MECHANICAL ENGINEERING TESTING & CONSULTING

Consulting Report MT1027a

Playground Safety Surface Test Report for The Hills Bark Blower

"Pine Mulch"

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18 pages

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Contents

1.0 Executive Summary

The Hills Bark Blower provide a pine mulch product for use as a loose-fill material for playground undersurfacing. The "Pine Mulch" material is produced from Radiata pine. It is processed from the shavings of a log peeling process, which are then subsequently passed through a shaker screen, graded and separated accordingly. The average particle size in this material is approximately $6mm \times 3mm \times 2mm$.

Impact absorption testing was performed on the loose-fill material when it was both in a dry condition and when it had been completely wet with water. The assessment of the supplied material 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*)
"Pine Mulch"	Dry Wet	2.8 3.3

Table 1: Critical Fall Heights for the product tested.

The critical fall heights for the material tested at a test depth of 200*mm* were 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 case is to be quoted for this material, as the product is most likely to be used outdoors with no protection from drying due to variations in weather conditions.

Therefore, **the critical fall height for the "Pine Mulch" product is 2.8*m*.**

The testing of the sample 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*)
"Pine Mulch"	Test Depth Material Allowance	200 100	200 100
	Depth to be Installed: +20% for Heavy Traffic Areas	**300** 360	**300** 360

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

If the product is to be used in both dry and wet conditions (i.e. installed outdoors) then it is to be installed to the depths shown in Table 2.

The material allowance was determined to be the same for the wet condition case as it was for the dry condition case. Therefore, **the recommended installation depth for the "Pine Mulch" material is 300*mm*.** However, a depth of 360*mm* is to be used in heavy traffic areas.

Important Note:

Long slender wood particles or individual pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. For the present sample, the presence of diamond-shaped pieces with sharp points, and the occasional presence of long, sharp, slender pine wood particles (of approximate size: $140mm \times 13mm \times 5mm$) were observed at the time of testing.

Small amounts of fine wood dust particles present in the dry sample tested were observed to become airborne when disturbed during handling. People who use or handle this product when it is in a dry condition risk inhaling these very fine wood dust particles.

2.0 Introduction

The impact absorption properties of the “Pine Mulch” material 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 sample was tested in both a “dry” and a “wet” test condition. The “dry” condition pine mulch 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.

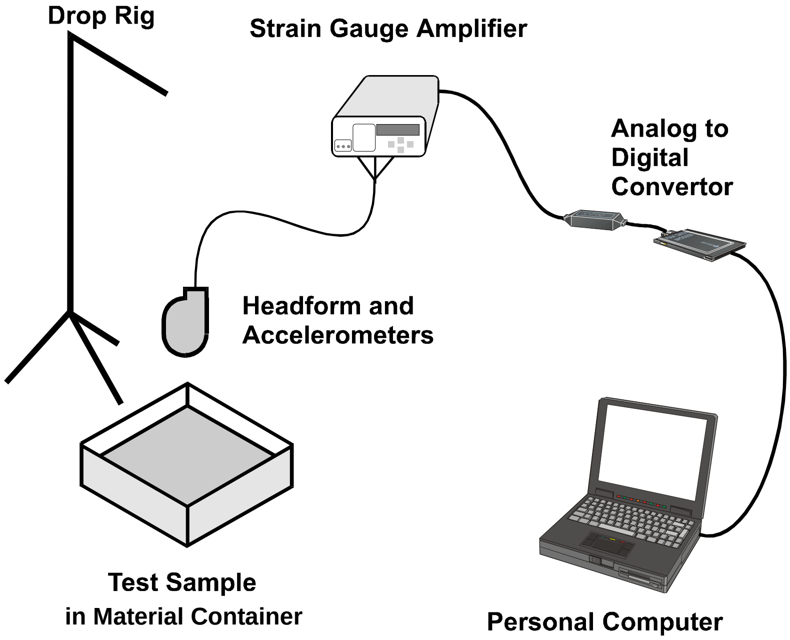


Figure 1: Setup of equipment.

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:

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

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 10*cm*, 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°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 10*cm*.

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

5.0 Results

Description: “Pine Mulch”

A brief description of the “Pine Mulch” product (according to the manufacturer) is given below.

> *“The Pine Mulch product is produced as a by-product of the process used to manufacture round pine logs. The raw pine radiata logs are first de-barked and subsequently fed through a machine that processes the logs to an even diameter. The process involves shaving and chipping the excess material from the logs until a consistent diameter is achieved. The processed material removed from the logs is screened and forms the basis of the “Pine Mulch” material as required”*

On average, the particle size in the sample tested ranged from approximately 15*mm*×10*mm*×1*mm* down to below 1*mm*×1*mm*×1*mm*. The average particle size was approximately 6*mm*×3*mm*×2*mm*.

The presence of long slender particles and smaller particles with sharp points in this pine mulch product raises 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*"
>
> Long slender wood particles or individual pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. For the present sample, the presence of diamond-shaped pieces with sharp points, and the occasional presence of long, sharp, slender pine wood particles (of approximate size: 140*mm*×13*mm*×5*mm*) were observed at the time of testing.

The presence of fine wood dust particles in the pine mulch product tested also 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*"
>
> Small amounts of fine wood dust particles present in the dry sample of this material became 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 “Pine Mulch” sample.

5.1 "Pine Mulch" - Dry Condition

200mm Test Depth:

The "dry" condition "Pine Mulch" material was placed into the material container to a depth of 200*mm*. The results from the drop tests are listed in Table 3. The dry sample had a measured moisture content of 8% at the time of testing. The sample surface temperature was 16°C.

Drop Test	Drop Height (*m*)	Locat'n	HIC Values			Peak g Values (*g*)		
1	2.7	H	216	760	698	59	133	128
	2.8	G	214	816	779	58	137	134
	2.9	A	195	800	932	55	136	150
	3.0	B	298	1007	1293	71	153	181
2	2.7	I	232	647	848	62	119	142
	2.8	D	230	793	841	61	134	142
	2.9	C	254	983	1205	64	152	175
	3.0	K	278	977	964	68	151	150
3	2.7	J	209	692	694	58	124	126
	2.8	L	287	827	920	70	137	148
	2.9	F	232	931	1016	61	146	158
	3.0	E	255	873	945	64	141	150

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 locations C & F exceeded the limit of HIC 1000 at a test height of 2.9*m*. The acceleration limit of 200 *g* was not exceeded in these tests.

Therefore, **<u>the critical fall height for the dry material is 2.8*m*</u>**.

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 "dry" "Pine Mulch" material are shown in Table 4:

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

Table 4: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200*mm* of material was compressed to after a series of drop tests at 2.8*m* was 100*mm*. This means it is reasonable to expect that 100*mm* of the (uncompressed) pine mulch material will compress to a minimum depth of 50*mm* over time. Therefore, the material allowance is 100*mm* for this case.

According to AS/NZS 4422:1996, the "Pine Mulch" 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 200*mm*, 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 100*mm* (the material allowance) shall be installed to achieve an additional 50*mm* 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. 60*mm*) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 300*mm*. But in areas of high traffic (under swings and runouts from slides) a depth of 360*mm* is recommended.

5.2 "Pine Mulch" - Wet Condition

200mm Test Depth

The "wet" condition "Pine Mulch" material was placed into the material container to a depth of 200*mm*. The results from the drop tests are listed in Table 5. The wet sample had a measured moisture content of 53% at the time of testing. The sample surface temperature was 17°C.

Drop Test	Drop Height (*m*)	Locat'n	HIC Values			Peak g Values (*g*)		
1	3.2	A	188	842	942	55	139	153
	3.3	B	196	699	964	55	123	151
	3.4	C	200	776	731	55	129	124
	3.5	D	247	1014	1164	62	155	170
2	3.2	H	213	598	847	58	110	139
	3.3	G	222	581	780	59	107	128
	3.4	J	266	858	1063	67	140	161
	3.5	E	236	750	928	61	126	145
3	3.2	L	232	681	838	61	120	139
	3.3	K	260	812	975	65	134	154
	3.4	F	249	708	908	63	121	143
	3.5	I	271	1174	1340	67	169	186

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 results for location J exceeded the limit of HIC 1000 at a test height of 3.4*m*. The acceleration limit of 200 *g* was not exceeded in these tests.

Therefore, **the critical fall height for the wet material is 3.3*m***.

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" "Pine Mulch" material are shown in Table 6:

Test Position	A	B	C	D	H	G	J	E	L	K	F	I
Uncompressed Depth (*mm*)	200	200	200	200	200	200	200	200	200	200	200	200
Compressed Depth (*mm*)	80	95	85	105	95	115	95	95	105	90	105	100

Table 6: Uncompressed and compressed material heights.

From the above depth observations, the average depth that 200*mm* of material was compressed to after a series of drop tests at 3.3*m* was 100*mm*. This means it is reasonable to expect that 100*mm* of the (uncompressed) pine mulch material will compress to a minimum depth of 50*mm* over time. Therefore, the material allowance is 100*mm* for this case.

According to AS/NZS 4422:1996, the "Pine Mulch" 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 200*mm*, 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 100*mm* (the material allowance) shall be installed to achieve an additional 50*mm* 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. 60*mm*) depth be installed in these areas.

Therefore, this material is to be installed at a depth of 300*mm*. But in areas of high traffic (under swings and runouts from slides) a depth of 360*mm* is recommended.

6.0 Conclusions

The testing of the supplied "Pine Mulch" material to AS/NZS 4422:1996 resulted in the critical fall heights outlined in Table 7.

Product	Material Condition	Critical Fall Height (*m*)
"Pine Mulch"	Dry	2.8
	Wet	3.3

Table 7: Critical Fall Heights for the product tested.

The critical fall heights for the material tested at a test depth of 200*mm* was 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 case is to be quoted for this material, as the product is most likely to be used outdoors with no protection from drying due to variations in weather conditions.

Therefore, **the critical fall height for the "Pine Mulch" product is 2.8*m*.**

The testing of the sample to AS/NZS 4422:1996 yielded the recommendations for installation depths shown in Table 8.

Product	Property	Dry Condition (Uncompressed) (*mm*)	Wet Condition (Uncompressed) (*mm*)
"Pine Mulch"	Test Depth	200	200
	Material Allowance	100	100
	Depth to be Installed:	**300**	**300**
	+20% for Heavy Traffic Areas	360	360

Table 8: Material depths to be installed (in *mm*) for the product tested.

If the product is to be used in both dry and wet conditions (i.e. installed outdoors) then it is to be installed to depths determined using the material allowances in the columns of Table 8.

The material allowance was determined to be the same for the wet condition case as it was for the dry condition case. Therefore, **the recommended installation depth for the "Pine Mulch" material is 300*mm***. However, a depth of 360*mm* is to be used in heavy traffic areas.

Important Note:

Long slender wood particles or individual pieces with sharp points present in any playground loose-fill material may present a risk of splintering to users. For the present sample, the presence of diamond-shaped pieces with sharp points, and the occasional presence of long, sharp, slender pine wood particles (of approximate size: 140*mm*×13*mm*×5*mm*) were observed at the time of testing.
.
Small amounts of fine wood dust particles present in the dry sample tested were observed to become airborne when disturbed during handling. People who use or handle this product when it is in a dry condition risk inhaling these very fine wood dust particles.

- APPENDIX A

The following 4 pages contain the test results for:

- "Pine Mulch" - Dry Condition – 200*mm* Test Depth (2 pages).
- "Pine Mulch" - Wet Condition – 200*mm* Test Depth (2 pages).

Playground Safety Surface Test Report: "Pine Mulch"
Prepared by MECHTEST: 15th June 2010
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 0.1*m*, 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 "Pine Mulch" which has an average particle size of approximately 6*mm*×3*mm*×2*mm* (see Test Report MT1027a 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 mulch material was poured into a container of dimensions 1.25*m*×1.25*m*×0.4*m*, to a height of 200*mm*. 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.

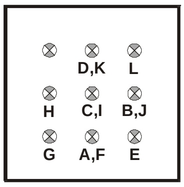


Figure A1 Schematic diagram of the test points used.

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

Conditions

Air temperature: 16ºC
Sample Moisture Content: 8%

Test Results:

Drop Height (*m*)	Loc'n	HIC Values			Peak *g* Values (*g*)		
2.7	H	216	760	698	59	133	128
2.8	G	214	816	779	58	137	134
2.9	A	195	800	932	55	136	150
3.0	B	298	1007	1293	71	153	181
2.7	I	232	647	848	62	119	142
2.8	D	230	793	841	61	134	142
2.9	C	254	983	1205	64	152	175
3.0	K	278	977	964	68	151	150
2.7	J	209	692	694	58	124	126
2.8	L	287	827	920	70	137	148
2.9	F	232	931	1016	61	146	158
3.0	E	255	873	945	64	141	150

See Test Report MT1027a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

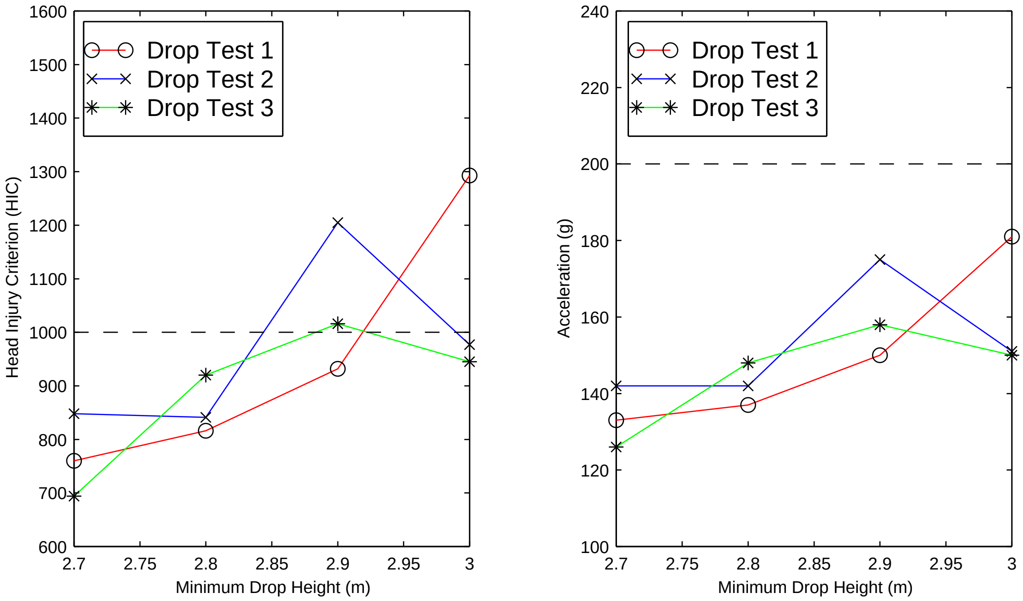
<u>The calculated critical fall height for this product, when dry, is 2.8*m*</u> based on the HIC values shown at locations C & F in the above table. The 200 *g* limit was not exceeded in these tests.

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 2.9*m* height in the second drop test.

References

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



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

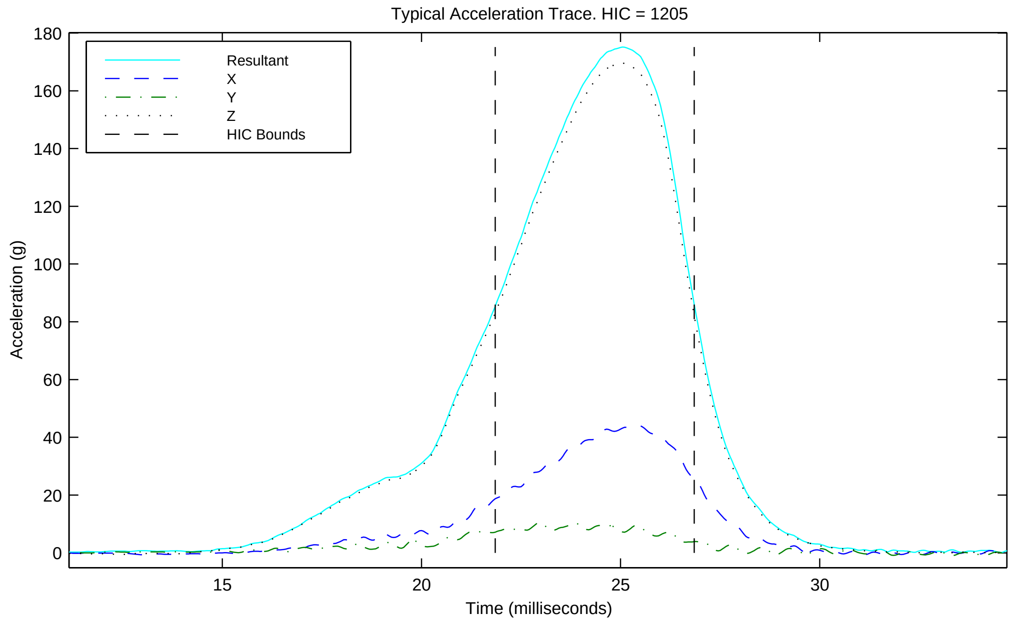


Figure A4 Typical Acceleration Trace.

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Playground Safety Surface Test Report: "Pine Mulch"
Prepared by MECHTEST: 16th June 2010
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 0.1*m*, 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 "Pine Mulch" which has an average particle size of approximately 6*mm*×3*mm*×2*mm* (see Test Report MT1027a 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 mulch material was poured into a container of dimensions 1.25*m*×1.25*m*×0.4*m*, to a height of 200*mm*. 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.

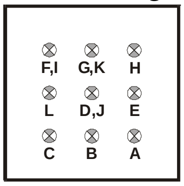


Figure B1 Schematic diagram of the test points used.

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

Conditions

Air temperature: 17ºC
Sample Moisture Content: 53%

Test Results:

Drop Height (*m*)	Loc'n	HIC Values			Peak *g* Values (*g*)		
3.2	A	188	842	942	55	139	153
3.3	B	196	699	964	55	123	151
3.4	C	200	776	731	55	129	124
3.5	D	247	1014	1164	62	155	170
3.2	H	213	598	847	58	110	139
3.3	G	222	581	780	59	107	128
3.4	J	266	858	1063	67	140	161
3.5	E	236	750	928	61	126	145
3.2	L	232	681	838	61	120	139
3.3	K	260	812	975	65	134	154
3.4	F	249	708	908	63	121	143
3.5	I	271	1174	1340	67	169	186

See Test Report MT1027a for compacted and uncompacted depths of the loose-fill material.

Critical fall height

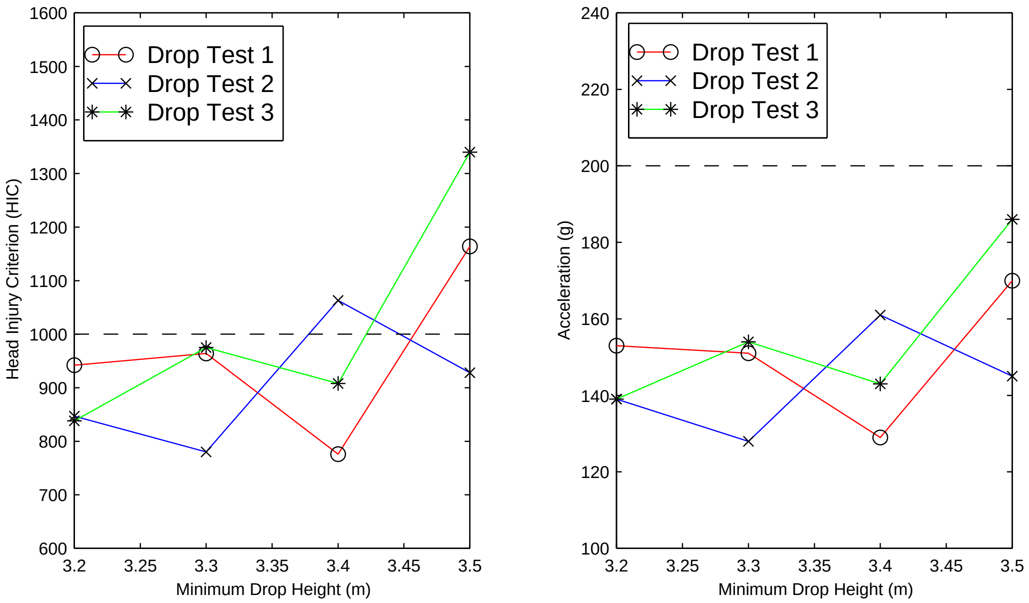
The calculated critical fall height for this product, when wet, is 3.3*m* based on the HIC values shown at location J in the above table. The 200 *g* limit was not exceeded in these tests.

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 3.4*m* height in the second drop test.

References

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



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

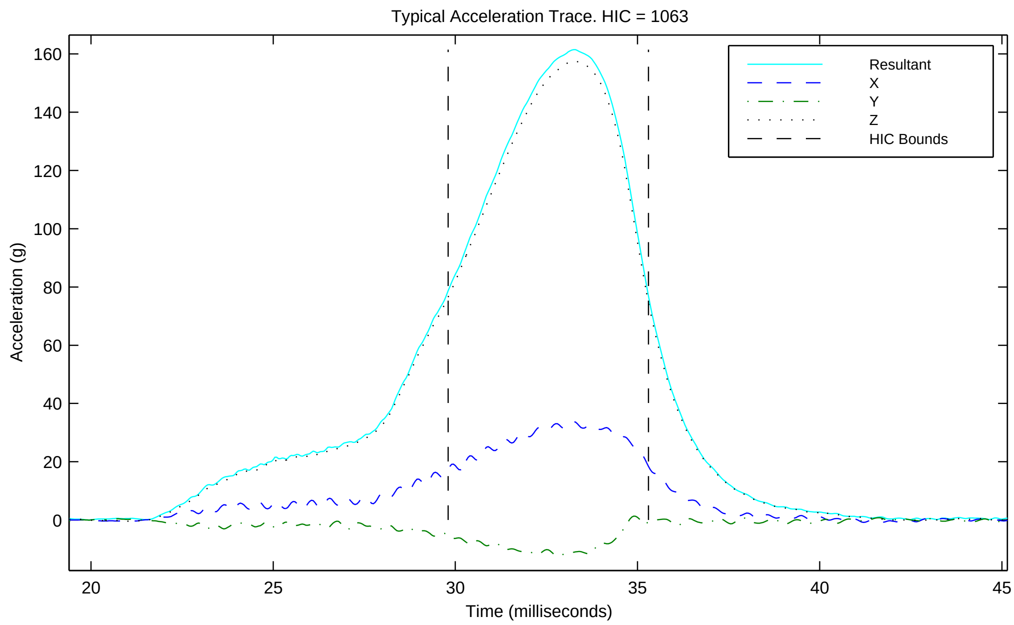


Figure B4 Typical Acceleration Trace.

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