TÜV AUSTRIA ACADEMY

Natural and loose-fill impact attenuating surfaces

Improving the standards

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University of Technology Sydney, Australia

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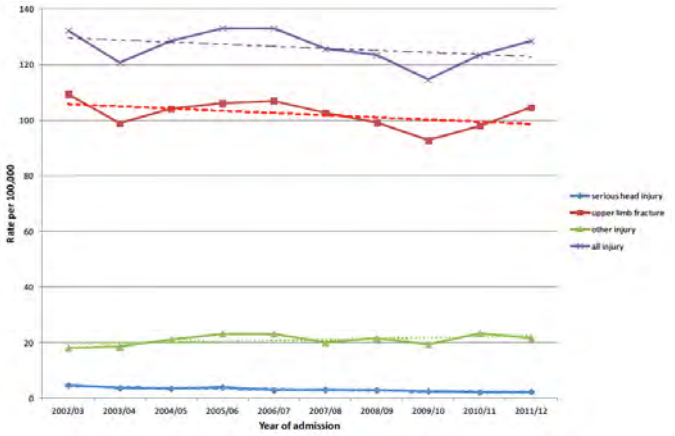
Introduction

- ✓ **Injury trends from falls in Australia (2002-2012)**
- ✓ **Natural and loose fill**
  - Advantages – disadvantages
  - IAS behaviour during impact
- ✓ **Properties of loose fill materials**
  - Force v displacement hysteresis curves
  - Sand – size, shape, grading and degradation…
  - Bark – depth, sharps…
- ✓ **Maintenance of sand and bark**
- ✓ **Consequences for EN 1177 and other IAS Standards**

Injury trends from falls in Australia



Playground equipment fall injury hospitalisations 2002-12

Source: Victorian Injury Surveillance Unit

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Natural and loose-fill surfaces

IAS Bark

Advantages	Disadvantages	Comments
Low initial cost	Easily displaced in high traffic and near forced movement devices	Reduces ongoing maintenance if designed and installed to 400 mm minimum
Retains excellent impact attenuation properties for many years	Some barks are not suitable for disability access	Only purchase bark that has no sharps (timber contamination)
Does not cause skin burns on a hot day (high Specific Heat 0.7-2.6)	Requires regular inspection	Can conceal hazardous objects (broken bottles, syringes)
Easy to install	Requires raking	
Readily available	Requires topping up	
Long life		
Natural surface		
Difficult to vandalise		

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Natural and loose-fill surfaces

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IAS Sand

Advantages	Disadvantages	Comments
Low initial cost	Easily displaced in high traffic and near forced movement devices	If sand gets contaminated with fines it loses impact attenuation properties and will need to be sieved in-situ or removed and replaced
Easy to install	Requires regular inspection	Can conceal hazardous objects (broken bottles, syringes)
Retains excellent impact attenuation properties for many years	Can get very hot and cause skin burns on a hot day (low Specific Heat = 0.19)	Mixing two different IAS can cause contamination if their grading curves are different
Readily available	Requires raking	Reduces ongoing maintentance if designed and installed to 400 mm minimum
Long life	Requires topping up	
Natural surface	Not suitable for disability access	
Difficult to vandalise	Conceals animal faeces	

IAS behaviour during impact – dry fine sand

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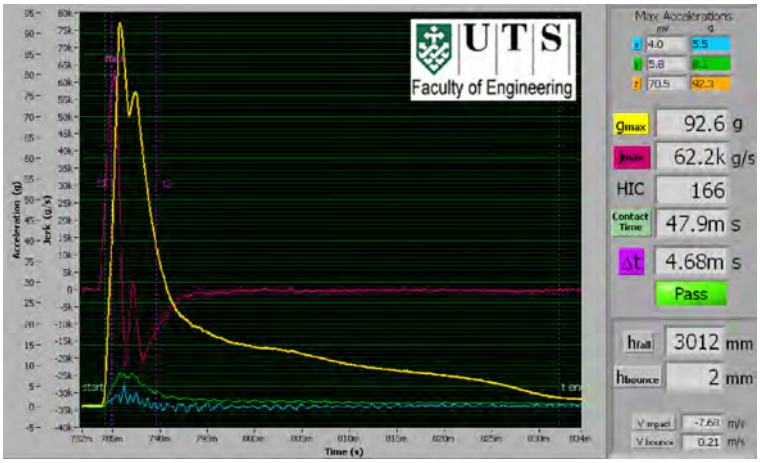

Sand (fine & dry): Acceleration v Time

1st drop in same location @ 3 m FHoF

IAS behaviour during impact – dry fine sand

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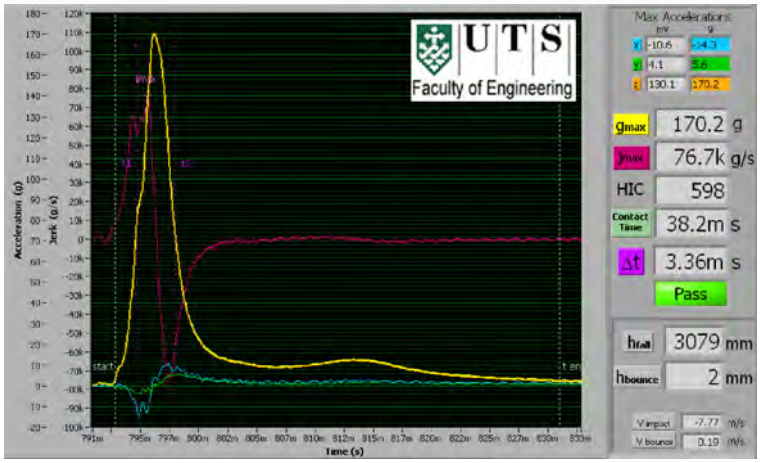

Sand (fine & dry): Acceleration v Time

2nd drop in same location @ 3 m FHoF

IAS behaviour during impact – dry fine sand

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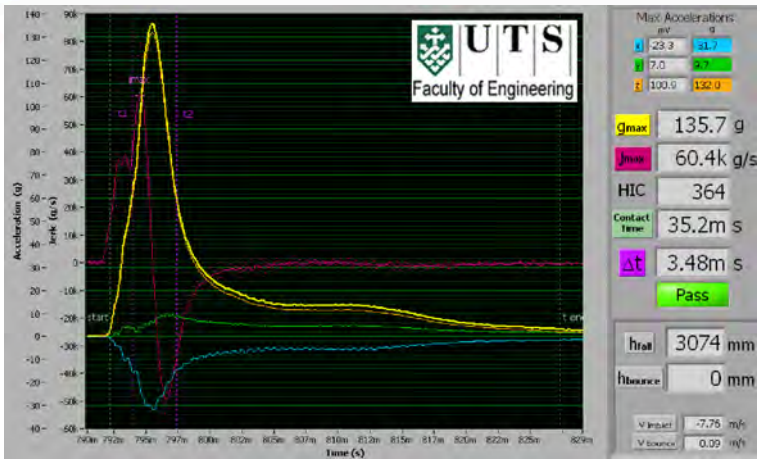

Sand (fine & dry): Acceleration v Time

3rd drop in same location @ 3 m FHoF

IAS behaviour during impact – wet fine sand

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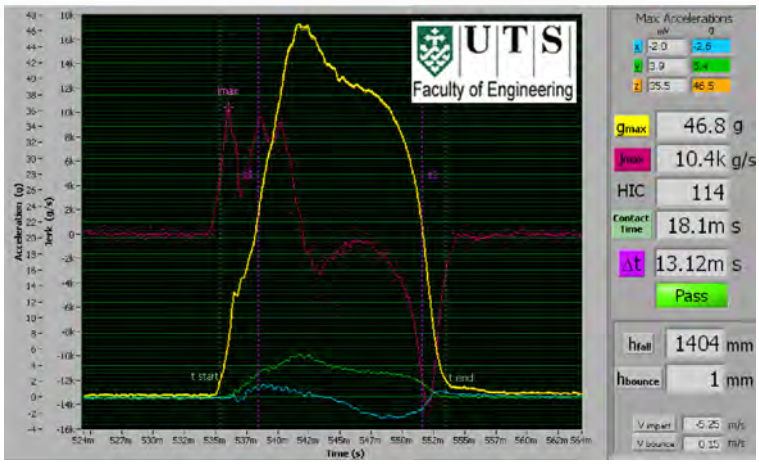

Sand (fine & wet): Acceleration v Time

1st drop in same location @ 1.4 m FHoF

IAS behaviour during impact – wet fine sand

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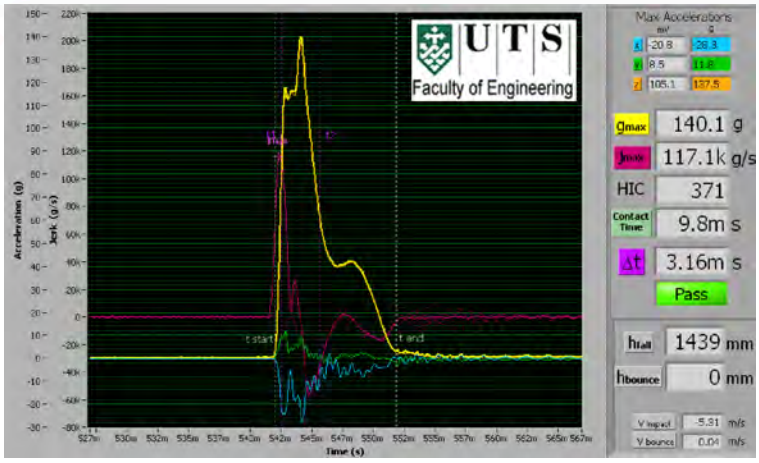

Sand (fine & wet): Acceleration v Time

2nd drop in same location @ 1.4 m FHoF

IAS behaviour during impact – wet fine sand

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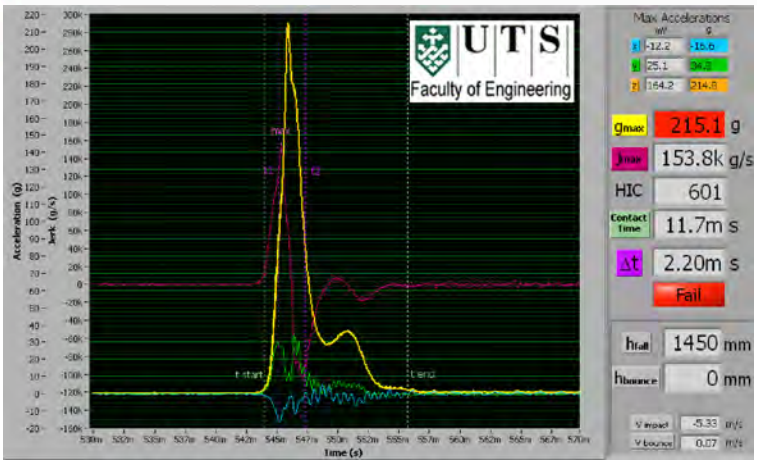

Sand (fine & wet): Acceleration v Time

3rd drop in same location @ 1.4 m FHoF

IAS behaviour during impact – dry bark

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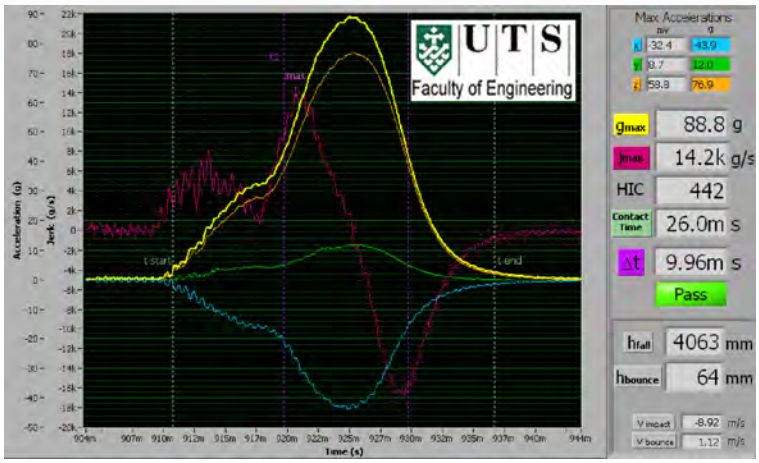

Bark (WA dry): Acceleration v Time

1st drop in same location @ 4 m FHoF

IAS behaviour during impact – dry bark

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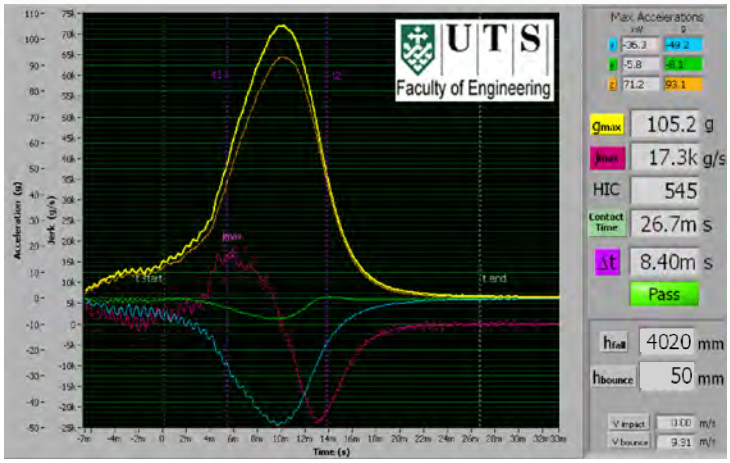

Bark (WA dry): Acceleration v Time

2nd drop in same location @ 4 m FHoF

IAS behaviour during impact – dry bark

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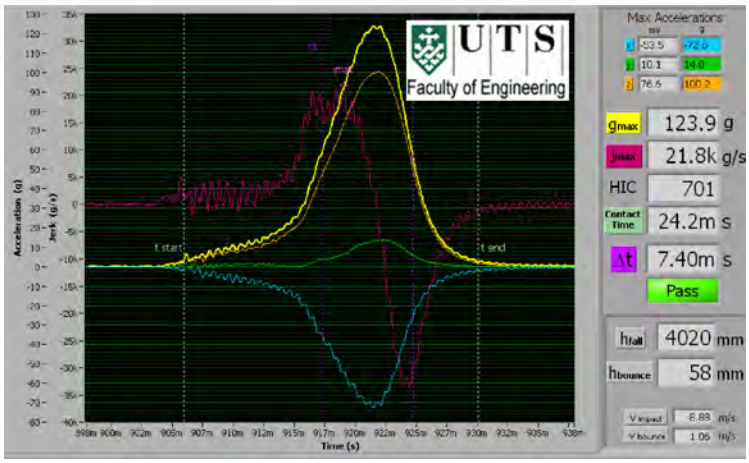

Bark (WA dry): Acceleration v Time

3rd drop in same location @ 4 m FHoF

IAS behaviour during impact – dry bark

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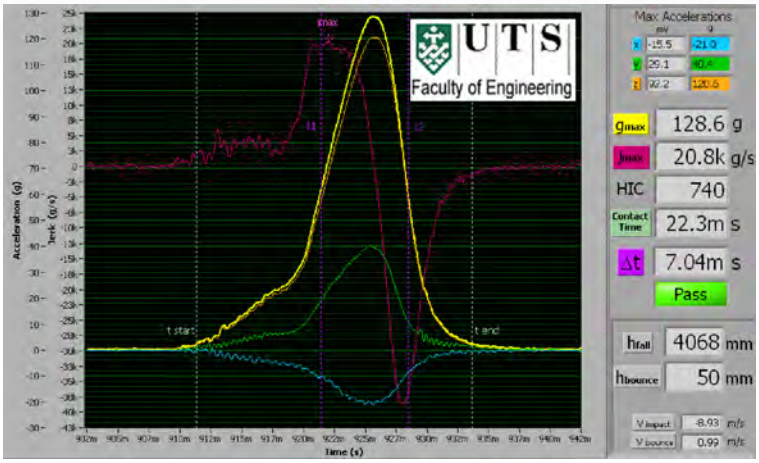

Bark (WA dry): Acceleration v Time

4th drop in same location @ 4 m FHoF

IAS behaviour during impact – dry bark

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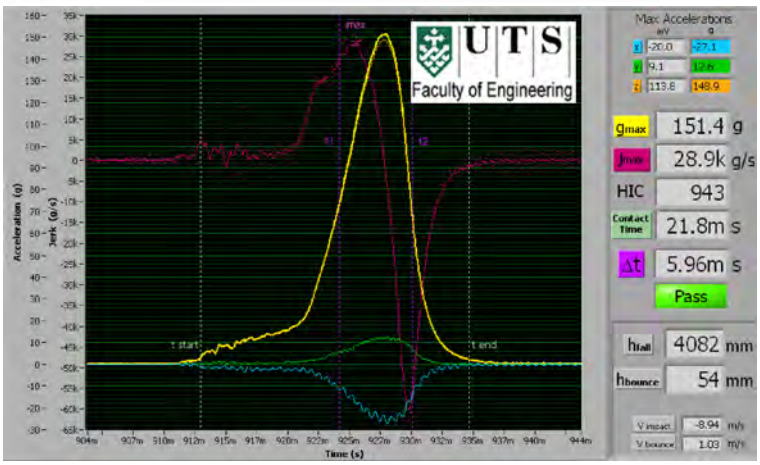

Bark (WA dry): Acceleration v Time

5th drop in same location @ 4 m FHoF

IAS behaviour during impact – wet bark

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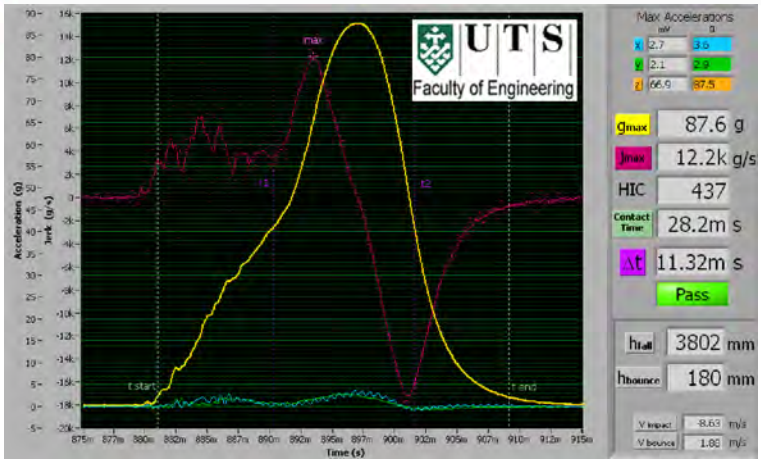

Bark (WA wet): Acceleration v Time

1st drop in same location @ 3.8 m FHoF

IAS behaviour during impact – wet bark

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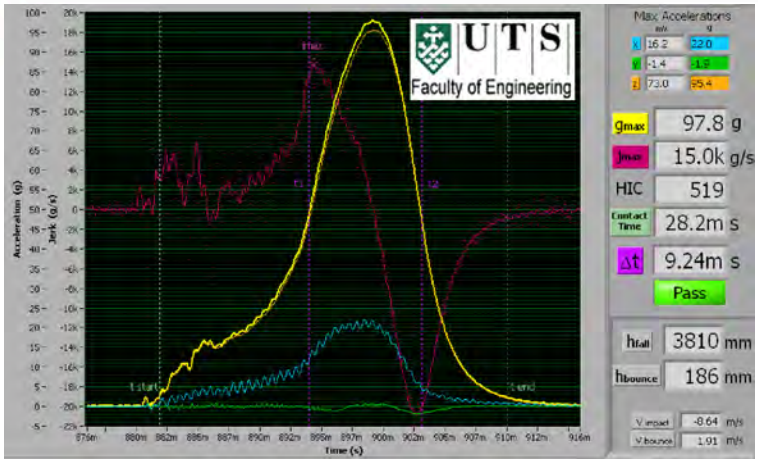

Bark (WA wet): Acceleration v Time

2nd drop in same location @ 3.8 m FHoF

IAS behaviour during impact – wet bark

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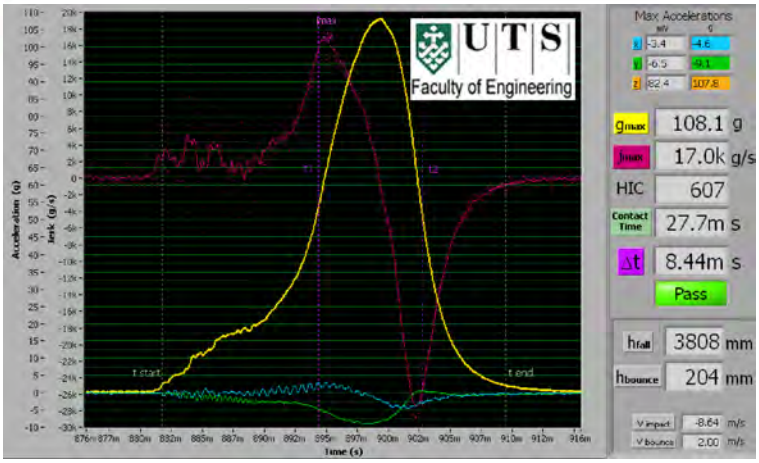

Bark (WA wet): Acceleration v Time

3rd drop in same location @ 3.8 m FHoF

Properties of loose-fill surfaces

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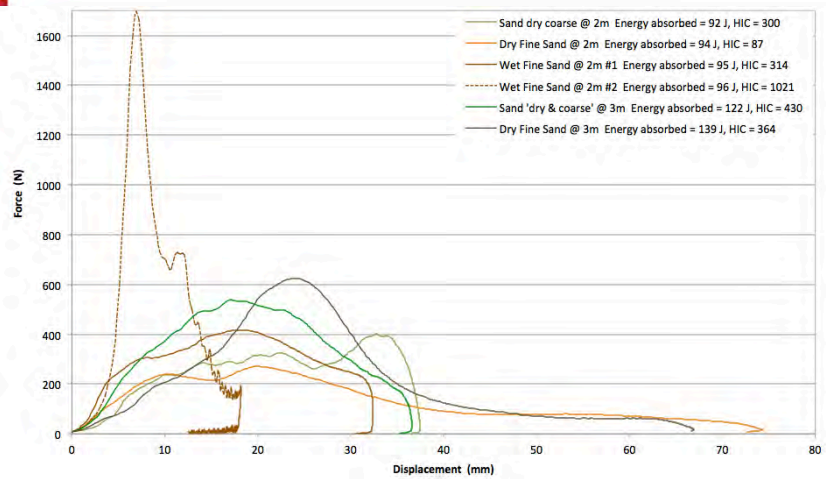

Force v Displacement hysteresis curves

Wet, dry, coarse & fine sand @ 2 m & 3 m FHoF

Properties of loose-fill surfaces

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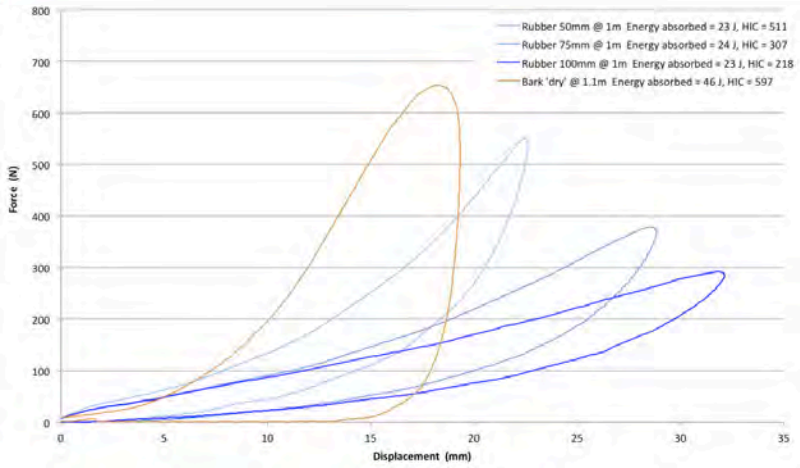

Force v Displacement hysteresis curves

rubber & bark @ 1 m FHoF

Properties of loose-fill surfaces

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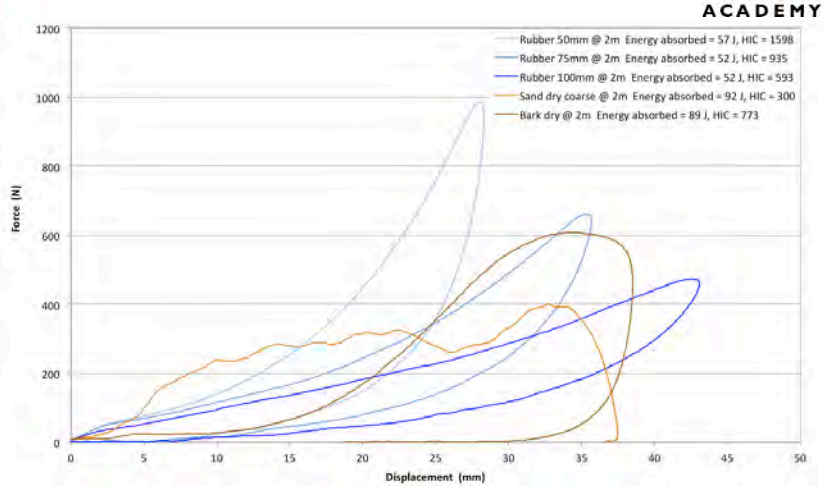

Force v Displacement hysteresis curves

rubber & bark @ 2 m FHoF

Properties of loose-fill surfaces

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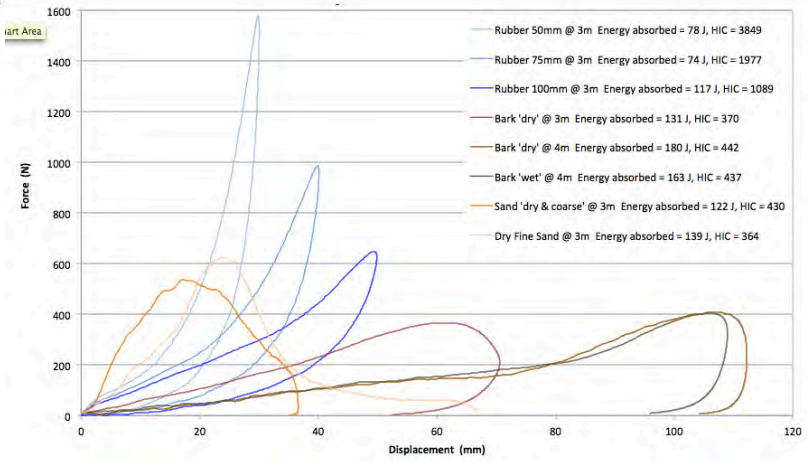

Force v Displacement hysteresis curves

rubber & bark @ 3 m & 4 m FHoF

Properties of loose-fill surfaces

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IAS Product	FHoF	HIC	% work
Rubber 50mm	1.0	511	0.51
Rubber 100mm	1.0	218	0.51
Rubber 75mm	1.0	307	0.53
Rubber 75mm	3.0	1977	0.55
Rubber 75mm	2.0	935	0.57
Rubber 100mm	2.0	593	0.57
Rubber 50mm	3.0	3849	0.58
Rubber 50mm	2.0	1598	0.63
Rubber 100mm	3.0	1089	0.86
Sand dry course 200mm	3.0	430	0.90
Bark wet 200mm #1	3.8	437	0.95
Bark dry 200mm #1	3.0	370	0.97
Bark dry 200mm #1	2.0	773	0.97
Bark dry 200mm #1	4.1	442	0.98
Sand fine & dry 200mm #1	2.1	87	1.00
Bark dry 200mm #1	1.0	597	1.00
Sand fine & dry 200mm #3	3.1	364	1.00
Sand fine & wet 200mm #1	2.1	314	1.00
Sand fine & wet 200mm #2	2.1	1021	1.00
Sand dry course 200mm	2.0	300	1.00

Percentage work performed by IAS

(rubber, bark & sand @ 1m, 2m, 3 m & 4 m FHoF)

Properties of loose-fill surfaces – Bark

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- ✓ **For bark IAS the following is recommended:**
  - Good site preparation
  - Only install on level ground
  - Install to minimum depth of 400 mm
  - Install over heavy duty geotextile membrane
  - Provide adequate sub-surface drainage
  - Fibrous bark has no sharp, pointed or large elements
  - Don't rotary hoe as this disturbs subsurface stratum and can bury or mix contaminates
- ✓ **Research has confirmed that decomposition improves the impact attenuation properties – so don't discard every year, let your bark decompose and mature like a good red wine**

Natural and loose-fill surfaces

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- ✓ **Many different types of sand exist and they are not all suitable for use as IAS within playgrounds**

Properties of loose-fill surfaces – Sand

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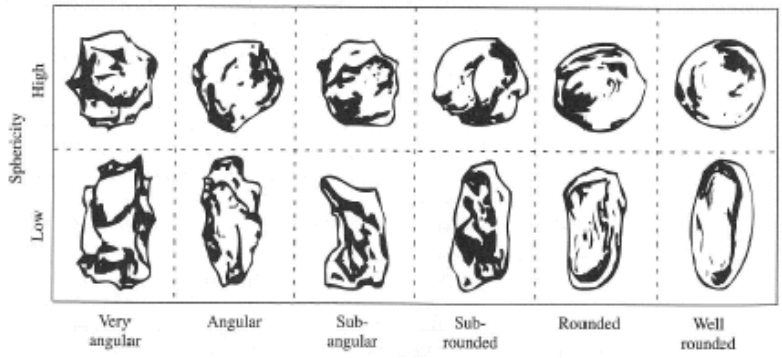
- ✓ **Particle shape – roundness and sphericity are important**
  - Angular particles compact and bind together
  - Rounded particles flow when impacted



Properties of loose-fill surfaces – Sand

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- ✓ **Particles all the same size**
  - The coefficient of uniformity must not exceed 2.75
  - Recommend coefficient of uniformity < 2.00
  - IAS Sand can be contaminated when topping up during maintenance by mixing two high quality sands of different grading size ie fine sand with a coarse sand
  - Assessment is by way of mechanical sieve analysis

Properties of loose-fill surfaces – Sand

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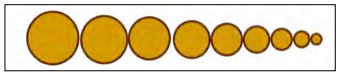
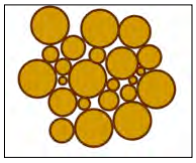
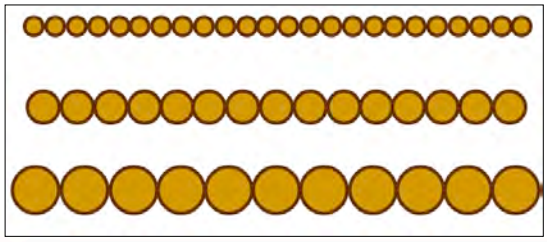
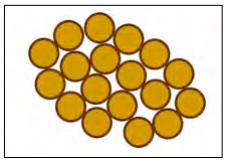
X **Well graded sand is undesirable**



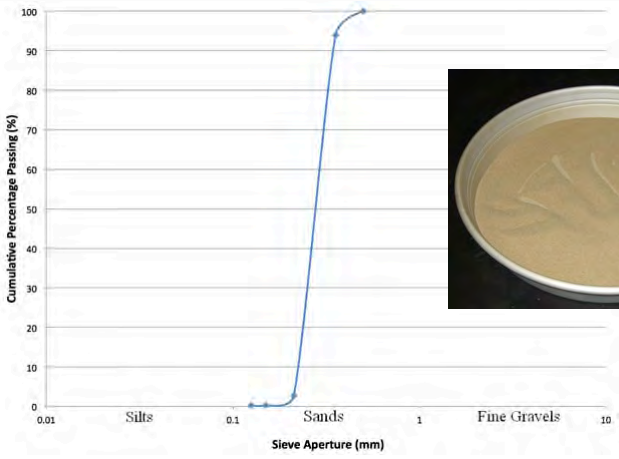


✓ **Uniformly graded sand is desirable**





Sieve grading curve of the tested 'fine' sand



Sand (fine): Sieve grading curve

Cumulative passing (%) v Sieve aperture (mm)

Properties of loose-fill surfaces – Sand

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✓ **No fines**

- Fines cause agglomeration of particles
- Fines cause airborne dust
- Fines make hands and clothes dirty

Properties of loose-fill surfaces – Sand

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✓ **Low degradation**

- Occurs over time and through playground usage
- Changes the particle size distribution
- Increase the percentage of fines
- Increase the coefficient of uniformity
- Test by accelerated ageing

Properties of loose-fill surfaces – Sand

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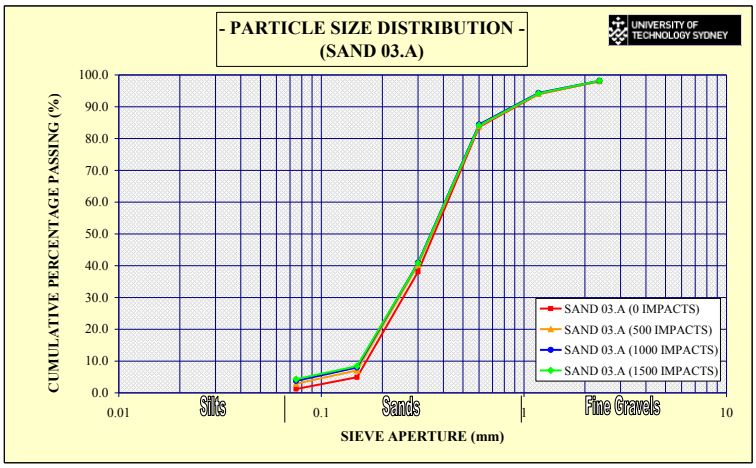
✓ Low degradation – good example



Properties of loose-fill surfaces – Sand

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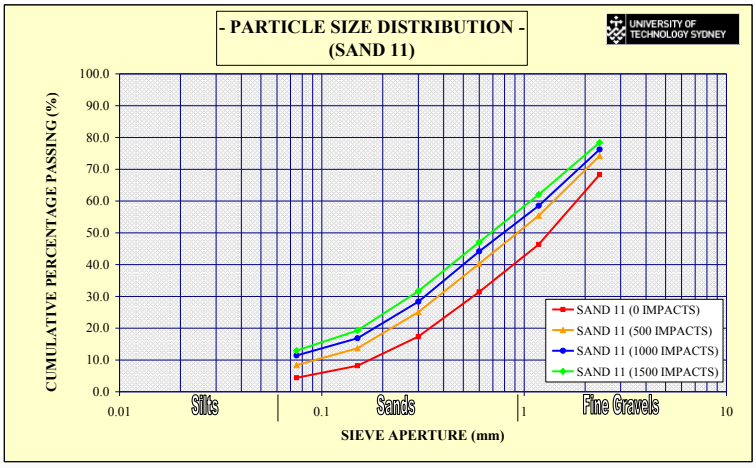
✓ Low degradation – poor example



Properties of loose-fill surfaces – Sand

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- ✓ **No solubles**
  - Solubles cause agglomeration of particles
  - Solubles act as a binder or glue
  - Causes sand to crust and cake
  - Washing reduces solubles
  - Watch out for solubles created during degradation

Sand selection process flow chart

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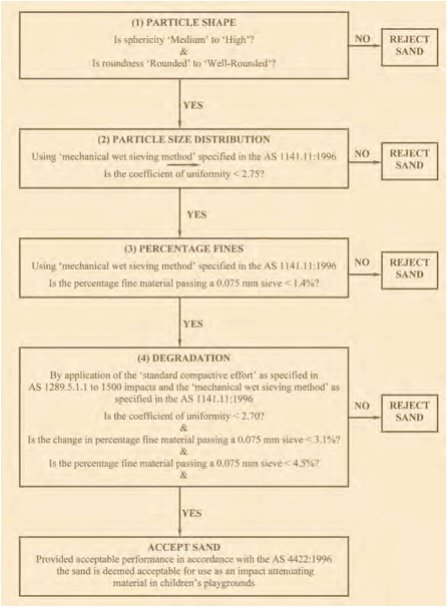

Maintenance of sand IAS

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In-situ sieving using portable vibrating sieve

Maintenance of sand IAS

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In-situ sieving using portable vibrating sieve

Maintenance of sand IAS

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Maintenance of sand IAS

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In-situ sieving using portable vibrating sieve

Maintenance of sand IAS

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In-situ sieving using portable vibrating sieve

Maintenance of bark IAS

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Bark only topped up & 'unfluffed' (compacted)

> 12 months low travel area

Maintenance of bark IAS

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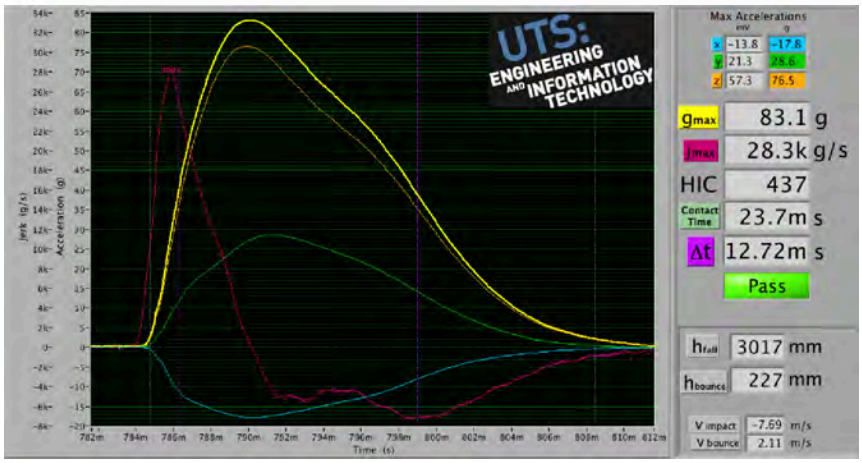

Bark 'unfluffed' > 12 months: Acceleration v Time

Low traffic – 1st drop in same location @ 3 m FHoF

Maintenance of bark IAS

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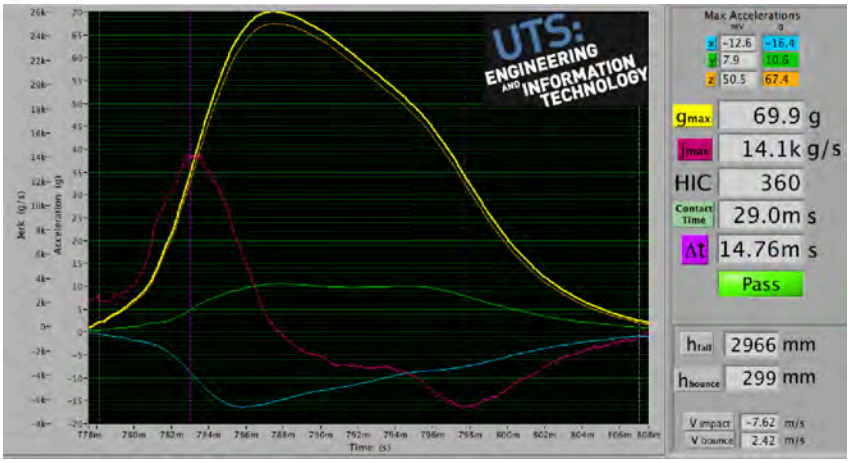

Bark 'unfluffed' > 12 months: Acceleration v Time

Low traffic – 4th drop in same location @ 3 m FHoF

Maintenance of bark IAS

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Bark only topped up & 'unfluffed' (compacted)

> 12 months high travel area

Maintenance of bark IAS

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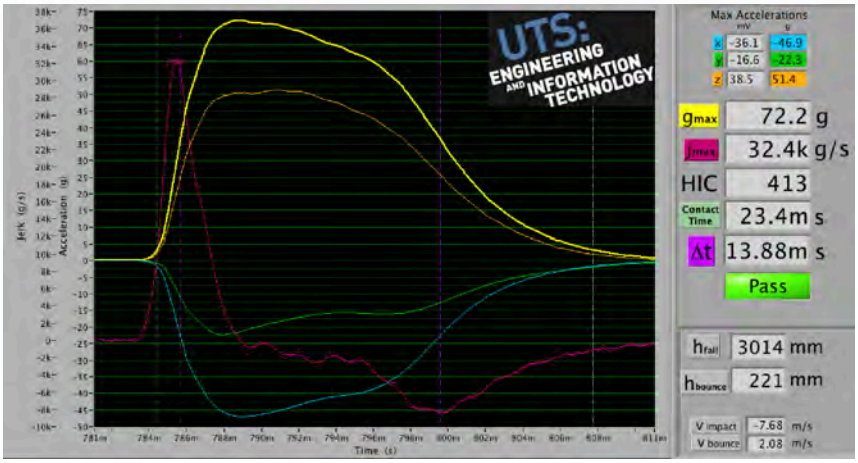

Bark 'unfluffed' > 12 months: Acceleration v Time

High traffic – 1st drop in same location @ 3 m FHoF

Maintenance of bark IAS

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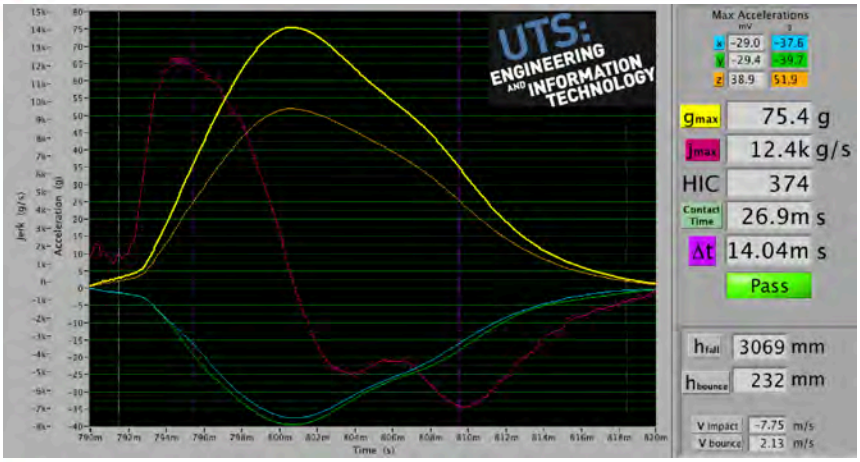


Bark 'unfluffed' > 12 months: Acceleration v Time

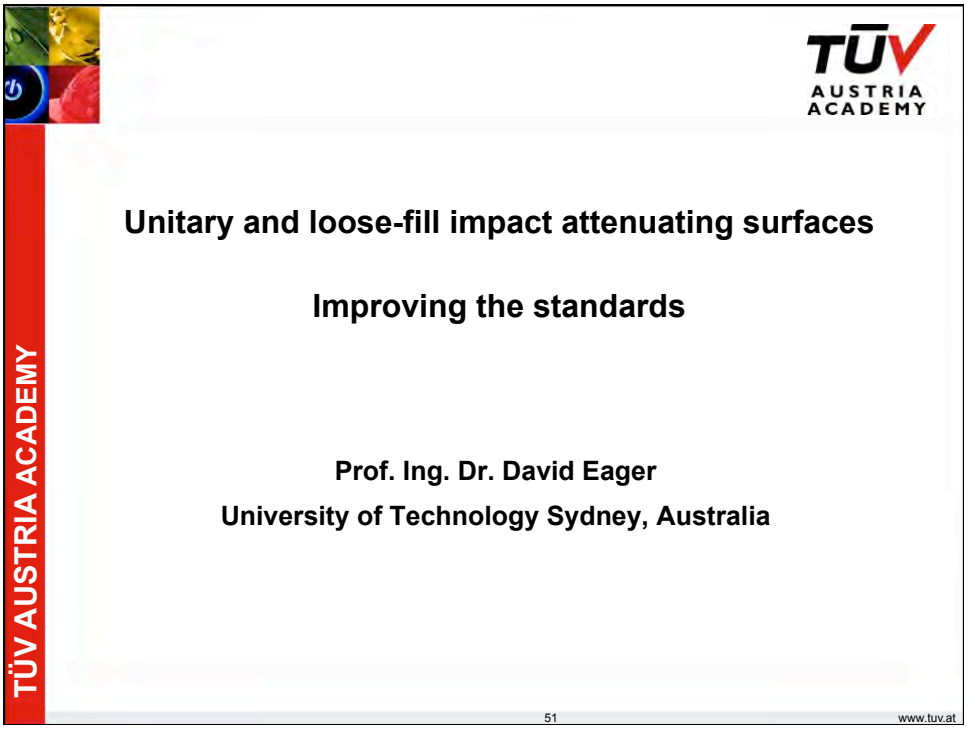
High traffic – 4th drop in same location @ 3 m FHoF

Maintenance of bark IAS

This is not a impact attenuating surface material !!!

Consequences for EN 1177 Standard

- ✓ **Bark – the following is recommended:**
  - Provided bark is correctly installed to depth of 400 mm there is no need for in-situ testing (if tested in laboratory)
  - Requires little maintenance apart from topping up to maintain 400 mm depth
- ✓ **Sand – in addition to a low HIC the sand shall have the following properties:**
  - Particles well rounded
  - Particles all the same size
  - No fines
  - Low degradation
  - No solubles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