Playground Surfacing

Choosing Safer Materials for Children's Health and the Environment

Lowell Center for Sustainable Production
UNIVERSITY OF MASSACHUSETTS LOWELL

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL

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This report was prepared by Lindsey Pollard and Rachel Massey (Lowell Center for Sustainable Production and Toxics Use Reduction Institute), with input from Molly Jacobs and Polly Hoppin (Lowell Center for Sustainable Production); Elizabeth Harriman, Joy Onasch, and Heather Tenney (Toxics Use Reduction Institute); Rebekah Thomson (The Field Fund); Kara Rubio (Women for a Healthy Environment); Katherine Butler (Recycling Works Massachusetts) and Hannah Donart. Work on this report was supported by a grant from The Heinz Endowments.

Cover photo: A school playground in Westford, Massachusetts with engineered wood fiber surfacing.

Playground Surfacing:
Choosing Safer Materials for Children's Health and the Environment

Introduction

Playground surfacing helps to protect children as they walk, run, jump, fall, and interact with their surroundings in the course of play. A range of materials are sold as playground surfacing. Some of these materials contain chemicals of concern for human health and the environment. In response to requests from communities, the Toxics Use Reduction Institute (TURI) and the Lowell Center for Sustainable Production at the University of Massachusetts Lowell have compiled information on a range of playground surfacing options, with a particular focus on chemicals that may be found in these materials.

Children are uniquely vulnerable to the effects of toxic chemicals because their organ systems are developing rapidly, their detoxification mechanisms are immature, and they have more hand-to-mouth exposure to environmental contaminants than adults.[1] For these reasons, it is particularly important to make careful choices about children's exposures. Adult caregivers who spend time at playgrounds, especially pregnant women, the elderly, or those with medical vulnerabilities such as asthma, can also be affected by chemicals in surfacing materials.

Based on the research presented in this report, wood products—especially engineered wood fiber (EWF) tested and verified to be free of chromated copper arsenate (CCA)—are safer choices for health and the environment. In addition, in cases in which unitary pour-in-place (PIP) surfacing is preferred, cork is a safer material choice. Synthetic products pose potential chemical hazards that can be avoided by using alternative materials.

Playground Surfacing Materials: Overview

Playground surfacing materials can be made from natural or synthetic materials including sand, pea gravel, wood, cork, rubber, plastic, and other materials. These materials come in a variety of forms; for example, wood options include wood chips or bark mulch, engineered wood fiber (EWF), or bonded EWF (EWF bound with adhesive). Materials containing rubber include shredded waste tires (also referred to as shredded tire mulch or rubber mulch), rubber tiles, and pour-in-place (PIP) surfacing.

The U.S. Consumer Product Safety Commission (CPSC) states that grass, dirt, concrete, asphalt, or other hard surfaces are not considered protective surfacing options for playgrounds.[2] Protective fall materials are typically installed on top of a prepared sub-base of gravel, soil, geotextile, or an impervious concrete slab.

Surfacing materials fall into two broad categories: loose-fill surfacing materials and unitary surfacing materials. Table 1 provides an overview of these material categories.

Loose-fill surfacing materials consist of loose particles such as sand, pea gravel, EWF, wood chips, or shredded tire mulch.[2]

Unitary surfacing materials consist of rubber tiles, rubber mats, or other materials (e.g., rubber granules, plastic, cork, or EWF) held in place with a binder. These materials may be poured in place and cured at the playground site to form a unitary surface.[2] Unitary surfacing installation designs vary among companies, but typically include a base layer, a cushioning layer, and a "decorative" top layer of bonded materials. The base layer is usually composed of either gravel, concrete or asphalt.[3, 4] For PIP and artificial grass installation, a cushioning layer made of either loose or bonded shredded waste tire is usually installed between the base and top layer.

Some unitary products can be added on top of loose fill or unitary surfaces to improve fall protection or add accessibility. For example, perforated rubber mats have a mesh structure and can be placed over loose-fill surfacing in high traffic areas to offer material stability.[5, 6]

Table 1. Playground surfacing materials: Loose-fill and unitary options

Category	Material
Loose-fill	Engineered wood fibers (EWF)*
	Wood chips or bark mulch
	Sand
	Pea gravel
	Shredded tire mulch
Unitary	Bonded EWF*
	Pour-in-place made with cork*
	Pour-in-place made with synthetic materials*
	Rubber tiles and mats*
	Perforated rubber mats*
	Artificial grass*

*Americans with Disabilities Act (ADA) compliant when properly installed

Health and Environmental Hazards

Chemicals of concern

Some materials used in playground surfacing contain toxic chemicals, creating potential hazards for manufacturers, installers, playground users, and the environment. This section provides a brief overview of chemical hazards that may be relevant when choosing a playground surfacing material.

Synthetic surfacing materials. A variety of rubbers or plastics can be used in playground surfacing. Loose-fill rubber products are generally made with shredded waste tires. Unitary rubber surfacing, including tiles and PIP surfacing, is made with granulated particles processed from materials such as waste tires, thermoplastic elastomer (TPE), or ethylene propylene diene terpolymer rubber (EPDM), and held together with chemical binders and adhesives. An additional material sometimes used is thermoplastic vulcanizate (TPV). In TPV, a vulcanized product such as EPDM is combined or coated with a thermoplastic, such as polypropylene. Chemicals of concern are found in both loose-fill tire rubber and unitary products.[7, 8] Pigments added to the materials may also be a source of concern.

Tires are made from styrene butadiene rubber (SBR) and a wide variety of intentionally added chemicals and materials, including stabilizers, fillers, and vulcanization (curing) agents. Additional substances can adhere to tires during use. Many chemicals found in tires are known to be hazardous to human health or the environment; these include polyaromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), 6-phenylenediamine (6PPD), and heavy metals such as lead and zinc, among others.[7–9] Recent research has identified additional chemicals of concern, including organophosphate esters (OPEs).[10]

A number of PAHs have been identified as known or suspected human carcinogens by the International Agency for Research on Cancer.[11] Many of these PAHs (e.g. benz(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, benzo(b)fluoranthene, indeno(1,2,3-c,d)pyrene, chrysene, and dibenz(a,h)anthracene) have been found in waste tire rubber, in the air around the rubber, or in leachate from the rubber, according to an EPA literature review.[12]

Several VOCs that are known or suspected carcinogens, such as benzene and hexane, have been measured in waste tire materials.[12] Metals found in waste tires, such as lead, pose concerns as well. For example, even low levels of lead in a child's blood can result in behavior and learning problems, slowed growth, and anemia.[13] Concerns associated with some other chemicals found in tires (e.g. phthalates) include endocrine disruption.[12]

TPE and EPDM are also used in unitary surfacing. These materials may potentially pose a lower level of concern than recycled tires, but they can contain hazardous chemicals as well.[14] These alternative materials can include a variety of chemicals, making it difficult to make broad statements about the safety of a given product unless one has access to more detailed information.

Waste tire material in playgrounds: A study by the Consumer Product Safety Commission (CPSC)

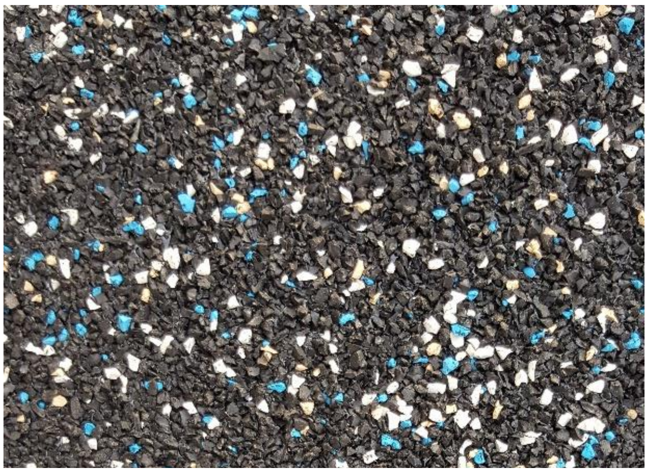
The "Federal Research Action Plan: Crumb Rubber" is a multi-agency study including the CPSC, the Environmental Protection Agency and the Centers for Disease Control, created to investigate potential health and environmental effects of chemicals in recreational surfacing made from waste tires. As one element of this study, the CPSC collected information on children's behavior when playing on loose-fill and unitary surfacing made from waste tires. The study shows that children frequently pick up or pick at, mouth, chew, or fall on surfaces.[a] The CPSC found there were exposure concerns deserving further investigation, and recommended precautions for limiting exposure to materials made from recycled tires. More recently, CPSC has reviewed toxicity reference values for use in future risk assessments for tire materials in playground surfacing.[b]

CPSC precautions for limiting exposure to materials made with recycled tires:

1. "Avoid mouth contact with playground surfacing materials, including mouthing, chewing, or swallowing playground rubber. This may pose a choking hazard, regardless of chemical exposure.
2. Avoid eating food or drinking beverages while directly on playground surfaces, and wash hands before handling food.
3. Limit the time at a playground on extremely hot days.
4. Clean hands and other areas of exposed skin after visiting the playground, and consider changing clothes if evidence of tire materials (e.g., black marks or dust) is visible on fabrics.
5. Clean any toys that were used on a playground after the visit."[c]

[a] Harsanyi, S. 2018. Summary of Playground Surfacing Focus Groups. United States Consumer Product Safety Commission. Retrieved from https://www.cpsc.gov/s3fs-public/Playground_Surfacing_Focus_Group_Report_2018.pdf; [b] CPSC Staff Statement on University of Cincinnati Report "Final Report on Technical Support Activities for a Screening-Level Risk Assessment of Playground Surfaces. 2022. https://www.cpsc.gov/s3fs-public/Final-Report-on-Technical-Support-Activities-for-a-Screening-Level-Risk-Assessment-of-Playground-Surfaces.pdf?VersionId=MyHH6XdEqwCuuFUkSr4a4sPnfJMjGVT3; [c] U.S. Consumer Product Safety Commission. 2018. Federal research action plan: crumb rubber. Retrieved from Crumb Rubber Information Center: https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Crumb-Rubber-Safety-Information-Center

According to a safety data sheet for a brand of artificial turf infill material made with TPE, the material was composed of styrene block copolymer, paraffin oil, calcium carbonate (chalk), carbon black, polyethylene, and unspecified stabilizers and antioxidants.[15] However, other TPE products may contain a range of other chemicals. EPDM rubber can contain PAHs, VOCs, OPEs, and a range of additives including carbon black, oils, and minerals.[10, 16]



PIP consists of granules of materials such as EPDM, TPE, or waste tires, held in place with adhesives.

Rubber surfacing products often contain a combination of synthetic materials such as EPDM, TPE, or other unidentified materials, combined with waste tire material. For example, one brand of perforated rubber mats uses 30% waste tire rubber and 70% "virgin" (non-recycled) rubber.[17]

It is important to understand the sources of any recycled materials in surfacing products. Some products are labeled as containing "recycled rubber" or "recycled SBR." These materials are often waste tire rubber. Many synthetic PIP systems include a layer of loose shredded tires underneath a bonded layer of either EPDM or TPE.

Pigments used in these materials may also contain toxic chemicals. One study attributed elevated concentrations of the OPE tris(2-ethylhexyl)phosphate in color-coated tire crumb infill to the color coating. This chemical is often used as a flame retardant and plasticizer. [10] The study also found that concentrations of metals in EPDM, such as chromium, were higher in some colors than in others.

Another synthetic surfacing product on the market is artificial grass, generally composed of plastic grass fibers and nylon or plastic backing. [18] The system may also include a polyurethane cushioning layer, fabric liner, and/or shredded waste tires. Many brands use waste tire granules, other synthetic rubbers and plastics, or natural materials such as sand and coconut husks in infill to hold the artificial grass in place. The chemical constituents of many infills pose health and environmental concerns.[14] There are also artificial grass products that do not contain infill. There may be chemicals of concern, such as per- and polyfluoroalkyl substances (PFAS), in the fibers and/or cushioning as well.[19]

Ingredients used in synthetic playground materials vary among brands. It is important for decision-makers to be aware of what chemical constituents are present by asking vendors or manufacturers directly for detailed safety data sheets, test data, and catalogs.

A playground in Lowell, MA, with wood chip surfacing.

Cork PIP. In general, cork is a safer material for use in unitary products. As with synthetic PIP, toxic chemicals may be used in the binder used to hold cork granules together. Binder hazards are described in the following section.

Binders and adhesives. Unitary surfacing materials contain binder and adhesive chemicals. The binder ingredients used to make and bind unitary rubber tiles, PIP, and bonded EWF vary depending on brand. Urethanes are typically used to bind rubber and/ or TPE granules together, and to glue rubber tiles or artificial grass pieces together, according to manufacturer safety data sheets reviewed by TURI. Similar ingredients are likely to be used as binder in cork products. Urethanes are made using chemicals in the diisocyanate family, such as methylene diphenyl diisocyanate (MDI). In general, diisocyanates are asthmagens and dermal and lung sensitizers.[20, 21] Hazardous chemicals found in binders mainly pose an occupational inhalation hazard during manufacturing and installation. According to a recent study, binders for PIP may also contain OPEs.[10]

Sand and pea gravel. Playground sand may contain trace amounts of crystalline silica dust. Airborne crystalline silica dust exposure is known to cause pulmonary diseases, including cancer, in an occupational setting.[22] Several brands of sand are advertised as being free of crystalline silica dust. According to manufacturer safety data sheets, pea gravel is primarily made from quartz, which should not pose chemical concerns in this setting.

Wood. Loose-fill wood chips, bark mulch, and EWF are all made from raw wood. Wood chips are made from ground fresh trees, and bark mulch is a byproduct of the industrial paper and lumber industries**.** EWF is a finely shredded wood mulch that is designed specifically for use as playground safety surface material.[2] Wood products can only be labeled EWF if they meet the specific particle size, consistency, purity, and drainage standards described in American Society for Testing and Materials (ASTM) 2075: *Standard specification for engineered wood fiber*.[2] EWF is also tested for levels of soluble hazardous elements such as lead, chromium, cadmium, and arsenic.[23]

The CPSC states in the *Public Playground Safety Handbook* that treated wood must not be used in playground surfacing, as it may contain chromated copper arsenate (CCA).[2] CCA is an insecticide and wood preservative composed of arsenic, chromium, and copper.[24] The CPSC also states that manufacturers of wood playground surfacing must provide test data to ensure that no CCA-treated wood has been mixed in with playground materials. The CPSC recommends avoiding use of any wooden playground surfacing products where the CCA content is unknown. It is essential for decision-makers to request and review test data before installing.

EWF dyed green and bonded together with chemical adhesive on a playground in Westford, MA.

Chemicals of concern: summary. With regard to chemicals only, the least hazardous choices for playground handlers and users are loose-fill wood products tested for absence of CCA; pea gravel; and sand tested for absence of crystalline silica dust. Of the unitary options reviewed, cork PIP has the fewest chemical hazards, though some chemicals of concern may be used in the binder. Pigments may also be a concern when added to playground surfacing materials. A summary of health and environmental hazards for all materials is presented in Table 4.

Environmental concerns

One environmental concern associated with playground surfacing is the potential for synthetic surfacing to produce contaminated runoff water. Numerous studies show that metals such as zinc, and toxic chemicals such as PAHs and phthalates, can leach from tire material into the environment.[12] The leached chemicals can be carried into natural systems by stormwater runoff. Even small amounts of these toxicants can create negative effects on aquatic life.[7] Any of the synthetic material options can also contribute to plastic and microplastic pollution since the synthetic pieces can migrate outside of intended play areas and break down into smaller pieces over time.

As unitary synthetic surfacing begins to age, it often deteriorates and exposes the loose-fill cushioning layer underneath. This lower layer is typically made with shredded waste tires.

Unitary surfacing installation may also lead to loss of water-permeable surface area. Overall, playground surfacing installation designs and material porosity vary among companies, allowing for different drainage capabilities. If the sub-base is an impervious material, such as concrete, or if the fall protection material allows for only minimal water filtration to the sub-base, the playground area may disrupt rainwater infiltration. Loss of stormwater filtration through soil leads to lowered water quality and a higher quantity of stormwater runoff into natural water systems such as rivers and wetlands.[25]

Loose synthetic PIP granules can migrate into the environment. These particles were found in an area adjacent to a playground located in Somerville, MA.

Surfacing materials made with waste tires also pose concerns if burned. In 2022, a playground in Poolesville, MD caught fire, creating environmental contamination concerns from smoke and runoff of burned materials.[26]

Disposal and Recycling

In 2018, TURI consulted Recycle Works Massachusetts on disposal options available for surfacing materials. End-of-life disposal options for synthetic playground surfacing materials are limited. Recycle Works Massachusetts noted that shredded tire mulch can only be disposed of at specialized facilities for a fee. In general, unitary synthetic products are not recyclable because of their adhesives. They can also be difficult to reuse because the materials are usually worn and damaged by the end of their life. Synthetic materials that cannot be recycled or reused are disposed of in a landfill, usually for a fee. In contrast, wood materials can be composted onsite or through a composting service. Some composting facilities will pick up or receive these materials for no charge.

Cork is a plant-based material with a variety of potential sustainable disposal options. According to a cork PIP vendor, the manufacturer is able to recycle playground material in their facility and manufacture other products with the recycled cork.[27] Used sand and pea gravel may be sifted and reused on other playgrounds, or in different applications, such as landscaping.

Heat hazards

Rubber has the potential to cause contact burns as it can heat up and transfer heat quickly to skin.[28] Thermal burns on playgrounds can occasionally result in serious injuries.[29] CPSC reported 29 thermal burns associated with playgrounds (mostly second- and third-degree burns) between 2001 and 2008. Of these, 14 involved playground surfacing.[30] These figures only represent what has been reported to CPSC, and may be underestimates.

Studies in hot climates have found that unshaded rubber surfacing reached temperatures at or above the temperature threshold for thermal burn injury.[28, 31] Dangerously hot temperatures on playgrounds, created by heat absorbing materials, can also create a microscale "heat island."[28]

A parents' group in Massachusetts measured the temperature of playground surfacing on a day when the air temperature measured 75° F. The parents' group documented a temperature over 170° F on a PIP playground surface.[32] Residents in Stamford, CT found that PIP surface temperatures consistently measured higher than asphalt, reaching temperatures 160° F.[33] For artificial grass surfacing, data from the Center for Sports Surface Research at the University of Pennsylvania indicates that all artificial turf reaches higher temperatures than natural grass.[34]

A parents' group in West Tisbury, MA, recorded a PIP surface temperature of 171° F with an air temperature of 75° F.

Other potential hazards

Loose-fill materials, in general, have the potential to hide foreign objects, and are more likely to be used by children as "play material" (i.e., throwing or putting in mouth). Drainage planning is recommended for all loose-fill products in order to minimize decomposition, mold growth, and particle migration.[2]

Performance Criteria

Critical fall height ratings

The CPSC requires that playground surfacing materials be tested for "critical height," or "an approximation of the fall height below which a life-threatening head injury would not be expected to occur."[2] The CPSC recommends testing the impact performance of playground materials annually, as playground material may degrade or be displaced over time. Communities can ask their chosen playground installation company about annual tests for impact performance. Communities may also choose to install play equipment that requires lower fall height protection.

Loose-fill surfaces have standard fill depths that offer protection for fall injury prevention. Table 2 shows the minimum required depth of each loose-fill material, and the maximum fall height at which injuries will be prevented, according to CPSC. It is important to note that EWF, wood chips, and shredded tire mulch all offer the same amount of fall protection when installed correctly (see Table 2). Loose-fill material (except shredded tire mulch) compresses by at least 25% after install due to use and weathering.[2] This compaction must be taken into account during installation and when planning long-term maintenance. Loose-fill material depths will also decrease over time due to displacement of materials outside of the play area. Critical height depths must be maintained over time by "topping-off" materials in order to preserve performance. A playground expert also noted in a 2023 interview that shredded tire mulch displaces more readily than other loose-fill options.

Unitary surface materials have varied quality and shock-absorption properties, and therefore do not have standard fill depths for fall heights.[2] Manufacturers must supply critical fall height test data for all playground surfacing, including specifications for unitary rubber tiles or pour-in-place materials.[2] Weather and age may also affect the quality of fall protection in unitary surfacing.

Early childhood education and day care centers accommodating only ground play that does not require fall protection may consider using sustainably managed natural grass as a play surfacing option. Some states do not permit use of certain loose-fill materials on play spaces for babies and toddlers.[35, 36]

Table 2. Minimum surfacing depths for compressed loose-fill materials

Compressed surfacing depth (inches)	Loose-fill material	Maximum protected fall height (feet)
6	Shredded tire mulch[a]	10
9	Wood chips, EWF	10
9	Bark mulch	7
9	Pea gravel	5
9	Sand	4

[a] Unlike other loose-fill materials, shredded tire mulch does not compress.
Source: U.S. Consumer Product Safety Commission, 2015

Accessibility

In addition to fall protection, chemical safety and other considerations, accessibility for persons with disabilities is an important aspect of playground planning. In order for a surfacing material to be labeled as compliant with regulations within the Americans with Disabilities Act (ADA), it must fulfill wheelchair accessibility specifications described in ASTM 1951: *Standard specification for* *determination of accessibility of surface systems under and around playground equipment*.[2] Both EWF and unitary surfacing options can offer accessibility when installed correctly and tested for compliance.[2] The wood pieces in EWF are sized to "knit" together when compacted, causing the pieces to remain in place to create an even, accessible surface. EWF must be raked to maintain evenness and performance especially under swings and slides. Using mats in high use areas, such as under swings and slides, can help keep the EWF in place.[37] For example, perforated rubber mats can improve the accessibility of loose-fill surfacing.[38] Unitary rubber, bonded wood and cork surfacing are inherently stable due to the chemical adhesives holding the surface material in place, provided that they are in good condition. Degradation of PIP surfaces over time can make it necessary to replace or repair the surface in order to maintain both fall safety and accessibility.

Costs

We contacted several suppliers and installers of playground surfacing materials to provide general, preliminary information on costs associated with materials discussed in this report. Table 3 summarizes these findings. This information is provided for general reference only; costs are likely to be variable, and this overview does not necessarily cover all the factors that may be relevant for an individual community.

Case Study: Cost summary for replacing shredded tire mulch with EWF

The town of Poolesville, MD managed seven playgrounds surfaced with shredded tire mulch. After learning about the chemical and heat hazards related to shredded tires, town decision-makers voted to replace the shredded tire mulch with EWF in all town playgrounds.[39]

The cost for removal and disposal of shredded tire mulch and installation of EWF by a local vendor cost $7,000 - $9,000 per playground. This work was completed in four days during the summer of 2023.[39]

Poolesville, MD removed the shredded tire mulch (left) on all town playgrounds and replaced it with engineered wood fiber (right).

Table 3. Cost estimates for initial installation, regular maintenance, and disposal of playground surfacing materials for a 2,500 square-foot playground[a]

Material	Initial installation costs	Maintenance activities and costs	Disposal[b]
LOOSE-FILL OPTIONS[c]			
Engineered wood fiber *(install depth: 12 in, max fall height: 10 ft)*	• Materials only: $4,000 • Materials and installation: $5,600 - $12,500 • Mats for high-use areas: $250 each	• Raking back into play area, top-off every three to five years • Cost of materials for 10% top-off: $400	Compost, many companies offer free drop-off or pick up
Sand *(install depth: 12 in, max fall height: 4 ft)*	• Materials only: $4,300	• Raking and leveling, top-off every two to three years. • Cost of materials for 10% top-off: $430	Reused (e.g., surfacing in community areas) or repurposed at a facility
Pea gravel *(install depth: 12 in, max fall height: 5 ft)*	• Materials only: $8,000	• Raking back into play area, top-off every one to two years • Cost of materials for 10% top-off: $800	Reused (e.g., other playgrounds or landscaping)
Shredded tire mulch *(install depth 6 in, max fall height: 10ft)*	• Materials only: $5,800-$15,000	• Raking back into play area, top-off every one to two years • Cost of materials for 10% top-off: $580-$1,500	Landfill or incineration; reuse; may be possible to recycle at specialized facilities for a fee
UNITARY OPTIONS			
Cork PIP	• Materials and installation on prepared site: $87,500	• Sweeping, blowing or vacuuming, inspection for damage • Patching cracks and heavily worn areas	Possible to recycle for use in other cork products at specialized facility
Perforated rubber mats	• Materials only: $14,400 • Materials and installation over other playground surfacing: $24,300	• Inspecting for damage • Mats are installed on top of other playground surfacing materials. Maintenance for base material will also need to be performed.	Landfill drop-off for a fee
Artificial grass	• Materials, site preparation, and installation of surfacing materials: $50,000	• Sweeping, blowing or vacuuming, inspection for damage • Patching heavily worn areas	Landfill; incineration or reuse is possible. Recycling options are limited.[40]
Rubber PIP	• Materials, site preparation, and installation of surfacing materials: $62,500- $98,300	• Sweeping, blowing or vacuuming, inspection for damage • Patching cracks and heavily worn areas	Landfill drop-off for a fee

[a] Costs were provided by suppliers in August and September 2023. These estimates offer a general cost comparison of playground surfacing options only. Costs will vary by location, brand, and playground specifications.

[b] Recycle Works Massachusetts and vendors provided disposal information for all surfacing materials except perforated rubber mats and artificial grass.

[c] Initial fill volumes for loose-fill materials, except shredded tire mulch, were estimated using minimum fill depths for maximum fall height protection plus 25% to account for compaction. Shredded tire mulch does not compress like other loose-fill materials.

Questions to Consider when Choosing a Playground Surfacing Material

Chemical contents, physical characteristics, and installation techniques vary among brands of surfacing products. Below are some questions that decision-makers may want to ask manufacturers and vendors on topics such as material contents, installation design, and disposal options.

- What are the chemical constituents of all layers of material?
- What tests have been conducted to check for chemicals in the material?
- What method of disposal is used for the materials when it is time to replace them?
- Are the materials permeable? What are the drainage options for the surfacing?
- What critical fall height protection can be achieved with the material?
- Will the installation company test fall protection performance annually?
- What is the surface temperature of the material located in the sun with air temperature above 80^{o} F?
- What is the lifespan of the materials and cost of maintenance?

Summary

From an environmental and health standpoint, wood products, especially EWF that is free of pigments and tested and verified to be free of CCA, are safer choices for playground surfacing material based on chemical content. Both wood chips and EWF also offer high fall protection and EWF offers ADA accessibility when correct material depth and evenness are maintained. Cork products can also be a safer option for communities or schools that wish to install a unitary surface. Synthetic products, made with or without waste tires, pose potential chemical hazards that can be avoided by using alternative materials. Table 4 summarizes the characteristics for each material reviewed in this document. Decision-makers are encouraged to request and carefully review data on contents and toxicity. It is also important to read installation instructions from manufacturers on their specific materials in order to make the safest and most informed choices.

Table 4. Summary of health, environmental, and performance criteria

Materials are listed in order of least concern (green) to greatest concern (dark orange) for playground users based on chemical hazard criteria. Some information on exposure is included as well. Pigments are not covered in this summary table, but can also be a source of chemical hazards.

Health & Environmental Hazard Criteria					Performance Criteria	
Material (color coding based on chemical hazards)	**Possible chemicals of concern**	**Health effects associated with chemicals of concern**	**Other human health concerns[a]**	**Environmental concerns**	**Fall protection**	**ADA compliant**
Engineered wood fiber (EWF), wood chips, bark mulch NOTE: Must be tested for absence of chromated copper arsenate (CCA)	Testing for absence of CCA is essential as CCA poses a high hazard to children's health.	—[b]	Mold growth possible[c]	—[b]	High	Yes (EWF only)
Sand NOTE: Must be tested for absence of crystalline silica dust **Pea gravel**	—[b]	—[b]	—[b]	—[b]	Low	No
Bonded EWF NOTE: Used on pathways only. **Cork PIP**	Chemicals in binders (e.g. MDI before curing)[41]	Binder: Primarily occupational exposure concern – respiratory or dermal effects, possible carcinogenicity.[21]	—[b]	Possibility of impervious surface[d]	Low to high, depending on design	Yes
Perforated rubber mats NOTE: Can include a range of rubber or plastic, including tire materials. Exposure may be reduced if mats are used sparingly.	PAHs, VOCs, heavy metals, phthalates, and others.[c, 7, 12]	Respiratory or dermal effects, carcinogenicity, endocrine disruption.[11, 13, 43]	—[b] (Heat hazards not assessed)	Possible runoff contamination, migration of synthetic materials offsite	Depends on material under the mats	Yes
Artificial grass NOTE: May be constructed with or without rubber (including tire materials), plastic, or other infill.	PAHs, VOCs, heavy metals, phthalates, and others found in some infills; chemicals in binders (e.g. MDI before curing); grass blades can pose concerns as well.[7, 8, 12, 15, 16,42]	Respiratory or dermal effects, carcinogenicity, endocrine disruption.[11, 13, 43]	Heat hazard	Possible runoff contamination, migration of synthetic materials offsite	Low to high, depending on design	Yes
Rubber tiles and synthetic PIP NOTE: Can include a variety of types of rubber or plastic, including tire materials.	PAHs, VOCs, heavy metals, phthalates; chemicals in binders (e.g. MDI before curing).[7, 8, 10, 12, 14–16]	Respiratory or dermal effects, carcinogenicity, endocrine disruption. Binder: Primarily occupational exposure concern – respiratory or dermal effects, possible carcinogenicity.[11, 13, 43]	Heat hazard	Possible runoff contamination, possibility of impervious surface[d], migration of synthetic materials offsite	Low to high, depending on design	Yes
Loose-fill shredded tire mulch NOTE: Exposure is greater with tire mulch as children handle, play with, or mouth the material.[44]	PAHs, VOCs, heavy metals, phthalates, and other chemicals of concern.[7, 10, 12, 14]	Respiratory or dermal effects, carcinogenicity, endocrine disruption.[11, 13, 43]	Heat hazard	Possible runoff contamination, migration of synthetic materials offsite	High	No

a. Information on skin abrasion hazards associated with playground surfacing was not included in this report.
b. TURI did not identify any priority concerns for hazards covered in this report.
c. Mold growth is unlikely provided that drainage is adequate.
d. Some installation designs include the addition of an impervious concrete sub-base.

Glossary of Acronyms

6PPD	6-phenylenediamine
ADA	Americans with Disabilities Act
ASTM	American Society for Testing and Materials
CCA	Chromated copper arsenate
CPSC	The U.S. Consumer Product Safety Commission
EPA	The U.S. Environmental Protection Agency
EPDM	Ethylene propylene diene terpolymer
EWF	Engineered wood fiber
MDI	Methylene diphenyl diisocyanate
OPE	Organophosphate ester
PAH	Polyaromatic hydrocarbon
PIP	Pour-in-place
SBR	Styrene butadiene rubber
TPE	Thermoplastic elastomer
TPV	Thermoplastic vulcanizate
VOC	Volatile organic compound

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Playground Surfacing

Choosing Safer Materials for Children's Health and the Environment

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Lowell Center for Sustainable Production
Wannalancit Business Center
600 Suffolk St., Lowell, MA 01854
Phone: 978-934-2980
Email: LCSP@uml.edu
www.uml.edu/lowell-center

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Toxics Use Reduction Institute
University of Massachusetts Lowell
126 John Street, Suite 14
Lowell, Massachusetts 01852
(978) 934-3275
www.turi.org

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