A LONGITUDINAL STUDY OF PLAYGROUND SURFACES TO EVALUATE ACCESSIBILITY

Final Report

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Abstract

The playground is a place for play and learning for all children, including children with disabilities. When the playground presents physical barriers such as inaccessible surfaces and routes, play, learning, development and the self-actualized benefits of the leisure experience can be stunted or even eliminated for a child with a disability. There are more than 100 different commercial varieties of playgrounds surfaces on the market. Lack of reliable product performance data on the effectiveness of safe, accessible playground surfaces relative to cost for installation and ongoing maintenance prohibits public playground owners from making informed choices on the selection of surfaces most appropriate for their public setting. The purpose of this study was to evaluate a variety of playground surfaces, their ability to meet accessibility requirements upon initial installation and maintenance over a five-year period. The research questions include: how well do various playground surfaces meeting the accessibility requirements upon installation? What are the costs for the various playground surfaces? What accessibility issues arise out of initial installation? What maintenance issues arise?

Results from this study indicate there is no perfect playground surface. Even within 12 months of installation, each type of surface has had some sort of issue or series of issues that may affect the product's performance and contribute to the necessity and frequency of surface maintenance to assure accessibility and safety for use by children on a daily basis.

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A Longitudinal Study of Playground Surfaces to Evaluate Accessibility Final Report

I. Introduction to the Study

Purpose

In 2008, the National Center on Accessibility (NCA) at Indiana University initiated a longitudinal study of playground surfaces with research funding by the U.S. Access Board. The purpose of this longitudinal study was to evaluate a variety of playground surfaces, their costs, and their ability to meet accessibility requirements while documenting deficiencies that arise upon initial installation or those that might require maintenance after a 3-5 year period of use.

Background

There are an estimated 2.9 million children with disabilities under the age of 18 in the United States (U.S. Census Bureau, 2009). More than 28 percent of American families have at least one family member with a disability (Wang, 2005). The Centers for Disease Control and Prevention report an estimated 17 percent of children ages 2-19 are obese with increased caloric intake, sedentary behavior and lack of physical activity viewed as contributing factors (CDC, 2010-2013). Playgrounds are one of the potential solutions to the health and wellness issues faced by children. In a study of perceptions, Devine (2004) suggests the meanings ascribed to ability, equal status, difference, and belonging [for people with disabilities] may be created within leisure situations as well as brought from other environments and applied in leisure. These findings would suggest that in the leisure environment of the playground, a child with a disability can be challenged, take risks and learn the difference between his ability and his functional impairment. The public playground is emerging into its own, becoming one of the most important environments for children to develop socialization skills and benefit from physical activity. On the playground children can discover who they are and learn what they can accomplish. They are challenged physically, socially, mentally and emotionally through a variety of play experiences. For children with disabilities, the playground experience is just as important as it is for children without disabilities. In some respects, it is even more important for children with disabilities. On the playground, a child with a disability is able to discover the important distinctions between his disability and his functional ability. The playground also provides a non-threatening recreation environment where children with disabilities can play, learn and form friendships with non-disabled peers. The playground is the ideal environment to facilitate inclusion between children with and without disabilities. However, if the playground equipment or surface is not accessible for a child with a disability, the opportunity for play, discovery and growth is lost (Skulski, Bloomer, et al., 2004).

When the playground presents physical barriers such as inaccessible surfaces and routes, play, learning, development and the self-actualized benefits of the leisure experience can be stunted or even eliminated for a child with a disability. Inaccessible surfaces can prevent children with physical disabilities who may use canes, crutches, walkers or wheelchairs from ambulating through the play area. Pushing a wheelchair over gravel or sand requires tremendous physical effort. When so much effort is exerted little to no energy is left for play (Skulski, 2007). The presence of physical barriers prevents children with disabilities from accessing all play elements on the playground. Most significantly, the inclusive play between children with disabilities and children without disabilities is threatened when the physical playground environment is not accessible through the provision of accessible equipment and accessible play surfaces (Skulski, Bloomer, et. al., 2004). Choosing play surfaces that are accessible upon installation and maintained for accessibility over time becomes one of the most critical decisions during the playground planning and design phases.

The 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design and the Architectural Barriers Act (ABA) Accessibility Standards require newly constructed playgrounds and those existing playgrounds that are altered to comply with a series of technical provisions for accessible play components and the accessible route to those components. Criteria specify a maximum running slope for a ground level accessible route (1:16 or 6.25%), maximum cross slope (1:48 or 2.08%), minimum clear width (60 inches), limit on a change of level along the route (no more than .50 inch), and vertical clearance up to 80 inches. In addition, the ground surface must meet the ASTM F1951-99 Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment. The technical provisions further state that ground surfaces shall be inspected and maintained regularly and frequently to ensure continued compliance with ASTM F1951-99. Ground surfaces that are part of the accessible use and also located in the use zones must meet ASTM F1292-99/04 Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment.

According to the Final Accessibility Guidelines for Play Areas Economic Assessment, the Americans with Disabilities Act Accessibility Guidelines are estimated to affect as many as 5,300 new playgrounds and 18,600 renovated playgrounds annually. Between 5,650 and 8,770 playgrounds at public schools and municipal parks are estimated to be replaced; and 380 to 520 new playgrounds are constructed at public schools and municipal parks each year. Thus, choosing play surfaces that are accessible upon installation and can be maintained as accessible becomes one of the most critical decisions during the playground planning and design phases.

In light of evolving safety and accessibility standards for playgrounds, coupled with complaints and litigation, park and recreation professionals are confronted with questions of how to install and maintain safe and accessible public playgrounds that are cost effective and able to withstand a full life cycle of public use. Results of an online buyers' guide search identifies more than 100 different commercial varieties of playground surfaces on the market. Many claim to meet the national standards for safety and accessibility. The range of product claims, advantages and disadvantages, the differential in costs for installation and maintenance, and claimed life cycle lead playground owners on a guessing game as to which product is most cost effective and reliable over time. Lack of reliable product performance data on the effectiveness of safe, accessible playground surfaces relative to costs for installation and ongoing maintenance prevents public playground owners from making informed choices on the selection of surfaces most appropriate for their public setting.

II. Research Methodology

The research design for this study of playground surfaces has been in development since 2005 with input from a national advisory committee. It is purposeful to derive quantitative and qualitative data through on-site inspections for a 3-5 year period. Advisory committee members represented the U.S. Access Board; the National Playground Safety Institute; Beneficial Designs; Northern Suburban Special Recreation Association; Bloomington (IN) Parks and Recreation Department; and the American Society for Testing and Materials. Periodic meetings and conference calls were held to review the research design. The advisory committee members provided feedback on the categories of surfaces to be evaluated, the criteria to be used for evaluation, the locations within each playground to be evaluated, data collection worksheets and on-site protocol. In addition, advisory committee members helped to expand the network for recruitment in the study and increase national awareness among playground owners.

Study Questions

The purpose of this study was to evaluate a variety of playground surfaces, their ability to meet accessibility requirement, their costs upon initial installation and maintenance issues over a 3-5 year period. The research questions include:

1. How well do various playground surfaces meet the accessibility requirements upon installation and over a five-year period?
2. What are the costs for the various playground surfaces?
3. What accessibility issues arise out of initial installation
4. What accessibility issues arise out of long term use and require additional maintenance?

Selection of Playgrounds

Newly constructed public playgrounds were selected for participation as test sites in the study. A purposive snowball sampling technique was used to recruit local park and recreation agencies by phone, e-mail and in person. This sampling technique utilizes acquaintances and word of mouth referrals so the sample grows or rolls larger like a snowball. The sampling technique is largely dependent on informed participants passing information on to other perspective participants. Selection was based upon: accessibility to children with and without disabilities; use of surface materials and products consistent with the study; geographic location; seasonal weather conditions; and willingness of owner/operator to participate as a partner in the study by sharing information and collecting data. The study is limited to the geographic area surrounding the Indiana University-Bloomington campus, Indianapolis and Chicago, within driving distance of the Bloomington-based research team and easily accessed at any given time during the season. The geographic area also supports a close network of practitioners in the field from which test sites could be recruited.

The sample population for this study depended upon an established, or to be established, congenial relationship with the playground owner and the research team. The data for analysis required the research team to make a number of inquiries to the operation, planning, budgeting and maintenance procedures conducted by the playground owner. Most importantly, if there were any instances where locations on the playground were found to be in non-compliance with the accessibility or safety guidelines, the playground owner was to be informed and then carried the burden of bringing those instances into compliance. Therefore an established relationship based on trust and mutual concern for safety, accessibility and the research questions was necessary.

Streeton, Cooke and Campbell (2004) summarized the advantage to the snowball sampling technique as an efficient way to locate hard-to-reach groups, especially when using a named contact to open doors otherwise apparently closed. Gruppetta (n.d.) summarized the positive aspects of snowball recruitment as reaching a wider range of participants; reduced possibility of coercion by the researcher; sensitive data is not yet made available to the researcher; a reduction of researcher bias; informal networks of communication; and cost effective. Alternatively, the negative aspects of snowball sampling are viewed as labor intensive; inappropriate for a probability sample; raising ethical considerations for the protection of privacy; concerns for the timeliness of the process; perceived coercion for the nominee; inability to select participants; and multiple nominations within the group that may narrow rather than open the pool of perspective participants (Gruppetta, n.d.; Streeton, et. al. 2004.). The depth of qualitative data for analysis forecasted to derive from the longitudinal study can be argued as outweighing the negative aspects of this particular sampling technique.

Limitations

The study is limited in the following ways:

1. Ability to generalize findings to the general population. Playgrounds are as different as children, each with their own distinguishing personality. Each one is very different in terms of design, frequency of use, the combination of playground equipment, surface materials, soil characteristics, site conditions, weather and climate.
2. Visitor use may have impact on the surface conditions. It is impossible to control the number of children using any given public playground. High visitor use may have an effect on certain surface types.
3. Weather conditions, adverse seasonal changes, sunlight and precipitation may have an effect on certain surface types.
4. Liability associated with sites found to be non-compliant with the standards may affect a playground owner's willingness to participate in the study.

Assumptions

Two industry standard specifications are used to determine the safety and accessibility of each surface: ASTM F1292-99/04 Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment and ASTM F1951-99 Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment. Both specifications are written as laboratory tests. For the purpose of this study, it was assumed that:

1. Playground surfaces selected for participation have documents indicating they have met the minimum specifications for ASTM F1292-99/04 and ASTM F1951-99 in a laboratory environment.
2. A Rotational Penetrometer can be used as a field instrument to determine firmness and stability for surfaces as they relate to accessibility.
3. A TRIAX 2000 can be used as a field instrument to determine impact attenuation.
4. Playground owners will be notified of evaluation results upon inspection and be given the opportunity to take corrective actions.

Definition of Terms

For the purposes of this study and further discussion, the following terms will be used:

Accessible. The element or feature meets the minimum technical specifications under the 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design and the Architectural Barriers Act (ABA) Accessibility Standards.

Firmness or Firm Surface. A firm surface resists deformation by either indentations or particles moving on its surface (2010 ADA Standards for Accessible Design, Advisory 302.1).

Loose Fill Surfaces. The predominant surface characteristic is one where many loose particles are combined to create the surface system. Loose fill surfaces may include gravel, pea gravel, sand, wood chips, mulch, engineered wood fiber and shredded rubber.

Rotational Penetrometer. A wheelchair caster placed on a spring loaded caliber in a metal tripod frame which suspends the caster about 6 inches over the surface. When the caster is released, the spring load gauge replicates the force of an individual in a wheelchair over a given surface. The penetration into the surface is measured for readings of “firmness” and “stability” of the surface.

Stability or Stable Surface. A stable surface is one that remains unchanged by contaminants or applied force, so that when the contaminant or force is removed, the surface returns to its original condition (2010 ADA Standards for Accessible Design, Advisory 302.1).

Triax 2000. A large tripod that can be raised to a fall height above the highest play surface on a playground. A large sphere replicating the shape of a child’s head is dropped from the top of the tripod and the impact on the surface is measured. A Triax is the instrument used to test playground surfaces for compliance with ASTM F1292-99/04, also known as the “head drop test.”

Unitary Surfaces. The predominant surface characteristic is whole. Unitary surfaces may include asphalt, concrete, rubber mats, tiles or a rubber fill product chemically bound and often referred to as “poured-in-place.”

Data Collection Procedures

Each playground owner identified a minimum of one newly constructed or planned playground using at least one surface material in the designated categories of study surfaces. The playground owners hosted the playground test sites and assisted with data collection for the study. Playground sites were limited to public playgrounds owned and/or operated by municipal parks and recreation agencies. The name and location of the playground sites were kept confidential and only broadly labeled by county/region during comparisons to other playground sites.

Upon consent to participate in this study, the playground owner was asked to designate a site coordinator (study liaison) to work with the research team. This individual was responsible for assisting with collecting data during the initial site visit and continued to work with NCA throughout the duration of the longitudinal study. It was preferred, but not necessary, that the designated staff representative was a Certified Playground Safety Inspector (CPSI) or Accessibility Coordinator. In the event any non-compliance issues were identified on site, the designee could easily be alerted and initiate the agency process for maintenance or other corrective actions.

Once brought into the study, the playground was associated with one of five categories of surface type for participation in the study:

1. Engineered wood fiber product;
2. Shredded rubber/crumb rubber;
3. Unitary rubber mat/tile surfaces;
4. Unitary rubber “poured in place” surfaces;
5. Combination or hybrid surface systems under development.

The playground surface products considered for this study had to initially meet the requirements of the 2010 Americans with Disabilities Act (ADA) Standards for Accessible Design and the Architectural Barriers Act (ABA) Accessibility Standards: 1008.2 Accessible Routes; 1008.2.6 Ground Surfaces; ASTM F1292-99/04 *Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment* as determined by the surface manufacturer in laboratory testing; ASTM F1951-99 *Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment* as determined by the surface manufacturer in laboratory testing. Information on the surface vendor, specifications, costs and labor for installation was then collected. In turn, the research team contacted each vendor to collect additional information on laboratory certification with ASTM F1951-99.

Nine critical areas were inspected within 12 months of installation and continue to be evaluated at least once a year for the longitudinal study:

1. Entry to playground where playground surface starts
2. Accessible route connecting accessible play elements
3. Egress point of slide(s)
4. Swings
5. Entry point(s) to composite structure(s)/transfer stations
6. Climber(s)
7. Ground level play element(s) such as spring rockers, play tables, interactive panels, etc
8. Sliding poles
9. Other areas (i.e. water play elements, etc)

Using the playground site plan and/or digital images, the research team and site coordinator identified the nine critical areas for data collection. Within 12 months of installation, the research team and site coordinator conducted a preliminary accessibility assessment of the playground surface and tested the surface for firmness and stability with the Rotational Penetrometer. This was considered the first site visit for the longitudinal study. On-site assessments continued annually throughout the longitudinal study. At the discretion of the playground owner, the playground surface was also tested for impact attenuation with the TRIAX (surface impact testing device). The playground owner was notified immediately of test results for both the Rotational Penetrometer (firmness/stability) and the TRIAX (impact attenuation) and given opportunity to correct surfaces where deficiencies or non-compliance with standards were noted.

Instrumentation for Analysis

Four instruments were used for data collection. First the owner was sent information sheet on the protocol for the study (Appendix A). Upon installation, the playground owner completed a questionnaire (Appendix B) on the type, size and intended age group of the playground, the total cost for the equipment, surface materials and installation. An on-site inspection form (Appendix C) was created to collect information on the nine locations identifying deficiencies in slope, cross slope, changes in level and openings in the surface. Following the visual inspection of the nine locations, testing for wheelchair accessibility specific to firmness and stability was conducted with the application of a Rotational Penetrometer (RP). A third form was developed to collect data on firmness and stability (Appendix D). Testing for impact attenuation per ASTM F1292-99/04 was conducted as an optional test at the discretion of the playground owner using the TRIAX 2000. This data was reported to the playground owner in the format prescribed by the ASTM F1292-99/04 test protocol.

Treatment of Data

The research design for this study was developed to collect data on surface conditions, evaluate surface performance, note deficiencies and compare results across surface types. Through further analysis, results of playground surface tests for firmness and stability were compared within surface categories and across surface categories to determine the mean, range and standard deviation of each surface type. Finally, data on initial installations costs and results of surface tests on firmness and stability were compared to determine whether there was correlation between the surface type, its costs and its results for firmness and stability. Descriptive statistics were used for analysis of data. A one-way analysis of variance (ANOVA) was used to determine if there was any statistical significance between surface categories. A bivariate correlation was run to determine any significance between surface deficiencies or non-compliance with the accessibility standards and the measurable results for firmness and stability. Lastly, qualitative data on the surface material conditions during the site visit was collected in order to provide a narrative description of findings.

III. Results of the Study

Approximately 35 playground sites were recruited for participation during the evaluation period from October 2008 through May 2011. Data collection concluded in September 2012 so that all playground sites in the study would have a minimum of two years data. All of the playground sites were located in public parks owned/operated by 16 different municipalities from Indiana, Illinois and Michigan. Sites included either neighborhood playgrounds or those located in regional parks. The 16 participating municipalities operated anywhere from 4 to 53 playgrounds each. The average number of playgrounds operated by a municipality was 24. None of the playground owners were coming into the study as "first time" owners. All of the owners had a history of managing playgrounds. They considered themselves somewhat knowledgeable of playground surface issues and eager to learn how they could improve upon their playground surface maintenance efforts for costs savings.

Playgrounds at schools, childcare facilities, churches and malls were excluded from participation in the study based on what might be perceived differences of maintenance resources between public park agencies and other entities. Three park agencies gave verbal commitments for participation in the study and then opted out of participation due to concern there may be possible negative budgetary implications should any deficiencies be identified during the site assessment and corrective actions become necessary.

Site Profiles by Surface Type

The surface categories selected for the study were purposefully designated based on their widely accepted perceived attributes as both safe and accessible. New playground sites were brought into the study each year as they were constructed and identified by the playground owners. Some playground sites were surfaced with one surface material/system while others were surfaced with a combination of two surface materials/systems. Table 1 provides a profile of the number of sites installed within each surface category.

Table 1
Playground Sites by Surface Type

Surface Type	Year 2	Year 3	Year 4	Year 5	Total
Poured in Place Rubber (PIP)	4	1	3	1	9
Poured in Place Rubber (PIP) w/Engineered Wood Fiber (EWF)	2	-	3	-	5
Tiles (TIL)	-	-	2	-	2
Tiles (TIL) w/Engineered Wood Fiber (EWF)	2	3	3	-	8
Engineered Wood Fiber (EWF)	1	2	3	-	6
Hybrid (HYB)	1	-	1	2	4
Hybrid (HYB) w/Poured in Place Rubber (PIP)	-	1	-	-	1

(N) = 35 sites

Markedly absent from the Table 1 of playground sites and the study were locations with shredded rubber surfacing. Public park playgrounds with shredded rubber surfacing were difficult to locate through direct recruitment with playground owners. Thus, requests for assistance identifying Midwest sites were made to the three major shredded rubber manufacturers and the international member association. None of the representatives from the major manufacturers or association responded to repeated requests from the research team. Finally during the last year of the study, six new installations with shredded rubber were identified with one agency. Two days prior to the first site visit, the agency pulled out of the study with concerns for how the surface material would perform. As such, public park playground installations with shredded rubber surfacing are not represented in this study.

The participating playground sites ranged from 2,300 sq. ft. to 12,500 sq. ft. The costs for surfaces, materials and installation, ranged from less than $1/sq. ft. to $21/sq. ft. Table 2 provides a profile of each playground, the installation date, total area, surface area, cost for equipment and cost for surfaces.

Of the sites evaluated, nine were surfaced entirely with poured in place rubber (PIP). It should be noted that seven of the sites were traditional PIP installations comprised of two layers, a wear layer with larger rubber particles and a custom top layer with granular particles. Two sites were installed as one layer comprised of bonded large particle rubber shreds. The surface cost for PIP ranged from $6.59/sq. ft. to $19.80/sq. ft. The wide range of cost per sq. ft. can be attributed to the fact that PIP is often sold on a sliding scale, the more material purchased, the cheaper the unit cost. The cost for PIP has also been dramatically affected over the last five years due to volatility in the petroleum market.

There were two sites surfaced completely with tiles (TIL). Traditionally TIL are constructed of bonded rubber, similar to PIP, but designed as 2 ft. x 2 ft. squares with interlocking sides. They are marketed as easier to install with more flexibility than PIP should they need to be reconfigured to accommodate new playground equipment. The cost for TIL ranged from $8.96/sq. ft. to $21/sq. ft. TIL was the most expensive of the five types of surfaces identified for study. This can be attributed to the number of small surface area installations where the use of TIL was less than 2,000 sq. ft. These installations limited the use of the TIL to connect the accessible route from the playground perimeter to the transfer system of the elevated composite structure. The remainder of the larger play area was surfaced with a loose fill material. Similar to PIP, the product is sold on a sliding scale and the cost has also been affected by price fluctuations in the petroleum market.

There were six sites surfaced entirely with engineered wood fiber (EWF). In addition, there were five sites surfaced with a combination PIP and EWF, and eight sites surfaced with a combination TIL and EWF. The EWF ranged in cost from $ .74/sq. ft. to $2.50/sq. ft. A design trend has emerged over the last 15-20 years whereby a unitary surface, such as PIP or TIL, is used as the primary accessible route to accessible equipment and the remainder of the equipment use zones is surfaced with a less costly loose fill material such as EWF or shredded rubber (SHR). While this may be viewed as a cost effective compromise to surface selection, the use of the loose fill material with some unitary systems has had a negative effect on the surfaces, which will be described later in this study.

There were a total of five sites with four different hybrid (HYB) surface systems evaluated in the study. One site used an outdoor carpet over engineered carpet padding infilled with silicone sand. Two sites used a system where the base consisted of 2 ft. x 2 ft. pillows filled with shredded rubber and covered by 5 ft. wide rubber top mats, resembling melted spaghetti, affixed at the seams similar to how carpet is seamed together. The remaining two sites used an artificial turf grass system, similar to that used on football fields. The HYB surface systems ranged in cost from $7.50/sq. ft. to $12.65/sq. ft.

Table 2
*Playground Sites, Total Area, Equipment and Surface Costs**

Playground	Install Date	Total Area (sq ft)	Equip. Cost Surface Cost	Surface Type	Surface Area	Surface Cost/sq ft
Poured in Place Rubber (PIP)	8/20/2008	5,796	$ 65,748 $ 57,091	PIP	5,796	$ 9.86
	7/2008	6,600	$114,890 $136,065	PIP	6,600	$17.50
	10/2008	4,725	$ 50,653 $ 50,015	PIP	4,725	$ 6.59
	5/9/2009	2,400	$ 52,317 $ 30,019	PIP	2,400	$ 7.98
	9/1/2010	7,720	$134,883 $ 81,986	PIP	7,720	$10.62
	4/1/2011	4,030	$ 51,840 $ 43,090	PIP	4,030	$10.70
	7/1/2011	7,230	$ 76,931 $ 65,088	PIP	7,230	$ 9.00
Tile	10/3/2008	2,571	$ 27,755 $ 23,025	TIL	2,571	$ 8.96
	8/1/2009	2,319	$ 21,993 $ 24,243	TIL	2,319	$10.45
Engineered Wood Fiber (EWF)	11/1/2008			EWF	4,000	$ 1.15
	9/1/2008	9,515	$101,962 $ 12,500	EWF	9,515	$ 2.11
	11/9/2009	12,000	$ 72,629 $ 12,500	EWF	12,000	$ 1.94
	5/1/2010	7,650	$ 96,302 $ 4,200	EWF	7,650	$ 1.82
	5/1/2010	12,510	$ 58,960 $ 6,735	EWF	12,510	$ 1.86
	10/13/2010	8,898	$ 50,847 $ 10,629	EWF	6,110	$ 1.00
PIP & EWF	11/1/2008	7,395	$ 70,000 $ 32,481	PIP EWF	855 6,265	$19.80 $ 1.80
	11/1/2008	5,240	$ 56,219 $ 26,536	PIP EWF	755 4,340	$19.80 $ 1.80
	6/1/2009	10,007	$133,794 $ 58,975	PIP EWF	4,218 5,789	$11.10 $ 1.65
	9/2010	6,700	$116,483 $ 40,500	PIP EWF	2,493 4,207	$15.00 $ .74
	5/1/2011	9,864	$109,360 $ 43,465	PIP EWF	1,764 8,100	$16.46 $ 1.80
Tile & EWF	10/24/2008	7,070	$ 63,145 $ 24,178	TIL EWF	1,100 5,970	$15.00 $ 1.08
	10/20/2008	8,772	$ 73,433 $ 27,971	TIL EWF	1,256 7,516	$15.29 $ 1.08
	5/2009	7,060	$ 46,900	TIL EWF	5,140 1,920	$ 8.73 $ 1.04
	10/1/2009	3,200	$ 47,820	TIL	740	$14.72

			$ 15,950	EWF	2,085	$ 1.80
			$ 66,840	TIL	1,136	$20.59
	8/1/2009	5,150	$24,801	EWF	4,014	$ 2.50
			$ 72,350	TIL	1,158	$21.00
	8/1/2009	6,585	$ 25,874	EWF	5,427	$ 2.50
			$125,488	TIL	1,242	$14.55
	9/2010	7,130	$ 29,791	EWF	5,888	$ 1.99
			$142,500	TIL	1,476	$15.00
	5/5/2011	4,651	$ 27,880	EWF	3,175	$ 1.03
Hybrid	8/1/2008	6,031	$ 43,564 $ 81,187	HYB	6,031	$12.65
	7/1/2008	8,500	$139,382 $111,626	HYB	8,500	$ 7.50
	9/15/2009	8,100	$ 87,000 $ 74,000	HYB	8,100	$ 9.14

**Installation data for nine sites was not available.*

Performance and the Surface Deficiency Score

Upon arrival at the playground site, a visual inspection was conducted at nine pre-determined locations within the play area. This visual inspection would be used as the same method to conduct an accessibility assessment of the playground surface upon installation and during routine inspections. A digital level and tape measure were used to identify instances along the accessible routes and at clear floor spaces where the surface running slope exceeded 1:16 (6.25%); the cross slope exceeded 1:48 (2.08%); there was a change in level greater than .50 inch; or an opening greater than .50 inch diameter.

In an effort to statistically analyze the frequency of identifiable deficiencies between surface types, the Surface Deficiency Score (SDS) was developed. If a surface location was found to have any of the four deficiencies (excessive running slope, cross slope, change in level, or openings), the location was awarded a value of 1 for each. An SDS of 0 shows no interruption of the accessible route or clear floor space at the location. An SDS maximum 4 could potentially be awarded at each location.

Table 3
Surface Deficiency Score (SDS)

Surface by Type	N	Mean	Mode
Poured in Place (PIP)	251	.04	0
Tiles (TIL)	150	.50	0
Engineered Wood Fiber (EWF)	289	1.94	2
Hybrid Surface Systems (HYB)	128	.30	0

(N) = Number of locations visually inspected. Mode indicates the most frequent score.

An analysis of the SDS among the sample sites indicated there was significant difference in the number of identified deficiencies between the various types of surfaces. Table 3 provides the

SDS for each surface type. As might be predicted among public playground owners, the PIP scored the lowest SDS with a Mean = .04, while EWF scored the highest with a Mean = 1.94.

It should be noted that a summary report of findings after the first year of installation was released in May 2011. During the first year analysis of 25 sites, the SDS for the EWF was significantly different from the other three surfaces. The EWF was found to have an SDS Mean = 2.16 and Mode = 3. In short, within the first 12 months of installation, the EWF locations where found to have more deficiencies with running slope, cross slope and changes in level. Over the course of the longitudinal study, the Mean SDS for the unitary surface types began to increase over time while the Mean SDS for the EWF leveled out, as shown in Table 4. This suggests deficiencies were visibly identifiable for EWF within 12 months of installation, whereas visible deficiencies for the unitary surfaces did not become measurable until sometime 24-36 months after installation. Reduction in the Mean SDS for PIP and HYB during Year 4 can be attributed to patch repairs conducted prior to expiration of the product warranties.

Table 4
Surface Deficiency Score (SDS) Mean by Year

Surface by Type	Year 1	Year 2	Year 3	Year 4	Year 5
Poured in place (PIP)	.00	.01	.07	.00	.50
Tiles (TIL)	.30	.42	.56	.89	--
Engineered Wood Fiber (EWF)	1.99	2.02	1.79	1.89	--
Hybrid Surface Systems (HYB)	.03	.33	.69	.05	.53

The greatest number of deficiencies in the playgrounds surfaced with EWF was identified along the accessible route connecting play elements, at climbers and other ground level components. EWF surface locations with greater surface area, such as the accessible route connecting play components had more occurrences of uneven wear, while play components meant for aggress or egress showed more signs where the 30 x 48 inch clear floor space had displaced surface material such as the “kick out” area at the ground level components, the bottom of slides and swings.

Two reoccurring issues were identified among at least four of the TIL sites. These sites had tiles with visible punctures holes ranging from .50 inch to more than 2 inches in diameter. Openings in the surface greater than a .50 inch can pose safety concerns for people using assistive devices such as canes, crutches or walkers. The second issue was with the seams. At the playground sites where both TIL and EWF were installed together, the EWF had begun to penetrate between the TIL seams either causing the seams to shift, pull apart from one another, or pull away from the subsurface it was affixed to at installation.

Performance for Surface Firmness and Stability

In addition to the visual inspection and calculation of the surface deficiency score, the firmness and stability of the surfaces were measured at each of the nine locations using the Rotational Penetrometer (RP). Research with the RP shows repeatability and reproducibility consistent to that of the test procedure for ASTM F1951-99 which utilizes a wheelchair work method. Similar to the F1951-99 lab test, smaller values would indicate less work force necessary to move across the surface, while higher values would indicate greater work force to move across the surface. Prior to taking readings of the playground surfaces, baselines were established on cement or asphalt. The baseline for firmness ranged from .14 to .16 inches and the baseline for stability ranged from .16 to .18 inches. The baseline measurements affirmed the RP was operable and calibrated. Using the RP at each location, five readings were taken and then averaged to result in one measurement for said location. Thus, in a playground identified with all nine locations, a total of 45 readings were collected, five at each location.

Table 5 shows the measurement mean for firmness and stability by surface type. Interestingly, all four of the surface types have a mean less than .50 inches for firmness. The second reading, for stability, begins to illustrate the difference among surface types. The mean for stability remains under .50 inches for the three types of unitary surfaces, while the loose fill, EWF, has a mean for stability of .78 inches.

Table 5
Firmness and Stability by Surface Type

		N	Mean	Std. Deviation	Std. Error	Min.	Max.
Firmness	PIP	251	.34531	.066074	.004171	.228	.542
	TIL	150	.27504	.029594	.002416	.206	.352
	EWF	288	.34227	.051240	.003019	.238	.568
	HYB	128	.41123	.052344	.004627	.290	.566
Stability	PIP	251	.38357	.070013	.004419	.260	.598
	TIL	150	.30989	.040060	.003271	.242	.596
	EWF	288	.78242	.138295	.008149	.474	1.176
	HYB	128	.46081	.061157	.005406	.326	.664

(N) = Number of locations visually inspected.

The stability measurement, the second measurement in the series using the RP, showed a wide range of results among the different surface types. The stability measurement had a minimal range of .04 to .06 inches for the unitary surfaces, while the loose fill EWF had a difference of .44 inches. Also of note was that the standard deviation for stability with the EWF was the highest at .13, double that of any other surface type. The high standard deviation for EWF raises questions whether the material characteristic for stability and its high variability can serve as a preliminary indicator that surface types with greater variance will require additional maintenance over time. Interestingly, the two surfaces that are most characteristically different from one another, PIP and EWF, do not have statistically different values for firmness in this study sample. As noted in Table 5, their mean for firmness is essentially the same.

Over the course of the study, members of the study advisory committee suggested that the sum of the firmness and stability measurements should be considered as a starting point to develop a pass/fail value for the field test with the RP. Table 6 shows the mean score for the measurements of firmness and stability when added together along with the range of high and low measurements. The TIL has the lowest Mean = .58 inches when the average measurements of firmness and stability are added together. As one might predict, EWF has the highest Mean = 1.12 inches for the sum of firmness and stability.

Table 6
Sum of Firmness and Stability by Surface Type

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PIP	251	.72888	.135319	.008541	.488	1.122
TIL	150	.58493	.066655	.005442	.450	.908
EWF	288	1.12469	.175450	.010338	.762	1.730
HYB	128	.87205	.112059	.009905	.616	1.216
Total	817	.86441	.251255	.008790	.450	1.730

(N) = Number of locations visually inspected

Qualitative Analysis by Surface Type

The observational data collected through the visual inspections of the sites and discussions with the playground owners provided invaluable lessons learned from the longitudinal study and may provide some explanation to the overall effectiveness of various types of surfaces.

Poured in Place Rubber

Nine were surfaced entirely with poured in place rubber (PIP), while five sites were combined with engineered wood fiber (EWF). The surface cost for PIP ranged from $6.59/sq. ft. to $19.80/sq. ft. The wide range of cost per sq. ft. can be attributed to the fact that PIP is often sold on a sliding scale, the more material purchased, the cheaper the unit cost. The cost for PIP has also been dramatically affected over the last five years due to volatility in the petroleum market.

Within the first 12 months of installation, the sites surfaced with PIP did not have any recorded locations where the surface samples exceeded the accessibility standards for slope, cross slope, changes in level or openings. The mean for the surface firmness and stability was well under .50 inches. From the “looks” of the surface locations, they appeared to be very accessible within a 12 month period from installation. However, a major concern was discovered at one of the test locations where the playground owner opted to also have the surface tested for impact attenuation and compliance with ASTM F1292-99/04. Various locations on site were tested using the TRIAX to record GMAX and HIC. The maximum values allowable by the standard are 200 for GMAX and 1,000 for HIC. Drop heights from composite equipment up to 8 ft. high passed the field test. But it was the PIP surface at two swing bays that was found in non-compliance with HIC scores well over the 1,000 HIC allowable under the standard. The playground owner used the terms of the warranty and purchase order as a binding agreement requiring the manufacturer, at its own expense, to return to the site and repair the surface installation. Approximately 2,000 sq. ft. at the swing bays was resurfaced to add more depth to the PIP. When the surface area was retested with the TRIAX, the HIC ranged from 650-750 at the swings, well under the 1,000 maximum allowable by the standard. Had the playground owner not discovered the non-compliant surface area until after the warranty had expired, it would have cost the agency in excess of $35,000 to correct the surface area serving four swings. During the course of the longitudinal study, at least two additional playgrounds surfaced with PIP were found in non-compliance with ASTM F1292-99/04. In each case, the playground owners required the installers to return to the site to make corrective actions.

Between 24-36 months, locations surfaced with PIP began to show signs of cracking and instances where the top layer of surface had worn off under the swings, slides, or other equipment with rapid motion. At one such site, the top granular layer of PIP began flaking off in 1-4 inch sections throughout the surface area, not just high traffic or rapid motion areas. As it turns out, the surface material at this site was not installed per the manufacturer's recommendations. The installation occurred in the late fall when the temperature was 40 degrees Fahrenheit and falling. The manufacturer installation instructions show the preferred atmospheric temperature for installation to be 40 degrees Fahrenheit and rising. The error in installation is attributed to the contractor and pressure to stay on schedule as the construction season came to a close for the winter. The playground owner insisted upon corrective measures. Another contractor was brought in to apply a top binding coat. This cost was absorbed by the sales representative.

As previously noted, two sites were installed as one layer comprised of bonded large particle rubber shreds. This type of installation is a break from the traditional product known as PIP and consisting of two layers, a wear layer with larger rubber particles and a custom top layer with granular particles. These two sites were assessed with locations throughout the playground where the large particles had separated from the bonded layer in chunks. This was notable in areas such as the swings and teeter totters. Particles were also separated from the bonded layer by the turning movement of the wheel on the Rotational Penetrometer during the site assessments. Under the terms of the product warranty, the playground owner required corrective action where the damaged sections were cut out and patched with new material.

Tiles

There were two sites surfaced completely with tiles (TIL), while eight additional sites were combined with engineered wood fiber (EWF). The 2 ft. x 2 ft. bonded rubber interlocking sections are marketed as easier to install and more flexible should they need to be reconfigured to accommodate new playground equipment. The cost for TIL ranged from $8.96/sq. ft. to $21/sq. ft. TIL was the most expensive of the five types of surfaces identified for study. This can be attributed to the number of small surface area installations where the use of TIL was less than 2,000 sq. ft. These installations limited the use of the TIL to connect the accessible route from the playground perimeter to the transfer system of the elevated composite structure. The remainder of the larger play area was surfaced with a loose fill material.

For one agency which manages more than 50 playgrounds, their selection of TIL was based on the agency's perceptions that installation by its own personnel would help to drive down the overall cost of the playground project, stretching more dollars when budgets are tight. They also believed that the TIL would create an accessible route with less maintenance requirements than the EWF predominately used on their other playgrounds. During the initial site visits, the TIL had started to shift on at least two playgrounds where the parks maintenance staff had installed the surface system as opposed to installation by a contractor certified by the manufacturer. The playground owner attributed the construction error to the learning curve involved with installation of the new surface and reported each new site was improved based on the experience maintenance staff was gaining. The agency's third playground with TIL was bordered by a landscaped paver retaining wall. Improper drainage from the landscape in the retaining wall was causing a build-up of silt on and under the tiles. Within the first month of installation, at least a dozen tiles at the border were pulled up to remove the silt build-up, the section was thoroughly cleaned, dried and the TIL were re-adhered to the concrete sub-base.

Maintenance staff was on site making the repairs when the accessibility assessment was conducted. The assessment team brought another area to their attention where the four tiles bordering the concrete walk at the entry to the playground were raised more than a quarter of an inch and adversely affecting the accessible route into the play area. Maintenance staff was able to remove the four tiles, shave the underside and re-install so that they were flush level with the concrete walk all while the assessment team was concluding the field testing.

As noted in Table 3, the Mean SDS for TILs continued to increase each year of the study. The mean for the firmness and stability of the tiles tested in the sample was also under .50 inches, similar to the PIP. Throughout the period of the study, there were reoccurring instances where the TIL were assessed with punctures holes ranging from .50 inches to more than 2 inches in diameter and where the seams had started to shift or buckle creating openings and changes in level along the accessible route. It was unclear whether the puncture holes were products of intentional vandalism or unintentional damage from users stepping on rocks and other foreign objects with enough force to penetrate the surface. One playground owner went so far as to install signage at a site “No high heels” with the image of a woman’s shoe. The maintenance staff was also able to replace the TIL with puncture holes following the site assessments.

Deficiencies were identified at two playground sites surfaced with a combination TIL and EWF. The intent of the playground design was to use the TIL as the primary accessible route to points of aggress/egress and fill the remaining use zone with EWF. The loose fill particles of EWF were scattered throughout the play area, across the tiles, concrete walkway and in the grass. Some of the particles had started to lodge in the TIL seams causing separation at the seams. There were even instances where the particles had lodged so deep in the seams that the adhesive had degraded and the TIL had separated from the concrete subsurface.

During Years 3-5, locations were identified where the TIL had cracked in the center unable to support repeated weighted foot traffic. These instances occurred where either the subsurface or structural integrity of the surface product was compromised.

Engineered Wood Fiber

There were six sites surfaced entirely with engineered wood fiber (EWF). In addition, there were five sites surfaced with a combination PIP and EWF, and eight sites surfaced with a combination TIL and EWF. The EWF ranged in cost from $ .74/sq. ft. to $2.50/sq. ft. One of the emerging playground surfacing trends is to install a unitary surface, such as PIP or TIL, as the primary accessible route to accessible equipment and fill the remainder of the equipment use zones with a less costly loose fill surface material, EWF or shredded rubber (SHR). While this has been thought to be a cost effective solution to playground surfacing, the loose fill material has caused more maintenance issues when combined with a unitary surface.

The playground sites in the sample with EWF experienced the greatest frequency of high SDS and mean for firmness and stability. Every playground installed with EWF was observed with undulation across the horizon of the surface area. The undulating surface material created changes in level, running and cross slopes exceeding the maximum allowable standards resulting in non-compliant accessible routes to play components. There was no observational difference in the issue of undulating surface between sites installed by maintenance personnel compared to sites installed by contractors. Review of installation data and discussions with staff indicated the loose fill surface installations did not follow the same procedures noted in the installation instruction by the surface manufacturer or in ASTM F1951-99 lab reports. EWF surface installations were mostly infilled, raked and leveled. A minimum amount of surface compaction was conducted, if any. This is a serious departure from the installation procedure used on the lab test samples for ASTM F1951-99, where the surface material is installed in 3-6 inch layers, watered, raked, compacted and installed with another layer following the same procedure and finally compacted with either a drum roller or mechanical tamper.

Some EWF marketing literature reports that the surface material will naturally settle and compact over time and with visitor use. Observations at new installations with heavy visitor use indicate the high traffic may actually create even greater peaks and valleys in the undulating surface. At the sites where the surface material has had the opportunity to naturally settle, several occurrences were noted where there were changes in level greater than .50 inches at the point of entry to the playground from the sidewalk or at transitions with unitary surfaces.

Large areas where the loose material had been displaced under heavy use areas with motion such as at swings, slides, sliding poles, climbers, spinners, and teeter totters were observed at all of the sample sites with EWF. A kick-out area at a swing could be as large as 3 ft. x 8 ft. with a depth of more than 5 inches. The accessibility standards require the minimum 30 x 48 inch clear floor space for transfer to/from the accessible play components have a level surface with less than a 2.08 percent cross slope in all directions. The displaced surface material at locations such as the bottom of slides, a swing, or ground level play component rendered the accessible route to the play component non-compliant with the accessibility standards. Maintenance issues at sites began to emerge where the product was filled at the kick-out area rather than the raked level, compacted and then filled and compacted. Where the kick-out areas had been filled, again it would eventually be displaced. This time it created higher undulating mounds at the front and back of the kick-out area and greater cross slopes within the required clear floor space.

At locations where the EWF was paired with a unitary surface, deficiencies were identified at the transition between the two surface materials. The EWF had settled by 1-5 inches creating a change in level of excessive running slope up to 16 percent at the transition. This was most prevalent at sites installed with PIP as the primary access route. At locations where TIL was intended as the primary accessible route and EWF was used as secondary safety surfacing, the EWF particles began contaminating the TIL seams.

To the layman, the terms EWF and woodchips are often, incorrectly, interchanged. The difference between EWF and wood chips is one where the EWF goes through several additional processes following the output from what would come from a typical landscape chipper. Unlike woodchips out of the chipping equipment, EWF is then shredded again, stamped/flattened and made pliable to the extent that the particles will weave together to create a traversable, impact attenuating surface. In addition, there is an ASTM standard specification for EWF, further distancing the material from any product made on site or purchased from a nursery or home improvement store. The ASTM standard for EWF requires the particles be small enough to pass through a series of three sieves, ¾ inch, 3/8 inch and No. 16 (0.0469 inch). The sample is considered compliant if there is no more than 1 percent residue is left on any individual sieve. Large wood particle chips, chunks and shredded twigs were found at all of the EWF sample sites. The observable quantity of large wood particles raised into question whether a test sample from any of the sites would comply with the ASTM standard specification for EWF and specifically the sieve test. In addition to the large particles, there were instances where vegetation and mold were found growing in the surface material.

A conference call was conducted with all of the playground owners prior to the release of the first year finding report in 2011. At this time, acquisition, installation and maintenance of EWF was thoroughly discussed. Owners cited the ability to buy directly from mills with ASTM-IPEMA lab certificates as a process to purchase the product at lesser cost than buying directly from the manufacturer. They also stated that no installation instructions accompanied the surfaces from the manufacturer or the mill,. Thus, none of the owners were aware of any need to install the surface materials in layers by watering and compaction.

Sites visited in 2012 showed a marked improvement in SDS where playground owners participated in the conference call and gained greater information on the compaction requirement for installation and maintenance. One site utilizing PIP as the primary access route and EWF as the secondary access route was assessed with less than 1 percent slope at the transition between the two surface materials.

Hybrid Surface Systems

There were a total of four sites with three different hybrid (HYB) surface systems evaluated in the study. All three systems have been purposefully designed and marketed to provide an impact attenuating and accessible surface to accommodate both safety and accessibility. One site used an outdoor carpet (HYB-A) over engineered carpet padding infilled with silicone sand. Two sites used a system where the base consisted of 2 ft. x 2 ft. pillows filled with shredded rubber and covered by 5 ft. wide rubber top mats (HYB-B), resembling melted spaghetti, affixed at the seams similar to how carpet is seamed together. The last site used an artificial turf grass system (HYB-C), similar to that used on football fields. The HYB surface systems ranged in cost from $7.50/sq. ft. to $12.65/sq. ft.

As tested within 12 months of installation, all three HYB surface systems were observed to have minimal deficiencies, comparable to the SDS with PIP. The means for firmness, stability and the standard deviation were also comparable to the other unitary surfaces, PIP and TIL.

The outdoor carpet (HYB-A) was installed by a professional contractor approved by the manufacturer. The top layer outdoor carpet is laid over an engineered carpet pad. Silicone sand is filled in over the top carpet layer to contribute to its ability for impact attenuation. The outdoor carpet installation comes in a variety of primary colors. The surface system was purposefully selected by the owner as a pilot site to observe how the product would perform over time. If it was deemed successful, the playground owner intended to use the product at other sites. After 12 months of installation, the top layer carpet began to shrink and separate at the seams creating openings and changes in level greater than ½ inch. Under the terms of the product warranty, the manufacturer returned to the site to make spot repairs where carpet remnants were inlaid at the widest gaps between the seams. Through the fifth year of installation, the carpet layers have continued to shrink and separate at the seams. Field testing for ASTM 1292-99/04 was also conducted annually at the request of the playground owner. Between years two and five, the HIC value at an 8 ft drop height went from 688 to 922. By year five, one location was within compliance for ASTM 1292-99/04 by less than 80 HIC. The manufacturer has since gone out of business and the owner has been left with a product warranty that is now useless.

The rubber top mat system (HYB-B) was installed at one site entirely by the manufacturer. Another playground owner chose to have its site installed by a combined crew of the manufacturer and park maintenance personnel. There were no observable differences from the two installations within the first 12 months. It was not until years three and four that the site installed entirely by the manufacturer started to show instances of separation at the seams. The playground owner attributed this to the park maintenance personnel's lack of knowledge for maintaining the surface system since they were not involved in the installation and did not have any other playground sites utilizing this surface system. During year four, the playground owner requested training from the manufacturer on the specific methods to mend seams and patch sections. By year five, the site showed improved attention to maintenance. The site installed by the combined crew did not show any issues of surface deficiencies. At this site, the originally planned surface was PIP. Because of construction changes on site, the playground owner grew concerned at the increased cost for the PIP and decided to try the HYB-B as a pilot installation. The park maintenance crew worked alongside the manufacturer to learn the process to install the surface base and top mat. The playground owner was purposeful in this decision in order to avoid long term costs to bring the manufacturer to the site for repairs or instances where equipment might be added or moved. The playground owner reports that maintenance personnel have grown in their knowledge working with the product and recently installed another playground utilizing the same surface system.

The artificial grass surface system (HYB-C) was installed by the manufacturer. The two locations each have a different base. The first site has an engineered carpet pad base and the top turf layer is filled in with rubber granules. The second site has a base comprised of packed shredded rubber. Neither site showed any measurable deficiencies during the first year of installation. During year two, the second site began to show signs of traffic patterns. These areas were not measurable with the digital level, however they should continue to be assessed over the life of the playground. Heavy pedestrian traffic can cause the artificial grass to fall flat. Both playground owners have planned for the manufacturer suggested maintenance. The first playground owner purchased mechanical equipment to rake and fluff the grass. The other playground owner brings a contractor back seasonally to do the same thing. One issue this playground owner had not planned for was the build-up of static electricity. During the second year site visit, the assessment team was unable to touch any of the metal playground support posts in a section of the playground without receiving a static charge. The playground owner met the assessment team on site and reported the problem emerged at the end of the first season of use. The playground owner contacted the manufacturer and was given a solution to apply to the surface to minimize the static electricity. The playground owner reports at least three applications of the solution were required at the beginning of the season in order for the static electricity to dissipate. The playground owner also reports disappointment with the manufacturer as this information was not shared with the owner during the time the system was being considered for purchase.

The playground owners for both HYB-C sites had included the requirement for third party testing for ASTM 1292-99/04 as part of their purchase agreements. As such, both sites were tested for impact attenuation by independent consultants following installation. While both sites were found in compliance for ASTM 1292-99/04, both playground owners have reported concerns for the HIC values at 8 ft drop heights and plan to closely monitor those locations.

Shredded Rubber

Shredded Rubber (SHR) is most often the byproduct of recycled tires shredded into particles, crumbs or nuggets, sized 3/8 to 7/8 inches. The surface material used as a play safety surface has gained some popularity as a means to reuse tires. During pilot site visits and testing of the study protocol, the research team found sites with SHR containing tramp metal. Some studies have shown mixed findings on the health effects and environmental impact for use (California Office of Environmental Health Hazard Assessment, 2007). There is a lack of research data on the ability of the SHR to perform as an accessible surface when installed in public park playgrounds. A loose fill surface, similar to EWF, SHR may experience many of the same issues such as undulation of the surface area and displacement resulting in inaccessible routes for play areas. Observational research outside of this study has shown the undulation and instability of the particles to be difficult for people with mobility impairments to traverse. Shredded rubber manufacturers and the member association did not respond to the research team requests to participate in the NCA longitudinal study. As such, public park playground installations with shredded rubber surfacing are not represented in this study. The inclusion of sites surfaced with shredded rubber would have been beneficial to the study in order for researchers to compare this loose fill material with the only other loose fill material in the study, namely EWF. A greater examination of the tramp metal in the particles may help to determine if there was an effect on the use of assistive devices such as wheelchairs, walkers, canes or crutches. The firmness and stability of the product material could have been studied much more thoroughly at real sites and analyzed with controlled laboratory findings such as that for ASTM F1951-99. Comparison of the two loose fill materials, EWF and SHR, may provide playground owners with a better understanding of how compaction during installation can affect the undulation and usability of the surface in the accessible routes. Comparison of the two materials may also give more guidance on the specific needs for maintenance of loose fill particles used for the accessible route.

IV. Discussion of Findings and Implications

The most valuable lesson to be learned from this longitudinal study, it is that there is no perfect playground surface. Even within 12 months of installation, each type of surface had some type of issue or series of issues that affected the product's performance and contribute to the necessity and frequency of surface maintenance to assure accessibility and safety for use by children on a daily basis. A playground surface with poured-in-place rubber had a use zone found in non-compliance with the ASTM standard for impact attenuation. Playgrounds surfaced with tiles were observed with puncture holes, buckling and separating seams that created openings and changes in level on the accessible route. Inaccessible routes with undulating surface material were identified at playgrounds with engineered wood fiber. A build-up of static electricity was found at one of the hybrid surface locations. Each occurrence and event was weighed and balanced with the product's feature advantages and drawbacks.

Findings

The evaluation of the 35 playground sites in this study has provided some important information on the design, installation, and maintenance of playground surface material for the accessible route in the use zone. The information can serve as guidance to both future playground planning and priorities for future research. The following are the predominant findings from this study:

1. No single type of surface material/system was found to be the most accessible surface or better than others when comparing its ability to meet the accessibility standards with issues related to installation and maintenance.

2. Within 12 months of installation, playground sites in the sample with the loose fill EWF were found to have the greatest number of deficiencies, such as excessive running slope, cross slope, and change in level, affecting the accessible route to play components.

3. Within 12 months of installation, playground sites in the sample with loose fill EWF were found to have the highest values for firmness and stability, indicating greater work force needed to move across the surface, while playground sites with the unitary surfaces TIL and PIP were found to have the lowest values for firmness and stability– indicating less work force necessary to move across the surface.

4. Deficiencies, such as excessive running slope, cross slope, changes in level, and openings for PIP, TIL and HYB began to emerge 24-36 months after installation.

5. Occurrences were identified in the sample where the surface material installation did not parallel either the manufacturer's installation instructions or the procedural instructions on the laboratory test sample for ASTM F1951-99.

6. A playground surface with fewer accessibility deficiencies and a lower measurement for firmness and stability did not necessarily meet the safety standards for impact attenuation.

7. Surface cost for material cannot serve as an indicator or predictor of performance.

There were also findings related to the design of the playground sites and with the selection of the specific playground surface materials or systems. There were instances where the accessibility standards were not properly applied to the playground design. For example, there may be swings designed to be on an accessible route and connected by the unitary surface.

However, the design may not have allocated for the 30 x 48 inch clear floor space to transfer at the swing or the required 60 inch diameter turning space adjacent to the swing. While the design itself may be the problem in some cases, failure to collect enough information about the site was also identified as a likely contributor to installation of accessible routes not fully compliant with the standards. Some playground designers and manufacturers do not necessarily consider the completion of a site survey as essential to the design and construction of the playground. The lack of site surveys for at least three playgrounds in the study created installation errors along the accessible routes. Each of the three sites were deemed "relatively flat" by their planning teams. When it came time to install the surface, the lack of planning for the accessible routes caused the contractors to improvise for surfaces to meet up with composite structures and points of egress resulting in routes that exceed the maximum allowable running and cross slopes. Lack of site surveys to plan effective drainage could also be considered as contributors to standing water, washed out sub-base stone, mold and vegetation growth. Construction changes on site also negatively affected the accessible route affecting running and cross slopes, transfer heights and required clear floor space.

Installation

Surface materials/systems were installed by both contractors and the playground owners' maintenance staff. PIP was exclusively installed by contractors specializing in the surface material. Participating playground owners believed the intensive installation requirements for PIP, from mixing the binder to troweling the material level, were best completed by contractors experienced with the surface material. The intensive installation requirements also made it necessary for the contractor to return to sites for repairs due to vandalism or patches at locations where equipment may have been removed. The costs for return repairs or patches were dependent upon whether the project was covered under the warranty. The most notable installation concerns were raised at sites where the PIP appeared in good condition, but when tested with the TRIAX did not meet the ASTM standard for impact attenuation. The PIP surface at two swing bays for a new installation was found in non-compliance with HIC scores well over the 1,000 HIC allowable under the standard. Had the playground owner decided not to utilize the field test for impact attenuation, they likely would not have learned of the product failure at the swings until well after the warranty had expired. This example further illustrates the critical need for field testing immediately following installation and throughout the life cycle of the playground.

Other deficiencies for PIP were cited in areas where the granules from the top layer began flaking off within the first three years of installation. This flaking condition has been linked to either inadequate ratio of bonding agent to granules when mixed on site; and/or failure of the bonding agent to properly cure when installed at 40 degrees Fahrenheit and falling. The manufacturer installation instructions show the preferred atmospheric temperature for installation to be 40 degrees Fahrenheit and rising. Left unattended over time, areas where the top granular layer has flaked away can lead to non-compliant clear ground space at play equipment such as swings, transfer systems and the egress of slides. Deficiencies related to installation methods may not become evident for months or even years. Thus, it is necessary for the playground owner to prepare for these situations prior to purchase through the terms of the warranty and/or specified funds for maintenance.

HYB-A (outdoor carpet) and HYB-C (artificial grass) were installed by contractors representing the manufacturers. These surface systems required installers experienced with laying the sub-surface, adjoining seams, and affixing the surface material to the border. Separation at the seams appeared to be the most prevalent concern following installation. Repairs to seams must be made by the contractor and costs are dependent upon the terms of the product warranty.

Three playground owners selected TIL and HYB-B (rubber top mat system) based on perceptions that the surface systems would be easy for park crews to install and maintain, thus producing cost savings for the agencies. The learning curve for installation of the TIL proved to be most challenging. The first installation of the TIL was perceived as so difficult for the park maintenance crew that any cost savings was mitigated by the lengthy learning process. By the time the playground owner had installed its fourth playground with TIL, the agency had decided to transition to a different surface. On the contrary, another playground owner that contracted the TIL installation to a preferred manufacturer's installer was very pleased. They cited the ease for their park maintenance crew to replace a tile here or there as a primary reason to continue use of the TIL. The playground owners using HYB-B reported the surface system was easy to install and maintain once their park maintenance crews received sufficient training from the manufacturer. One of the playground owners using HYB-B had gone on to install their second playground site with no issues or complaints.

EWF was most frequently installed by park maintenance crews and perceived as relatively easy compared to other surface materials. Sites installed with EWF were found to have the highest SDS within the first year of installation including deficiencies with excessive running slope, cross slope and change in level. Upon further inquiry with the playground owners, it was found that none of the owners were aware of EWF manufacturers' recommendations for installing the material in layers, applying water and compacting each layer. The lack of EWF particle compaction and layered installation is considered the major contributing factor leading to undulation within the surface area at the participating playground sites. Since this information has been shared with the playground owners, many have begun to rethink their approach to EWF installation. One of the playground owners transitioned to installation where the EWF is delivered by truck and blown into the sites by a contractor as opposed to traditionally dumped, shoveled and raked by their maintenance crew. The playground owner believed there to be better control of the depth and reach of the blown EWF. However, they did not consider it to be a cost savings. The park maintenance crew was still required to level and compact surface areas where they believed the EWF delivery crew had not done a satisfactory job of achieving an accessible route and level transitions between the EWF and PIP. Other playground owners are considering the installation of EWF as an opportunity to use volunteers to assist in compaction by running drum roller teams across the surface area.

Maintenance

Maintenance is one of the greatest factors affecting the accessibility of the surfaces in the sample. There was a lack of installation/maintenance information provided by the manufacturer to the playground owner prior to purchase and there was a steep learning curves related to working with various surface systems. Each of the 16 participating municipalities had maintenance personnel trained through the either the National Playground Safety Institute (NPSI) or the Illinois Park District Risk Management Association (PDRMA). The participating agencies recognized maintenance as a critical need in order to provide a safe environment for the public to recreate. All of the municipalities had "playground crews" responsible for visiting each playground site, making visual inspection of the area, collecting trash, and completing repairs as needed. The playground crews ranged in number from 1-3 staff, usually with one full-time employee and 2-3 seasonal staff during the summer months. At least 30 minutes was spent on site. However, the frequency of visits to each site varied among the different agencies. Large playgrounds at regional parks and sites where programming occurred were most often visited. Some were visited daily during peak summer months. Smaller neighborhood parks may have been visited 1-3 times per week or two times per month.

Surface deficiencies were found to exist at each site regardless of the frequency of visits by the playground crew. Any correlation between the frequency of maintenance and the SDS was inconclusive. However, over the course of the longitudinal study, the research team found that where the playground crews became more engaged in the study, the maintenance specific to accessibility began to improve. This finding was most evident at sites visited in 2012, the final season of data collection. A marked improvement in SDS was noted at sites where playground owners had become more fully engaged in the study. They participated in two conference calls for study updates, made inquiries, and/or participated during research team site visits to gain greater understanding of the assessment process. At least three EWF sites had improved SDS where the surface material was observed as more level and better compacted than previous site visits. One site utilizing PIP as the primary access route and EWF as the secondary access route was assessed with less than 1 percent slope at the transition between the two surface materials. This was observed as the most improved and maintained transition between surface materials of the sample.

PIP was recorded as the surface material requiring the least instances of maintenance. Maintenance areas were noted where the surface had cracks, buckles, openings or a granular layer had worn away under high traffic areas like swings, transfer steps and the egress at slides. While PIP had the least instances requiring maintenance, it is still notable because the surface repairs can be extensive. Repairs must be done by either the original installer or professional certified by the manufacturer resulting in added costs. The patch repairs also necessitate cutting away a larger section of surfacing in order to fill and level the deficient area.

A greater number of TIL sites were recorded in need of maintenance than originally hypothesized. TIL deficiencies included punctures holes ranging from .50 inches to more than 2 inches in diameter; and instances where the seams had started to shift or buckle creating openings and changes in level along the accessible route. The playground owners reported mixed opinions on continued use of the TIL systems. The playground owner that had invested the most, both in material and staff training, had the highest number of surface deficiencies requiring maintenance. After five years of use, the playground owner decided to go with a different unitary surface system. Yet, a neighboring playground owner who had the surface installed by a contractor, only had to replace one tile during the study. The playground crew reported the replacement of the tile took two people less than an hour and it was relatively easy. The contrasting experiences of the two agencies could be as simple as products supplied by two different manufacturers.

EWF sites were recorded in need of maintenance most frequently and earliest in the study. As has been mentioned previously, maintenance issues were most needed to correct accessible routes and clear ground spaces where the running slope and cross slope exceeded the accessibility standards.

Findings from the study illustrate the critical need for maintenance, regardless of the type of surface material used for the accessible route. It is essential for ongoing maintenance from visual site inspections to patch repairs or material replenishment be planned at the conception of the new playground project. Further, the maintenance crew should be trained in both playground safety and the accessibility requirements to ensure ongoing compliance with the standards.

Implications

The qualitative data from the on-site inspections support the perceived advantages and disadvantages of the unitary and loose fill materials as described in the literature review. The initiation of the surface deficiency score can quantify where the surface samples fail to comply with the standards for slope, cross slope, vertical change in level, or openings in the surface. Further, the measurement of firmness and stability can serve as an indicator of the variable characteristic of the surface sample.

Lack of playground sites with shredded rubber for participation in the study prohibited collection of quantitative and qualitative data regarding the accessibility of this loose fill surface material. The recycled shredded rubber industry, over the last five to eight years, has positioned itself as the provider of a "green," environmentally friendly product that is safe and accessible. As such, there is a marked absence of public data as to how this particular type of surface material would compare to PIP, TIL, EWF and HYB. Comparison of shredded rubber with the only other loose fill surface material in the study, EWF, could not be made. There are no data to show how the two surface materials compare to one another or how the two surface materials in the category of loose fill would compare to the category of unitary surface material. Without descriptive statistical analysis of the firmness and stability of shredded rubber as a playground surface, playground operators do not know how the material will perform over time in the field.

Proper installation in accordance to the manufacturer's instructions, per the standards, and by experienced personnel is critical. Sites where the various surface materials have been installed by park personnel with limited experience on the installation procedures, ASTM specifications, and accessibility standards were reported with deficiencies within 12 months of installation. It is critical for the installation crew to fully understand and adhere to the manufacturer's instructions, less the terms of the warranty be rendered null and void.

Visual inspection alone cannot determine if the playground surface is accessible and impact attenuating in accordance with the ASTM standards. The discovery of areas in the sample where the surface was found in non-compliance for ASTM F1292-99/04 impact attenuation was alarming for both the research team and the playground owner based on the beautiful appearance of the newly installed surface, the cost for the surface and the assumption that it was installed with the specific intent of minimizing injury for children using the play equipment. A playground surface may have few to no identifiable deficiencies specific to the accessibility of the route, however, this does not have any relation to whether the surface has the ability to absorb the impact from a child's fall per the safety standards. Field tests for compliance with ASTM F1292-99/04 must be conducted following installation and be part of an ongoing maintenance routine to ensure the integrity of the safety resilient surface system.

There needs to be a portable field instrument to determine compliance for ASTM F1951-99. The current test protocol is designed for a laboratory environment and the cost for the equipment to measure the work force of the manual wheelchair moving across the surface is upward of $20,000. The cost is prohibitive to playground owners and contractors that need to confirm the surface material has been properly installed and maintained to the same specifications the sample was tested and certified to ASTM 1951-99 in the lab. For the purpose of this study, the Rotational Penetrometer was used as the field instrument to measure firmness and stability in lieu of the costly equipment for ASTM F1951-99. Documented research has shown the Rotational Penetrometer to have a high degree of repeatability and reproducibility (ASTM, May 27, 2005; ASTM, September 2010). [1]

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[1] Results of interlab studies determining the repeatability and reproducibility of the Rotational Penetrometer were reported through work items of the ASTM F08.63 Subcommittee on Playground Surfaces. For more information, contact ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959.

PIP and EWF represent the most diverse characteristics of each category in this study. Findings from this study provide expanded knowledge on the objective measurement of firmness and stability along with the variability of the material characteristics contributing to the accessibility of the surface. The measured values for firmness and stability, standard deviation and the sum of the values illustrate the variability of the material characteristics and composition. If manufacturers reported the average values for firmness and stability, similar to the ASTM requirement to provide laboratory test results for the critical fall heights of the surface sample, playground owners could gain a better understanding of the variability of the surface material and select a surface material more appropriate to their agency resources for installation and long-term maintenance. However, again, to ensure consistency, repeatability and reproducibility, an ASTM field test protocol is critical. Published information on the correlation between the surface material's firmness and stability in relation to the frequency of non-compliance with the accessibility standards for running slope, cross slope, changes in level and openings, could create a greater awareness among playground owners and positively influence their purchasing decisions and maintenance practices. If the playground owner had a better understanding of the values measured with the Rotational Penetrometer, they might also be better equipped to establish an installation baseline and maintenance targets for the surface material.

Data on the performance of the hybrid surface systems may be promising enough to lead to further research and product development as the next generation of accessible protective playground surfacing. Although, much more research needs to be conducted among all three brands of hybrid surfaces in this study to evaluate the longevity for impact attenuation, durability for high public use, resistance to vandalism, and ability to withstand various outdoor climates. Product development in this category of hybrid surface systems, where there is some type of loose fill base covered by a unitary mat, could eventually provide a more middle ground in terms of costs and overall performance if the data on longevity and durability are made available up front for the playground owner prior to the decision to purchase.

Conclusion

Preliminary results from this study indicate that there is no perfect playground surface. Even within 12 months of installation, each type of surface had some type of issue or series of issues that may affect the product's performance and contribute to the necessity and frequency of surface maintenance to assure accessibility and safety for use by children on a daily basis. The public playground has the potential to provide immeasurable opportunities supporting the development of children of all abilities. The design, installation and maintenance of play equipment and the surface material is critical to achieving an inclusive environment that facilitates child development and enables children with disabilities to fully participate with their non-disabled peers. Failure to recognize the significant role of the surface material is to design for segregation. Where the playground surface material fails to comply with safety standards for impact attenuation, children are put at risk of injury. Where the playground surface fails to comply with the minimum accessibility standards, children with mobility impairments may be regulated to the sidelines only to look on.

Playground owners need to become educated on, not only the minimum safety and accessibility standards, but the practical application of the standards to the newly installed playground surface in order to inspect the surface and ensure it is compliant. To fully benefit from the product's marketed advantages and costs-savings, decision-makers should request much more information from the manufacturer including specific instructions for installation and maintenance along with results of laboratory tests and surface preparation for the lab tests that are consistent with the installation instructions. Decision-makers should dialogue with the surface supplier regarding realistic, objective measurements to evaluate surface performance and maintain the surface material over the life span of the playground. The communication gap between the manufacturer's literature and the owner's perception of installation and maintenance must be bridged if the owner is to fully benefit from the available products on the market today.

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APPENDIX A

INDIANA UNIVERSITY – BLOOMINGTON
STUDY INFORMATION SHEET
Playground Surface Study

As a public playground owner, you are invited to participate in a research study of playground surfaces. The purpose of this study is to evaluate the accessibility and safety of surfaces in newly constructed playgrounds. This research study is designed to test a variety of playground surfaces, their ability to meet accessibility and safety guidelines and their cost effectiveness upon initial installation and ongoing maintenance over a five year period. In addition, this study will compare the seasonal maintenance costs to continuously meet accessibility and safety guidelines. This study is conducted through the National Center on Accessibility at Indiana University with support from the U.S. Access Board.

INFORMATION

Upon consent to participate in this study, the playground owner will be asked to designate a site coordinator (study liaison) to work with the research team. This individual will be responsible for assisting with collecting data and working directly with the National Center on Accessibility. It is preferred that the designated staff representative is a Certified Playground Safety Inspector (CPSI) or Accessibility Coordinator. The playground owner/site coordinator will be asked to submit a paragraph describing the playground and its features. The research team will associate the site into one of six potential categories for participation in the study: engineered wood fiber product; shredded rubber / crumb rubber; unitary rubber mat surfaces; unitary rubber “poured in place” surfaces; loose fill material used with a binding product; or combination or hybrid surface systems under development.

The playground owner/site coordinator will be asked to submit surface vendor information to the research team. In turn, the research team will contact the vendor to collect additional information on laboratory certification. While the brand name of the surface product will be kept confidential, this study will require that the vendor provide laboratory testing results pertinent to ASTM F1292-99/04, F1951-99, and F2075 (as applicable).

Using the playground site plan, the research team and site coordinator will identify the nine critical areas for data collection: 1) entry to playground where playground surface starts; 2) accessible route connecting accessible play elements; 3) egress point of slide(s); 4) swings; 5) entry point(s) to composite structure(s)/transfer stations; 6) climber(s); 7) ground level play element(s) such as spring rockers, play tables, interactive panels, etc; 8) sliding poles; 9) other areas (i.e. water play elements, etc). The site plan will be labeled with locations 1-9 to identify the critical test areas. One copy will be kept on file with NCA. One copy of the site plan should be kept on file with the site coordinator in order to ensure the same locations are inspected and tested. Using the corresponding numbered tent cards, photos will be taken of each area 1-9 during the first scheduled data collection.

Upon installation, the research team and site coordinator will conduct a preliminary accessibility assessment of the playground surface and test the surface for firmness and stability with the Rotational Penetrometer. At the discretion of the playground owner, the playground surface will also be tested for impact attenuation with the TRIAX (surface impact testing device). The site coordinator and research team will work together to complete the installation log. Following the preliminary accessibility assessment, the playground surface will be assessed seasonally/monthly and the surface conditions/maintenance log will be completed. The playground surface will be assessed at a minimum of two to four times per year for five years. A schedule will be established cooperatively with the site coordinator and research team. The playground owner will be notified immediately of test results for both firmness/stability and impact attenuation and given opportunity to correct surfaces where deficiencies or non-compliance with standards may occur.

BENEFITS

Participation in this study will provide essential data to the research team on the playground surfaces' ability to meet accessibility criteria in field installations along with associated costs for complying with accessibility and safety standards. This research, in turn, will give future playground owners more information on the issues and costs for installing and maintaining playground surfaces so they can make more informed choices on the playground surface most appropriate to their needs and available resources.

CONFIDENTIALITY

The park/playground will be coded by county, state, study start date and surface type. The name of the park and playground will not be identified in the research or technical reports.

CONTACT

If you have questions at any time about the study or the procedures, you may contact the researcher, Jennifer Skulski, National Center on Accessibility, 501 North Morton St, Suite 109, Bloomington, IN 47404, (812) 856-4422, or by e-mail: jskulski@indiana.edu.

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have not been honored during the course of this project, you may contact the office for the Indiana University Bloomington Human Subjects Committee, Carmichael Center L03, 530 E. Kirkwood Ave., Bloomington, IN 47408, 812/855-3067, or by e-mail at iub_hsc@indiana.edu.

PARTICIPATION

Your participation in this study is voluntary, you may refuse to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty and without loss of benefits to which you are otherwise entitled. If you choose to withdraw from the study before the study is completed, you will have the options of: 1) permitting the research team to use data collected up to the time of withdrawal; 2) having the data returned to you; or 3) having the data destroyed.

Playground/Park ______________________________

Address ______________________________

City, State, Zip ______________________________

Playground description ______________________________

____

____

Surface(s) to be installed:

- ☐ Engineered wood fiber product;
- ☐ Shredded rubber / crumb rubber;
- ☐ Unitary rubber mat surfaces;
- ☐ Unitary rubber “poured in place” surfaces;
- ☐ Loose fill material used with a binding product;
- ☐ Combination or hybrid surface systems under development.

____

____

Playground Partner Agency Name ______________________________

Site Coordinator ______________________________

Mailing Address ______________________________

City, State Zip ______________________________

Phone ______________________________

Fax ______________________________

E-mail

____

Date for scheduled for installation ______________________________

APPENDIX B

National Center on Accessibility
Playground Surface Study
Installation Log

This worksheet is to be completed at the time of playground surface installation.

Playground Information

Playground Name: ____________________ Installation Date: __________

Playground Location: ____________________

Owner/Operator: ____________________

Site Coordinator: ____________________

Surface Installation Supervisor: ____________________

This playground is:
- ☐ Located at a public school
- ☐ Located at a private school
- ☐ Located at a private religious school
- ☐ Located at a day care center
- ☐ Located in a city park
- ☐ Located in a state park
- ☐ Located on a national park or federal land
- ☐ Other____________________

This playground is designed for (check all that apply):
- ☐ Ages 0-2
- ☐ Ages 2-5
- ☐ Ages 5-10
- ☐ Ages 10-12
- ☐ Ages 12-14

Name of Equipment Manufacturer: ____________________

Total cost for equipment: __________ Total sq. ft. for playground: __________

Total cost for surfacing: __________

Total cost for playground development: __________

Surface Product Information

1. Surface System Name: ____________________
   Manufacturer: ____________________
   Vendor/Sales Rep: __________ Phone: __________
   Address: __________ E-mail: __________
   Product Description: ____________________
   Cost per sq ft: ____________________

2. Surface System Name: ____________________
   Manufacturer: ____________________
   Vendor/Sales Rep: __________ Phone: __________
   Address: __________ E-mail: __________
   Product Description: ____________________
   Cost per sq ft: ____________________

3. Surface System Name: ____________________
   Manufacturer: ____________________
   Vendor/Sales Rep: __________ Phone: __________
   Address: __________ E-mail: __________
   Product Description: ____________________
   Cost per sq ft: ____________________

Installation

1. Surface System

Top Surface Name: ______________________

Description: ______________________

____

Sq ft: ____________ Depth of Installation: ____________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: ____________

Total number of hours to install this surface (# people x # hours): ____________

Cost for material per sq ft: ____________

Total cost for labor: ____________

Notes:

Sub-Base Product Name: ______________________

Description: ______________________

____

Sq ft. ____________ Depth of Installation: ____________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: ____________

Total number of hours to install this surface (# people x # hours): ____________

Cost for material per sq ft: ____________

Total cost for labor: ____________

Notes:

Base Product Name: ______________________

Description: ______________________

____

Sq ft. ____________ Depth of Installation: ____________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: ____________

Total number of hours to install this surface (# people x # hours): ____________

Cost for material per sq ft: ____________

Total cost for labor: ____________

Notes:

Drainage System: ______________________

Description: ______________________

Drainage system installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install drainage system: ____________

Total number of hours to install drainage system (# people x # hours): ____________

Cost for material per sq ft: ____________

Total cost for labor: ____________

Notes:

Installation

2. Surface System

Top Surface Name: ____________________

Description: ____________________

____

Sq ft: __________ Depth of Installation: __________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: __________ Total number of hours to install this surface (# people x # hours): __________

Cost for material per sq ft: __________ Total cost for labor: __________

Notes:

Sub-Base Product Name: ____________________

Description: ____________________

____

Sq ft. __________ Depth of Installation: __________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: __________ Total number of hours to install this surface (# people x # hours): __________

Cost for material per sq ft: __________ Total cost for labor: __________

Notes:

Base Product Name: ____________________

Description: ____________________

____

Sq ft. __________ Depth of Installation: __________

This surface was installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install this surface: __________ Total number of hours to install this surface (# people x # hours): __________

Cost for material per sq ft: __________ Total cost for labor: __________

Notes:

Drainage System: ____________________

Description: ____________________

Drainage system installed by:
- ☐ Manufacturer
- ☐ Contractor
- ☐ Park and/or facility staff

Total number of people to install drainage system: __________ Total number of hours to install drainage system (# people x # hours): __________

Cost for material per sq ft: __________ Total cost for labor: __________

Notes:

Installation

3. Surface System

Top Surface Name: ______________________________

Description: ______________________________

____

Sq ft: ______________ Depth of Installation: ______________

This surface was installed by:
☐ Manufacturer
☐ Contractor
☐ Park and/or facility staff

Total number of people to install this surface: ______________ Total number of hours to install this surface (# people x # hours): ______________

Cost for material per sq ft: ______________ Total cost for labor: ______________

Notes:

Sub-Base Product Name: ______________________________

Description: ______________________________

____

Sq ft. ______________ Depth of Installation: ______________

This surface was installed by:
☐ Manufacturer
☐ Contractor
☐ Park and/or facility staff

Total number of people to install this surface: ______________ Total number of hours to install this surface (# people x # hours): ______________

Cost for material per sq ft: ______________ Total cost for labor: ______________

Notes:

Base Product Name: ______________________________

Description: ______________________________

____

Sq ft. ______________ Depth of Installation: ______________

This surface was installed by:
☐ Manufacturer
☐ Contractor
☐ Park and/or facility staff

Total number of people to install this surface: ______________ Total number of hours to install this surface (# people x # hours): ______________

Cost for material per sq ft: ______________ Total cost for labor: ______________

Notes:

Drainage System: ______________________________

Description: ______________________________

Drainage system installed by:
☐ Manufacturer
☐ Contractor
☐ Park and/or facility staff

Total number of people to install drainage system: ______________ Total number of hours to install drainage system (# people x # hours): ______________

Cost for material per sq ft: ______________ Total cost for labor: ______________

Notes:

APPENDIX C
On-Site Inspection Form

Playground Code & Date	1. Surface at entry to playground where surface of accessible route starts	2. A point on the accessible route connecting accessible play elements	3. Surface at egress point(s) of slides	4. Surface at swings	5. Surface at entry point(s) to composite structures/transfer stations	6. Surface at climbers
Top surface name						
Description						
Surface temperature						
Air temperature						
Does the surface display any of the following characteristics (check all that apply):						
Uneven wear						
Settling						
Dugouts (larger areas greater than 1 ft in length)						
Ruts (smaller areas less than 1 ft in length)						
Cracking						
Buckling						
Does the surface show signs of displacement? (yes or no)						
If yes, measure the area of displaced suface (the kick-out area):						
Width of area _________ x ________ inches						
Depth of area _______________ inches						
Does this surface location show any other signs of wear? (yes or no)						
If yes, please describe condition:						
Does this surface location require maintenance or repair? (yes or no)						
If yes, please describe the required maintenance or repair:						
Was the required maintenance or repair performed? (yes or no)						

Playground Code & Date ______________________

	7. Surface at ground level play elements	8. Surface at sliding poles	9. Surface at other areas (i.e. water play elements, etc)
Top surface name			
Description			
Surface temperature			
Air temperature			
Does the surface display any of the following characteristics (check all that apply):			
Uneven wear			
Settling			
Dugouts (larger areas greater than 1 ft in length)			
Ruts (smaller areas less than 1 ft in length)			
Cracking			
Buckling			
Does the surface show signs of displacement? (yes or no)			
If yes, measure the area of displaced suface (the kick-out area):			
Width of area _________ x ________ inches			
Depth of area _______________ inches			
Does this surface location show any other signs of wear? (yes or no)			
If yes, please describe condition:			
Does this surface location require maintenance or repair? (yes or no)			
If yes, please describe the required maintenance or repair:			
Was the required maintenance or repair performed? (yes or no)			

APPENDIX D

National Center on Accessibility- Playground Surface Study
Rotational Penetrometer Data Form

Playground Information

Playground Code: ______________________

RP Operator: ______________ RP Data Recorder: ______________

Rotational Penetrometer

Manufacturer: Beneficial Designs

Serial number: BDRP- ______________ Date of last calibration: ______________

Tire pressure set at 36 psi on (date): ______________ By: ______________

Date & Test Conditions

Date: ______________ Time: ______________

Atmospheric Temperature: ______________ F Relative Humidity: ______________ %

If the temperature is more than 10 F different than the temperature at the tire pressure check, re-inflate tire before starting to test.

Test Results

1. Surface at entry to playground where surface of accessible route starts:

Surface description: ______________________

Surface temperature: ______________ F

Trial 1	Firmness:		Stability:	
Trial 2	Firmness:		Stability:	
Trial 3	Firmness:		Stability:	
Trial 4	Firmness:		Stability:	
Trial 5	Firmness:		Stability:	
Average:	Firmness:		Stability:	

2. A point on the accessible route connecting accessible play elements:

Surface description: ______________________

Surface temperature: ______________ F

Trial 1	Firmness:		Stability:	
Trial 2	Firmness:		Stability:	
Trial 3	Firmness:		Stability:	
Trial 4	Firmness:		Stability:	
Trial 5	Firmness:		Stability:	
Average:	Firmness:		Stability:	

3. Surface at egress point(s) of slides:

Surface description: ______________________

Surface temperature: ______________ F

Trial 1	Firmness:		Stability:	
Trial 2	Firmness:		Stability:	
Trial 3	Firmness:		Stability:	
Trial 4	Firmness:		Stability:	
Trial 5	Firmness:		Stability:	
Average:	Firmness:		Stability:	

4. Surface at swings:

Surface description: ______________________________

Surface temperature: ____________ F

Trial 1	Firmness:	________	Stability:	________
Trial 2	Firmness:	________	Stability:	________
Trial 3	Firmness:	________	Stability:	________
Trial 4	Firmness:	________	Stability:	________
Trial 5	Firmness:	________	Stability:	________
Average:	Firmness:	________	Stability:	________

5. Surface at entry point(s) to composite structures/transfer stations:

Surface description: ______________________________

Surface temperature: ____________ F

Trial 1	Firmness:	________	Stability:	________
Trial 2	Firmness:	________	Stability:	________
Trial 3	Firmness:	________	Stability:	________
Trial 4	Firmness:	________	Stability:	________
Trial 5	Firmness:	________	Stability:	________
Average:	Firmness:	________	Stability:	________

6. Surface at climbers:

Surface description: ______________________________

Surface temperature: ____________ F

Trial 1	Firmness:	________	Stability:	________
Trial 2	Firmness:	________	Stability:	________
Trial 3	Firmness:	________	Stability:	________
Trial 4	Firmness:	________	Stability:	________
Trial 5	Firmness:	________	Stability:	________
Average:	Firmness:	________	Stability:	________

7. Surface at ground level play elements:

Surface description: ______________________________

Surface temperature: ____________ F

Trial 1	Firmness:	________	Stability:	________
Trial 2	Firmness:	________	Stability:	________
Trial 3	Firmness:	________	Stability:	________
Trial 4	Firmness:	________	Stability:	________
Trial 5	Firmness:	________	Stability:	________
Average:	Firmness:	________	Stability:	________

8. Surface at sliding poles

Surface description: ______________________________

Surface temperature: ______________ F

Trial 1	Firmness:	______	Stability:	______
Trial 2	Firmness:	______	Stability:	______
Trial 3	Firmness:	______	Stability:	______
Trial 4	Firmness:	______	Stability:	______
Trial 5	Firmness:	______	Stability:	______
Average:	Firmness:	______	Stability:	______

9. Surface at other areas (i.e. water play elements, etc)

Surface description: ______________________________

Surface temperature: ______________ F

Trial 1	Firmness:	______	Stability:	______
Trial 2	Firmness:	______	Stability:	______
Trial 3	Firmness:	______	Stability:	______
Trial 4	Firmness:	______	Stability:	______
Trial 5	Firmness:	______	Stability:	______
Average:	Firmness:	______	Stability:	______

APPENDIX E

Photos from On-Site Assessments

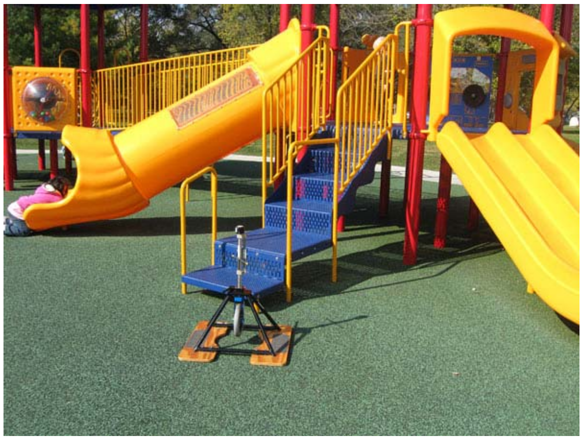

Photo 1: PIP at transfer system.

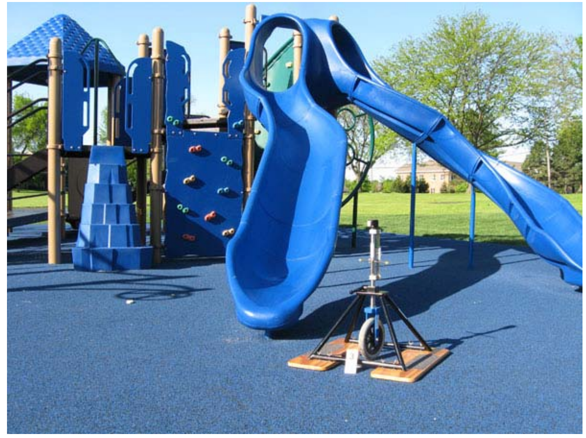

Photo 2: PIP with no recorded locations where the surface samples exceeded the accessibility standards.

Photo 3: PIP location measured for firmness and stability using Rotational Penetrometer.

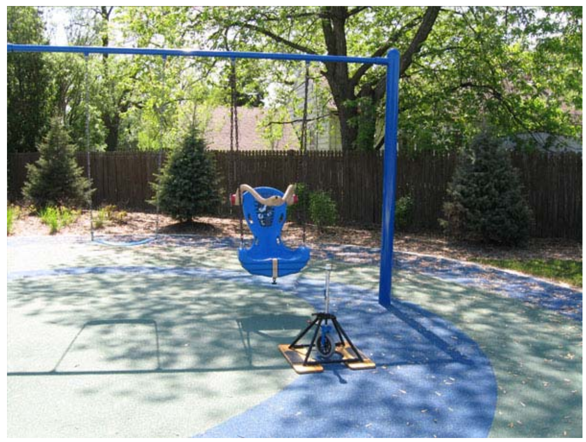

Photo 4: PIP location at swings found in non-compliance with HIC scores over 1,000.

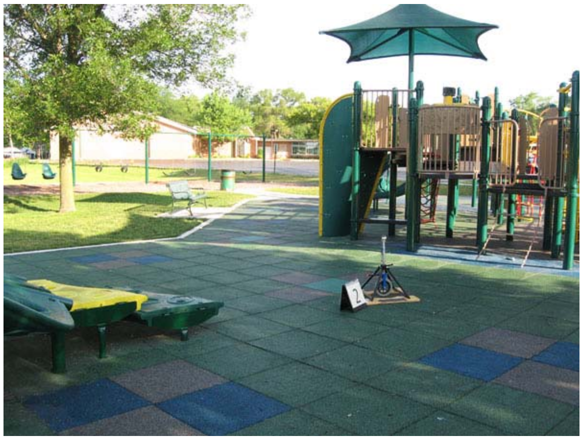

Photo 5: TIL on access route.

Photo 6: TIL at egress for slide.

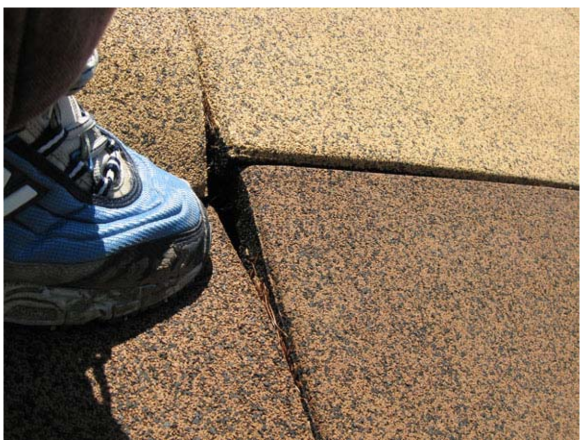

Photo 7: TIL where seams have started to shift.

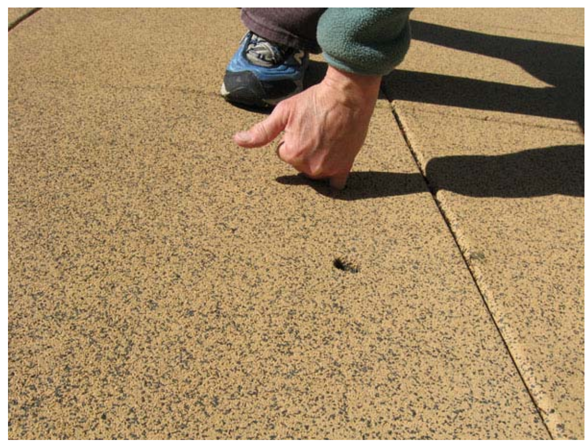

Photo 8: TIL with puncture holes.

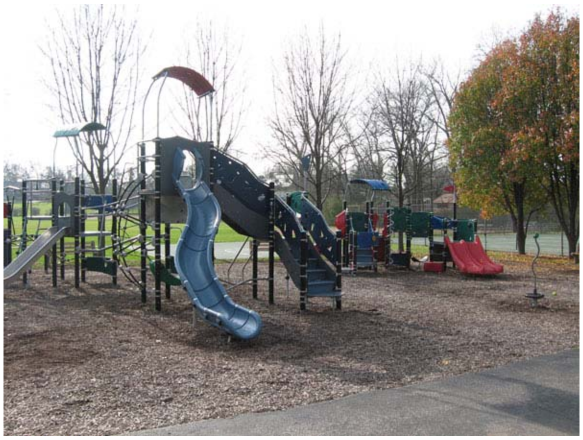

Photo 9: EWF noted with observed undulating surface.

Photo 10: EWF with displaced area under swings.

Photo 11: EWF with noted cross slope at ground level play component.

Photo 12: EWF with measurable displaced surface material at ground level play component.

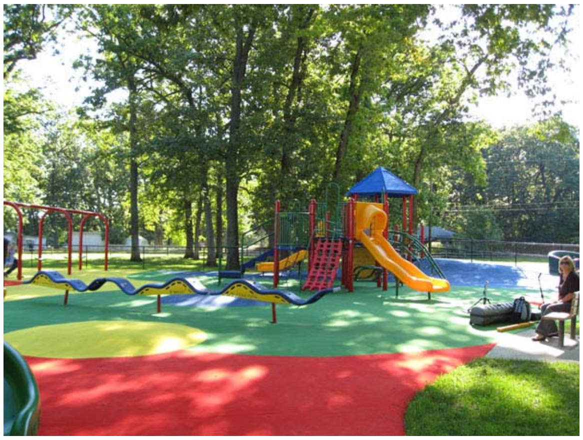

Photo 13: HYB surface system designed with outdoor carpet as top layer over engineered carpet pad base and infilled with silicone sand.

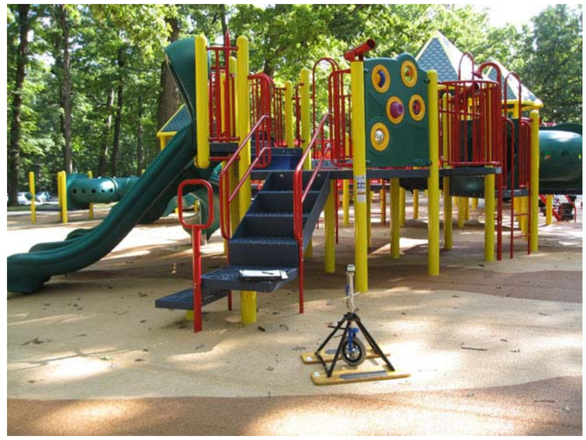

Photo 14: HYB surface system with rubber mat top layer over shredded rubber base contained in pillow forms.

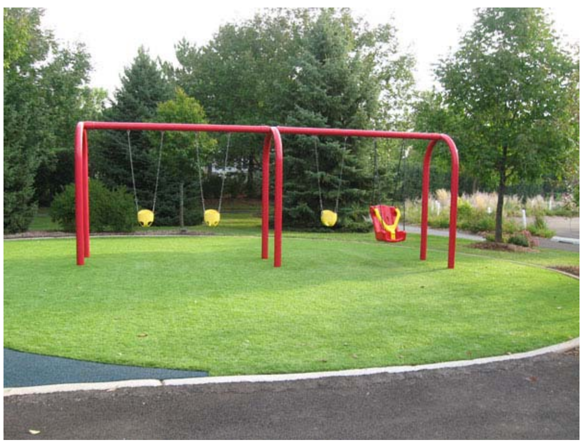

Photo 15: HYB turf grass surface system.