are:

- Australian Standard AS/NZS 4422:1996, “Playground surfacing - Specifications, requirements and test method”.
- Australian Standard AS 2512.1:1996, “Methods of testing protective helmets”.
- International Standards Organization ISO 6487, “Road vehicles-measurement techniques in impact tests - Instrumentation”.

4.0 Equipment and Procedure

The equipment used in the experimental testing is shown in Figure 1.

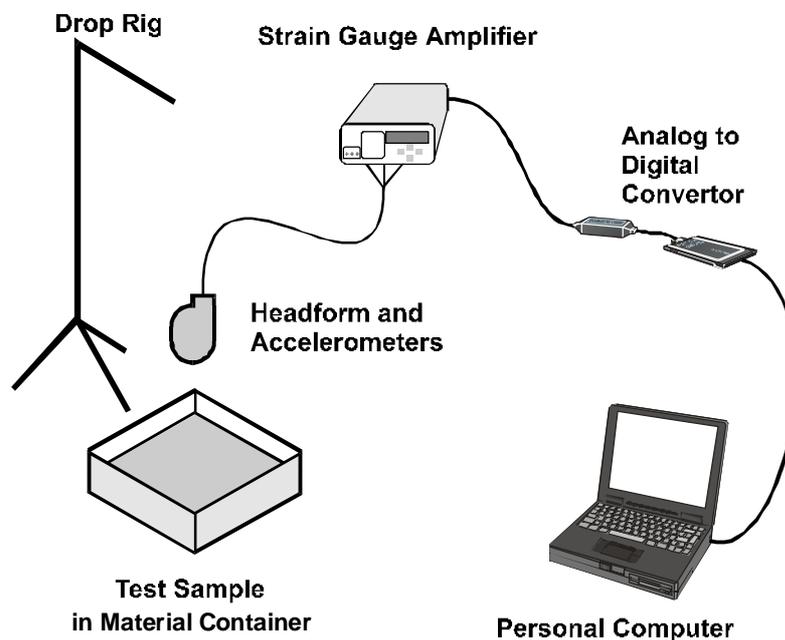


Figure 1: Setup of equipment used for the determination of critical fall height

A description of the test equipment that was used to perform the impact testing is outlined below:

Drop Testing Rig: The testing rig is a portable stand that is used to raise the headform. A pin is released which permits the headform to fall unguided onto the test sample. The height to which the headform is raised is measured with a measuring tape between the upper surface of the sample and the lowest point of the hanging headform.

Headform: The headform is made from aluminium and has an anatomical shape that complies with the J-Type headform from AS 2512.1. It has a mass of 5.1kg. A tri-axial accelerometer (Endevco 7268C-2000) is mounted at the centre of gravity of the headform. The frequency range of the accelerometers is from 0-1000Hz. This complies with channel class 1000 of ISO 6487. A cable connects the tri-axial accelerometer to the strain gauge amplifiers.

Strain Gauge Amplifiers: The 3-channel Endevco Model 136 DC strain gauge amplifier is configured for full bridge circuit configurations. High precision balancing resistors are used to convert the half bridge accelerometers into a full bridge circuit. Anti-aliasing filters (at 10kHz) are used for each channel.

Recording Equipment: The output from the strain gauge amplifiers is connected to an analog to digital (A/D) converter board inside a notebook portable computer. The A/D board samples at 20.0kHz. The collection of data is triggered automatically based on the starting point of an impact event as determined from the constant monitoring of a selected channel value. The data acquisition procedure has a pre-trigger capability, such that the data is collected over a time period spanning from just before to just after the impact event. A sine wave at 200Hz is supplied to one of the A/D channels to provide a check that the sampling rate is accurate.

Material Container: Loose-fill material was placed into a wooden frame which has internal dimensions of $1.25m \times 1.25m \times 0.40m$. The wooden frame does not have an underside so that the loose-fill material sits on a flat concrete floor.

All testing was conducted at the Thebarton Campus of the University of Adelaide in a laboratory environment.

The testing method follows the Australian Standard AS/NZS 4422:1996. In general terms, the sample to be tested was placed on a concrete floor beneath the drop testing rig, the J-type headform was released from various heights and the deceleration of the headform was measured as it struck the test sample. The critical fall height is determined as the height when the Head Injury Criteria (HIC) equals 1000. The Head Injury Criteria is calculated as:

$$\text{HIC} = \left[(t_2 - t_1) \left(\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a dt \right)^{2.5} \right]_{\text{MAX}}$$

where

a = the dimensionless ratio of the deceleration experienced by the headform to the deceleration due to gravity (in g).

t_2, t_1 = instant of time during the impact, chosen such that HIC is maximised, where $t_2 > t_1$.

The critical fall height is the height at which the HIC equals 1000, rounded down to the nearest 10cm, as specified in AS/NZS 4422:1996.

The test procedure is listed below:

1. Prior to testing, the manufacturer's calibration values for the tri-axial accelerometer are checked by aligning each axis in a vertical direction so that a voltage measurement can be obtained for positive and negative accelerations due to gravity.
2. The acceleration measurement obtained using the instrumented headform is verified by dropping it onto a standard rubber mat, both before and after testing, to ensure consistency and accuracy of data measurement.
3. If specified, a "dry" condition sample is obtained by placing the sample onto a series of flat trays inside a heated enclosure (approximately $40^\circ\text{C}+$) for a period of 24 hours or more.
4. If specified, a "wet" condition sample is obtained by thoroughly soaking the test material, then allowing it to drain for one hour. The wet condition testing is then to be carried out within eight hours of the sample being drained. If testing is not completed within this time, the wet conditioning procedure is repeated.
5. The test sample is placed beneath the headform.
6. A portion of the test sample is collected just prior to testing for determining the moisture content. The percentage of moisture present in the sample is determined by measuring the difference in sample mass, before and after a thorough drying procedure.
7. The uncompressed depth of the loose-fill material is measured.
8. The headform is raised and held in position. The vertical height between the test sample and the lowest part of the headform is measured with a tape measure.
9. The headform is released and is allowed to fall unguided to the point at which it strikes the test sample. The collection of data on the A/D board is triggered based on the beginning of the impact event. Data is collected from just before to just after the impact event.

10. The compressed depth of the loose-fill material is measured at the completion of dropping the headform three times at the same impact site.
11. The data is analysed to determine the HIC value and Maximum g value for the drop test.
12. The headform is moved to a new location, then steps 7-11 are repeated.
13. Steps 7-12 are then repeated so that a total of three (final) HIC values are obtained for each of four separate heights. The heights are selected so that HIC values are determined below 1000, close to 1000 and above 1000.
14. Graphs are drawn of the HIC values versus the drop height. The critical fall height is determined by the height at which the HIC value equals 1000 (or acceleration equals 200 g), rounded down to the nearest 10cm.

The samples were tested at the locations shown in the Test Sheets in Appendix A.

5.0 Results

5.1 Sample 1 Test: "Playbark - 15mm"

5.1.1 Description:

A brief description of the "Playbark - 15mm" product (according to the manufacturer) is given below.

"The 'Playbark-15mm' product is produced from raw pine bark sourced from Queensland (stripped from slash pine logs), and passed through a tub grinding process. The material is then subsequently screened into more consistent size gradings. The material which passes through screen holes 15mm in diameter, but not through screen holes of 7mm in diameter, is separated out, forming the basis of the "Playbark - 15mm" pine bark product."

On average, the pine bark particle sizes commonly observed in the sample tested ranged from approximately 80mm×12mm×6mm down to below 1mm×1mm×1mm. The average pine bark particle sizes were measured to be approximately between 20mm×15mm×2mm and 15mm×15mm×2mm.

The presence of slender particles and particles with sharp points in this pine bark product raises a concern in relation to one of the general requirements specified in AS/NZS 4422:1996, Section 5. This is:

"5.2 The surfacing should be free from any sharp edged parts or any hazardous projections"

Slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the present test sample, the occasional presence of sharp-tipped, long slender wood particles (up to an approximate size of: 135mm×9mm×3mm) were observed at the time of testing.

The presence of fine wood particles in the pine bark product tested raises a concern in relation to another general requirements specified in AS/NZS 4422:1996, Section 5. This is:

"5.4 The surfacing should not contain any component known to present an inhalation hazard e.g. sawdust or finely shredded rubber"

Fine wood particles present in the dry sample of this material became momentarily airborne when disturbed during handling. It is possible that inhaling these particles may present a risk to people who use or handle this product when in a dry condition.

A photograph of the test sample is given in Figure 2:



Figure 2: A photograph of the "Playbark - 15mm" test sample.

5.1.2 “Playbark - 15mm” – Dry Condition

200mm Test Depth:

The “dry” condition “Playbark - 15mm” material was placed into the material container to a depth of 200mm. The results from the drop tests are listed in Table 3. The dry sample had a measured moisture content of 7% at the time of testing. The sample surface temperature was 25°C.

Drop Test	Drop Height (m)	Location	HIC Values			Peak g Values (g)		
1	3.1	G	138	688	943	45	121	151
	3.2	B	121	671	979	41	119	158
	3.3	F	120	789	1063	41	133	167
	3.4	A	139	915	1192	41	141	173
2	3.1	I	130	526	772	42	104	136
	3.2	D	134	801	911	44	134	151
	3.3	E	141	995	830	42	155	137
	3.4	C	138	1196	990	43	176	160
3	3.1	J	140	806	647	44	136	123
	3.2	H	103	786	1016	37	136	163
	3.3	K	145	710	977	45	121	154
	3.4	L	184	930	1296	55	144	181

Table 3: Measurements of HIC and Peak g values for various drop heights.

The results shown in Table 3 should be read in conjunction with the Test Sheets in Appendix A. The third impact test result for location H exceeded the limit of HIC 1000 at a test height of 3.2m. The acceleration limit of 200 g was not exceeded in these tests.

Therefore, **the critical fall height for the dry material is 3.1m.**

The variations in the maximum HIC results for different test positions at the same fall height may be attributable to any one of the following factors:

- The headform was observed to occasionally rebound differently after striking the test sample a number of times at the same location. Small differences in the headform rebound characteristics after the first drop often caused a reasonable degree of variation to the maximum HIC and acceleration results achieved by the third drop at the same location.
- The thickness of material left after each headform strike (therefore, the degree of material compression) was found to vary slightly from site to site. The particles in this test sample appeared to displace relatively easily, but in a manner that differed in degree from site to site, especially after the third consecutive test drop performed at any given test location. This appeared to contribute to a degree of variation in the measured HIC values on some subsequent drops.

The uncompressed and compressed depths of the “dry” “Playbark - 15mm” material are shown in Table 4:

Test Position	G	B	F	A	I	D	E	C	J	H	K	L
Uncompressed Depth (mm)	200	200	200	200	200	200	200	200	200	200	200	200
Compressed Depth (mm)	85	90	80	65	90	85	70	75	90	80	85	80

Table 4: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200mm of material was compressed to after a series of drop tests at 3.1m was 85mm. According to the standard: AS4422:1996, it is deemed reasonable to expect that 115mm of the (uncompressed) pine bark material will compress to a minimum depth of 50mm over time. Therefore, the material allowance is 115mm for this case.

According to AS/NZS 4422:1996, the dry "Playbark - 15mm" material should be installed to a depth specified by the following requirements:

Loose-fill material will compact with use. To allow for this compaction, the material shall be installed to a depth of 200mm, which is sufficient to achieve the compacted depths in the testing outlined above.

Loose-fill material will deteriorate with use. To allow for this, an extra 115mm (the material allowance) shall be installed to achieve an additional 50mm compacted depth.

In areas of heavy traffic (under swings and runouts from slides), material displacement may occur. It is recommended that an additional 20% (i.e. 65mm) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 315mm. But in areas of high traffic (under swings and runouts from slides) a depth of 380mm is recommended.

5.1.3 “Playbark - 15mm” – Wet Condition

200mm Test Depth:

The “wet” condition “Playbark - 15mm” material was placed into the material container to a depth of 200mm. The results from the drop tests are listed in Table 5. The wet sample had a measured moisture content of 37% at the time of testing. The sample surface temperature was 25°C.

Drop Test	Drop Height (m)	Location	HIC Values			Peak g Values (g)		
1	3.6	D	231	578	686	61	107	123
	3.7	A	235	779	841	61	131	137
	3.8	C	235	729	760	60	123	130
	3.9	I	242	1086	891	61	163	143
2	3.6	L	205	727	615	57	125	114
	3.7	E	262	579	1024	65	109	158
	3.8	G	270	595	806	67	109	134
	3.9	H	234	645	1161	61	115	169
3	3.6	K	190	706	994	54	125	157
	3.7	J	230	743	882	61	129	141
	3.8	F	230	869	1007	61	140	154
	3.9	B	261	793	966	66	131	149

Table 5: Measurements of HIC and Peak g values for various drop heights.

The results shown in Table 5 should be read in conjunction with the Test Sheets in Appendix A. The third impact test result for location E exceeded the limit of HIC 1000 at a test height of 3.7m. The acceleration limit of 200 g was not exceeded in these tests.

Therefore, **the critical fall height for the wet material is 3.6m.**

The variations in the maximum HIC results for different test positions at the same fall height may be attributable to any one of the following factors:

- The headform was observed to occasionally rebound differently after striking the test sample a number of times at the same location. Small differences in the headform rebound characteristics after the first drop often caused a reasonable degree of variation to the maximum HIC and acceleration results achieved by the third drop at the same location.
- The thickness of material left after each headform strike (therefore, the degree of material compression) was found to vary slightly from site to site. This may also contribute to some variation in the measured HIC values on some subsequent drops. In some cases, the material was observed to partially lift at the impact site, immediately after the headform rebound.
- The headform occasionally hitting the edge of a previous drop location on subsequent impacts a particular location occasionally resulted in the deflection and rotation of the headform during the moment of impact.

The uncompressed and compressed depths of the “wet” “Playbark - 15mm” material are shown in Table 6:

Test Position	D	A	C	I	L	E	G	H	K	J	F	B
Uncompressed Depth (mm)	200	200	200	200	200	200	200	200	200	200	200	200
Compressed Depth (mm)	105	95	90	90	90	100	95	80	100	100	100	100

Table 6: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200mm of material was compressed to after a series of drop tests at 3.6m was 95mm. According to the standard: AS4422:1996, it is deemed

reasonable to expect that 105mm of the (uncompressed) pine bark material will compress to a minimum depth of 50mm over time. Therefore, the material allowance is 105mm for this case.

According to AS/NZS 4422:1996, the wet "Playbark - 15mm" material should be installed to a depth specified by the following requirements:

Loose-fill material will compact with use. To allow for this compaction, the material shall be installed to a depth of 200mm, which is sufficient to achieve the compacted depths in the testing outlined above.

Loose-fill material will deteriorate with use. To allow for this, an extra 105mm (the material allowance) shall be installed to achieve an additional 50mm compacted depth.

In areas of heavy traffic (under swings and runouts from slides), material displacement may occur. It is recommended that an additional 20% (i.e. 60mm) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 305mm. But in areas of high traffic (under swings and runouts from slides) a depth of 365mm is recommended.

5.2 Sample 2 Test: “Playbark – 10mm”

5.2.1 Description:

A brief description of the “Playbark - 10mm” product (according to the manufacturer) is given below.

“The ‘Playbark-10mm’ product is produced from raw pine bark sourced from Tumut, NSW, (stripped from slash pine logs), and passed through a tub grinding process. The material is then subsequently screened into more consistent size gradings. The material which passes through screen holes 10mm in diameter, but not through screen holes of 7mm in diameter, is separated out, forming the basis of the “Playbark - 10mm” pine bark product.”

On average, the pine bark particle sizes in the sample tested ranged from approximately 30mm×13mm×3mm down to below 1mm×1mm×1mm. The average pine bark particle sizes were measured to be approximately between 15mm×10mm×4mm and 10mm×10mm×3mm.

The presence of slender particles and particles with sharp points in this pine bark product raises a concern in relation to one of the general requirements specified in AS/NZS 4422:1996, Section 5. This is:

“5.2 The surfacing should be free from any sharp edged parts or any hazardous projections”

Slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the present test sample, the occasional presence of sharp-tipped, long slender wood particles (up to an approximate size of: 72mm×4mm×2mm) were observed at the time of testing.

The presence of fine wood particles in the pine bark product tested raises a concern in relation to another general requirements specified in AS/NZS 4422:1996, Section 5. This is:

“5.4 The surfacing should not contain any component known to present an inhalation hazard e.g. sawdust or finely shredded rubber”

Fine wood particles present in the dry sample of this material became momentarily airborne when disturbed during handling. It is possible that inhaling these particles may present a risk to people who use or handle this product when in a dry condition.

A photograph of the test sample is given in Figure 3:



Figure 3: A photograph of the “Playbark - 10mm” test sample.

5.2.2 “Playbark - 10mm” – Dry Condition

200mm Test Depth:

The “dry” condition “Playbark - 10mm” material was placed into the material container to a depth of 200mm. The results from the drop tests are listed in Table 7. The dry sample had a measured moisture content of 6% at the time of testing. The sample surface temperature was 21°C.

Drop Test	Drop Height (m)	Location	HIC Values			Peak g Values (g)		
1	3.1	H	135	587	966	45	109	151
	3.2	B	134	809	956	45	134	153
	3.3	A	149	899	1040	48	143	160
	3.4	L	159	824	1000	49	134	158
2	3.1	I	122	486	723	41	97	126
	3.2	C	148	755	853	46	129	144
	3.3	E	165	696	801	50	120	135
	3.4	F	168	743	1138	51	124	167
3	3.1	K	142	490	820	45	96	137
	3.2	D	129	704	972	44	123	155
	3.3	J	158	654	857	50	116	140
	3.4	G	156	678	1068	49	117	159

Table 7: Measurements of HIC and Peak g values for various drop heights.

The results shown in Table 7 should be read in conjunction with the Test Sheets in Appendix A. The third impact test result for location A exceeded the limit of HIC 1000 at a test height of 3.3m. The acceleration limit of 200 g was not exceeded in these tests.

Therefore, **the critical fall height for the dry material is 3.2m.**

The variations in the maximum HIC results for different test positions at the same fall height may be attributable to any one of the following factors:

- The headform was observed to occasionally rebound differently after striking the test sample a number of times at the same location. Small differences in the headform rebound characteristics after the first drop often caused a reasonable degree of variation to the maximum HIC and acceleration results achieved by the third drop at the same location.
- The thickness of material left after each headform strike (therefore, the degree of material compression) was found to vary slightly from site to site. The particles in this test sample appeared to displace relatively easily, but in a manner that differed in degree from site to site, especially after the third consecutive test drop performed at any given test location. This appeared to contribute to a degree of variation in the measured HIC values on some subsequent drops.

The uncompressed and compressed depths of the “dry” “Playbark - 10mm” material are shown in Table 8:

Test Position	H	B	A	L	I	C	E	F	K	D	J	G
Uncompressed Depth (mm)	200	200	200	200	200	200	200	200	200	200	200	200
Compressed Depth (mm)	85	80	85	80	75	85	85	75	75	80	85	75

Table 8: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200mm of material was compressed to after a series of drop tests at 3.2m was 80mm. According to the standard: AS4422:1996, it is deemed reasonable to expect that 125mm of the (uncompressed) pine bark material will compress to a minimum depth of 50mm over time. Therefore, the material allowance is 125mm for this case.

According to AS/NZS 4422:1996, the dry "Playbark - 10mm" material should be installed to a depth specified by the following requirements:

Loose-fill material will compact with use. To allow for this compaction, the material shall be installed to a depth of 200mm, which is sufficient to achieve the compacted depths in the testing outlined above.

Loose-fill material will deteriorate with use. To allow for this, an extra 125mm (the material allowance) shall be installed to achieve an additional 50mm compacted depth.

In areas of heavy traffic (under swings and runouts from slides), material displacement may occur. It is recommended that an additional 20% (i.e. 65mm) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 325mm. But in areas of high traffic (under swings and runouts from slides) a depth of 390mm is recommended.

5.2.3 “Playbark - 10mm” – Wet Condition

200mm Test Depth:

The “wet” condition “Playbark - 10mm” material was placed into the material container to a depth of 200mm. The results from the drop tests are listed in Table 9. The wet sample had a measured moisture content of 45% at the time of testing. The sample surface temperature was 23°C.

Drop Test	Drop Height (m)	Location	HIC Values			Peak g Values (g)		
1	3.7	C	214	516	723	58	99	122
	3.8	A	226	740	985	60	123	150
	3.9	B	308	724	1021	71	120	151
	4.0	I	253	879	994	61	136	148
2	3.7	D	248	655	815	62	113	132
	3.8	F	267	681	793	65	115	128
	3.9	H	273	774	976	68	124	145
	4.0	K	252	725	1129	62	119	158
3	3.7	E	271	744	812	66	124	132
	3.8	G	275	613	825	67	109	134
	3.9	L	243	861	922	61	134	140
	4.0	J	280	782	1250	66	126	169

Table 9: Measurements of HIC and Peak g values for various drop heights.

The results shown in Table 9 should be read in conjunction with the Test Sheets in Appendix A. The third impact test result for location B exceeded the limit of HIC 1000 at a test height of 3.9m. The acceleration limit of 200 g was not exceeded in these tests.

Therefore, **the critical fall height for the wet material is 3.8m.**

The variations in the maximum HIC results for different test positions at the same fall height may be attributable to any one of the following factors:

- The headform was observed to occasionally rebound differently after striking the test sample a number of times at the same location. Small differences in the headform rebound characteristics after the first drop often caused a reasonable degree of variation to the maximum HIC and acceleration results achieved by the third drop at the same location.
- The thickness of material left after each headform strike (therefore, the degree of material compression) was found to vary slightly from site to site. This may also contribute to some variation in the measured HIC values on some subsequent drops. In some cases, the material was observed to partially lift at the impact site, immediately after the headform rebound.
- The headform occasionally hitting the edge of a previous drop location on subsequent impacts a particular location occasionally resulted in the deflection and rotation of the headform during the moment of impact.

The uncompressed and compressed depths of the “wet” “Playbark - 10mm” material are shown in Table 10:

Test Position	C	A	B	I	D	F	H	K	E	G	L	J
Uncompressed Depth (mm)	200	200	200	200	200	200	200	200	200	200	200	200
Compressed Depth (mm)	100	105	115	90	110	100	100	95	115	105	95	90

Table 10: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200mm of material was compressed to after a series of drop tests at 3.8m was 105mm. According to the standard: AS4422:1996, it is deemed

reasonable to expect that 95mm of the (uncompressed) pine bark material will compress to a minimum depth of 50mm over time. Therefore, the material allowance is 95mm for this case.

According to AS/NZS 4422:1996, the wet "Playbark - 10mm" material should be installed to a depth specified by the following requirements:

Loose-fill material will compact with use. To allow for this compaction, the material shall be installed to a depth of 200mm, which is sufficient to achieve the compacted depths in the testing outlined above.

Loose-fill material will deteriorate with use. To allow for this, an extra 95mm (the material allowance) shall be installed to achieve an additional 50mm compacted depth.

In areas of heavy traffic (under swings and runouts from slides), material displacement may occur. It is recommended that an additional 20% (i.e. 60mm) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 295mm. But in areas of high traffic (under swings and runouts from slides) a depth of 355mm is recommended.

6.0 Conclusions

The testing of the supplied “Playbark - 15mm” and “Playbark - 10mm” materials to AS/NZS 4422:1996 resulted in the critical fall heights outlined in Table 11.

Product	Material Condition	Critical Fall Height (m)
“Playbark - 15mm”	Dry	3.1
	Wet	3.6
“Playbark - 10mm”	Dry	3.2
	Wet	3.8

Table 11: Critical Fall Heights for the product tested.

The critical fall heights for the materials tested at a test depth of 200mm were determined to be lower for the dry test than for the wet test in each case. The lesser critical fall height value between both the dry and wet test cases are to be quoted for each material, as the products are most likely to be used outdoors with no protection from drying due to variations in weather conditions.

The critical fall height for the “Playbark - 15mm” product is 3.1m.

The critical fall height for the “Playbark - 10mm” product is 3.2m.

The testing of the samples to AS/NZS 4422:1996 yielded the recommendations for installation depths shown in Table 12.

Product	Property	Dry Condition (Uncompressed) (mm)	Wet Condition (Uncompressed) (mm)
“Playbark - 15mm”	Test Depth	200	200
	Material Allowance	115	105
	Depth to be Installed:	315	305
	+20% for Heavy Traffic Areas	380	365
“Playbark - 10mm”	Test Depth	200	200
	Material Allowance	125	95
	Depth to be Installed:	325	295
	+20% for Heavy Traffic Areas	390	355

Table 12: Material depths to be installed (in mm) for the product tested.

If either “Playbark” products are to be used in both dry and wet conditions (i.e. installed outdoors) then each shall be installed according to the depths shown in the unshaded “Dry Condition” column of Table 12.

The material allowance was determined to be greater for the dry condition cases than it was for the wet condition cases. Therefore, **the recommended installation depth for the “Playbark - 15mm” material is 315mm.** However, a depth of 380mm is to be used in heavy traffic areas.

The recommended installation depth for the “Playbark - 10mm” material is 325mm. However, a depth of 390mm is to be used in heavy traffic areas.

Important Notes:

Slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the present “Playbark - 15mm” test sample, the occasional presence of sharp-tipped long slender wood particles (up to an approximate size of: 135mm×9mm×3mm) were observed at the time of testing. For the “Playbark - 10mm” test sample, similar particles of approximate size: 72mm×4mm×2mm were observed.

Small amounts of fine wood dust particles present in the dry samples for both materials tested, and were observed to become momentarily airborne when disturbed during handling in each case. People who use or handle this product when it is in a dry condition risk inhaling these airborne fine wood dust particles.

APPENDIX A

The following 8 pages contain the test results for:

- “Playbark - 15mm” - Dry Condition – 200mm Test Depth (2 pages).
- “Playbark - 15mm” - Wet Condition – 200mm Test Depth (2 pages).
-
- “Playbark - 10mm” - Dry Condition – 200mm Test Depth (2 pages).
- “Playbark - 10mm” - Wet Condition – 200mm Test Depth (2 pages).

Playground Safety Surface Test Report: “Playbark - 15mm”

Prepared by **MECHTEST**: 4th December 2012
for The Hills Bark Blower - “Dry” Test Condition

Introduction

AS/NZS 4422:1996 specifies testing requirements to determine the critical fall height for playground safety surfaces. The critical fall height is determined by installing the loose fill safety surface into the holding container in an “*as poured*” condition and determining the fall height at which one of two safety criteria are exceeded; those criteria are the Head Injury Criterion exceeding 1000, and the maximum acceleration due to the impact exceeding 200 g. The critical fall height is determined by dropping an instrumented headform from various heights onto the surface and measuring the acceleration due to the impact. Heights tested include those which produce measurements that satisfy the relevant criterion and those which exceed the relevant criterion.

It should be noted that the results reported here relate specifically to the installation of the product as specified by the standard AS/NZS 4422:1996 (i.e. in an “*as poured*” condition), with no allowance made for incorrect installation, ageing or degradation of the product. These results should always be used in consultation with the installing authority. No allowance has been made for any variation to the moisture content of the sample in this test.

The critical fall height has been calculated relative to a nominated piece of equipment and no assumption has been made about the height of the user above that equipment. The critical fall height is quoted to the nearest 0.1m, rounded down, as specified in AS/NZS 4422:1996.

Product Tested

The product tested was supplied by The Hills Bark Blower, of Round Corner, NSW and is described as “*Playbark - 15mm*”, which has an average particle size of approximately between 20mm×15mm×2mm and 15mm×15mm×2mm (see Test Report MT-12-1127a for a full material description). The product was tested in an “*dry*” condition. This was achieved by placing the sample in a heated enclosure for a period of at least 24 hours. The testing was conducted at the Thebarton Campus of the University of Adelaide.

Installation and substrate

The loose pine bark material was poured into a container of dimensions 1.25m×1.25m×0.4m, to a height of 200mm. The substrate was a concrete floor.

Testing

This product was tested to the requirements for AS/NZS 4422:1996. The testing locations on the product sample are shown in Figure A1.

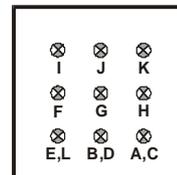


Figure A1 Schematic diagram of the test points used.

The sample was repoured into the container prior to subsequent tests at repeated locations.

Conditions

Air temperature: 25°C

Sample Moisture Content: 7%

Test Results:

Drop Height (m)	Loc'n	HIC Values			Peak g Values (g)		
3.1	G	138	688	943	45	121	151
3.2	B	121	671	979	41	119	158
3.3	F	120	789	1063	41	133	167
3.4	A	139	915	1192	41	141	173
3.1	I	130	526	772	42	104	136
3.2	D	134	801	911	44	134	151
3.3	E	141	995	830	42	155	137
3.4	C	138	1196	990	43	176	160
3.1	J	140	806	647	44	136	123
3.2	H	103	786	1016	37	136	163
3.3	K	145	710	977	45	121	154
3.4	L	184	930	1296	55	144	181

See Test Report MT-12-1127a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

The calculated critical fall height for this product, when dry, is 3.1m. This is based on the HIC value exceeding 1000 at a height of 3.2m at location H in the above table. The 200 g limit was not exceeded in these tests.

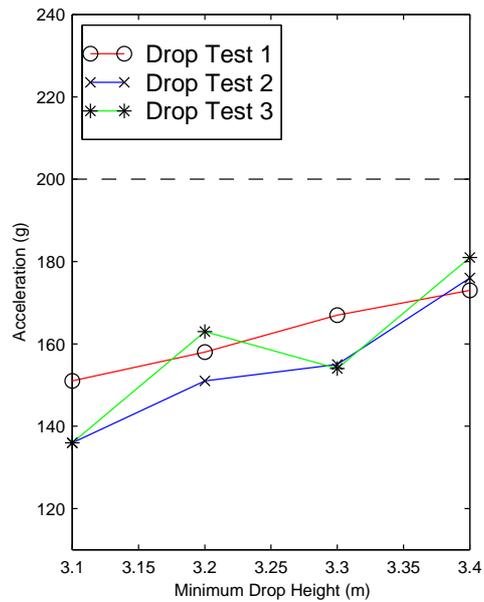
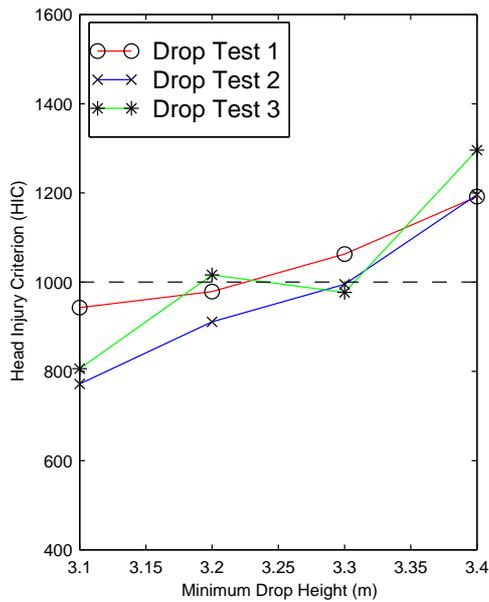
Graphical results

Figures A2 and A3 (overleaf) show how the HIC value and the peak acceleration vary with the minimum fall height.

Figure A4 shows an actual acceleration trace from the tests; specifically from the 3.2m height in the third drop test.

References

AS/NZS 4422:1996, Playground surfacing – Specifications, requirements and test method



Figures A2 & A3 Maximum HIC and acceleration values for the Drop Heights tested.

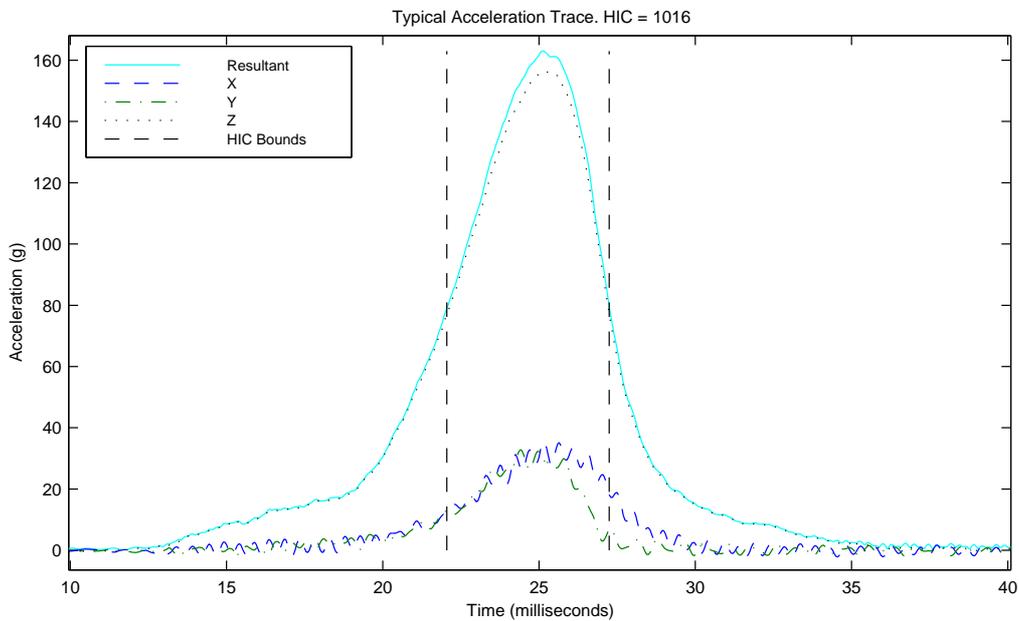


Figure A4 Typical Acceleration Trace.

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Playground Safety Surface Test Report: “Playbark - 15mm”

Prepared by **MECHTEST**: 21st November 2012
for The Hills Bark Blower - “Wet” Test Condition

Introduction

AS/NZS 4422:1996 specifies testing requirements to determine the critical fall height for playground safety surfaces. The critical fall height is determined by installing the loose fill safety surface into the holding container in an “as poured” condition and determining the fall height at which one of two safety criteria are exceeded; those criteria are the Head Injury Criterion exceeding 1000, and the maximum acceleration due to the impact exceeding 200 g. The critical fall height is determined by dropping an instrumented headform from various heights onto the surface and measuring the acceleration due to the impact. Heights tested include those which produce measurements that satisfy the relevant criterion and those which exceed the relevant criterion.

It should be noted that the results reported here relate specifically to the installation of the product as specified by the standard AS/NZS 4422:1996 (i.e. in an “as poured” condition), with no allowance made for incorrect installation, ageing or degradation of the product. These results should always be used in consultation with the installing authority. No allowance has been made for any variation to the moisture content of the sample in this test.

The critical fall height has been calculated relative to a nominated piece of equipment and no assumption has been made about the height of the user above that equipment. The critical fall height is quoted to the nearest 0.1m, rounded down, as specified in AS/NZS 4422:1996.

Product Tested

The product tested was supplied by The Hills Bark Blower, of Round Corner, NSW and is described as “Playbark - 15mm”, which has an average particle size of approximately between 20mm×15mm×2mm and 15mm×15mm×2mm (see Test Report MT-12-1127a for a full material description). The product was tested in a “wet” condition. This was achieved by thoroughly soaking the product and allowing it to drain for 1 hour. Testing was then performed within 8 hours of the product being drained. The testing was conducted at the Thebarton Campus of the University of Adelaide.

Installation and substrate

The loose pine bark material was poured into a container of dimensions 1.25m×1.25m×0.4m, to a height of 200mm. The substrate was a concrete floor.

Testing

This product was tested to the requirements for AS/NZS 4422:1996. The testing locations on the product sample are shown in Figure B1.

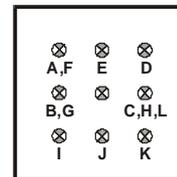


Figure B1 Schematic diagram of the test points used.

The sample was repoured into the container prior to subsequent tests at repeated locations.

Conditions

Air temperature: 25°C

Sample Moisture Content: 37%

Test Results:

Drop Height (m)	Loc'n	HIC Values			Peak g Values (g)		
3.6	D	231	578	686	61	107	123
3.7	A	235	779	841	61	131	137
3.8	C	235	729	760	60	123	130
3.9	I	242	1086	891	61	163	143
3.6	L	205	727	615	57	125	114
3.7	E	262	579	1024	65	109	158
3.8	G	270	595	806	67	109	134
3.9	H	234	645	1161	61	115	169
3.6	K	190	706	994	54	125	157
3.7	J	230	743	882	61	129	141
3.8	F	230	869	1007	61	140	154
3.9	B	261	793	966	66	131	149

See Test Report MT-12-1127a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

The calculated critical fall height for this product, when wet, is 3.6m. This is based on the HIC value exceeding 1000 at a height of 3.7m at location E in the above table. The 200 g limit was not exceeded in these tests.

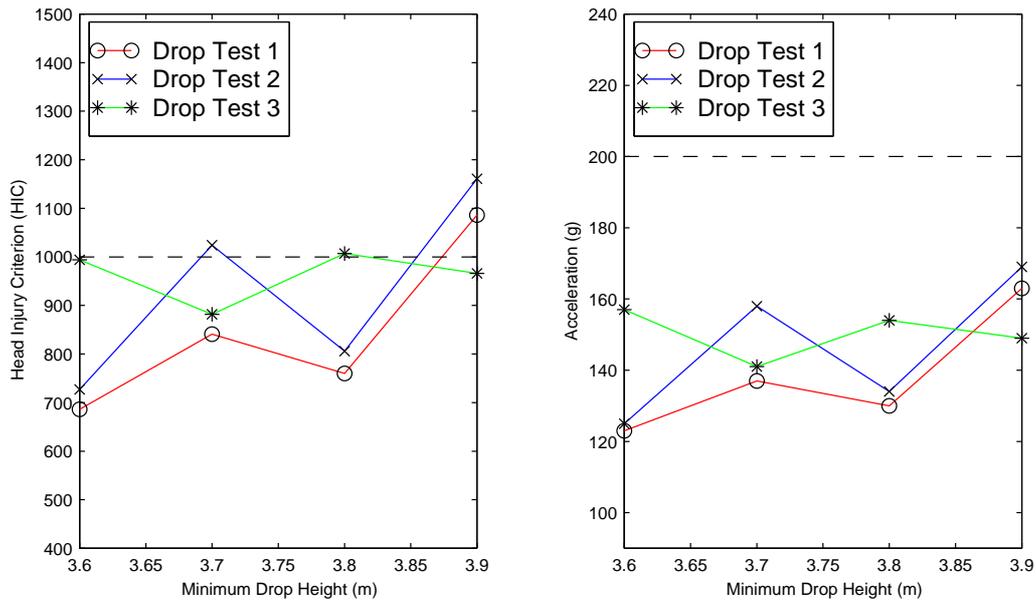
Graphical results

Figures B2 and B3 (overleaf) show how the HIC value and the peak acceleration vary with the minimum fall height.

Figure B4 shows an actual acceleration trace from the tests; specifically from the 3.7m height in the second drop test.

References

AS/NZS 4422:1996, Playground surfacing – Specifications, requirements and test method



Figures B2 & B3 Maximum HIC and acceleration values for the Drop Heights tested.

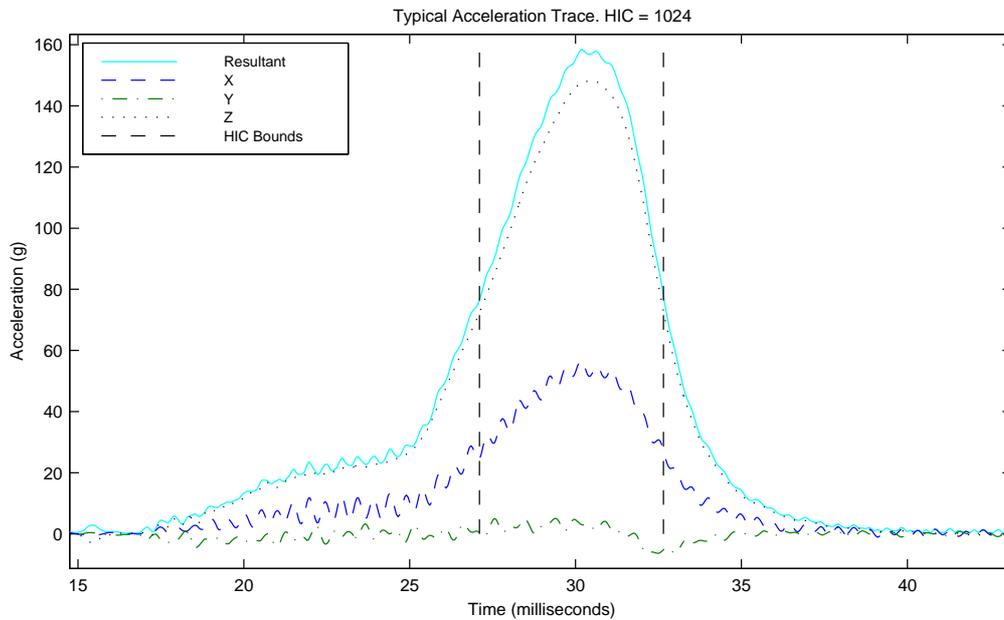


Figure B4 Typical Acceleration Trace.

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Playground Safety Surface Test Report: “Playbark - 10mm”

Prepared by **MECHTEST**: 7th December 2012
for The Hills Bark Blower - “Dry” Test Condition

Introduction

AS/NZS 4422:1996 specifies testing requirements to determine the critical fall height for playground safety surfaces. The critical fall height is determined by installing the loose fill safety surface into the holding container in an “*as poured*” condition and determining the fall height at which one of two safety criteria are exceeded; those criteria are the Head Injury Criterion exceeding 1000, and the maximum acceleration due to the impact exceeding 200 g. The critical fall height is determined by dropping an instrumented headform from various heights onto the surface and measuring the acceleration due to the impact. Heights tested include those which produce measurements that satisfy the relevant criterion and those which exceed the relevant criterion.

It should be noted that the results reported here relate specifically to the installation of the product as specified by the standard AS/NZS 4422:1996 (i.e. in an “*as poured*” condition), with no allowance made for incorrect installation, ageing or degradation of the product. These results should always be used in consultation with the installing authority. No allowance has been made for any variation to the moisture content of the sample in this test.

The critical fall height has been calculated relative to a nominated piece of equipment and no assumption has been made about the height of the user above that equipment. The critical fall height is quoted to the nearest 0.1m, rounded down, as specified in AS/NZS 4422:1996.

Product Tested

The product tested was supplied by The Hills Bark Blower, of Round Corner, NSW and is described as “*Playbark - 10mm*”, which has an average particle size of approximately between 15mm×10mm×4mm and 10mm×10mm×3mm (see Test Report MT-12-1127a for a full material description). The product was tested in an “*dry*” condition. This was achieved by placing the sample in a heated enclosure for a period of at least 24 hours. The testing was conducted at the Thebarton Campus of the University of Adelaide.

Installation and substrate

The loose pine bark material was poured into a container of dimensions 1.25m×1.25m×0.4m, to a height of 200mm. The substrate was a concrete floor.

Testing

This product was tested to the requirements for AS/NZS 4422:1996. The testing locations on the product sample are shown in Figure C1.

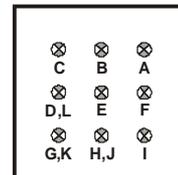


Figure C1 Schematic diagram of the test points used.

The sample was repoured into the container prior to subsequent tests at repeated locations.

Conditions

Air temperature: 21°C

Sample Moisture Content: 6%

Test Results:

Drop Height (m)	Loc'n	HIC Values			Peak g Values (g)		
3.1	H	135	587	966	45	109	151
3.2	B	134	809	956	45	134	153
3.3	A	149	899	1040	48	143	160
3.4	L	159	824	1000	49	134	158
3.1	I	122	486	723	41	97	126
3.2	C	148	755	853	46	129	144
3.3	E	165	696	801	50	120	135
3.4	F	168	743	1138	51	124	167
3.1	K	142	490	820	45	96	137
3.2	D	129	704	972	44	123	155
3.3	J	158	654	857	50	116	140
3.4	G	156	678	1068	49	117	159

See Test Report MT-12-1127a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

The calculated critical fall height for this product, when dry, is 3.2m. This is based on the HIC value exceeding 1000 at a height of 3.3m at location A in the above table. The 200 g limit was not exceeded in these tests.

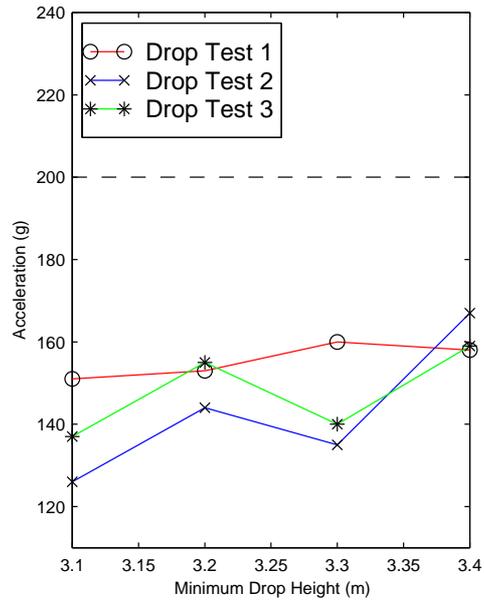
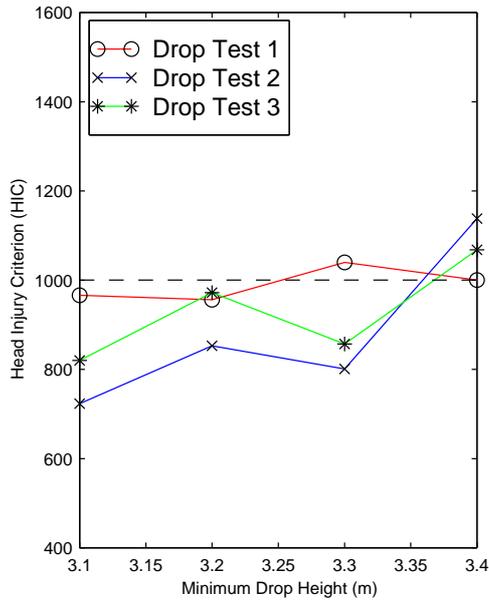
Graphical results

Figures C2 and C3 (overleaf) show how the HIC value and the peak acceleration vary with the minimum fall height.

Figure C4 shows an actual acceleration trace from the tests; specifically from the 3.3m height in the first drop test.

References

AS/NZS 4422:1996, Playground surfacing – Specifications, requirements and test method



Figures C2 & C3 Maximum HIC and acceleration values for the Drop Heights tested.

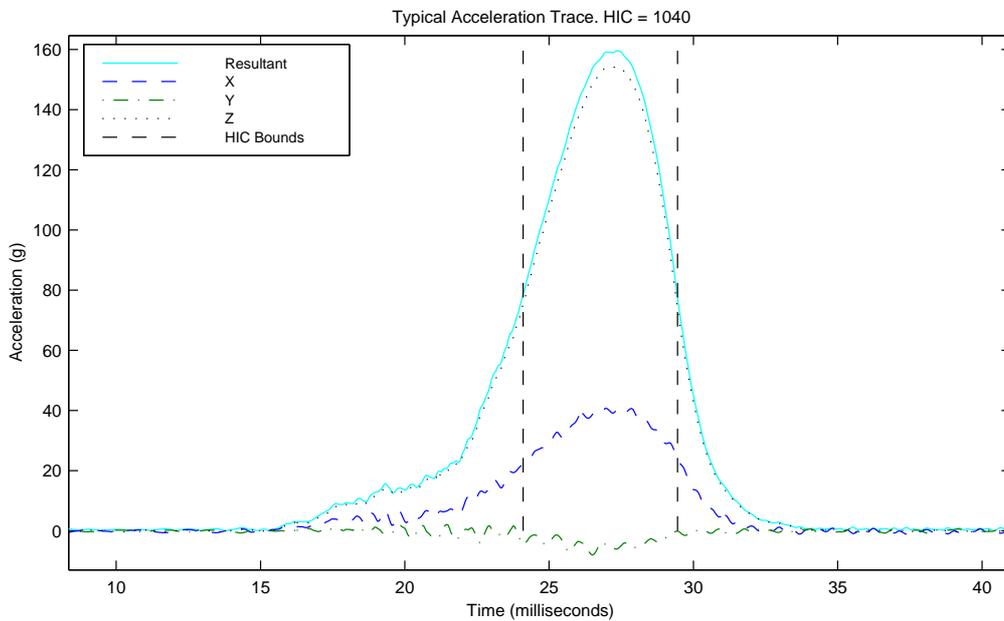


Figure C4 Typical Acceleration Trace.

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Playground Safety Surface Test Report: “Playbark - 10mm”

Prepared by **MECHTEST**: 6th December 2012
for The Hills Bark Blower - “Wet” Test Condition

Introduction

AS/NZS 4422:1996 specifies testing requirements to determine the critical fall height for playground safety surfaces. The critical fall height is determined by installing the loose fill safety surface into the holding container in an “*as poured*” condition and determining the fall height at which one of two safety criteria are exceeded; those criteria are the Head Injury Criterion exceeding 1000, and the maximum acceleration due to the impact exceeding 200 g. The critical fall height is determined by dropping an instrumented headform from various heights onto the surface and measuring the acceleration due to the impact. Heights tested include those which produce measurements that satisfy the relevant criterion and those which exceed the relevant criterion.

It should be noted that the results reported here relate specifically to the installation of the product as specified by the standard AS/NZS 4422:1996 (i.e. in an “*as poured*” condition), with no allowance made for incorrect installation, ageing or degradation of the product. These results should always be used in consultation with the installing authority. No allowance has been made for any variation to the moisture content of the sample in this test.

The critical fall height has been calculated relative to a nominated piece of equipment and no assumption has been made about the height of the user above that equipment. The critical fall height is quoted to the nearest 0.1m, rounded down, as specified in AS/NZS 4422:1996.

Product Tested

The product tested was supplied by The Hills Bark Blower, of Round Corner, NSW and is described as “*Playbark - 10mm*”, which has an average particle size of approximately between 15mm×10mm×4mm and 10mm×10mm×3mm (see Test Report MT-12-1127a for a full material description). The product was tested in a “wet” condition. This was achieved by thoroughly soaking the product and allowing it to drain for 1 hour. Testing was then performed within 8 hours of the product being drained. The testing was conducted at the Thebarton Campus of the University of Adelaide.

Installation and substrate

The loose pine bark material was poured into a container of dimensions 1.25m×1.25m×0.4m, to a height of 200mm. The substrate was a concrete floor.

Testing

This product was tested to the requirements for AS/NZS 4422:1996. The testing locations on the product sample are shown in Figure D1.

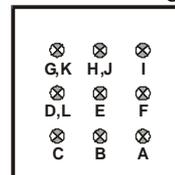


Figure D1 Schematic diagram of the test points used.

The sample was repoured into the container prior to subsequent tests at repeated locations.

Conditions

Air temperature: 23°C

Sample Moisture Content: 45%

Test Results:

Drop Height (m)	Loc'n	HIC Values			Peak g Values (g)		
3.7	C	214	516	723	58	99	122
3.8	A	226	740	985	60	123	150
3.9	B	308	724	1021	71	120	151
4.0	I	253	879	994	61	136	148
3.7	D	248	655	815	62	113	132
3.8	F	267	681	793	65	115	128
3.9	H	273	774	976	68	124	145
4.0	K	252	725	1129	62	119	158
3.7	E	271	744	812	66	124	132
3.8	G	275	613	825	67	109	134
3.9	L	243	861	922	61	134	140
4.0	J	280	782	1250	66	126	169

See Test Report MT-12-1127a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

The calculated critical fall height for this product, when wet, is 3.8m. This is based on the HIC value exceeding 1000 at a height of 3.9m at location B in the above table. The 200 g limit was not exceeded in these tests.

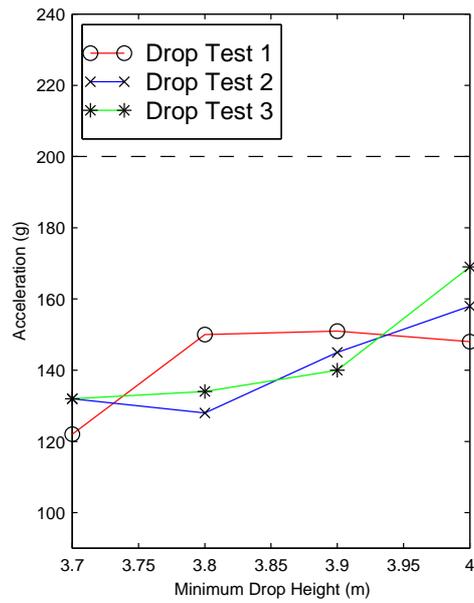
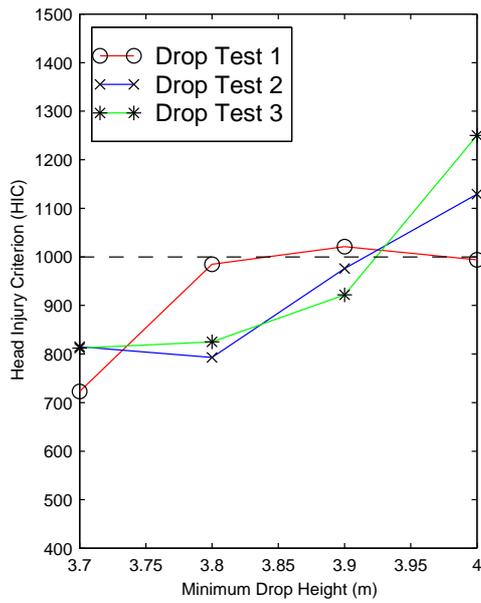
Graphical results

Figures D2 and D3 (overleaf) show how the HIC value and the peak acceleration vary with the minimum fall height.

Figure D4 shows an actual acceleration trace from the tests; specifically from the 3.9m height in the first drop test.

References

AS/NZS 4422:1996, Playground surfacing – Specifications, requirements and test method



Figures D2 & D3 Maximum HIC and acceleration values for the Drop Heights tested.

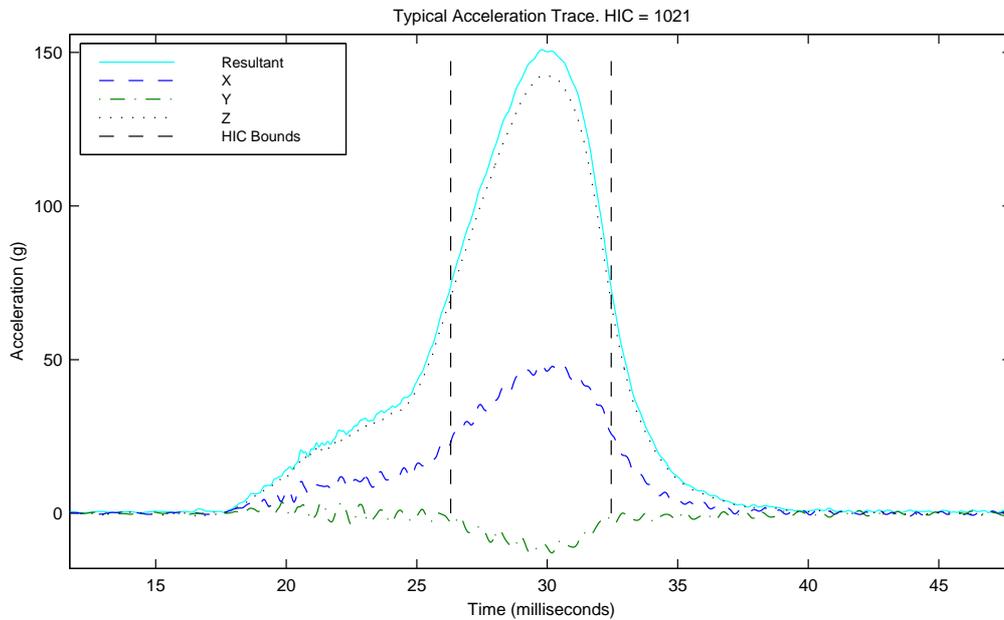


Figure D4 Typical Acceleration Trace.

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APPENDIX B

- The following two pages contains the Test Certificates, summarising the key findings of the testing of the “*Playbark – 15mm*” test sample, and the “*Playbark – 10mm*” test sample - as described in MechTest Report: MT-12-1127a.

(2 pages).

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January 2013

T E S T C E R T I F I C A T E

This is to certify that the product sample "*Playbark - 15mm*", supplied by The Hills Bark Blower (*as described in MechTest Report: MT-12-1127a*), has been assessed according to the impact test procedure described in **Australian/New Zealand Standard: AS/NZS 4422:1996**.

Tests were conducted on the impact absorption properties of this loose-fill pine bark material when it was in both a dry and wet condition at a test depth of 200mm. As a result of these tests, the following minimum specifications were determined:

Product: "***Playbark - 15mm***"

Test Date: **4th December 2012**

Critical fall height: **3.1m**.

Recommended installation depth: **315mm**.

Installation depth for heavy traffic areas (under swings and slides): **380mm**.

Notes:

- Long slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the current test sample, the occasional presence of long, sharp, slender pine wood particles (up to size: 135mm×9mm×3mm) were observed at the time of testing.
- Some fine wood dust particles present in the dry sample tested were observed to become airborne when disturbed during handling. Therefore, a potential inhalation risk may exist to people who use or handle this product when in a dry condition.

This page represents a summary of the major findings of the MechTest report: MT-12-1127a. For more detailed information regarding any aspect of the test procedure, the interpretation of test results or the description details of the product tested, please refer to the MechTest Report: MT-12-1127a (in its entirety). A copy of this report may be requested from:

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January 2013

T E S T C E R T I F I C A T E

This is to certify that the product sample "*Playbark - 10mm*", supplied by The Hills Bark Blower (*as described in MechTest Report: MT-12-1127a*), has been assessed according to the impact test procedure described in **Australian/New Zealand Standard: AS/NZS 4422:1996**.

Tests were conducted on the impact absorption properties of this loose-fill pine bark material when it was in both a dry and wet condition at a test depth of 200mm. As a result of these tests, the following minimum specifications were determined:

Product: "***Playbark - 10mm***"

Test Date: **7th December 2012**

Critical fall height: **3.2m**.

Recommended installation depth: **325mm**.

Installation depth for heavy traffic areas (under swings and slides): **390mm**.

Notes:

- Long slender wood particles or pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. In the current test sample, the occasional presence of long, sharp, slender pine wood particles (up to size: 72mm×4mm×2mm) were observed at the time of testing.
- Some fine wood dust particles present in the dry sample tested were observed to become airborne when disturbed during handling. Therefore, a potential inhalation risk may exist to people who use or handle this product when in a dry condition.

This page represents a summary of the major findings of the MechTest report: MT-12-1127a. For more detailed information regarding any aspect of the test procedure, the interpretation of test results or the description details of the product tested, please refer to the MechTest Report: MT-12-1127a (in its entirety). A copy of this report may be requested from:

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