PLAYGROUND SURFACES:
AN EVALUATION OF SURFACES FOLLOWING INSTALLATION TO DETERMINE ACCESSIBILITY FOR CHILDREN WITH DISABILITIES

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DEDICATION

This thesis is dedicated to my loving son Quinn. I started writing the proposal for this thesis when I was seven months pregnant with you. I didn't know joy until you came into my life. I made the formal proposal when you were three. Now you are five, learning all you need to know in kindergarten, and I am finally presenting a finished document of findings. Lessons from Mom: Finish what you start! Find your passion. Do what you love. Love what you do. Take a stand for what you believe in. Always make time for play. And never forget how very much I love you.

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Read on!

Then, let's go play!

ABSTRACT

The playground is a place for play and learning for all children and especially for 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 playground surfaces on the market in 2010. Lack of reliable product performance data on the effectiveness of safe, accessible playground surfaces relative to costs 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 and their costs upon initial installation. The research questions include: how well do various playground surfaces meet the accessibility requirements upon installation? What are the costs for the various playground surfaces and are the costs related to performance? What accessibility issues arise out of initial installation?

A total of 25 sites were visited to evaluate the surface conditions for accessibility and gather information on the costs for installation. The playground surfaces were categorized as either poured in place rubber, rubber tiles, engineered wood fiber, shredded rubber or a hybrid surface system. A visual inspection was conducted at nine pre-determined locations within the play area. Locations were awarded a deficiency score at occurrences where the surface location was not in compliance with the minimum accessibility standards of the Americans with Disabilities Act. In addition, the surface locations were measured for firmness and stability with a Rotational Penetrometer.

Results from this study indicate that there is no perfect playground surface. Even within 12 months of installation, each type of surface has 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.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIXES

Chapter 1

INTRODUCTION

Since the inception of the first known playgrounds in the United States dating back to the early 1900's, public play areas have been recognized and valued as essential developmental environments for children (Frost, Brown, Sutterby, & Thornton, 2004). The playground is a place for play and learning for all children and especially for children with disabilities. 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. In the playscape, the child with a disability can be exposed to new stimuli, further develop motor skills, exercise creativity and imagination, and, most importantly, make friends through play with other non-disabled peers (Skulski, 2006).

When the playground presents physical barriers such as inaccessible surfaces and routes, play, learning and development, the self-actualized benefits of the leisure experience can be stunted or even eliminated for the child with a disability. Inaccessible surfaces can prohibit 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 can be maintained as accessible becomes one of the most critical decisions during the playground planning and design phases.

Surfaces for use on public playgrounds must meet a host of national, state, and local performance standards. With the rise of playground injuries and the evolution of playground safety standards, it is no longer considered appropriate to simply place public playground equipment in the middle of an open field or area surrounded with questionable surfacing such as gravel, grass, dirt, asphalt, concrete, aggregate or pea gravel (CPSC, 2000; ASTM, 2004; NPSI, 2008). The use of safety surfacing has become a critical component for the provision of public playgrounds. Results of an online buyers' guide search identifies more than 100 different commercial varieties of playground surfaces on the market (NRPA, 2010). 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.

Statement of the Problem

Lack of reliable product performance data on the effectiveness of safe, accessible playground surfaces relative to costs for installation and ongoing maintenance prohibits public playground owners from making informed choices on the selection of play surfaces most appropriate for their public setting.

Purpose of Study

The purpose of this study was to evaluate a variety of playground surfaces, their ability to meet accessibility requirements and their costs upon initial installation. The research questions included:

1. How well do various playground surfaces meet the accessibility requirements upon installation?
2. What are the costs for the various playground surfaces and are the costs related to performance?
3. What accessibility issues arise out of initial installation?

Justification

The U.S. Access Board estimated the accessibility guidelines for play areas under the Americans with Disabilities Act Accessibility Guidelines to affect as many as 5,300 new playgrounds and 18,600 renovated playgrounds annually (U.S. Access Board & EOP Foundation, 2000). In the Final Accessibility Guidelines for Play Areas Economic Assessment (2000), the U.S. Access Board estimated between 5,650 and 8,770 public school and municipal park playgrounds are replaced annually. It further estimated that between 380 and 520 new playgrounds are constructed at public schools and municipal parks each year.

Playground owners are challenged to plan, install and maintain playgrounds that are designed with play value along with safe, accessible equipment and surfaces priced within their budgetary constraints. There is significant cost differential between loose fill and unitary playground surfaces, both for the material and installation. While unitary playground surfaces have been described as more accessible and usable for children with disabilities, the cost ranges from $7.50 to $20 per sq. ft. (Miller, 2010; NCA, 2003). The cost for the surface can consume a large portion of the playground budget. Loose fill surfaces like engineered wood fiber are more readily available, easy to install by park maintenance staff, and a fraction of the costs, $1.08 to $2.50 per sq. ft. (Spencer, 2005; Miller, 2010; NCA, 2003). However, loose fill products like engineered wood fiber are described as more difficult to use by children with disabilities using assistive devices such as wheelchairs, walkers, crutches and canes (Skulski et al., 2004). In addition, the loose fill materials are known for "spill" where the product can be displaced easily and spill over the boundaries of the playground. The loose fill material is known for dugouts and ruts under excessively worn and kicked-out areas such as under swings and at the bottom of slides. Also of concern, loose fill material is known for hiding foreign objects and debris along with the tendency for children to throw the material at one another. With all that taken into consideration, manufacturers of engineered wood fiber will argue that this particular product is more resilient to a child's fall and scores much better on impact attenuation than unitary surfaces (Robbins, 2004). Over a three to five year life cycle, it is unclear as to how often maintenance such as leveling off the loose fill product, filling in or topping off is required in order to maintain the surface at safety and accessibility levels dictated by the American Society for Testing and Materials (ASTM) and the U.S. Access Board. Based on commentary and ongoing discussion of park and recreation professionals in the field, it stands to reason that an owner of a playground with loose fill surface material may actually spend more money in material and labor to maintain the loose fill surface over a three to five year life cycle than an owner of a playground with unitary surface which may costs far less to maintain over that same time period. This study will investigate the costs for initial installation while a larger-scale longitudinal study conducted by the National Center on Accessibility will investigate both initial installation and maintenance over a five year period.

Delimitations

The study was delimited in scope by the following:

1. Data from this study was derived from a larger scale longitudinal study administered through the National Center on Accessibility (NCA) at Indiana University with funding from the U.S. Access Board.
2. Playground sites included those operated by municipal park and recreation departments covered under Title II of the ADA
3. Playground sites were installed within a 12-month period from the initial assessment visit.
4. A purposeful sample of playgrounds was selected from the area surrounding Indiana University-Bloomington, Indianapolis and Chicago.
5. Playground surfaces were evaluated on site using a Rotational Penetrometer (RP) to determine firmness and stability of the surface.
6. Evaluation of the playground surfaces for ASTM requirements for impact attenuation were conducted at the optional discretion of playground owners.

Limitations

The study was limited by the following:

1. Ability to generalize findings to 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 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. Risks of liability may affect a playground owner's willingness to participate in the study or contribute to attrition.

Assumptions

Two industry standard specifications are used to determine the safety and accessibility of each surface: ASTM F1292 *Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment* and ASTM F1951 *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 and ASTM F1951-99 in a laboratory environment.
2. A Rotational Penetrometer, as described in further detail in Chapter II, can be used 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 Americans with Disabilities Act Accessibility Guidelines (ADAAG) or the Americans with Disabilities Act – Architectural Barriers Act Accessibility Guidelines (ADA-ABA).

Firmness or Firm Surface. A firm surface resists deformation by either indentations or particles moving on its surface (ADA-ABA Accessibility Guidelines, 2004).

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. The instrument used in field testing for compliance with ASTM F1951, also known as the "wheelchair test." Two methods can be used to determine compliance with ASTM F 1951. The Rotational Penetrometer, developed by Beneficial Designs, uses 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 (ADA-ABA Accessibility Guidelines, 2004).

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, 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."

Chapter 2

RELATED LITERATURE

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 (U.S. Census Bureau, 2005). The Centers for Disease Control and Prevention report an estimated17 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). Playgrounds are one of the potential solutions to the health and wellness issues faced by children. 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 et al., 2004).

In light of evolving safety and accessibility standards for playgrounds, coupled with an upswing in 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. This study will evaluate a variety of playground surfaces, their ability to meet accessibility requirements and their costs upon initial installation. Before pursuing this investigation, a thorough discussion of the national standards for playground surfaces, the types of playground surfaces, their characteristics including advantages and disadvantages, and relativity to accessibility, safety, and cost is necessary.

National Guidelines

Each year in the United States, more than 200,000 children ages 14 and younger are treated in emergency rooms for playground related injuries (Centers for Disease Control & Prevention, 2004; Tinsworth, 2001). To reduce the risk of injury and ensure safe, accessible playgrounds, there are three entities that have set national standards and guidelines for public playground surfaces and equipment: the U.S. Consumer Product Safety Commission (CPSC), the American Society for Testing and Materials (ASTM), and the U.S. Access Board. In 1981, the CPSC began publishing the Handbook for Public Playground Safety. The publication has been revised several times over the last 20 years and provides detailed technical guidelines for designing, constructing, operating and maintaining public playgrounds (CPSC, 1997). Compliance with the CPSC technical guidelines among public playground owners and operators is voluntary. However while compliance is voluntary, the CPSC guidelines are recommended as preferred practice among the membership of the National Recreation and Park Association (NRPA) and its child organization, the National Playground Safety Institute (NPSI) which conducts a national certification program of playground safety inspectors. The guidelines are also recognized among the industry of playground equipment manufacturers.

The American Society for Testing and Materials is an international member organization mostly comprised of industry manufacturers. Two sub-committees, one on playground equipment and another on playground surfaces, are responsible for the second set of national standards. The standard specifications to be considered as related to playground surfaces include: ASTM F1292 *Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment* (1999) and ASTM F1951 *Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment* (1999). Similar to the CPSC guidelines, the ASTM standards are voluntary and recommended as best practice within the playground equipment and surface industry. In many instances, compliance with the ASTM standards is required in order to secure product liability insurance.

The third set of national standards were developed by the U.S. Access Board and stand under the enforcement of the U.S. Department of Justice as directed in the Americans with Disabilities Act of 1990 (ADA). The Americans with Disabilities Act Accessibility Guidelines (ADAAG) were released in 1991, but only addressed the built environment. In efforts to harmonize accessibility standards affecting federal agencies and those under the ADA, the U.S. Access Board released the Americans with Disabilities Act – Architectural Barriers Act Accessibility Guidelines (ADA-ABA, 2004). These revisions have undergone a 15-plus year process to incorporate accessibility guidelines specific to recreation facilities such as playgrounds, golf courses, swimming pools, sports courts and fitness facilities. The U.S. Department of Justice adopted the newest revisions and chapter specific to recreation facilities in September 2010 as enforceable regulations of the ADA Standards for Accessible Design (2010 Standards). These new standards specify requirements for access by people with disabilities on public playgrounds covered under Title II – Public Services and Title III – Public Accommodations of the ADA. Under the 2010 Standards, surfaces should be accessible meeting requirements for ADA-ABA 1008.2 Accessible Routes and ADA-ABA 1008.2.6 Ground Surfaces addressing firmness and stability. Since the ADA is a federal civil rights law, compliance with the accessibility standards is mandatory. Non-compliance is subject to investigation by the U.S. Department of Justice or private right of action pursued in federal court which can result in injunctive relief, compensatory and punitive damages.

In order for a playground surface to be considered "accessible" under the ADA-ABA Accessibility Guidelines, the accessible route must have a clear width of 60 inches while the surface itself is firm and stable; the running slope for a ground level accessible route must be no greater than 1:16, the cross slope must be no greater than 1:48; changes in level cannot exceed .50 inches and must be beveled if they are between .25 and .50 inches; and the overhead clearance along the accessible route must be a minimum of 80 inches. During the evaluation of accessible surfaces used in outdoor developed areas, special attention is paid to the surfaces' ability to be firm and stable since many outdoor surfaces consist of loose fill materials such as gravel, aggregate, natural stone, dirt and others. According to the definitions set forth by the U.S. Access Board, 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. A firm surface resists deformation by either indentations or particles moving on its surface (ADA-ABA Accessibility Guidelines, 2004). For further guidance, the Access Board standard has adopted the ASTM standards for determining impact attenuation and wheelchair accessibility. Thus, for a play surface to be considered appropriate, both safe and accessible under the Access Board guidelines, it must meet the standard provisions for ASTM F1292-99 and ASTM F1951-99.

In the field, ASTM F1292-99 is known as the "head drop test." A Triax is the instrument used to conduct the test. It is 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.

ASTM F1951-99 is commonly referred to as the "wheelchair test." This is a laboratory test whereby the work force required for a 165 (+ 11 or -4.4) lb. individual in a manual wheelchair to propel across a given surface. The lab test uses a 7 percent ramp as a baseline for the wheelchair rider. After the baseline is established, the rider conducts a series of straight propulsions over the sample surface for a minimum distance of 6.56 ft and the force is measured. A second series is then run where the wheelchair rider makes a 90 degree turn and the force is measured again. If the average work per foot for the sample surface is less than the work force to propel up the 7% ramp, then the surface sample is considered as passing ASTM F1951-99. The advantage of the ASTM F1951-99 test procedure is that it provides a starting point to compare various surfaces by an objective measurement. However, the primary disadvantage and criticism of the protocol is that it is designed as a lab test in a controlled environment and cannot be easily replicated in the field, outdoors at multiple playground sites (Kutska, Huber & Skulski, 2008).

A field test method has been developed by Beneficial Designs, the same engineering firm that developed the original test protocol for ASTM F1951-99. The field test uses a portable instrument known as a Rotational Penetrometer (RP). The RP design includes 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. While this field test method has not yet been adopted by ASTM, it has been recognized by national experts in the field as a relatively easy method and portable device to conduct ongoing tests of playground surfaces for firmness and stability (Kutska et al., 2008).

Categorizing Playground Surfaces

The national standards developed over the last 25 years not only require playground surfaces to be safe and withstand the impact of a child's fall, the surfaces are also required to be accessible for use by children with disabilities who may use wheelchairs, walkers, crutches or other assistive devices. The selection of the playground surface can directly affect the play experience for a child with a disability based on whether or not the surface itself is accessible, usable, firm and stable. Schappet (2003) suggested that the selection of surfacing elements can be even more important than the selection of play equipment or the other details of the playground's design. When a child cannot get onto the playground or is prevented from moving from one area to another due to an uneven surface connection or an inaccessible surface, the entire playground becomes a less valuable asset (Schappet).

Generally, playground surfaces can be categorized as either unitary surfaces or loose fill surfaces (CIPC, 2003; CPSC, 2000; Henderson, 1997; Huber, 2001). Unitary surfaces may include asphalt, concrete, rubber mats, tiles or a rubber fill product chemically bound and often referred to as "poured-in-place." Loose fill products may include gravel, pea gravel, sand, wood chips, mulch, engineered wood fiber and shredded rubber. ASTM standards for surface resiliency and impact attenuation often rule surfaces such as concrete, asphalt, gravel, and sand as inappropriate for public playgrounds since they cannot provide the shock absorbency necessary to minimize injury from a child's fall (Henderson, 1997; CPSC, 2000).

Costs for Playground Surfaces

The cost to build a public playground today is significant. The formula (U.S. Access Board, 2000; Ruth, 2003) used to estimate costs associated with developing a new playground:

> Cost of playground equipment (x) + Cost of installation (.30x) + Cost of surfacing (.12x) + Cost of design fees, grading, landscaping, and other expenses (.10x) = Total project cost or budget

Thus, the selection of $10,000 of playground equipment to include a slide, swings, spring rockers and a few other ground level activities can result in a total playground budget over $15,000 once surfacing and installation costs are taken into account. It is also important to consider this cost is only for the initial purchase and installation. It does not factor the costs for ongoing maintenance of the equipment and surface. Henderson (1997) noted that the initial cost of resilient playground surfacing depends not only on the cost of the surfacing material but also on the site preparation and installation costs. Loose fill materials may require the installation of containment barriers or timbers and drainage systems with a stone sub-base. Inadequate drainage can lead to the deterioration of some loose fill products and harbor mold. Unitary surfaces such as rubber mats and poured-in-place rubber surfaces require hard sub-bases like asphalt or concrete in order to affix or adhere the product within the playground borders.

In 2003, the National Center on Accessibility conducted an informal survey of various playground surfaces to identify the cost variation and product longevity as described by the individual manufacturers (Table 1). As illustrated by Table 1, the material costs for loose fill engineered wood products are significantly less than unitary surfaces such as rubber tiles or mats, or the poured-in-place rubber product. However, loose fill surface materials require more work or effort put forth by a person with a disability using an assistive device such as a wheelchair, walker, cane or crutches to ambulate across the playground surface. In 1998 Beneficial Designs conducted pilot research for the U.S. Access Board to determine the energy required to negotiate certain surfaces used in outdoor developed areas. Approximately 39 adults ranging in age from 18 to 50 participated in the study; a total of 10 adults were manual wheelchair users, six were ambulatory with assistive devices, nine were ambulatory without the need for assistive devices; and 14 indicated they had no mobility limitation (Axelson, Chesney, Longmuir, Rose, Smith & Ysselstein, 1999).

Table 1

Surface by Type, Cost, Warranty, Life Expectancy and Suggested Maintenance

Type of Surface	Cost per sq ft Cost for 3,000 sq ft Play Area	Warranty Life Expectancy	Suggested Maintenance
Engineered Wood Fiber A	$ 0.83 $2,500	10 years 10 years	Rake heavy use areas during routine maintenance.
Engineered Wood Fiber B	$ 1.50 $4,500 plus installation	20 years, mats must be installed in high use areas and under swings and slide or warranty is void 20 years, plus periodic top-offs	Areas of constant wear and impact should be raked level. Monthly for public facility and once or twice per year for private facility.
Shredded Rubber	$ 4.00 $12,000 +	4 years 10-12 years	Spread evenly, maintain often. Check depth regularly.
Rubber Tile Mats A	$ 5.58 to $ 6.78 $16,750 to $20,365 plus installation	5 years 15 to 20 years	Wash with mild detergent and hose off.
Rubber Tile Mats B	$ 5.99 to $ 7.49 $17,970 to $22,470 plus installation	3 to 5 years 7 to 10 years	Repaint top surface every 3 to 5 years.
Poured-in-Place Rubber	$ 7.00 to $ 8.00 $21,000 to $24,000	4 years 10 to 12 years	Sweep or blow debris.

Playground surface material costs, life expectancy, warranty and maintenance as described by the manufacturer. (National Center on Accessibility, 2003).

Axelson. et al. (1999) found that ambulation tended to be more difficult (i.e., increased energy consumption, higher ratings of perceived exertion, higher levels of difficulty ratings and decreased velocity) on woodchips and engineered wood fiber surfaces compared to asphalt, surfaces with applied soil stabilizers and path fines. Thus, while the loose fill materials are less costly, they are not as accessible for people with disabilities as unitary surfaces.

The most prominent public debate put forth during the development of accessibility guidelines for playgrounds by the U.S. Access Board between 1996 and 2000 was that accessible play surfaces are far more costly than non-accessible play surfaces. Prior to the release of the 2000 accessibility guidelines, it was thought that many schools may eliminate or decrease the size of playgrounds or reduce the number of play components to compensate for increased costs (Christoph, 1997). The Access Board's economic assessment (2000) suggested that operators may choose to build a smaller play area, defer replacing an existing play area or even remove play equipment once it has reached the end of its life cycle. The Access Board (2000) recognized this as the social costs of implementing the accessibility guidelines under the ADA and further contended that individuals with disabilities may not have the combined market power to ensure that play areas are designed to be accessible, thus the accessibility guidelines and civil rights laws are necessary to prohibit discrimination of underserved populations. While this concern is frequently discussed among practitioners in the field today, research findings on whether or not the number of new playgrounds has increased or decreased due to the release of the 2000 accessibility guidelines and related costs for surfaces do not currently exist.

Among practitioners, the initial cost for materials and installation is primarily considered in budget planning. The practice of factoring ongoing maintenance costs into annual budgets up until the last five years has been rare. It has only come into a best practice as recommended through the National Playground Safety Institute which suggests that maintenance should be considered before the playground is ever built. In the design and construction of playgrounds, maintenance should be a primary consideration (Kutska, 1996). The availability of research findings comparing the costs for ongoing maintenance of unitary and loose fill play surfaces is relatively sparse. The Access Board's economic assessment (2000) concluded that the expense of installing higher priced surfacing that needs less maintenance could be less than the expense of installing a lower priced surfacing that needs more maintenance and that this instance is most likely to occur in regions with relatively high labor rates. Henderson (1997) conducted a preliminary comparison of two mid-size playgrounds comparing the cost of one with organic loose fill surface and the other with rubber tile surface. The time, frequency and costs associated with inspecting and maintaining the play surfaces were observed. For the loose fill surface material, additional maintenance time, costs and materials were needed to rake, level and top off the play surface. The annual cost for the maintenance of the 5,000 sq ft playground with a loose fill material identified as wood chips resulted in an annual cost of $2,948 (Henderson, 1997). The annual cost for maintenance of a 2,600 sq ft playground with rubber tile surface was $624 (Henderson, 1997). The results of this preliminary study showed that each type of surface had some advantages and drawbacks in terms of maintenance costs.

Several organizations have documented the advantages and disadvantages of various surfaces to give guidance to playground owners during the surface selection process (Table 2).

Table 2
Advantages and Disadvantages by Surface Type

Playground Surface	Advantages	Disadvantages
Engineered Wood Fiber	• Low initial cost • Ease of installation • Good drainage • Less abrasive than sand • Attractive appearance • Readily available	• Accessibility of product is dependent on maintenance. • Environmental conditions can reduce impact attenuation • The greater the level of moisture, the faster the rate of decomposition • Easily displaced by children's activity, throwing or blowing • Subject to microbial growth when wet • Conceals trash and foreign objects • Spreads outside of containment area • Can be flammable • Subject to theft
Shredded Rubber	• Easy to install • Not abrasive • Drains well • Does not support microbial growth • Durable	• Accessibility of product is dependent on maintenance • Difficult to walk on • May be flammable • May contain metal components • May contain lead and other toxins • Small or dust sized particles may enter and remain in lungs • When wet, small particles will stick to clothing • Wide variation in quality • May be thrown or scattered • May become lodged in bodily openings such as nose and ears • Easily displaced by children's activity • Conceals trash and foreign objects

		• Spreads outside of containment area
Rubber Tile Mats	• Accessible • Low maintenance • Easy to clean • Consistent shock absorbency • Material not displaced by children's activity • Generally low life cycle costs • Good footing • Generally no retaining edges are required	• Initial cost relatively high • Sub-surface may be critical for thinner materials • Must be used on level uniform surfaces • May be flammable • Subject to vandalism • May curl up and cause tripping • May be susceptible to frost damage • Location of seams, anchors and other fasteners may not attenuate impact to the same degree as the balance of the mat or tile • Mechanical fasteners or anchors can become dislodged and present a hazard to the user
Poured-in-Place Rubber	• Accessible • Low maintenance • Easy to clean • Consistent shock absorbency • Material not displaced by children's activity • Generally low life cycle costs	• Initial cost relatively high • Sub-surface may be critical for thinner materials • Must be used on level uniform surfaces • May be flammable • Subject to vandalism • May be susceptible to frost damage • May become hard over time as a result of environmental degradation

Summary of advantages and disadvantages of playground surface materials. (Adapted from CIPC, 2003; CPSC, 2000; Huber, 2001).

In addition, several playground designers have noted other key factors for choosing playground surfaces. Christoph (1997) stated that in addition to maintenance and cost considerations, factors such as resiliency, flammability, color and attractiveness to children should be weighed. Schappet (2003) suggested looking at how the surface material will connect the environment, matching surfaces to the use of equipment (such as placing loose fill under climbers and other equipment where falls are more frequent) and selection that was interesting to sensory experiences. A combination of loose fill and unitary surfaces may be the best alternative for achieving an accessible playground environment that remains within the budgetary constraints for municipal park agencies and public schools (Christoph, 1997; Access Board, 2000; Axelson, 1999, Skulski, 2004).

Summary

As evident throughout the literature, additional research is needed to provide more guidance to playground owners on the selection of playground surfaces in order to ensure the next generation of public playgrounds is accessible and usable by children with disabilities. Specifically, additional research is needed to show the difference in maintenance frequency and cost between unitary play surfaces and loose fill surfaces over the period of the products' life spans. Lack of information currently available has led playground owners to choose loose fill materials for initial installation based on the low cost of the material. Loose fill materials have greater frequency to wear unevenly in certain areas of the playground depending on the volume of use. Ruts and dugout areas often occur under swings, slides and other areas of egress where the loose fill material may become displaced. Over a three to five year life cycle, it is unclear as to how often maintenance such as leveling off the loose fill product, filling in or topping off is required in order to maintain the surface at safety and accessibility levels dictated by ASTM and the U.S. Access Board.

Chapter 3

METHODS

This study on the accessibility of playground surfaces after installation was part of a larger study conducted by the National Center on Accessibility at Indiana University. In 2008, NCA received financial support from the U.S. Access Board to begin a longitudinal study of playground surfaces. The NCA study was designed to evaluate the effectiveness of surfaces for accessibility upon initial installation and maintenance over a five year period. The purpose of the current study was to evaluate a variety of playground surfaces, their ability to meet accessibility guidelines, and their costs upon initial installation.

Overview of Research Design

The research discovery presented herein concentrated on the first phase of installation, while the much larger-scale NCA study will evaluate the surfaces over five years and include an evaluation of maintenance factors. The research presented here adjoined the existing NCA study design, but concentrated on the specific installation phase and resulting data in an effort to evaluate a variety of playground surfaces, their ability to meet accessibility requirements and their costs upon initial installation as defined within the first 12 months. The research design was purposeful to derive quantitative and qualitative data through the first year and the entirety of the longitudinal study.

It should be noted at this time that the researcher for the study presented here also serves as the principle investigator for the NCA longitudinal study. The research design for this study has been in development since 2005. A national advisory committee was formed to review the protocol for the longitudinal study. Advisory committee members represented:

- The National Playground Safety Institute, a program of the National Recreation and Parks Association setting criteria for certification of playground safety inspectors;
- The U.S. Access Board, the federal designated agency establishing accessibility guidelines for playgrounds and other buildings and facilities covered under the Americans with Disabilities Act;
- Beneficial Designs, the rehabilitation engineering that developed the protocol for ASTM F1951 and the Rotational Penetrometer; and
- Consultants in playground accessibility and safety, serving either on the U.S. Access Board Recreation Advisory Committee, U.S. Access Board Regulatory Negotiation Committee on Play Areas or the American Society for Testing and Materials F08.63 Subcommittee on Playground Surfaces.

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.

Selection of Playgrounds

The study presented here was limited to the first season following installation in a geographic area surrounding the Indiana University-Bloomington campus, Indianapolis and Chicago. This geographic area was selected so that the test sites were within driving distance of the Bloomington-based research team and easily accessed at any given time during a season. The geographic area also supported a close network of practitioners in the field whereby test sites were recruited. Newly constructed public playgrounds were selected for participation as test sites in the study. Selection was based upon:

1. Accessibility to children with and without disabilities;
2. Use of surface materials and products consistent with the study;
3. Geographic location;
4. Seasonal weather conditions; and
5. Willingness of owner/operator to participate as a partner in the study by sharing information and collecting data.

A purposive snowball sampling technique was used to recruit local park and recreation agencies by phone, e-mail and in person. The sample population was recruited through an initial news release disseminated by the NCA (Appendix A). Follow up to inquiries received through NCA were conducted and a study information sheet (Appendix B) was forwarded. The snowball sampling technique was dependent upon the informed professionals and perspective participants passing on study information to assist in recruiting others for participation. 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. They contend the technique offers credibility to researchers and their needs by allowing the use of named contacts to develop across networks creating a three-dimensional matrix of confirmable information. Moreover, the snowballing technique enables investigators the major advantage of reaching parts other methods cannot reach (Streeton, et al.; Platzer and James, 1997). 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.

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.

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.

An application for IRB approval was submitted for the recruitment and collection of the initial installation data gathered from the playground owners. However, based on the information sought specific to the playgrounds and not the individuals, IRB determined this data collection did not warrant IRB approval.

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 for participation in the study: engineered wood fiber product; shredded rubber/crumb rubber; unitary rubber mat surfaces; unitary rubber "poured in place" surfaces; or combination of hybrid surface systems under development. 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.

Based on feedback from advisory committee members, five categories of playground surfaces were evaluated in this study:

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

The playground surfaces considered for this study had to initially meet the requirements of:

1. ADA-ABA 1008.2 Accessible Routes;
2. ADA-ABA 1008.2.6 Ground Surfaces;
3. ASTM F 1292-99 *Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment* as determined by the surface manufacturer in laboratory testing;
4. ASTM F 1951-99 *Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment* as determined by the surface manufacturer in laboratory testing; and
5. ASTM F2075 *Standard Specification for Engineered Wood Fiber for Use as a Playground Safety Surface Under and Around Playground Equipment*.

Nine critical areas were inspected upon installation for this study and continued to be evaluated on a seasonal basis 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 will continue 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 firmness/stability and impact attenuation and given opportunity to correct surfaces where deficiencies or non-compliance with standards was noted.

Instrumentation for Analysis

Four instruments were used for data collection. First, upon initial installation of the playground surface, the playground owner completed a questionnaire on installation (Appendix C). This questionnaire collected information on the type, size and intended age group of the playground. Additionally through this questionnaire, data was collected on the total cost for the equipment, surface materials and installation. The surfaces and sub-surfaces, manufacturers and sales representatives were further identified in this section. An on-site inspection form (Appendix D) was created to collect information on the nine locations including identification of uneven wear, setting, cracking, buckling or other signs of displacement have occurred. This form was updated mid-way through the study to more accurately reflect the accessibility standards by 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 (Appendix E). Testing for impact attenuation per ASTM F1292 was conducted as an optional test at the discretion of the playground owner using the TRIAX 2000.

Treatment of Data

The research design for this study was developed to collect data on surface conditions, evaluate surface performance, note deficiencies and compare across installation costs for each playground 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 for surface tests on firmness and stability were compared to determine whether there was correlation between the surface type, its costs and its pending 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.

Chapter 4

RESULTS OF THE STUDY

The purpose of this study was to evaluate a variety of playground surfaces, their ability to meet accessibility requirements and their costs upon initial installation. How well do various playground surfaces meet the accessibility requirements upon installation? What are the costs for the various playground surfaces and are the costs related to performance? What accessibility issues arise out of initial installation?

More than 100 park and recreation agencies in Indiana and Illinois were sent an e-mail news release explaining the research study and requesting participation. The snowball recruiting process for new playground installations was initiated in the Fall of 2008. Unfortunately, the summer season of recruitment was delayed due to restructuring of the IRB process and notification that the inquiry with the site coordinators for assistance with data collection did not warrant IRB approval. Numerous inquiries were made to NCA, however, most people wanted to be informed of the results upon completion of the study. Professional contact was initiated through the NCA network of agencies where a previous collaborative relationship had already been established. Once an agency agreed to participation in the study, agency personnel helped to spread word and recruit additional agencies for participation. Approximately 27 sites were selected for participation during the evaluation period from October 2008 through September 2010. Two agencies gave verbal commitments for participation in the study and then opted out of participation concerned with the possibility of negative budgetary implications should any deficiencies be identified during the site assessment and corrective actions become necessary. Thus, a total of 25 sites were visited to evaluate the surface conditions for accessibility and gather information on the costs for installation.

Site Profiles by Surface Type

Table 3 provides a profile of each playground, the installation date, total area, surface area, cost for equipment and cost for surfaces. The playground sites ranged from 2,400 sq. ft. to 12,000 sq. ft. The costs for surfaces, materials and installation, ranged from $1.08/sq. ft. to $21/sq. ft.

Of the sites evaluated, five were surfaced with poured in place rubber (PIP). The surface cost for PIP ranged from $6.59/sq. ft. to $19.80/sq. ft. PIP was the most expensive of the five types of surfaces identified for study. 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 three years due to volatility in the petroleum market.

There were three sites surfaced completely with tiles (TIL). The tiles 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 $15.29/sq. ft. Similar to PIP, the product is sold on a sliding scale and the cost has been affected by price fluctuations in the petroleum market.

Table 3

*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
	5/9/2009	2,400	$ 52,317 $ 30,019	PIP	2,400	$ 7.98
	10/1/2008	4,725	$ 50,653 $ 50,015	PIP	4,725	$ 6.59
	7/1/2008	6,600	$114,890 $136,065	PIP	6,600	$17.50
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
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
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
	10/1/2009	3,200	$ 47,820 $ 15,950	TIL EWF	740 2,085	$14.72 $ 1.80
	8/1/2009	5,150	$ 66,840 $24,801	TIL EWF	1,136 4,014	$20.59 $ 2.50
	8/1/2009	6,585	$ 72,350 $ 25,874	TIL EWF	1,158 5,427	$21.00 $ 2.50

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 three sites was not available.*

There were five sites surfaced entirely with engineered wood fiber (EWF). In addition, there were three sites surfaced with a combination PIP and EWF, and six sites surfaced with a combination TIL and EWF. 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). The EWF ranged in cost from $1.08/sq. ft. to $2.50/sq. ft.

There were a total of four sites with three 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 last site 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.

Markedly absent from the Table 3 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 would respond to repeated requests from the research team. As such, public park playground installations with shredded rubber surfacing are not represented in this study.

Performance and the Surface Deficiency Score

Upon arrival, a visual inspection was conducted at nine pre-determined locations within the play area: the entry to the playground where the playground surface starts; the accessible route connecting accessible play elements; egress point of slide(s); swings; the entry point(s) to composite structure(s)/transfer stations; climber(s); ground level play element(s) such as spring rockers, play tables, interactive panels, etc.; sliding poles; and other areas (i.e. water play elements, etc). The purpose of the visual inspection was to identify instances where changes in level, excessive slope or other surface characteristics could create a barrier for children with mobility impairments either along the accessible route to a play component or the 30 x 48 inch clear floor space at the component used to position for transfer from a mobility assistive device to the play equipment. At each location, the surface was visually inspected to determine if it displayed any of the following deficiencies: uneven wear; settling; dugouts (large areas greater than 1 ft. in length); ruts (small areas less than 1 ft. in length); cracking, buckling; displacement; or other signs of wear. Midway through the study, the visual inspection was modified to identify instances where the surface, either in the 30 x 48 clear floor space or on the accessible route was determined as exceeding the accessibility standards. These instances included locations where the 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. If yes, the location was awarded a value of 1 for each characteristic of deficiency with a maximum Surface Deficiency Score (SDS) of 4 for each location. An SDS of 0 shows no interruption of the accessible route or clear floor space at the location.

Table 4
Surface Deficiency Score (SDS) within One Year of Installation

Surface by Type	N	Mean	Mode
PIP	50	.00	0
TIL	39	.36	0
EWF	70	2.16	3
HYB	26	.04	0

Table 4 provides the SDS for each surface type within one year of installation. As might be predicted among public playground owners, within one year of installation PIP scored the lowest SDS with a Mean = 0, while EWF scored the highest with a Mean = 2.16.

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 four 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.

A One-Way Analysis of Variance (ANOVA) was conducted to determine if there were significant differences with the SDS among types of surfaces. Outliers were not removed for the purpose of retaining the original sample and conducting further analysis later during the longitudinal study. Table 5 shows the multiple comparisons of the SDS between the different types of surfaces.

Table 5
Post Hoc Test: Multiple Comparisons of Surface Deficiency Score (SDS) by Surface Type, Tukey HSD

(I) Type of Surface	(J) Type of Surface	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
PIP	Tiles	-.359*	.130	.032	-.70	-.02
	EWF	-2.157*	.113	.000	-2.45	-1.86
	HYB	-.038	.147	.994	-.42	.34
Tiles	PIP	.359*	.130	.032	.02	.70
	EWF	-1.798*	.122	.000	-2.11	-1.48
	HYB	.321	.154	.164	-.08	.72
EWF	PIP	2.157*	.113	.000	1.86	2.45
	Tiles	1.798*	.122	.000	1.48	2.11
	HYB	2.119*	.140	.000	1.76	2.48
HYB	PIP	.038	.147	.994	-.34	.42
	Tiles	-.321	.154	.164	-.72	.08
	EWF	-2.119*	.140	.000	-2.48	-1.76

*. The mean difference is significant at the 0.05 level.

Within 12 months of installation, analysis of the SDS among the sample sites indicated there was significant difference in the number of identified deficiencies between EWF and the other three surfaces. There was also a significant difference of the SDS between PIP and TIL. There was no significance difference in the number of identified deficiencies with the HYB surface type in comparison to PIP or TIL among the sample sites.

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. Prior to taking measurements, a solid surface such as cement or asphalt was tested with the Rotational Penetrometer to confirm the device was calibrated and results were within the established baselines. On smooth or brushed concrete, the baseline for firmness ranged from .14 to .16 inches and the baseline for stability ranged from .16 to .18 inches.

Table 6 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 6
Firmness and Stability by Surface Type

		N	Mean	Std. Deviation	Std. Error	Min.	Max.
Firmness	PIP	50	.36308	.060747	.008591	.228	.480
	Tiles	39	.27805	.028579	.004576	.216	.342
	EWF	70	.34206	.051741	.006184	.258	.568
	HYB	26	.43969	.060899	.011943	.336	.566
Stability	PIP	50	.40876	.069118	.009775	.264	.598
	Tiles	39	.31687	.056598	.009063	.246	.596
	EWF	70	.78200	.130442	.015591	.518	1.162
	HYB	26	.49385	.069247	.013580	.372	.606

The stability measurement, the second measurement in the series using the Rotational Penetrometer, showed a wide range among the different surface types. The stability measurement had a 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. 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.

ANOVA was conducted to determine if there was a statistically significant difference in the means for firmness and stability among the four surface types in the study sample. Table 7 illustrates the multiple comparisons of means for firmness and stability. 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 6, their mean difference for firmness is only. 02 inches. Aside from this comparison of firmness for PIP and EWF, all of the rest of the surfaces show a statistically significant difference in mean values for firmness and stability.

Table 7

Post Hoc Test: Multiple Comparisons of Surface Firmness Mean and Surface Stability Mean by Surface Type, Tukey HSD

Dependent Variable	(I) Type of Surface	(J) Type of Surface	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Firmness Ave	PIP	Tiles	.085029*	.011108	.000	.05623	.11383
		EWF	.021023	.009627	.132	-.00394	.04599
		HYB	-.076612*	.012571	.000	-.10921	-.04401
	Tiles	PIP	-.085029*	.011108	.000	-.11383	-.05623
		EWF	-.064006*	.010389	.000	-.09095	-.03707
		HYB	-.161641*	.013164	.000	-.19578	-.12751
	EWF	PIP	-.021023	.009627	.132	-.04599	.00394
		Tiles	.064006*	.010389	.000	.03707	.09095
		HYB	-.097635*	.011941	.000	-.12860	-.06667
	HYB	PIP	.076612*	.012571	.000	.04401	.10921
		Tiles	.161641*	.013164	.000	.12751	.19578
		EWF	.097635*	.011941	.000	.06667	.12860
Stability Ave	PIP	Tiles	.091888*	.020396	.000	.03900	.14478
		EWF	-.373240*	.017678	.000	-.41908	-.32740
		HYB	-.085086*	.023084	.002	-.14494	-.02523
	Tiles	PIP	-.091888*	.020396	.000	-.14478	-.03900
		EWF	-.465128*	.019077	.000	-.51459	-.41566
		HYB	-.176974*	.024172	.000	-.23965	-.11430
	EWF	PIP	.373240*	.017678	.000	.32740	.41908
		Tiles	.465128*	.019077	.000	.41566	.51459
		HYB	.288154*	.021926	.000	.23130	.34501
	HYB	PIP	.085086*	.023084	.002	.02523	.14494
		Tiles	.176974*	.024172	.000	.11430	.23965
		EWF	-.288154*	.021926	.000	-.34501	-.23130

*. The mean difference is significant at the 0.05 level.

During the course of field data collection, the question had been raised as to whether analysis of the standard deviation among surface types is a better comparison, and perhaps predictor, of the variability of a surface's material composition. Thus, another ANOVA and post hoc test Tukey HSD were run comparing the standard deviation scores for firmness and stability. Table 8 shows the multiple comparisons of standard deviation for firmness and stability. When the standard deviation of measurements for firmness and stability are compared, the only statistically significant difference is between EWF and the other three surface types in the sample. There was no significant difference in standard deviation for firmness and stability among the three unitary surfaces in the study when compared to one another. This could suggest a statistical difference between unitary and loose fill surface materials when their standard deviation for firmness and stability are compared. It also reiterates the research question for the longitudinal study as to whether surfaces with greater characteristic variability will require more maintenance over time.

Table 8

Post Hoc Test: Multiple Comparisons of Surface Firmness Standard Deviation and Surface Stability Standard Deviation by Surface Type, Tukey HSD

Dependent Variable	(I) Type of Surface	(J) Type of Surface	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Firmness SD	PIP	Tiles	.003009	.003134	.772	-.00512	.01113
		EWF	-.009797*	.002716	.002	-.01684	-.00275
		HYB	.000522	.003547	.999	-.00868	.00972
	Tiles	PIP	-.003009	.003134	.772	-.01113	.00512
		EWF	-.012806*	.002931	.000	-.02041	-.00521
		HYB	-.002487	.003714	.908	-.01212	.00714
	EWF	PIP	.009797*	.002716	.002	.00275	.01684
		Tiles	.012806*	.002931	.000	.00521	.02041
		HYB	.010319*	.003369	.013	.00158	.01905
	HYB	PIP	-.000522	.003547	.999	-.00972	.00868
		Tiles	.002487	.003714	.908	-.00714	.01212
		EWF	-.010319*	.003369	.013	-.01905	-.00158
Stability SD	PIP	Tiles	.005350	.007802	.902	-.01488	.02558
		EWF	-.064511*	.006762	.000	-.08204	-.04698
		HYB	.005875	.008830	.910	-.01702	.02877
	Tiles	PIP	-.005350	.007802	.902	-.02558	.01488
		EWF	-.069861*	.007297	.000	-.08878	-.05094
		HYB	.000526	.009246	1.000	-.02345	.02450
	EWF	PIP	.064511*	.006762	.000	.04698	.08204
		Tiles	.069861*	.007297	.000	.05094	.08878
		HYB	.070387*	.008387	.000	.04864	.09213
	HYB	PIP	-.005875	.008830	.910	-.02877	.01702
		Tiles	-.000526	.009246	1.000	-.02450	.02345
		EWF	-.070387*	.008387	.000	-.09213	-.04864

*. The mean difference is significant at the 0.05 level.

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 Rotational Penetrometer.

Table 9 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 = .60 inches when the average measurements of firmness and stability are added together. As one might predict, EWF has the highest Mean = 1.07 inches for the sum of firmness and stability. It should be noted that the means for both EWF and HYB are quite close in value.

Table 9
Sum of Firmness and Stability by Surface Type

	N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PIP	50	.77184	.128745	.018207	.492	1.078
Tiles	39	.59492	.079460	.012724	.462	.908
EWF	70	1.12406	.168176	.020101	.782	1.730
HYB	26	.93354	.127251	.024956	.708	1.168
Total	185	.89054	.248761	.018289	.462	1.730

Again, ANOVA with the sum measurements for firmness and stability and a Post Hoc Test Tukey HSD were conducted to determine the variance among surface types. Table 10 details the statistically significant difference between all of the surfaces when the mean measurements for firmness and stability are added together.

Table 10

Post Hoc Test: Multiple Comparisons of the Sum of Firmness and Stability, Tukey HSD

(I) Type of Surface	(J) Type of Surface	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
PIP	Tiles	.176917*	.029317	.000	.10090	.25294
	EWF	-.352217*	.025410	.000	-.41811	-.28633
	HYB	-.161698*	.033180	.000	-.24774	-.07566
Tiles	PIP	-.176917*	.029317	.000	-.25294	-.10090
	EWF	-.529134*	.027420	.000	-.60024	-.45803
	HYB	-.338615*	.034744	.000	-.42871	-.24852
EWF	PIP	.352217*	.025410	.000	.28633	.41811
	Tiles	.529134*	.027420	.000	.45803	.60024
	HYB	.190519*	.031517	.000	.10879	.27224
HYB	PIP	.161698*	.033180	.000	.07566	.24774
	Tiles	.338615*	.034744	.000	.24852	.42871
	EWF	-.190519*	.031517	.000	-.27224	-.10879

*. The mean difference is significant at the 0.05 level.

A Pearson Correlation analysis of data was conducted to determine if there was a relationship between the sum of firmness and stability for a specific type of surface with that of its SDS from the visual inspection. Table 11 shows there to be a bivariate correlation between the sum of firmness and stability and the SDS with three of the four types of surfaces. There was no correlation shown with the HYB surface systems. The HYB category of surfaces encompassed surface materials with very different characteristics and therefore it is realistic that no correlation could be shown for this group. While there appears to be a relational correlation between the sum of firmness and stability and the number of deficiencies at a surface location among the other three categories of surfaces, this should not suggest that either the sum of firmness and stability or the SDS have an effect on one or the other.

Table 11
Bivariate Correlations Between the Sum of Firmness and Stability with the Surface Deficiency Score (SDS) by Surface Type

Type of Surface			Sum Firmness & Stability	SDS
PIP	Sum of Firmness & Stability	Pearson Correlation	1	.[a]
		Sig. (2-tailed)		.
		N	50	50
	SDS	Pearson Correlation	.[a]	.[a]
		Sig. (2-tailed)	.	
		N	50	50
Tiles	Sum of Firmness & Stability	Pearson Correlation	1	.371*
		Sig. (2-tailed)		.020
		N	39	39
	SDS	Pearson Correlation	.371*	1
		Sig. (2-tailed)	.020	
		N	39	39
EWF	Sum of Firmness & Stability	Pearson Correlation	1	-.369**
		Sig. (2-tailed)		.002
		N	70	70
	SDS	Pearson Correlation	-.369**	1
		Sig. (2-tailed)	.002	
		N	70	70
HYB	Sum of Firmness & Stability	Pearson Correlation	1	-.022
		Sig. (2-tailed)		.916
		N	26	26
	SDS	Pearson Correlation	-.022	1
		Sig. (2-tailed)	.916	
		N	26	26

a. Cannot be computed because at least one of the variables is constant.
*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

When visually comparing PIP and EWF, the surfaces lie on opposite ends of the spectrum and by contrast could represent the global categorization of unitary and loose fill playground surfaces. The correlation among these global categories may suggest that an either relatively low or high SDS for a location would also translate to the same relational low or high measurements for firmness and stability. However, as shown in Table 7, there is no statistical difference in firmness measurements between PIP and EWF.

Table 12
Bivariate Correlations Between Stability and the Surface Deficiency Score (SDS) by Surface Type

Type of Surface			Stability	SDS
PIP	Stability	Pearson Correlation	1	.[a]
		Sig. (2-tailed)		.
		N	50	50
	SDS	Pearson Correlation	.[a]	.[a]
		Sig. (2-tailed)	.	
		N	50	50
Tiles	Stability	Pearson Correlation	1	.388*
		Sig. (2-tailed)		.015
		N	39	39
	SDS	Pearson Correlation	.388*	1
		Sig. (2-tailed)	.015	
		N	39	39
EWF	Stability	Pearson Correlation	1	-.322**
		Sig. (2-tailed)		.007
		N	70	70
	SDS	Pearson Correlation	-.322**	1
		Sig. (2-tailed)	.007	
		N	70	70
HYB	Stability	Pearson Correlation	1	-.047
		Sig. (2-tailed)		.821
		N	26	26
	SDS	Pearson Correlation	-.047	1
		Sig. (2-tailed)	.821	
		N	26	26

a. Cannot be computed because at least one of the variables is constant.
*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Since there is a statistically significant difference in the stability measurements for these two surface categories, a Pearson Correlation analysis of data was run to determine if there was a relationship between the stability of the surface and the SDS. Table 12 shows that among the study sample, there is a correlation between the stability measurement of the surface and SDS. This could suggest that surfaces measured with greater stability will have a fewer number of accessibility deficiencies while surfaces with lesser stability will have more identifiable accessibility deficiencies.

Qualitative Analysis by Surface Type

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

Poured in Place Rubber Surfaces

Assessment of the sample playground locations with PIP showed the surface locations to have no instances of surface deficiencies such as cracking, buckling, uneven wear or displacement of the surface material. The mean for the surface firmness and stability was well under .50 inches. There were no recorded locations where the surface samples exceeded the accessibility standards for slope, cross slope, changes in level or openings. 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 had opted-in to also have the surface tested for impact attenuation and compliance with ASTM F1292. 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. A report of field test results for GMAX and HIC at the various test locations was submitted to the playground owner and, in turn, forwarded to the surface manufacturer. 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.

The discovery of surface failures for impact attenuation came at the onset of field data collection and illustrated two significant lessons. First, visual inspection alone cannot determine if a playground surface is both accessible and impact attenuating in compliance with the ASTM standards F1292 and F1951. Second, the field test procedure for impact attenuation is critical for the playground owner to assure the surface has been installed correctly and the terms of the warranty are met in order to gain full use of the product life cycle. 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.

<u>Tiles</u>

The mean for the firmness and stability of the tiles tested in the sample was also under .50 inches, similar to the PIP. The two reoccurring instances where the SDS really started to add up quickly was where the TIL had 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 to the assessment team 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. 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 agency had selected the TIL based on 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. The playground owner attributed the construction error to the learning curve involved with installation of the new surface and reported each new site was looking more 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. 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 been compromised and the TIL had separated from the concrete subsurface.

Engineered Wood Fiber

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 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, where the surface material is installed in 3 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. This raises the question, had the EWF been more fully compacted during installation and as part of regular maintenance, would the SDS and results for firmness and stability been more acceptable?

Some EWF marketing literature and sales representatives report 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. This type of change in level makes the accessible route non-compliant with the standards. Then there were instances where so much settling had occurred with the EWF that excessive running slopes up to 15 percent were identified at the beveled transitions from the EWF to the unitary surfaces like the PIP and TIL.

EWF is designed with the intent that the particle layers at the base should begin to decompose and contribute to the product’s ability to absorb impacts such as falls from equipment. If too much of the top layer has been displaced or decomposed, the surface material may not perform to its fullest extent for impact attenuation.

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 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.

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 raises 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, mold growing in the surface area was observed at two of the sample sites.

Hybrid Surface Systems

There were three different hybrid surface systems included in this sample at four playground sites. The first hybrid surface system was designed as a playground surface with outdoor carpet as a top layer over engineered carpet pad base and infilled with silicone sand. The second hybrid system was a rubber mat top layer over a shredded rubber base contained in pillow forms and a stone sub-base for drainage. The third surface was an artificial turf grass. All three systems have been purposefully designed and marketed to provide an impact attenuating and accessible surface to accommodate both safety and accessibility. As tested within 12 months of installation, all three surface systems were observed to have minimal deficiencies, comparable to the SDS with PIP. The means for firmness, stability and the standard deviation was also comparable to the other unitary surfaces, PIP and TIL.

Three sites, different surface systems, were installed by experienced contractors. The fourth site was installed by park maintenance personnel. The staff reported the installation took them longer than was anticipated, but that they have become more experienced with the system and are hopeful about their ability to maintain the system should any maintenance be necessary.

Performance and the Cost Factor

Is there any relationship between the different types of surfaces, their SDS, firmness and stability, and their costs upon initial installation? The mean cost per sq. ft. for each surface was determined, PIP (\$13.23), TIL (\$15.14), HYB (\$9.76), EWF

($1.77). Factors such as the volatility of market price for certain surfaces, sliding unit costs, and limited sample preclude the comparison of surface performance and cost for this study. The old adage “You get what you pay for” certainly cannot be applied here. The least expensive surface material may have had the most frequent occurrence of deficiencies specific to the accessible route, but the most expensive surface had a case with the gravest failure of compliance for impact attenuation. Suffice it to say, the unit cost for the surface material does not necessarily mean it will predict the level of performance for either safety or accessibility. The longitudinal study may provide a better opportunity for data analysis of performance and necessity of maintenance related to cost.

Chapter 5

DISCUSSION OF FINDINGS, IMPLICATIONS AND FUTURE RESEARCH

The purpose of this study was to evaluate a variety of playground surfaces, their ability to meet accessibility requirements and their costs upon initial installation. To achieve this goal, a sample of newly installed playground surfaces was evaluated for deficiencies of the accessible route, firmness and stability of the surface material, and qualitative summary of the issues evolving from installation.

Summary of Study Procedures

Data was collected from 25 playground sites within 12 months of installation. The purposeful sample included sites installed with poured-in-place rubber, rubber tiles, engineered wood fiber, and hybrid surface systems. A three-part procedure was conducted at each site. First and upon selection of the site, the playground owner provided information on the size and cost of the surface area. On site, nine pre-determined locations on the playground were visually inspected for changes in level, openings, running and cross slopes affecting the accessible route and clear floor space. Third, the firmness and stability of the surface material was measured at each location with a Rotational Penetrometer. A fourth optional step was given to the playground owner, to test the surface for impact attenuation in compliance with ASTM F1292. A Surface Deficiency Score (SDS) was awarded to each location for identified deficiencies affecting the accessible route and clear floor space for play equipment. The SDS and measurements for firmness and stability were analyzed along with qualitative data collected from the site visits.

Discussion of Findings

If there is any valuable lesson to be learned in this study and for the first year of the longitudinal study, it is that there is no perfect playground surface. Even within 12 months of installation, each type of surface has 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. 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. Each occurrence and event was weighed and balanced with the product's feature advantages and drawbacks. The following are the predominant findings from this study:

1. Within 12 months of installation, playground sites in the sample with the loose fill EWF were found to have the greatest number of deficiencies affecting the accessible route to play components.
2. 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, while playground sites with the unitary surfaces TIL and PIP were found to have the lowest values.
3. Among the playground site sample with PIP, TIL and EWF, there was a correlation between the number deficiencies and the sum value for firmness and stability of the material in instances where both values are either very high or very low.

4. 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.
5. 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.
6. The relationship between surface cost and performance in this sample was inconclusive and should be further investigated in the longitudinal study.

Limitations

This study had several limitations. The sample was purposeful in selection in order to gather more data-rich qualitative information for the longitudinal study. However, the sample size was relatively small compared to the general population and as such the findings are limited in the ability to generalize to the greater population. The sites were concentrated to the Midwestern states of Indiana, Michigan and Illinois. Factors such as playground equipment selection, surface materials, soil characteristics, site drainage, weather and climate cannot be controlled, thus similar sites in other areas of the country may have different results as well. It was not possible to accurately count or control the number of visitors to each playground. High visitor use may have an effect on certain surface types, but the study design did not account for this influence. The research team was unable to identify and recruit sites with shredded rubber. Finally, risk of liability affected recruitment of sites and attrition of at least two municipalities.

Implications

The evaluation of the 25 playground sites in this study has provided some important information on the design, installation and inspection of playground surface materials for the accessible route in the use zone. This information can serve as guidance to both future playground planning and priorities for future research.

The qualitative data from the on-site inspections supports the perceived advantages and disadvantages of the unitary and loose fill materials as described in the literature review. The initiation of the 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.

It should be noted that no public playground sites with shredded rubber could be identified for participation in this study. Major manufacturers of recycled shredded rubber along with the national trade association were contacted on multiple occasions and requests were made to assist the research team in identifying public playground sites installed with shredded rubber for inclusion in the study. No responses to the research team inquiries were received. 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 data as to how this particular type of surface material would compare to PIP, TIL, EWF and HYB. 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. Comparison of shredded rubber with the only other loose fill surface material in the study, EWF, could not be made. Thus, there is still a lack of comparative data on performance of EWF and shredded rubber. There is 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 accessibility of shredded rubber as a playground surface, use of the material on the accessible route should be carefully considered.

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 have already been reported with deficiencies within 12 months of installation. It is critical for the installer and crew to fully understand and adhere to the manufacturer's installation 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 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 must be conducted following installation to ensure the integrity of the safety resilient surface system.

Moreover, there needs to be a portable field instrument to determine compliance for ASTM F1951. The current test protocol is designed for a laboratory environment and the cost for the equipment to measure the 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 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. However, use of the Rotational Penetrometer was conducted in the absence of a directive standard protocol from ASTM as to how the playground surface should be tested in a field installation. Lack of an ASTM protocol for the field test method for ASTM 1951 could influence the repeatability or reproducibility of this study or any other comparative study measuring the firmness and stability of the playground surface samples.

Common knowledge prior to the onset of this study broadly categorizes playground surfaces as either unitary or loose fill. 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, as 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.

Could hybrid surface systems become the next generation of protective surfacing for public play areas? Data on the performance of the hybrid surface systems may be promising enough to lead to further research and product development. 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 is made available up front for the playground owner prior to the decision to purchase.

Future Research

This study has been limited to defining and evaluating performance of different types of playground surfaces by visual inspections of the accessible route and measurement of firmness and stability of locations on the playground.

Findings from this study indicate a number of surface deficiencies in accordance with the accessibility standards were identified where park maintenance personnel with limited experience completed the installation of the surface material. This reiterates one of the research questions for the longitudinal study on whether park personnel will be able to meet the necessary requirements of the surfaces that may demand more knowledge of the surface material, frequent maintenance and a greater standard of care. Further research should study whether the existing job competencies for park maintenance personnel are sufficient or need to be expanded in order to maintain the playground surface materials in compliance for safety and accessibility. In addition, further study should investigate other quantitative and qualitative distinctions between surface types installed by qualified contractors versus maintenance personnel with less familiarity with the surface material and procedures for installation.

As shredded rubber continues to gain a larger percentage of the market, research on the performance of the surface material is essential. Public playground sites with shredded rubber surface material should be added to the longitudinal study or be made part of a new study to gain greater information on the material's ability to comply with the accessibility guidelines and measurements for firmness and stability in relation to the other categories of surfaces.

Based on the significantly lower cost of EWF, further investigation should be conducted to determine if EWF installed per the manufacturer's specific instructions and similar to lab test procedure might draw better results for SDS and firmness and stability.

While the relationship of performance and cost of different surface types is inconclusive in this sample, the question should continue to be investigated in the longitudinal study. The long term maintenance costs for different surfaces could drive the purchasing decision and have greater influence with decision makers if more research data on this question were available to playground owners.

Lastly and most importantly, if playground owners are to make fully educated decisions on the most appropriate surface for their playground, further research must be conducted with children with disabilities to measure their perceived ease or difficulty using these surfaces. Without more research including the input from children with disabilities, this study and all the others are just numbers.

Conclusion

Results from this study indicate that there is no perfect playground surface. Even within 12 months of installation, each type of surface has 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 the conscious or unconscious decision 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 will 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. 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 product's marketed advantages and costs-savings.

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APPENDIX A

National Center on Accessibility
National Playground Surface Research Study

Background

The provision of public play spaces for children can be a costly venture for public entities. Playground surfaces range in price from $1-20 per sq ft. for the surface material alone. Additional costs are associated with installation and maintenance. Product features such as impact attenuation to ensure safety and firmness and stability for accessibility also factor into the overall cost of the surface. Within the United States, playground equipment and surfaces voluntarily comply with the guidelines and standards set forth by the Consumer Product Safety Commission (CPSC), American Society for Testing and Materials (ASTM), and the Americans with Disabilities Act– Architectural Barriers Act Accessibility Guidelines (ADA-ABA). Under ASTM surfaces are encouraged to meet ASTM F1292 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. Under the ADA-ABA surfaces should be accessible meeting requirements for ADA-ABA 1008.2 Accessible Routes and ADAAG 1008.2.6 Ground Surfaces addressing firmness and stability. Based on these requirements, playground owners must rely on assurances from the surface manufacturers and vendors that the surface itself meets each standard. During planning, construction, renovation and maintenance phases, playground owners are often challenged about which playground surfaces to install. What surfaces are safe for all children? What surfaces are accessible to children with disabilities or their caregivers with disabilities? And out of those, what surfaces are cost effective enough to weather several seasons of use?

Purpose

The National Center on Accessibility and the U.S. Access Board have initiated a national research study to address these questions. 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 3-5 year period. In addition, this study will compare the seasonal maintenance costs to continuously meet accessibility and safety guidelines.

Advisory Committee

A national advisory committee has been formed to review the protocol for this study. Advisory committee members represent:

- U.S. Access Board
- National Playground Safety Institute
- Beneficial Designs
- Northern Suburban Special Recreation Association
- Bloomington (IN) Parks and Recreation Department
- American Society for Testing and Materials

Test Sites

The National Center on Accessibility is collaborating with park and recreation agencies to participate as Playground Partners in this study. The Playground Partner will identify a minimum of two newly constructed or planned playgrounds using at least two different surface products. The Playground Partners will host the playground test sites and assist NCA with data collection for this study. Newly constructed playgrounds will be selected for participation as test sites in the study. Selection is based upon:

- Accessibility to children with and without disabilities;
- Use of surface materials and products consistent with the study;
- Geographic location and seasonal weather conditions; and
- Willingness of owner/operator to participate as a partner in the study by sharing information and collecting data.

Playground surfaces to be included in this study will be categorized as:

1. Engineered wood fiber product;
2. Shredded rubber / crumb rubber;
3. Unitary rubber mat surfaces;
4. Unitary rubber "poured in place" surfaces;
5. Loose fill material used with a binding product;
6. Combination or hybrid surface systems under development.

In addition, the playground surfaces considered for this study must initially meet the requirements of: ADA-ABA 1008.2 Accessible Routes; ADA-ABA 1008.2.6 Ground Surfaces; ASTM F 1292 Standard Specification for Impact Attenuation of Surface Systems Under and Around Playground Equipment as determined by the surface manufacturer in laboratory testing; ASTM F 1951-99 Standard Specification for Determination of Accessibility of Surface Systems Under and Around Playground Equipment as determined by the surface manufacturer in laboratory testing; and ASTM F2075 Standard Specification for Engineered Wood Fiber for Use as a Playground Safety Surface Under and Around Playground Equipment.

To Participate

If you are interested in participating in this research study, e-mail **nca@indiana.edu** or call us with the following information:

- Your name and contact information
- Agency/organization name and address
- Scheduled date for new playground installation
- Information on the type of playground surface to be used

Follow the Study

www.ncaonline.org

National Center on Accessibility
Indiana University Research Park
501 North Morton St, Suite 109
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APPENDIX B

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, 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 C

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 D

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 E

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 F

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.