ISO versus Hemi Heads

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Testing of soft-fall surfaces to determine Critical Fall Heights is prescribed in Australia and New Zealand by the Standard AS/NZS 4422 – 1996, *Playground surfacing – Specifications, requirements and test method*. This Standard specifies the use of a 5 kg head or missile of the shape ISO size J as in AS/NZS 2512.1.

The Triax 2000 impact testing system is sometimes used in Australia for this testing. This system uses the head specified in ASTM 1292 – a hemispherical head of diameter 6.3 inches and mass 10.1 pound (~ 4.6 kg). This head is different from that specified in AS/NZS 4422, so apart from non-compliance does it produce different results?

Theoretical considerations

Consider first the effect of the difference in masses.
Assume the heads are dropped from height h onto a linear spring of constant k.
Then by conservation of energy:

$$mgh = \frac{1}{2} k x^2$$

where m is the mass of the head and x is the maximum compression of the spring.
Also

$$mgh = \frac{1}{2} F^2 / k$$

Where F is the maximum force developed by the mass.

Equating F = ma gives

$$mgh = \frac{1}{2} (ma)^2 / k$$

Where a is the maximum deceleration experienced by the mass.
Or

$$a = 2\ k\ mgh/\sqrt{(m)}$$

ie. g-max (the usual measure of a) is inversely proportional to the square root of m
or

$$\text{g-max} = C / \sqrt{(m)}$$

C being some constant.

The Hemi head is 9 % less than the ISO head, so using small differentials this implies that the g-max it produces in impact drops is 4.5 % greater.

These calculations are complicated by two factors:
- the spring constant of surfaces in generally non-linear which is expected to produce a perturbation to the calculations:
- the different head shapes may produce differing penetrations of the surface.

There is however a theoretical basis for expecting different results from using the two heads, but is it significant? A practical trial using a number of different surfaces has been carried out to investigate the matter.

Tests

Samples

Three different materials giving a range of Critical Fall Heights from 500 mm to 2 m were tested.

Foam 50:	open cell rubber foam 50 mm thickness, density 47.5 kg/m^3
Rubber 35:	shredded rubber mat thickness 32 mm, density 620 Kg/m^3
Rubber 65:	shredded rubber mat thickness 65 mm, density 500 kg/m^3

Testing

The materials were tested using procedures prescribed by AS/NZS 4422 ie. 3 Drop Tests (of four impacts each) were made on each material. The drop heights corresponding to g-max = 200 and HIC = 1000 were determined graphically for each of the materials.
Critical Fall Heights were determined from these values.

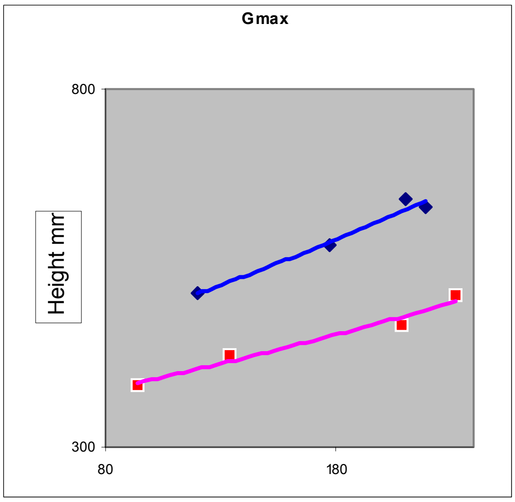
The uncertainty (at the 95 % confidence level) which depends on the calibration trains for the equipment used as well as the scatter of measurement points (random variation) was calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement" 1993.

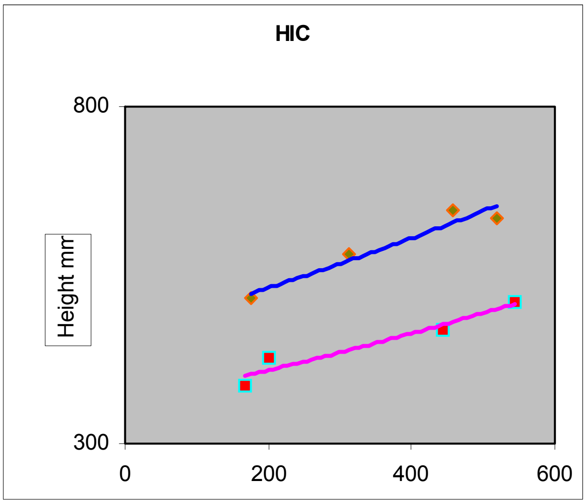
Equipment

A Uniaxe-II impact tester with calibration traceable to International Standards was used for these measurements.
The equipment usually employs an ISO J size head in accordance with AS/NZS 4422. This head was replaced by a hemispherical head complying with the ASTM Standard for the "Hemi" measurements shown.

Results

Results of one Drop Test each using the ISO and Hemi heads on the Rubber Foam sample are shown in the two graphs.





A summary of the results (intersection heights in mm) for the three samples is shown below.

ISO Head

Foam 50		Rubber 35		Rubber 65	
g-max	HIC	g-max	HIC	g-max	HIC
622 (23)	781 (101)	1109 (32)	1072(54)	2367 (205)	1846(121)
603 (24)	770 (121)	1083 (46)	**1030 (57)**	2439 (156)	**1801 (97)**
617 (50)	707 (150)	1095 (30)	1060 (40)	2273 (90)	1837 (147)

Hemi Head

g-max	HIC	g-max	HIC	g-max	HIC
474 (27)	677 (176)	1096 (46)	1065 (53)	2670 (486)	1922 (108)
460 (36)	620 (150)	1095 (24)	**1030 (56)**	2450 (141)	**1905 (107)**
481 (33)	680 (130)	1086 (27)	1053 (50)	2559 (301)	1911 (116)

Figures give intersections of height and g-max = 200 or HIC = 1000, with the Uncertainty of results shown in brackets.

Critical Fall Heights are shown in bold. (These should be rounded down to 0.1 metre ie 460 becomes 0.4 m)

Comments

Significant differences in Critical Fall Heights are obtained using the two different head forms. The differences appear to be material dependent rather than systematic.

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