Impact Attenuation Performance of Playground Surfacing Materials: Effects of Altering the Complying HIC Values of ASTM F1292

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INTRODUCTION

ASTM F1292 is the standard that addresses playground surfacing impact attenuation requirements. Currently the standard requires impact tests to be below the threshold of 1000 HIC (Head Injury Criterion) averaging the second and third drop at each test site[1].

The impact attenuation standards were developed from contemporary automotive safety standards, yet the Federal Motor Vehicle Safety Standards (FMVSS) have since revised their limit to HIC <700 [2, 3]. A limit of HIC <1000 allows a tolerable head injury risk (Abbreviated Injury Scale (AIS) 2) of <89% while the HIC <700 lowers that to <65% (Figure 1). An AIS level 2 injury is moderate injury that does come with a fatality probability of 0.1%-0.4% [2, 3].

PURPOSE

The purpose of this study is to assess the change in compliance of a variety of already installed playground surfacing materials if the HIC score were altered from 1000 to 700.

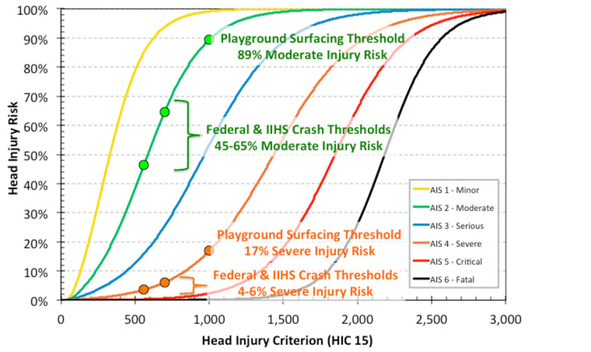

Figure 1: Prasad and Mertz (1985) injury risk functions for HIC at the six AIS severity levels. This is the basis for automotive crash test requirements. AIS 2 (green) and AIS 4 (orange) are labeled to represent the relative risk of injury at a HIC of 1000 (ASTM F1292), compared to the NHTSA requirements of HIC 700 or the IIHS *Acceptable/Good* limit of 560 HIC.

METHODOLOGY

- Following ASTM F1292[1] field testing provision procedures, impact attenuation testing occurred on sand, pea gravel, unitary surfacing (rubber tile or poured-in-place) and wood products (engineered wood fiber, wood chips or wood mulch) (Figure 2).
- Specifically, the study examined and compared the percentages of impact test locations above 1000 & 700 HIC for each surface type.

Figure 2: The surfacing materials which had their impact attenuation performance assessed for this study's intent. From left to right are (a) sand, (b) pea gravel, (c) rubber tile (unitary), (d) poured-in-place (unitary), and (e) wood product.

RESULTS

Figure 3 presents the percentage of impact test locations attenuating impact with a HIC of >1000 including the average fall height of these non-complying test locations. Figure 4 highlights the percentage of impact test locations attenuating impact with a HIC of >700 also including the average fall height.

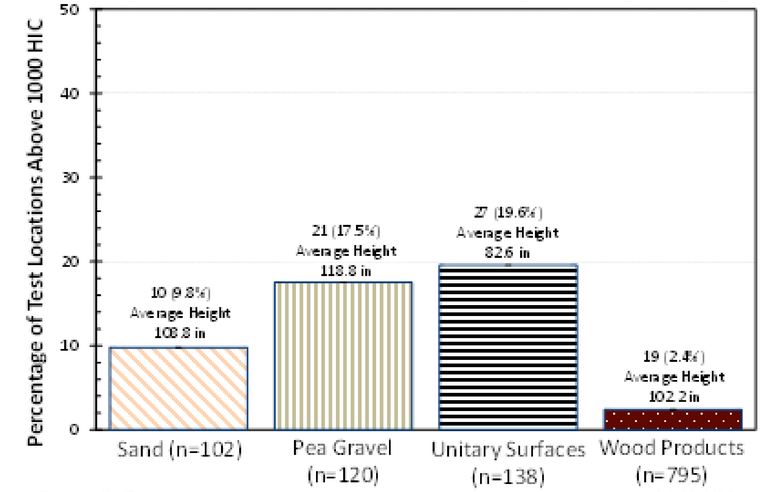

Figure 3: The percentage of impact test locations performing above 1000 HIC.

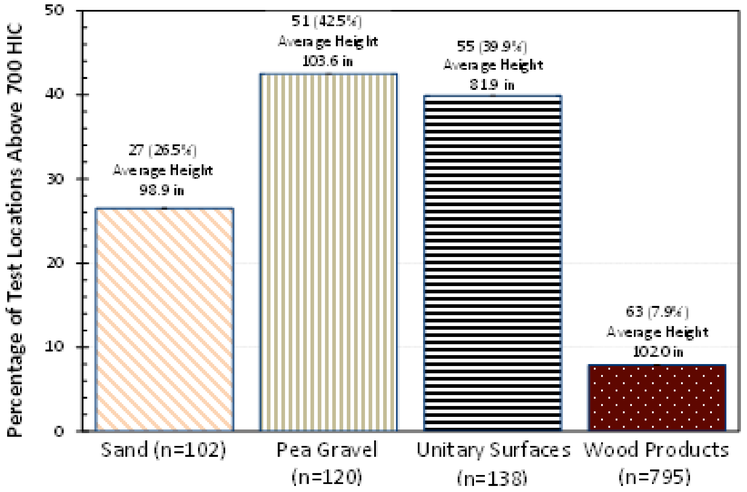

Figure 4: The percentage of impact test locations performing above 700 HIC.

- Unitary surfaces yielded the largest percentage of test locations above 1000 HIC (19.6%), while wood products presented the lowest percentage above 1000 HIC (2.4%).
- Pea gravel presented 17.5% of sites above 1000 HIC and sand presented 9.8% above 1000 HIC.
- Pea gravel had the greatest percentage of locations with HIC above 700 (42.5%), while wood products still presented the lowest percentage above 700 HIC (7.9%).
- Unitary surfaces presented 39.9% of sites above 700 HIC and sand presented 26.5% above 700 HIC.
- Lowering the standard from 1000 HIC to 700 HIC, lowers the average fall heights of the non-complying test locations.

POOR ATTENUATION: UNITARY vs. PEA GRAVEL

HIC >1000

HIC >700

- Assuming similar surfacing conditions, it would be expected that the higher the fall height, the higher the percentage of non-complying test locations.
- Unitary had the lowest average fall height, yet the highest percentage of locations with HIC >1000.
- Pea gravel had the highest average fall height and percentage of locations with HIC >700.

CONCLUSIONS

Best to Worst Attenuation

Wood products are marginally affected by an additional 5.5 percentage points in non-complying test locations, while pea gravel experiences an additional 25 percentage points in non-complying test locations. The larger increase in non-complying test locations that pea gravel presents implies that pea gravel has more attenuation performance within the 700 – 1000 HIC range. The fact that unitary surfaces complied the least with the standard of <1000 HIC, yet had the lowest average non-complying test location fall height illustrates that unitary surfacing performed quite poorly in attenuating impact during this study.

Fall Height & Attenuation

Not only would the choice of surfacing materials be affected by altering the standard from <1000 HIC to <700 HIC, but also the height of complying equipment. Equipment height may need to be lowered if the standard were to be altered.

Future Steps

A method of adopting a new standard may be proposed with future research through a phase-in process. This would allow existing playgrounds to gradually meet tighter standards while playground maintenance and new installations can be performed with specific intent for the playground surface used.

REFERENCES

1) ASTM Standard F1292 (2013).
2) Eppinger R (1999). National Highway Traffic Safety Administration (NHTSA), USA.
3) Eppinger R (2000). National Highway Traffic Safety Administration (NHTSA), USA.
4) Prasad P, Mertz HJ. (1985). SAE 85---1246.

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