

Development and Assessment of Engineered Wood Fiber (EWF) Playground Surfacing Maintenance Guidelines from Impact Attenuation Testing

Heather Olsen¹ Brooke Ewer² Caitlin Colicchio² Eric Kennedy²

¹ Department of Health & Recreation, University of Northern Iowa

² Biomedical Engineering Department, Bucknell University

INTRODUCTION

- Playground injuries result in 200,000 emergency department visits each year in the US, with falls on the surface accounting for 75% of them (Adelson, 2018)
- ASTM F1292 is a standard identifying allowable Head Injury Criterion (HIC) and g-max values to assess a playground as compliant or not in the goal of preventing severe head injuries sustained during falls (ASTM, 2019)
- Direct *in-situ* field testing of playground surfaces, such as Olsen (2018), allows for an assessment of real-world surface impact attenuation performance, and an assessment of the safety of surfacing based on voluntary standards, such as ASTM F1292
- Real world data can also be used to generate generalized guidelines for surfacing performance

OBJECTIVE

The purpose of this study is to perform meta-analysis of playground safety surfacing from field testing to develop more a detailed methodology when recommending surface conditions required for proper protection

METHODS

- Collected field test impact attenuation data (EWF ~ 400 test sites)
- Categorized each test site by impact attenuation data and surface depth
- Assessed compliance of each site by compliance rates (percentage) to ASTM F1292
- Three categories of *Safe*, *Caution*, and *Danger* were developed based on compliance rates and then applied to the data (Table 1)

Table 1: Surface Depth vs fall height tables with specified *Safe*, *Caution*, or *Danger* criteria based on compliance rates from field-testing

Safe: 100% Compliant

Caution: 90-100% Compliance and/or a separation between *Safe* and *Danger* conditions

Danger: <90% Compliant and/or undesirable conditions

Equipment	Engineered Wood Fiber Surface Depth (in)					
Fall Height (ft)	0.0 - 2.9	3.0 - 5.9	6.0 - 8.9	9.0 - 11.9	12.0 - 14.9	15+
0.0 - 1.9	<div>Danger</div>	<div>Caution</div>	<div>Safe</div>			
2.0 - 3.9						
4.0 - 5.9						
6.0 - 7.9						
8.0 - 9.9		<div>Safe</div>	<div>Safe</div>			
10.0 - 11.9						
12+					<div>Safe</div>	

- Performance verification of *Safe*, *Caution*, *Danger* categories conducted utilizing Insurance Institute for Highway Safety (IIHS) HIC performance ranges (IIHS, 2014)

RESULTS AND DISCUSSION

Table 2: Comparison of surface depth performance recommendations (*Safe*, *Caution*, and *Danger*) relative to IIHS head injury performance levels.

Performance Category	Engineered Wood Fiber Recommendations			
	Safe	Caution	Danger	Grand Total
Level I HIC: 0.0-559.9	100% (n=175)	96% (n=170)	56.8% (n=25)	93.4% (n=370)
Level II HIC: 560.0-699.0	0% (n=0)	1.7% (n=3)	11.4% (n=5)	2% (n=8)
Level III HIC: 700.0-839.9	0% (n=0)	0.6% (n=1)	9.1% (n=4)	1.3% (n=5)
Level IV HIC 840.0-999.9	0% (n=0)	1.7% (n=3)	4.5% (n=2)	1.3% (n=5)
Fail HIC: 1000.0+	0% (n=0)	0% (n=0)	18.2% (n=8)	2% (n=8)
Grand Total	100% (n=175)	100% (n=177)	100% (n=44)	100% (n=396)

- Investigation assessed the overall level of performance of each of the three proposed maintenance-guide conditions (*Safe*, *Caution*, *Danger*) and the overall attenuation performance with respect to the IIHS head injury performance levels
- Cross-comparison of the two metrics allowed the assessment and validation of anticipated real-world impact attenuation performance for each of the maintenance-guide conditions (Table 2)

CONCLUSIONS & KEY TAKAWAYS

- Surface conditions (combinations of fall height and surface depths) categorized as *Safe* were not only fully compliant with current ASTM F1292 metrics (< 1000 HIC and < 200 g-max), but they also exhibited excellent overall performance, with 100% performing at levels of 560 HIC or below (Level I performance).
- Surface conditions (combinations of fall height and surface depths) categorized as *Caution* continued to provide impact protection that would be compliant with current ASTM F1292 metrics (< 1000 HIC and < 200 g-max), but with some performance outliers in HIC ranges at Level II, III and IV. Caution categories are intended to provide a warning to initiate maintenance practices while surfaces still provide compliant attenuation.
- Surface conditions (combinations of fall height and surface depths) categorized as *Danger* showed inconsistent attenuation results. Over 1/6 of these test site combinations were non-compliant with current ASTM F1292 metrics (> 1000 HIC and/or > 200 g-max). The “Danger” category highlights undesirable surface conditions – with minimal surface depth (< 3 inches) that provides no protection from additional wear or displacement, and otherwise inconsistent distribution between Level I-IV and non-compliant attenuation.

- The proposed maintenance guides and performance assessment tables were developed to provide general guidelines that aid in the development of maintenance schedules and underscore the ability of maintenance programs to exceed existing performance requirements
- Manufacturer’s data provides the most specific information about product performance, matched to installation and equipment needs (fall height, maintenance intervals, environmental conditions, etc.)
- Increased data collection and continued surveillance analysis is required: These guidelines are not intended to be a true substitute for direct field testing of a playground’s surfacing performance and should be expanded for alternative surfaces

ACKNOWLEDGEMENTS

The authors wish to thank the Bucknell College of Engineering for undergraduate sponsorship of this project. The national sampling of playground dataset was funded by the U.S. Consumer Product Safety Commission, CPSC-S-16-0061.

REFERENCES

- Adelson SL (2018) Clinical Pediatrics 57(5): 584-592
- ASTM International (2019) F1292
- Olsen HM (2018) National Study of Public Playground Equipment and Surfacing. CPSC- S-16 0061
- IIHS (2014) Mod. Overlap Frontal Crashworthiness Eval. Guidelines for Rating Injury Measures