# BACKGROUND

Over 200,000 children are injured on playgrounds, requiring an emergency room visit, every year. Falls are a leading cause of playground-related injury<sup>1</sup>.

Wear-mats above the loose fill are placed under heavy traffic equipment, like swings and slight to prevent the erosion and dispersion of loose-fill (Fig 1). Wear-mats maintain the surface depth; however, a firmer



Figure 1: Wear-mats above loose fill

surface is introduced to the top of the playground surface. There is a lack of information related to the safety of wear-mats as there has not been a study conducted examining impact attenuation performance of wear-mats.

This study conducted a preliminary field test of wear-mats at public playgrounds located in parks and schools to analyze whether wear-mats improved or hindered the impact attenuation performance of the surface.



Figure 2: Test sites for wearmats and surrounding loose fill



**Figure 3: :** TRIAX<sup>™</sup> 2015 impactor used to capture HIC during field testing

# METHODOLOGY

Wear-mats were tested in parallel to the surrounding loose fill following a field testing provision adapted from ASTM F1292<sup>2</sup>. The procedure involved 3 drops at 3 different sites on the (1) wear-mats and (2) the immediately adjacent loose fill (Fig 2).

Head Injury Criterion (HIC) scores were calculated using the : TRIAX<sup>™</sup> impactor, to estimate risk of head injury (Fig 3). F1292 has established thresholds of 1000 HIC and 200 g-max, however, this study will only focus on HIC score, which is the most sensitive metric of impact attenuation.

The 9 separate drops on each of the surfaces were averaged for each test site. To evaluate the effect of placing wear-mats below heavy traffic, the impact attenuation of wear-mat was compared with that of the immediately adjacent loose fill.

A paired two-tailed t-test was performed to determine if there was a significant difference in HIC performance between the two groups.

# Are Playground Wear-mats Above Loose Fill **Improving Impact Attenuation Performance?**

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## **RESULTS & DISCUSSION**

The large difference in impact attenuation performance between wear-mats and the surrounding loose fill is highlighted in figure 4. The presence of these wear-mats introduces a firmer surface that clearly interrupts the impact attenuation of the loose below.

The surrounding loose fill with no wear-mat (n=15) average 371 HIC score, while the surfaces with wear-mats above the loose fill (n=15) averaged 1195 HIC score, a 322% increase.



Wear-mats Above Loose Fill (n=15) Surrounding Loose Fill (n=15) **Figure 4:** HIC performances for the wear-mats above loose fill and the surrounding loose fill with standard deviations.

Injury risk curves were utilized to estimate potential head injury risk from these HIC scores (Figure 5). The average HIC score for the surrounding loose fill (371) estimates a 22% and 2% chance of an AIS 2 and 4 head injury.

The average HIC score for the immediately adjacent wear-mats (1195) estimates a 96% chance of a AIS 2 head injury, over 4x more likely. More surprisingly, a 29% chance of AIS 4 injury, just under 15x more likely than the surrounding loose fill.

This different was monitored much more closely with a paired two-tailed t-test that resulted in a p-value of <0.001, backing the claim that these two surfaces are different in their impact attenuation performances.



**Figure 5:** Head injury risk for various AIS levels given certain HIC scores, based on a 50<sup>th</sup> percentile male adult<sup>3,4</sup>.

**Table 1:** Comparison of wear-mat and surrounding loose
 fill with the difference of wear-mat HIC performance minus surrounding loose fill performance

| Surfacing Material | Surrounding      | Wear-mat Above   | Delta |
|--------------------|------------------|------------------|-------|
|                    | Loose Fill (HIC) | Loose Fill (HIC) | (HIC) |
| Wood Products      | 265              | 3041             | 2776  |
| Wood Products      | 219              | 2856             | 2637  |
| Wood Products      | 182              | 2223 1           | 2042  |
| Wood Products      | 116              | 1907 1           | 1790  |
| Wood Products      | 256              | 1395 1           | 1140  |
| Sand               | 216              | 1165 1           | 949   |
| Wood Products      | 448              | 1348 1           | 900   |
| Pea Gravel         | 614              | 975 1            | 361   |
| Pea Gravel         | 924              | 1135 1           | 211   |
| Wood Products      | 268              | 373 1            | 105   |
| Wood Products      | 389              | 468 1            | 79    |
| Wood Products      | 253              | 285 1            | 33    |
| Wood Products      | 177              | 206              | 29    |
| Wood Products      | 191              | 142 🚽            | -48   |
| Sand               | 749              | 401 🚽            | -348  |

### Wear-mats may increase HIC scores by as much as **322%**



The findings of the study strongly point to the necessity for continued research and investigation of wear-mats installed on top of loose-fill surfacing materials. Increased awareness on the performance of wear-mats is essential for the safety of the child users. It is critical that wear-mats are tested for compliance with F1292 prior to installation.

Further research is needed to increase the sample size to definitively determine whether wear-mats are effective at both prevention of loose fill displacement, while retaining the impact attenuation properties of the loose fill material.

This study examined the effect of wear-mats placed above the surface, but some wear-mats are placed underneath the surface at a variable depth within in the surface. These placement options should also be examined to understand the best possible usage of wear-mats on playgrounds in order to increase safety on playground across the country.

- 2) ASTM (2013). Impact Attenuation of Surfacing Materials Within the Use Zone of Playground Equipment. 1-24.
- 3) Mariotti, G. V. (n.d.). Raccolta casi Working Model, visualNastran & SimWise visualNastran Pedestrian Model.
- FMVSS No. 201

\*The national sampling of playground dataset was funded by the U.S. Consumer Product Safety Commission, CPSC-S-16-0061

Table 1 shows the difference in impact attenuation performance between the wear-mats and the adjacent surfaces for **each playground**.

87% of the wear-mats had a higher HIC scores than the surrounding loose fill, with 33% demonstrating an increase of over 1000 HIC.

However, 5 of the wear-mats were within 100 HIC or lower when compared to the surrounding loose fill, indicating that not all wearmats are significantly detrimental to the impact attenuation of the surface.

Wear-mats were as much as **14x** more likely to lead to an AIS 4 head injury

# REFERENCES

1) Hanway, S. (2016). Injuries Associated with Playground Equipment 2009-2014. US CPSC.

4) Natl. Highw. Traffic Saf. Adm. (NHTSA). 1995. Final economic assessment, upper interior head protection.