THE URBAN FABRIC

Wenlin Yang
MLA Landscape Architecture, RISD

Upcycling Textile Waste into Raw Material
for Urban Ground Surface Design

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A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

By Wenlin Yang
Date May 28, 2022

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ABSTRACT

Landscape surface materials have the opportunity to ground us in our experience and use of materials in the built environment. Surface materials describe the physical textures of the urban areas and include soft and hard landscape solutions, streetscapes, and roads. In modern landscape design, turf, concrete, asphalt, brick, or rubber are the most common materials for urban parks or playgrounds. However, the unlimited use and lack of awareness about urban landscape surface materials have become a common trend. This "take-make-discard" culture has negatively impacted our environment ecologically, economically, and socially.

This thesis study focuses on upcycling textile waste into a recyclable, degradable, and decomposable material for public pavements, especially in public parks and playgrounds. It aims to understand the larger landscape and ecological impacts of existing materials in comparison to a new set of proposed materials, while also revealing the potential opportunities of utilizing circular second-hand material strategies.

The material exploration combines research and critique of existing surface materials with an investigation of recycling strategies of textile materials. It then proposes new types of hybrid surface materials that embrace weathering by adding the degradable characteristic of textiles as a new standpoint for thinking about ground surfaces. Ultimately, this research studies the benefits and negative impacts on the environment of public parks from the perspectives offered by this new set of proposed materials, as well as their social interactions and economic conditions.

CONTENTS

KEY TERMS

Sustainability

The needs of the present without compromising the ability of future generations to meet their own needs.

- Brundtland Commission, Our Common Future, 1991

Circular Economy

A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. It aims to gradually decouple growth from the consumption of finite resources – for big and small businesses, for organizations and individuals, globally and locally.

- Ellen Macarthur Foundation

Upcycle

verb
Reuse discarded objects or materials in such a way as to create a product of higher quality or value than the original.

- Oxford Languages

Reciprocal Landscape

A concept that accepts that humans coexist in the world and share their resources with the more-than-human world and that consumers share responsibilities along-side producers. Finally, all beings and things share spatial and material conditions. Construction materials are understood not as fixed commodities or interest products but along a continuum with the landscapes they come from and the people who shape them.

- Jane Hutton, Reciprocal Landscapes, 2019

Non-site

It describes where the materials are in use instead of coming from. In landscape architecture, non-site is typically the designed urban environment that can't produce its own sources.

- Jane Hutton, Reciprocal Landscapes, 2019

Weathering

noun
The process of wearing or being worn by long exposure to the atmosphere.

- Oxford Languages

Park Typology

It describes the four most common types of urban parks:
Pleasure Ground (1850–1900),
Reform Park (1900–1930),
Recreation Facility (1930–1965),
Open Space System (1965–?),
and Sustainable Park (1990-).

- Cranz G., Boland M., Defining the Sustainable Park: A Fifth Model for Urban Parks, 2004

Urban Fabric

It describes the physical characteristics of urban areas, including the streetscapes, buildings, soft and hard landscaping, roads, and other infrastructure. Urban fabric can be thought of as the physical texture of a metropolitan area.

- Designing Buildings

Fabric

noun
The material is produced by weaving or knitting together fibers such as cotton, nylon, wool, silk, or other threads.

- Oxford Languages

0-1

Figure 0-1
Photos of McGann Playground, Boston, 2021

INTRODUCTION

In the summer of 2021, I visited several playgrounds in Massachusetts for my job, ranging from structures built in the early 1990s to more recent sites built within the last five years. I walked around and observed that the majority of the playgrounds from the 1990s are now abandoned. They look worn, under-maintained, and sad. Reasons for this may include the fact that ground-surface materials are either broken or outdated and a lack of maintenance of the play structures. These observations became my motivation to begin exploring the topics of my thesis. I wanted to research and eventually design a better surface material that could last longer, be easy and affordable to maintain, and bring users a new sensorial experience. Especially in the built environment in urban areas, people who like to use their feet to feel the environment can enjoy the proposed materials.

I found that asphalt, concrete, turf, sand, rubber, or gravel are considered common urban building materials in the early research stages. Their predominance in construction impacts urban areas globally. Rapid urbanization has embraced the “take-make-discard” culture (Till C. and Franklin K., 2018). This approach has negatively impacted our urban environment ecologically, economically, and socially. In order to change this type of cultural norm, I am inspired by designers and practitioners who practice sustainably and believe in utilizing waste matter as a new source for material making.

Due to its abundance in the world and the culture mentioned above, I explore textile waste in my research. Its wide availability and properties, such as elasticity, have a high potential to repurpose waste matter into a new object of added value.

The study aims to understand existing surface materials in urban parks while investigating repurposing recycled materials at the scale of local neighborhoods in urban construction. It analyzes the new materials in relation to social and environmental conditions to help readers best understand the larger landscape and ecological impacts of existing materials while also foregrounding potential opportunities for utilizing circular design strategies. This thesis operates in three stages: study, experimentation, and design of the new materials; identification and analysis of the benefits and negative impacts of the new materials on local environments; and exploring the influence of these materials on the users’ sensorial experiences.

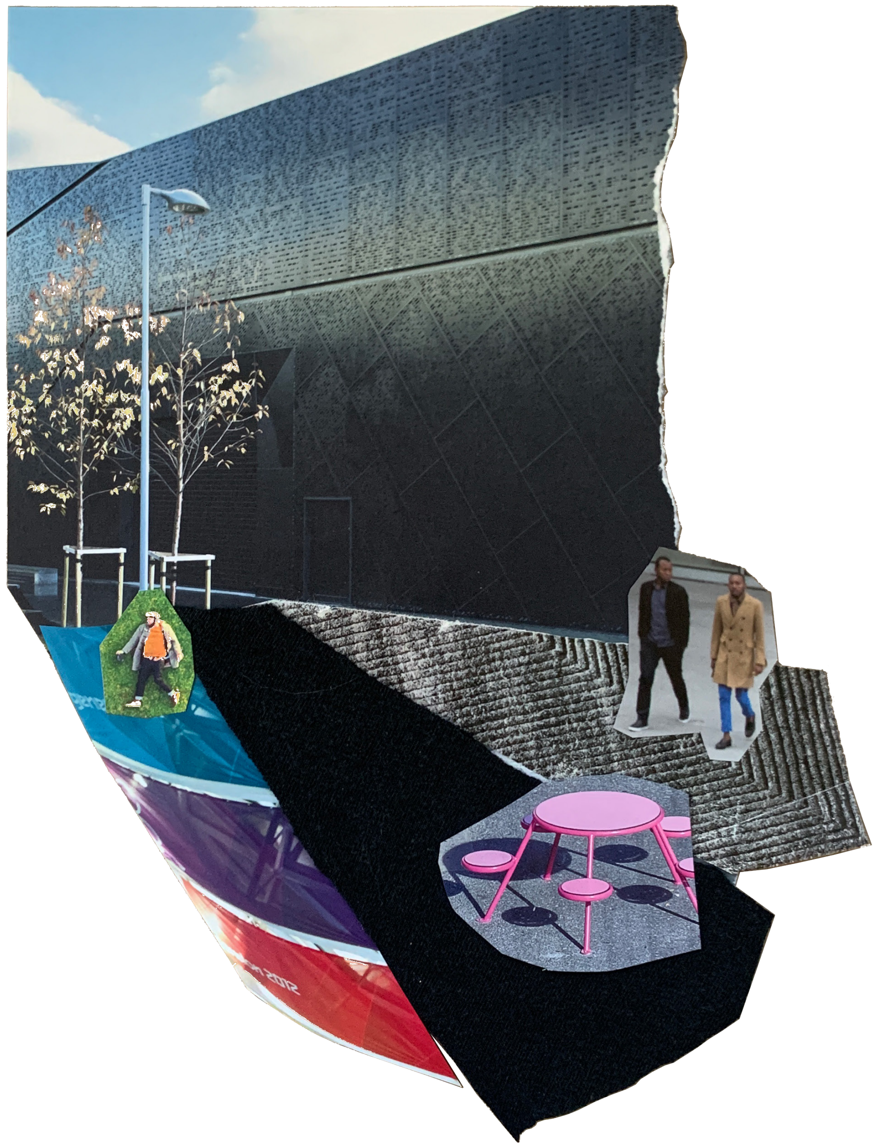
This thesis focuses on developing a new set of materials resulting from upcycling textile waste. The ambition is to replace existing unsustainable surface materials commonly used in public parks and playgrounds in order to improve the local environment.

“Matter intra-acts within the world, it is inherently agentic, discursive, and an important participant in the making of the world.”

— Jane Hutton, *Reciprocal Landscapes*, 2019

0-2

Figure 0-2
New Urban Fabric Concept
The exploration of extended life cycles of textile when used as part of new urban surface materials.



0-3

0-4

Figure 0-3
The Varieties of Urban Surface
The observation of human behaviors is influenced by the different appearances of surface material in urban parks.

Figure 0-4
New Fabric in Three Dimensional Structure
The study of the opportunity for using recycled fabric in large-scale structures or equipment.

Thesis Diagram

Asphalt, concrete, turf, sand, rubber, or gravel are considered common urban building materials, and they impact construction globally. Rapid urbanization has embraced the "take-make-discard" culture. This approach to construction has negatively impacted our urban environment ecologically, economically, and socially. This thesis focuses on developing a new set of materials resulting from upcycling textile waste. The ambition is to improve or replace existing unsustainable surface materials commonly used in public parks and playgrounds in order to improve the local environment.

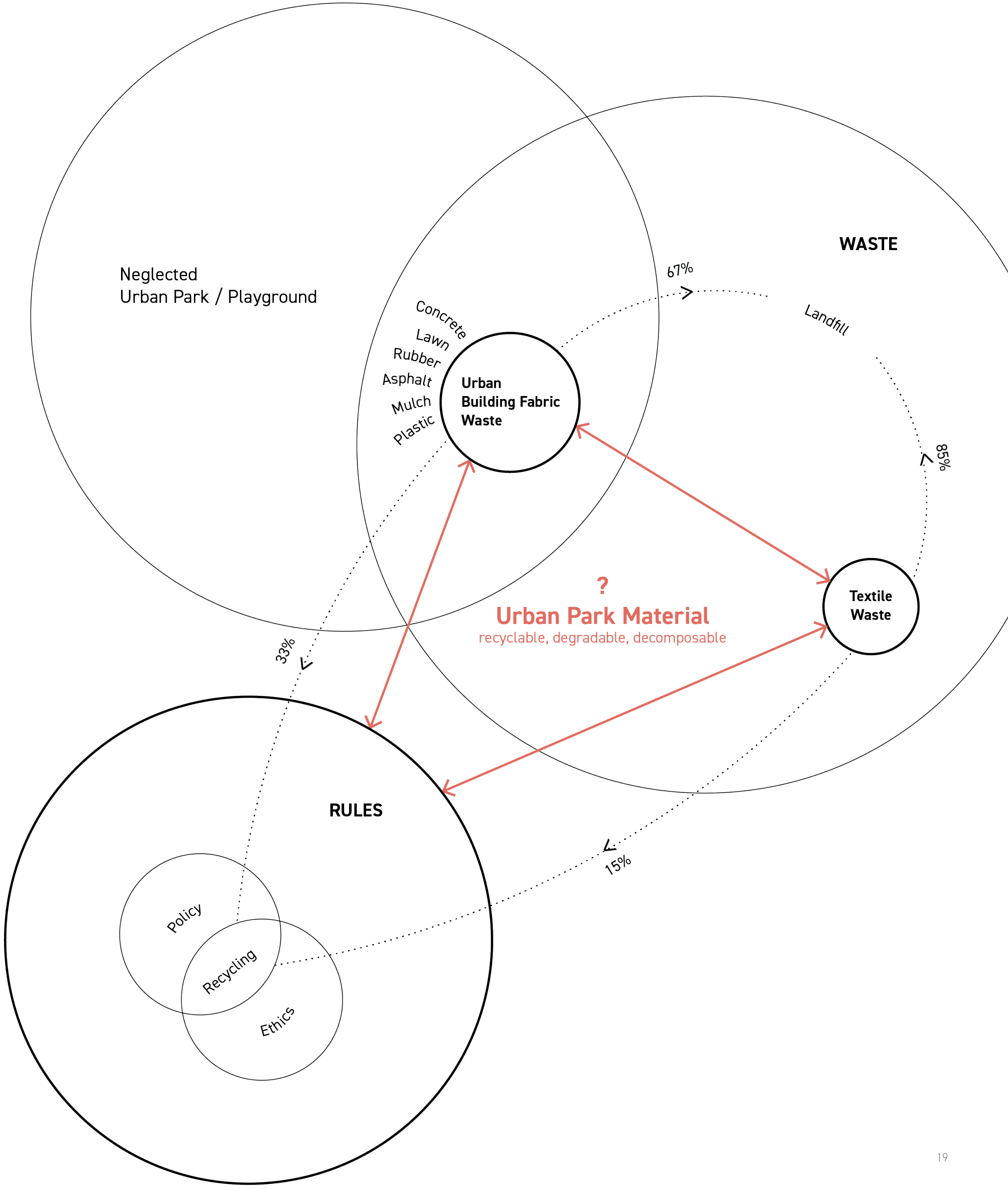


Figure 0-5
The Relation of Waste Matters under Social Rules

Overarching

What does an environmentally friendly landscape material look like?
How do we utilize more recycled materials in construction processes?
Why are some non-sustainable materials still highly used?

History

What is the history of recyclable, degradable, and decomposable materials?
What are the history of urban surface material and playground surface material?

Small Scale

How can we envision new and more sustainable materials?
Could they incorporate fabric, natural material, or human waste?
How to make a material stable to use?
How often do the new materials need to be maintained?
What are the benefits the new materials may bring to the environment?

Larger Context

How can the new materials fit into larger contexts, such as the environment or the existing material market?

Material Reflection

What are the negative impacts of these materials?
What are the influences on the users?
What are their pollution-related and safety concerns?

CHAPTER 01
Urban Landscape Ground Surface Materials Study

How can we objectively view urban landscape architecture through the role of surface material?

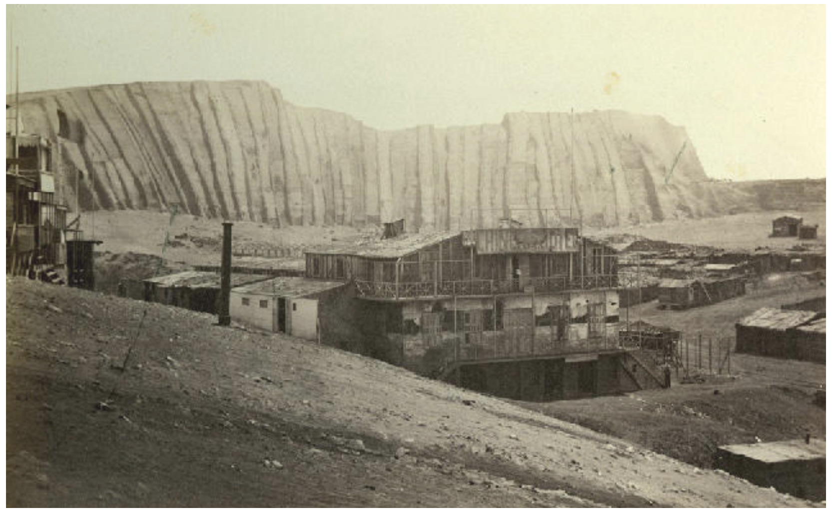
1-1

Figure 1-1
The Collection of Common Urban Ground Surface Material.

Figure 1-2
The invisible, visible, and future impacts of urban building fabric.

Urban Building Fabric Impacts

Urban building fabric defines the physical characteristics of the urban areas, including streetscapes, architecture, walls, soft landscaping, hardscapes, streets, or infrastructure. For all the physical aspects of the urban building fabric, there is a shared list of building materials that impact construction globally. Most common materials include asphalt, concrete, turf, sand, rubber, gravel, or metal. All the materials used in urban construction are a function of their availability and suitability, as well as various cultural norms. (Høibø, O., Hansen, E., Nybakk, E., and Nygaard, M., 2018) Rapid urbanization has pushed the development of the "take-make-discard" culture of building materials, which negatively impacted the environment from three directions: invisible, visible, and future impacts.



1-3

1-4

Figure 1-3
The Ecological Decimation and Environmental Overdraft
Gardner, A. (1865). *The Great Heap.* photograph.

Figure 1-4
The High Demands of Flat and Hard Surfaces
Cranz, G. (1982). *Stanford Park, Chicago South Park District, ca. 1915.* The politics of park design Book by Galen Cranz (p. 92). photograph, MIT Press.

Environmental Hassle from Landscape Building Materials

Unwarping the topic of urban landscape surface materials, understanding the history of the evolution of the urban park system is primary, which reveals the people's decisions on the park typology and shifting amenities needed for those parks. In history, the lack of awareness of the ecological performance of parks in the landscape field has created a “take-make-discard” culture on planting, infrastructures, maintenance, and construction.

In “Defining the Sustainable Park,” sociologist Galen Cranz and landscape architect Michael Boland state that urban parks have responded to social problems, various ideas about nature, or ecological problems in both past and present. (Cranz, G., Boland, M., 2004) However, in the history of park design, the shifting of design principles from only caring for social purposes to concerning actual ecological fitness took almost 150 years.

In the United States, urban parks became popular in the mid to late 1800s. Beginning with Frederick Law Olmsted's pastoral-style pleasure parks, such as Central Park, it is beneficial to city dwellers for public health. In *Reciprocal Landscapes*, landscape architect Jane Hutton clarifies that, in order to keep those sweeping pastoral landscapes for social reform, ecological guano deposits in Peru and South Pacific were exploited, exhausted, and imported as fertilizer in America, which brought unseen consequences to ecological decimation and the environmental overdraft. Then, in the early to mid-1900s, the vision for urban parks began to transform into reform parks or recreation facilities, which provide play and recreation opportunities in the neighboring range to reduce class conflict, reinforce the family unit, or socialize immigrants to American life. (Cranz, G. & Boland, M., 2004) The high demands of acreage for fields, playgrounds, and courts displaced undulating surfaces into flat and hard surfaces, including sand, turf, asphalt, concrete, etc. (Cranz, G., 1982), which are still prevalent in use today. As a consequence, the mining, nursing, extracting, and excavating industries started to proliferate, which accelerated the environmental impact in the global dimension.

Amenity

A desirable or useful feature or facility of a building or place. Park amenity indicates any asset, including but not limited to monuments, fountains, bridges, walls, pavements, seats, benches, structures, or equipment within a park or park space.

- Oxford Dictionary / Law Insider

Guano

The excrement of seabirds and bats is used as a highly effective fertilizer for plant growth.

- Oxford Dictionary

"The materials used in building are a function of the availability and suitability of materials, as well as various cultural norms and traditions."

— Høibø, O., Hansen, E., Nybakk, E., & Nygaard, M, *Preferences for urban building materials: Does building culture background matter?* †, 2018

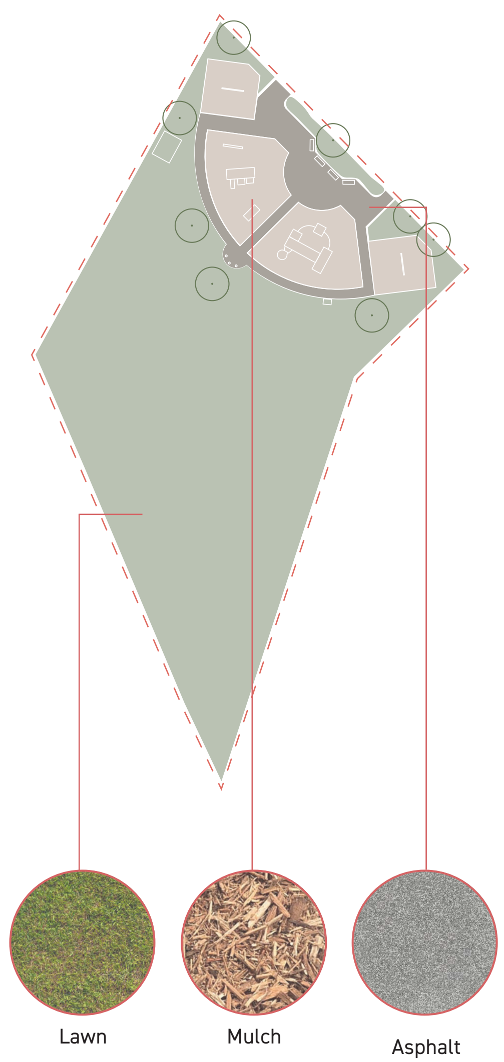
Case Studies

Zooming into the city scale - cities in the New England region - to identify the most popular urban park surface materials.

Case Study 01

The Reform Park

McGann Playground
266 West St., Boston, MA
1.2 Acres
1992



The McGann Playground is a small-sized and symmetrical park in the inner city located at Hyde Park, Boston, a highly residential neighborhood. The existing condition was designed and built-in 1992. The park was developed with play equipment for children without the other illusion of nature. As a standard Reform Park, the surface materials include mulch in play lots, asphalt as paths, and lawn as open spaces.

The mulch typically should be replaced at least once a year; if the playground has lots of use, it needs to be replaced every six months.

The open space with lawn is a significant area for McGann Playground; in the Massachusetts region, lawns in public are recommended to be mowed at least once a week.

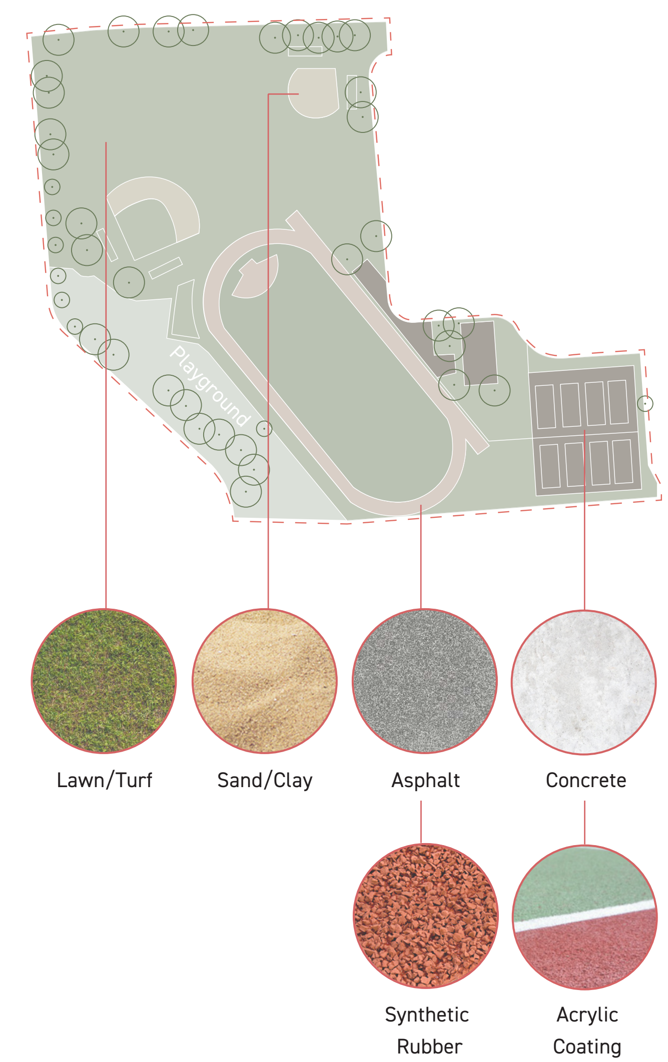
The asphalt path is significantly cheaper than other surface options, and it can last 30 years of service. However, risks are involved, which cause the need to repair every five years from crack or split. The hot weather also can cause it to soften and become sticky.

Figure 1-5
McGann Playground Material Analysis

Case Study 02

The Recreation Facility

Hope High School Recreation Facility
324 Hope St., Providence, RI
13 Acres
Early 1990s



Founded in 1898, Hope High School is part of Rhode Island's Providence Public School District. The current building was completed in 1936, with the original layout of the Recreation Facility, which remains the same in the present day. The latest update of the existing outdoor athletic facility was in the early 1990s. Like most outdoor recreation spaces, the selection of surface materials includes lawns, sand for the baseball field, asphalt for the track, concrete, and acrylic coating for tennis courts.

The best maintenance for natural grass athletic fields requires mowing, fertilization, irrigation, aeration, and overseeding to keep the grass healthy and safe for all seasons.

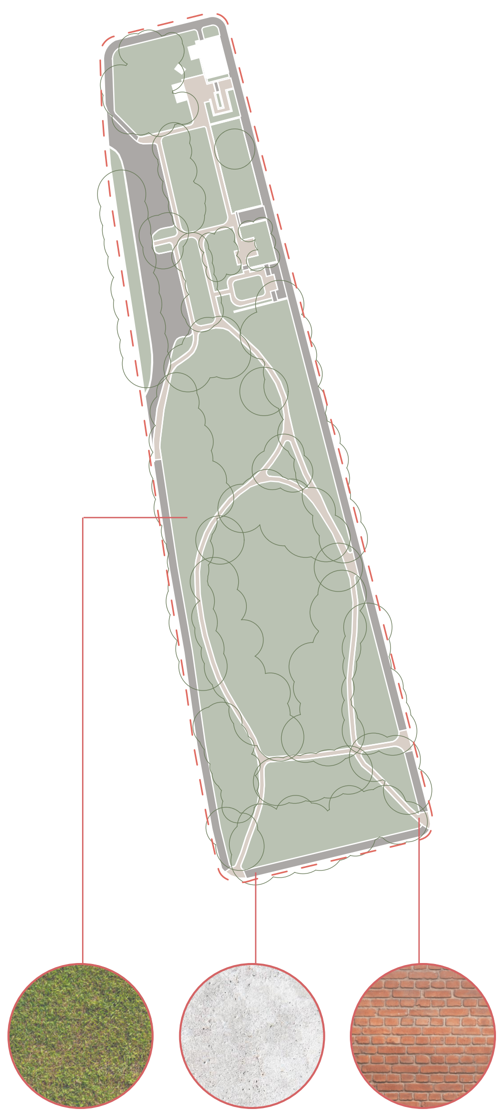
The baseball field requires careful maintenance: dragging, raking, filling, and repairing. The tennis courts' surfaces require resurfacing every three to seven years, and the running track needs replacement every 10-15 years.

Figure 1-6
Hope High School Recreation Facility Material Analysis

Case Study 03

The Open Space System

Roger Williams National Memorial
282 N Main St., Providence, RI
4.5 Acres
Late 1970s



The Roger Williams National Memorial was initially established in 1636 and redeveloped in the late 1970s as an urban park in Providence, Rhode Island, to commemorate the life of Roger Williams, a founder of Providence. The majority of the park has an open lawn area surrounded by heavy canopies, and the northern part of the park has more hardscapes, such as concrete and brick surfaces, with the visitor center in the corner.

Unlike other landscape materials, bricks require cleaning and sealing every two years. But bricks can also be reused more efficiently to reduce the environmental costs of new brick manufacture and old brick disposal.

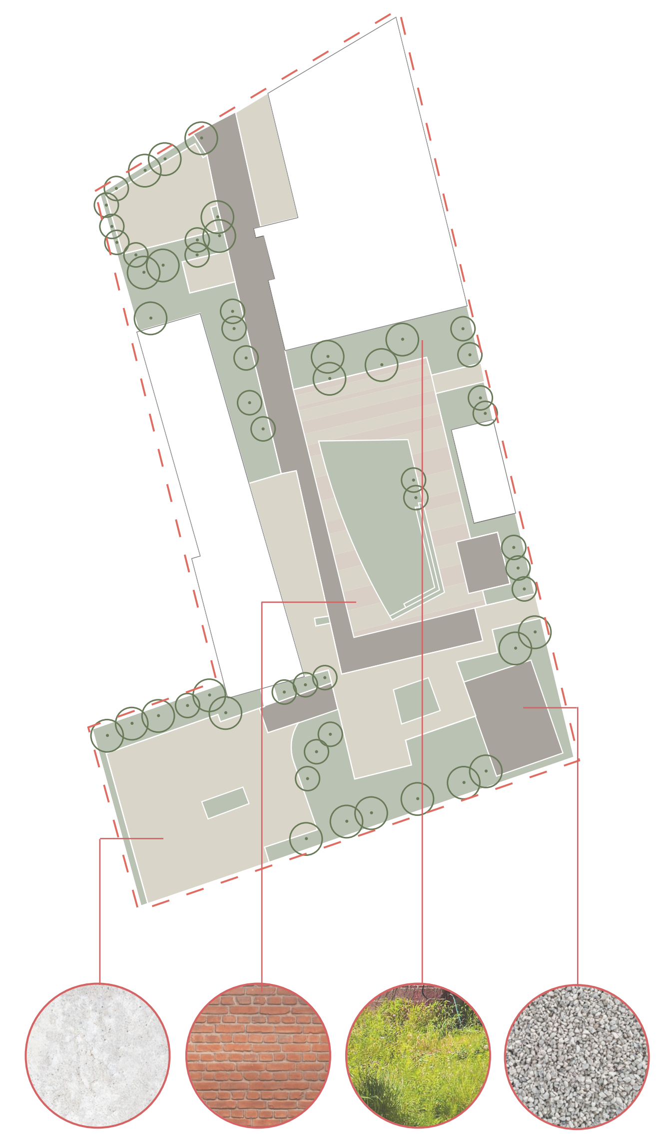
Concrete paths and asphalt parking lots lead to different repairing conditions. The concrete path has a typical lifespan of 25-30 years. However, the asphalt parking lot needs to be repaired every 2-3 years.

Figure 1-7
Roger Williams National Memorial Material Analysis

Case Study 04

The Sustainable Park

The Steel Yard
27 Sims Ave, Providence, RI
3.8 Acres
2003



The Steel Yard is a historical industrial complex for steel fabrication built in the early 20th century in Providence, Rhode Island. The site was redeveloped in 2003 and functions as a campus for industrial arts education, workforce training, and small-scale manufacturing.

The design team faced the challenge of working with a brownfield from history. So the designers focused on soil remediation and stormwater filtration, using typical materials such as concrete, bricks, lawn, and gravel innovatively.

At the center, there is 'the carpet' over the contaminated soil, which is a combination of heavy and light-duty pavements, impermeable and permeable materials, including bricks, gravel, and geotextile barrier.

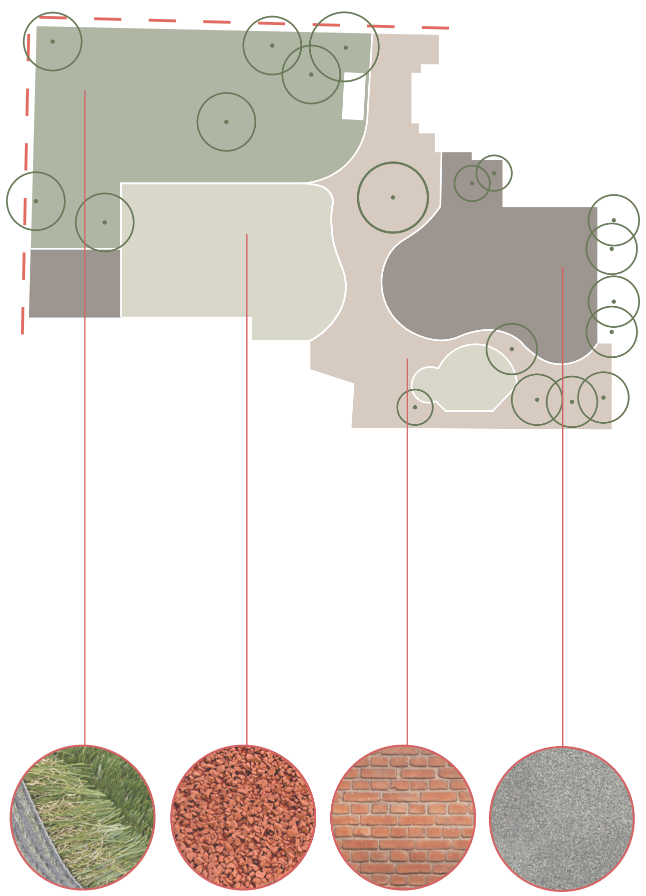
On the edge of buildings and property, they planted 'moat' instead of lawn to function as stormwater management which infiltrates runoff and provides habitat for volunteer vegetation.

Figure 1-8
The Steel Yard Material Analysis

Case Study 05

The Renovated Reform Park

Wheeler School
216 Hope St., Providence, RI
0.75 Acres
2007



The Wheeler School accommodates students from nursery up to 12th-grade in Providence, Rhode Island. Pressley Associates Landscape Architecture completed the new landscape design of the central campus in 2007, and it includes gathering space, outdoor recreation, a play structure, and a synthetic turf field.

The campus was facing the challenge of mismatching paving and furnishing, obsolete play structures, etc. So the school and designers expected a comprehensive spatial programming design with the low-maintenance requirements.

The selective play area includes a large synthetic lawn by Field Turf Tarkett, which uses relatively less water and chemicals from manufacturing to maintenance. In addition, Field Turf reuses material from landfills such as tires and recycling old turf infill. A clean, mud-free, all-seasonal material helps schools reduce maintenance and replacement cost.

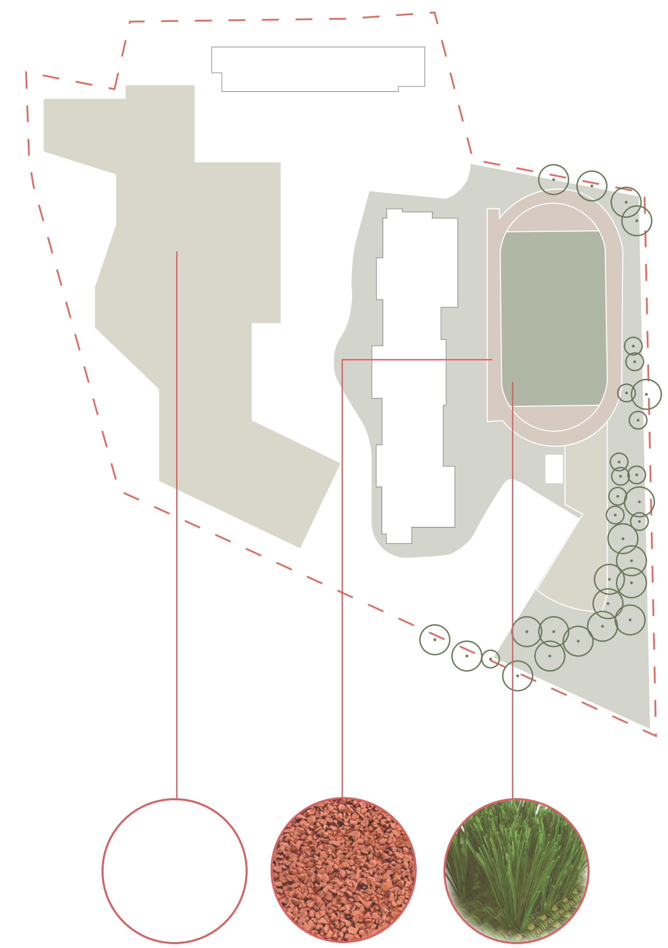
For the playground, Wheeler chose rubber tiles by Euro Flex, which use recycled material, have higher durability, and have higher safety levels.

Figure 1-9
The Wheeler School Playground Material Analysis

Case Study 06

The Renovated Recreation Facility

East Providence High School
2000 Pawtucket Ave, East Providence, RI
31.6 Acres
2021 - Present



East Providence High School has been following Providence's Climate Justice Plan since 2019 to ensure the school system is sustainable and will be carbon neutral by 2050.

A typical turf field has crumb rubber as infill, which can heat up to 180 degrees, be slippery and cause injuries. East Providence High chose to develop its athletic field with a sustainable system, including synthetic woven turf by GreenField Turf, a premier shock pad, and 100% organic infill. This system provides consistent and stable support, and it also saves many tons of crumb rubber.

The rest of the recreational facility will be completed by 2022.

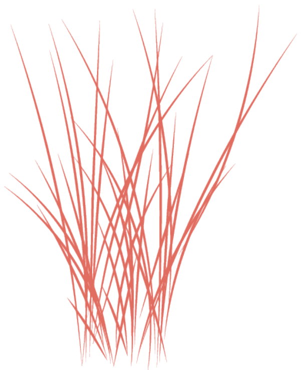
Figure 1-10
East Providence High School Material Analysis

Common Ground Surface Material in the Built Environment

A summary of the most commonly used ground surface materials from case studies includes the history, characteristics, environmental impacts, maintenance requirements, and sustainable use options.

LAWN

More surface area is devoted to lawns than any other single irrigated crop in the US.



DESCRIPTION

Lawns are areas of soil-covered land planted with short, mown grasses for aesthetic and recreational purposes.

HISTORY

Lawn first dates back to the early medieval period and are used for grazing livestock in Europe. It became popular in the 18th century for walkways and social areas. After the invention of mowing machines by Edwin Beard Budding in 1830, the market for lawns increased globally.

CHARACTERISTICS

- An efficient playing surface mitigates erosion and provides a shock pad for players.
- Lawn waste can be used as compost and feed source.
- Expensive and vulnerable to drought.

POTENTIAL IMPACTS

- Increase the use of petrochemicals, fertilizers, pesticides, and water, which causes climate change and pollution
- Reduce biodiversity

MAINTENANCE

Lawns need seeding, laying sod, planting new lawns every year, and mowing twice a week.

SUSTAINABLE OPTIONS

- Organic lawns - no or use organic pesticides and fertilizers with organic land care techniques
- Replace by low-maintenance groundcover
- Artificial turf

WOOD MULCH

Wood mulch once considered as the most popular playground material.

DESCRIPTION

Mulch is a layer of material applied on the top of the soil; it is usually made of organic material, like tree bark. Playground mulch is made from clean wood from the sawmill.

HISTORY

Modern mulching techniques started in the 17th century. By the 20th century, many people began to use the mulching method for their ornamental flowers and landscape designs.

CHARACTERISTICS

- Retaining soil moisture
- Regulating soil temperature
- Reducing weed growth
- Enhancing the visual appeal of the area
- Improving soil productivity
- Blocking water from rains
- Reducing oxygen in the soil
- Protecting children from getting injured

POTENTIAL IMPACTS

- Splinters
- Mold
- Freezing
- Not ADA accessible
- Children placing the mulch in the mouths, noses, and ears

MAINTENANCE

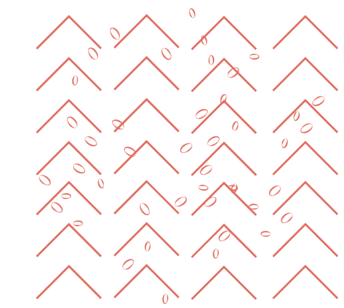
Wood mulch needs yearly replacement in playground.

OTHER MULCH VARIETIES

- Organic residues
- Compost
- Rubber mulch
- Plastic mulch
- Rocks

ASPHALT

Commonly used in road construction to create asphalt concrete.



DESCRIPTION

A black sticky liquid or semi-solid petroleum found in natural deposits is commonly used as glue mixed with aggregate for pavement construction. The word “asphalt” is short for “asphalt concrete,” a composite material.

HISTORY

The earliest natural asphalt used for sealing and waterproofing dates back to ancient times, and it was first used for paving in the 1870s with the rise of automobiles.

CHARACTERISTICS

- Surface durability
- Changing with temperature
- Porous surfaces
- Braking efficiency
- Low roadway noise

POTENTIAL IMPACTS

- Air pollution under hot and sunny weather
- Asphalt deterioration by cold and high heat weather
- Soften base by water trapping

MAINTENANCE

Sealing small cracks every three years.

SUSTAINABLE BENEFIT

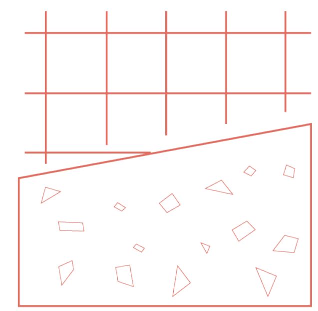
Asphalt is a commonly recycled material. The recycled asphalt can be reactivated for new pavement mixes.

SUSTAINABLE OPTIONS

- Open concrete grids
- Recycled asphalt

CONCRETE

The most widely used building material.



DESCRIPTION

An artificial composite material mixed with water, cement, asphalt, aggregate, gravel, sand, or rocks hardens over time as building materials, road surfaces, or bonding agents.

HISTORY

The earliest concrete material was found in Greece, dating back to 1400–1200 BC. It became widespread in many Ancient Roman structures from 300 BC to 476 AD.

CHARACTERISTICS

- High durability
- High Workability with the form/mold
- High compressive strength
- Low tensility
- High fire resistance

POTENTIAL IMPACTS

- Greenhouse gas emissions
- Sand mining
- Increased surface runoff
- Toxic ingredients
- Heavy soil erosion
- Water pollution

MAINTENANCE

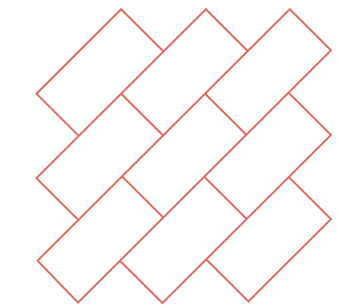
- Sealing the concrete cracks
- Power washing once every two years

SUSTAINABLE OPTIONS

- Increasing recycled materials into the mix
- Reducing water demand

BRICK

One of the longest-lasting and strongest building materials



DESCRIPTION

Brick is a block made of clay to build walls, pavements, and other elements by joining them with mortar.

STORY

The oldest bricks are dried mudbricks dating before 7500 BC, and the earliest fired bricks appeared around 4400 BC. The brick market increased massively with the Industrial Revolution in the late 18th century. Bricks started being commonly used as pavements in the late 19th century, and by the mid-20th century, they were replaced with inexpensive asphalt concrete.

CHARACTERISTICS

- Small and light enough to transport and use
- Insulating temperature
- High shock resistance
- High refractoriness
- Absorbing and releasing thermal energy
- Mold and fungus resistant

POTENTIAL IMPACTS

- Requires periodic sealing
- Uneven pavers could not be ADA friendly

MAINTENANCE

Clean and reseal every three to five years.

SUSTAINABLE BENEFIT

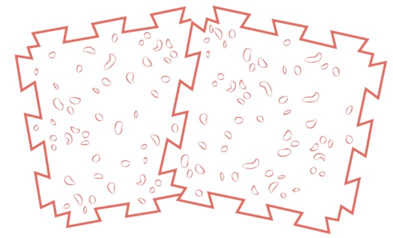
- Long lifecycle
- Energy efficiency
- Minimal waste
- Many recycling options

VARIETIES

- Fired bricks
- Air-dried bricks
- Chemically bricks
- Concrete bricks

RUBBER

Two-thirds of rubber made in the US is synthetic.



DESCRIPTION

Natural rubber is made from organic latex from the rubber tree. Harvested latex gets processed into rubber for commercial use. But rubber surfacing is usually synthetic and made from petrochemicals, commonly used for playgrounds, recreation facilities, driveways, etc.

HISTORY

The earliest rubber was found in Mesoamerica and dated back to the 1600s. The need for rubber started expanding in the 1890s for bicycle tires. In 1909, Fritz Hofmann made the first synthetic rubber, which was then used widely for commercial purposes.

CHARACTERISTICS

- Electrical insulation
- Versatile: able to apply on any surfaces such as asphalt, brick, wood, dirt, etc.
- High slip-resistant
- Shock-pad material
- Long-Lasting
- Thermal stability
- Fungal or bacteria resistant

POTENTIAL IMPACTS

- Petrochemicals are non-renewable resource
- Potential latex allergy
- Environmental pollution such as water, air, noise

MAINTENANCE

- Regularly cleaning: broom, wash, brush
- Sealing once two years
- Annual inspect

SUSTAINABLE BENEFIT

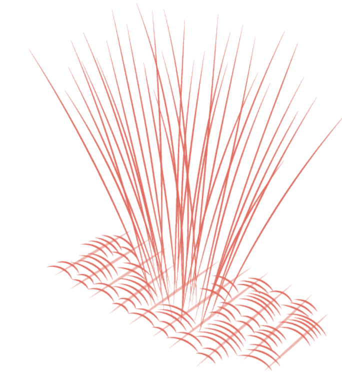
Natural rubber is degradable and renewable.

SUSTAINABLE OPTIONS

- Sustainable rubber farming
- Recycle and repurpose rubber
- Natural rubber

SYNTHETIC TURF

It is often used for sports played on grass. Since 1990 it has been used in residential and commercial areas.



DESCRIPTION

Synthetic turf is a surface made of synthetic fibers to mimic a natural lawn.

STORY

David Chaney created the first notable artificial turf in the late 1960s. The first artificial turf was installed in 1964 in a recreation area at the Moses Brown School in Providence, RI.

CHARACTERISTICS

- High durability
- No irrigation, trimming, or sunlight is needed.
- High visual contrast in all seasons
- No allergy-causing
- 10-20 years lifetime
- More bouncing and faster traveling
- Second-generation has longer fibers and sand infill.
- Third-generation has infill with the mix of sand and recycled rubber which are most widely used today.

POTENTIAL IMPACTS

- Use of petroleum and toxic chemicals from infill cause health and safety concerns.
- Synthetic turf could be hotter than the lawn.
- Does not support wildlife.
- The synthetic fibers and rubber infill can be washed into the environment.

MAINTENANCE

Periodic maintenance is required, including cleaning and brushing.

SUSTAINABLE OPTIONS

- Replace by plant-based artificial turf
- Chose the organic infill

Common Ground Surface Material Comparison

This evaluation chart is designed to compare the listed ground surface materials to know the price range, strength level, maintenance requirements, and sustainable level of each material for further research.

Figure 1-11
Ground Surface Material Comparison Chart
Evaluation System: * Low, ***** High

MATERIAL	STRENGTH	MAINTENANCE	COST	SUSTAINABILITY
LAWN	**	*****	****	**
WOOD MULCH	**	***	*	****
ASPHALT	***	**	**	***
CONCRETE	*****	*	**	**
BRICK	****	**	***	****
RUBBER	***	***	****	**
SYNTHETIC TURF	****	**	****	**

1-11

"The things we make must not only rise from the ground but return to it, soil to soil, water to water."

— William McDonough, *Design Ecology Ethics and The Making of Things*, 1993

Chapter 02
Alternative Material - Textile Waste

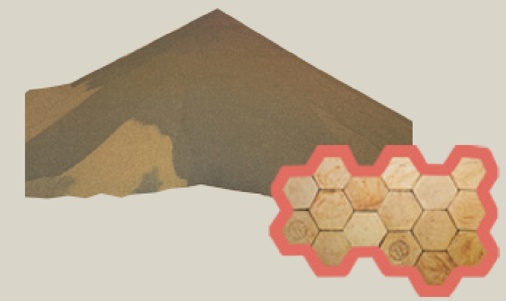
How can a ground surface material, which is not easily changed, be reconsidered and re-generated through waste matters?

2-1

Figure 2-1
The Collection of Common Used Fabric

2-2

2-3



2-4

2-5

2-6

2-7

Value of Upcycling Waste Matter

Makers become alchemists, designers become scientists, and artisans become social entrepreneurs. They are all crossing boundaries in the pursuit of a multidisciplinary approach (Franklin K. and Till C., Radical Matter: Re-thinking Materials for a Sustainable Future, 2018). I was inspired by designers and practitioners who create new objects out of waste matters and upcycle them to new values to tell the layered stories.

Figure 2-2 to Figure 2-7
Case Studies of Rethinking Materials

2-2 Silverwood Door Weight - Sophie Rowley - Door weight made by old newspapers

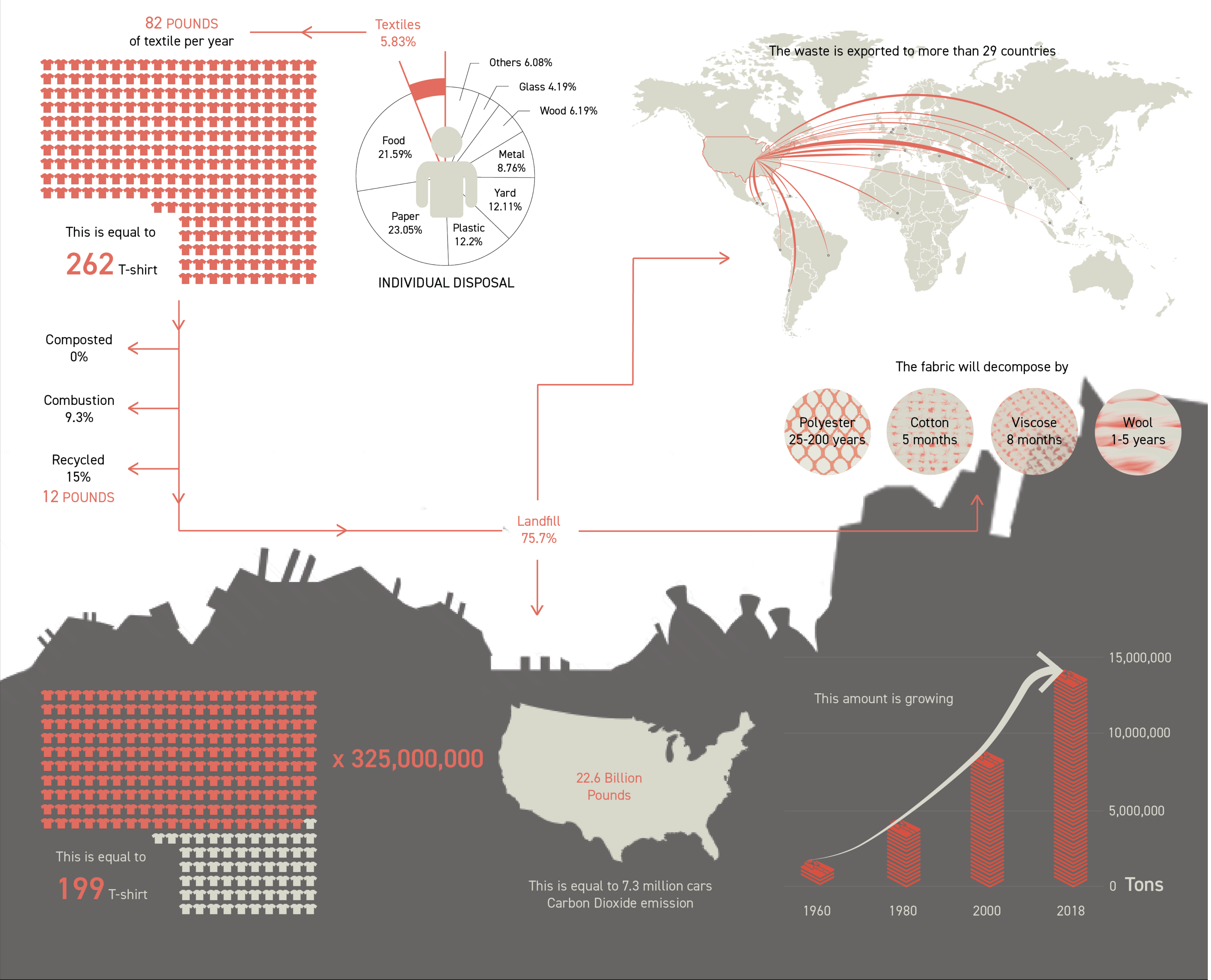
2-3 Polyspolia - Will Yates-Johnson - Endless broken up material made by resin, plaster, pigment, and wax

2-4 Shit Products - Gianantonio Locatelli and Luca Cipelletti - Tiles made by dry dung

2-5 Structural Skin - Jorge Penadés - Furniture made by leather waste

2-6 Solidwool - Justin and Hannah Floyd - Chair made by wool

2-7 Flax Chair - Christien Meindertsma - Chair made by natural fibre



Textile Waste Flow

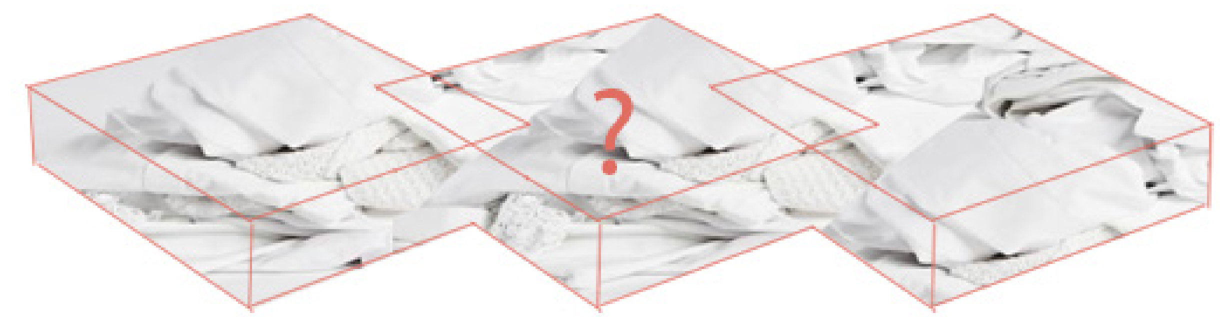
In the United States, 25 billion pounds of textiles are generated per year. This amount equals 82 pounds per person or 262 T-shirts. However, the majority of the waste (75.7%) goes to landfills directly, even though it can still be valuable and recyclable.

The increase in wasted textiles is causing environmental issues such as the massive use of water and energy resources in production and the release of toxic chemicals from decomposition. It also brings economic problems, such as disturbing the market and lowering the payment rate in developing countries, and social issues, such as concealing related forced and child labor.

Figure 2-8
Textile Waste Flow
Textiles include clothing, footwear, accessories, towels, beddings, etc. This graphic shows the facts about textile waste in the United States, from individual to national scale.

Fiber Studies

How to experiment with textiles to develop a new way to recycle textile waste?



2-9

Figure 2-9
Regenerate Textile Waste

Classification of Textile Fibers

Fibers are classified by their chemical origin.

NATURAL FIBERS
occur in nature in fiber form and can be classified as vegetable, animal, and mineral.

PLANT FIBERS
found in the cell walls of plants are cellulosic in composition.

Cotton *
Kapok
Flax
Hemp
Ramie
Bamboo
Jute
Sisal
Coir
Abaca

ANIMAL FIBERS
produced by animals or insects are proteins in the composition.

Wool *
Mohair
Cashmere
Camel Hair
Alpaca
Silk
Hair
Yak

MINERAL FIBERS
are mined from certain types of a rack.

Asbestos

* Selective Fibers for Textile Testing

SYNTHETIC FIBERS
have taken the natural material of cellulose, processed it chemically, and changed its form and other characteristics into fibers.

REGENERATED CELLULOSE FIBRES
derived from the plant fiber cellulose, converted by chemical treatment.

Rayon *
Acetate
Soybean Protein
Milk Casein

SYNTHETIC FIBRES
are synthesized by combining carbon, oxygen, hydrogen, and other simple chemical elements.

Polyester *
Nylon *
Acrylic
Spandex
Olefin
PVC

* Selective Fibers for Textile Testing

Common Used Fiber Materiality

Some of these fibers were known and used by humankind in the earlier years of civilization and modern times. Other fibers have acquired varying degrees of importance in recent years.

WOOL

Grows from the skin of sheep.

DESCRIPTION

It is naturally crimped, and wavy with a lofty and slightly greasy hand feel before treatment.

CHARACTERISTIC

- Weaker than cotton
- Absorbs moisture better than cotton
- Strengthen decreases and shrink when wet
- Mildew develops when wool is damp
- High elasticity
- Fades and weakens under continuous sunlight
- Scales make it possible to be felted
- Biodegradable
- Suitable for mechanical recycling with relatively long fibers

COMPOSITION

49% carbon + 24% oxygen + 16% nitrogen + 7% hydrogen
+ 4% sulfur make keratin protein

COTTON

The most popular fiber in the world.

DESCRIPTION

It is a seed fiber grown as a protective case around the cotton plant's seed; it is soft and fluffy to the touch and is usually off-white.

CHARACTERISTIC

- Lightweight
- Durable remain strong when wet.
- Breathable
- Dry well and discolored after wash
- Not stable - shrink
- No static electricity

COMPOSITION

90% cellulose + 6% moisture + natural impurities
+ coating (waxlike - adhesive quality)

RAYON

A versatile fiber often referred to as artificial silk.

DESCRIPTION

It is derived from the cellulose of the cell walls of short cotton fibers or pine wood - converted by chemical treatment - produced into fiber form.

CHARACTERISTIC

- Smooth and soft
- Silky and lustrous
- Highly breakable, especially when wet
- Absorbs moisture quickly
- High flammable
- Takes dye well
- Tends to shrink

POLYESTER

One of the most widely used fibers

DESCRIPTION

A synthetic fiber derived from petroleum with dihydric alcohol and terephthalic acid.

CHARACTERISTIC

- Soft and drapes easily
- Holds shape well
- Highly durable
- Pill resistance in filament form
- Mildew and soil resistant
- Lower price than most fabrics

NYLON

One of the strongest fibers

DESCRIPTION

It is derived from petroleum, one of the strongest fibers, and is very elastic.

CHARACTERISTIC

- - Smooth and soft
- - Extremely durable, even when wet
- - Heat sensitive and prone to melt
- - High elasticity
- - Fast drying
- - Soil resistant
- - Mildew and fungi resistant
- - Easily gathers static electricity

Fabric Tests

What are the material properties of different fibers?
How do they react with moist and organic matter?

2-10

Figure 2-10
The collection of donated clothing made by the common used fibers.

100% WOOL

100% POLYESTER
Donated by Pian Zhang

85% COTTON 15% POLYESTER
Donated by Hillary Huang

100% COTTON

100% NYLON
Donated by Yuanrui Wang

85% COTTON 15% NYLON
Donated by Hillary Huang

100% RAYON
Donated by John Noftsker

50% COTTON 50% POLYESTER

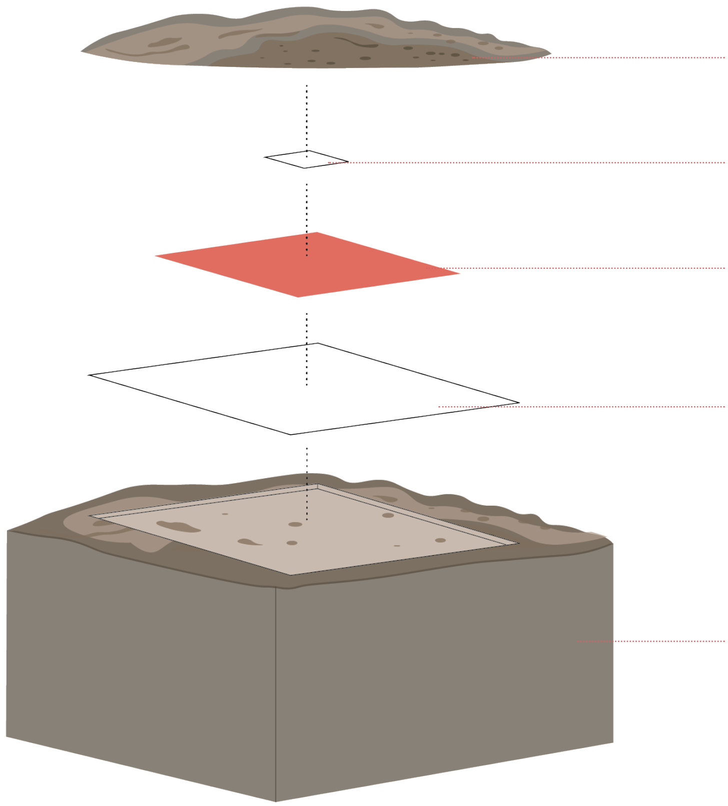
80% RAYON 20% NYLON

Figure 2-11
Fabric Selection
In the textile industry, various options can be used as raw materials. This fabric test mainly chooses one or two fibers based on the prevalent trend under each classification (natural fibers and synthetic fibers). Due to cotton and polyester having a more significant proportion of the market, 40% each, there are extra selected testing samples for those two fibers blended with other materials.

Fabric Testing Method 01 - Outdoor Tests

The selected fabrics have been buried under layers of organic soil, leaves, and natural waste since February 2022 to test the decomposing rate, moist reaction, and organic matter reaction such as fungi, insects, biome, etc.

2-12



2-13

2-14

2-15

2-16

Figure 2-12
Selected fabrics are cut into two sizes of 8*8" for outdoor testing.

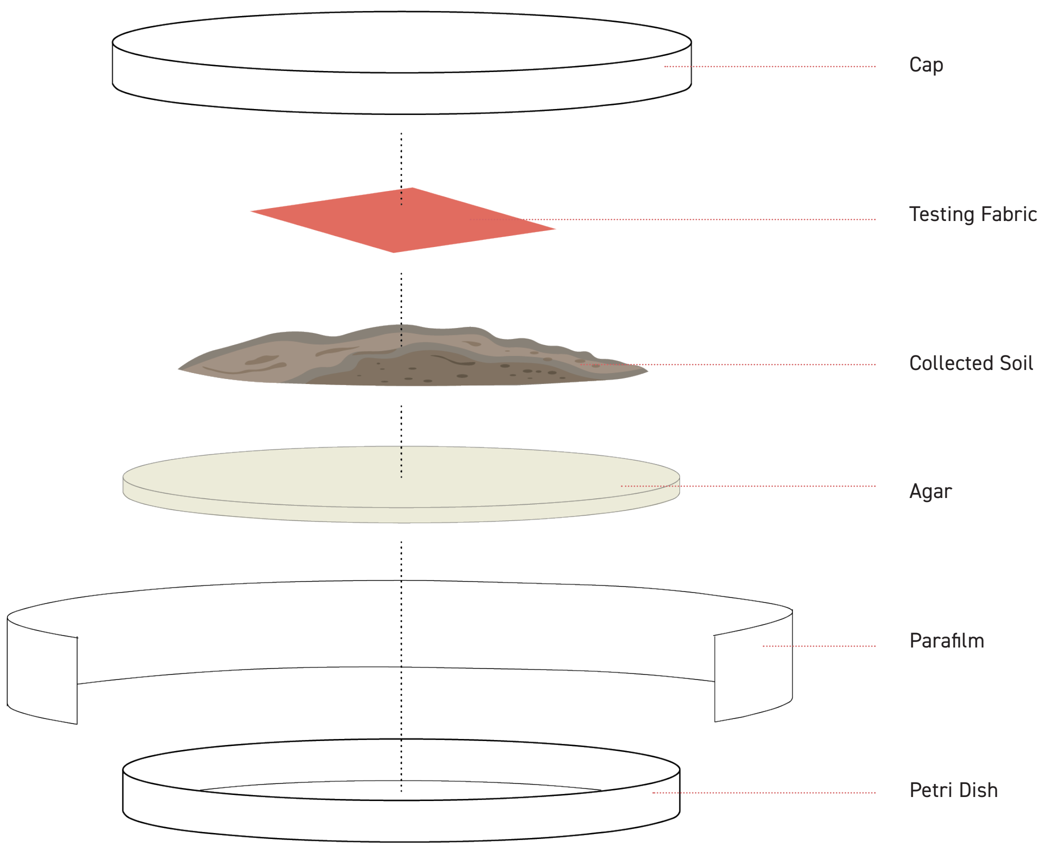
Figure 2-13
Outdoor Fabric Testing Strategy Diagram

Figure 2-14 to Figure 2-16
Photos of Outdoor Fabric Tests

Fabric Testing Method 02 - Indoor Control Tests

In order to keep the temperature of fabric testing above 75 °F, three sets of experiments are tested indoors. Fabric tests are placed under controlled conditions: the same Petri dishes containing agar, the same soil from the outdoor testing location, and the testing fabrics. Parafilm sealed two tests for fungi growth, and one set was left open for oxygen access.

2-17



2-18

2-19

Figure 2-17
Selected fabrics are cut into two sizes of 1.5*1.5" for indoor testing.

Figure 2-18
Indoor Fabric Control Testing Strategy Diagram

Figure 2-19
Photos of Fabric Indoor Control Tests

The Documentation of Fabric Test 01 - Outdoor Tests

Due to the cold weather in late winter and early spring, there are not many reactions for all testing fabrics until May 2022, three months after burying materials down into the soil.

Overaching Observation:

- Planting is growing through fabrics.
- Worms and snails are spotted on or around fabrics.

Specific Observation:

- Wool expanded with moisture, and the color is faded.
- Rayon or fabric with rayon became easy to break when touching.

100% WOOL | 100% COTTON | 100% RAYON | 100% NYLON | 100% POLYESTER | 85% COTTON 15% POLYESTER | 80% RAYON 20% NYLON | 85% COTTON 15% NYLON | 50% COTTON 50% POLYESTER

02/02/22

03/06/22

04/03/22

05/02/22

The Documentation of Fabric Test 02 - Indoor Control Tests

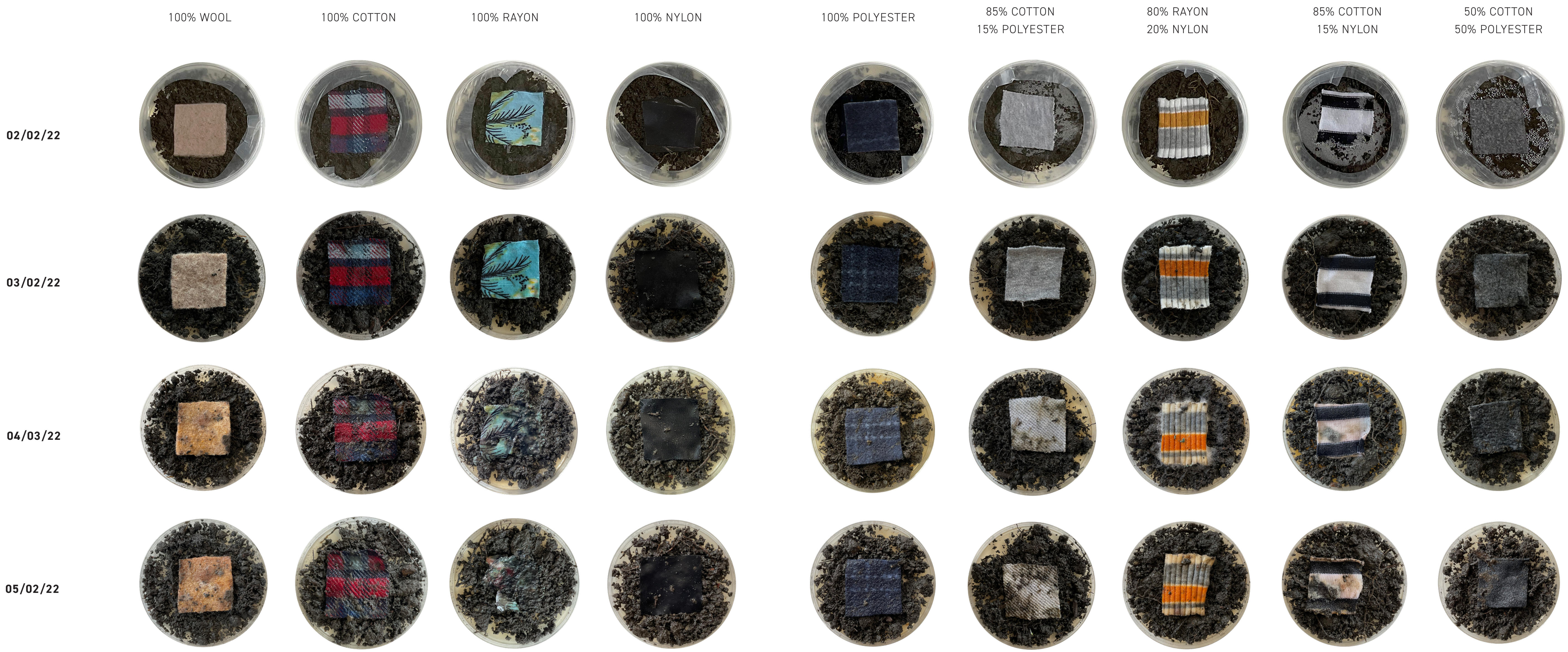
The following images are from one of the sealed tests; the other two sets of tests are documented in the appendix.

Overarching Observation:

- Fungi are spotted in all tests.
- The smell of decomposition differs between natural and synthetic fabrics; synthetic or fabrics with synthetic composition have an unpleasant pungent smell.
- Natural or fabrics with natural composition become moldy and have color changes (faded or darkened).
- Not many reactions find in synthetic fabrics.

Specific Observation:

- One seed grows in the sealed petri dish.
- Rayon disappeared in two months for all sets of experiments.



The Documentation of Fabric Tests - Organic Matters

2-20

2-21

2-22

2-23

Figure 2-20 to Figure 2-23
Photos of The Reaction between Fabrics and Organic Matters

2-20 Planting is growing through fabrics.

2-21 Worms are spotted on or around fabrics.

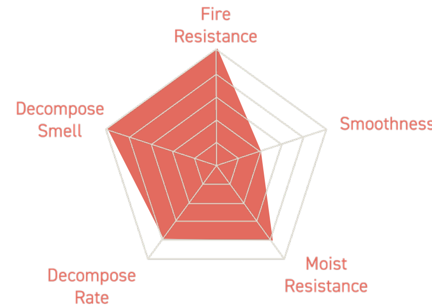
2-22 Fungi are spotted in all tests.

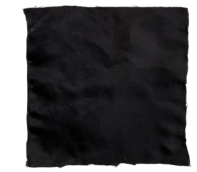
2-23 One seed grows in the sealed petri dish.

Fabric Evaluation

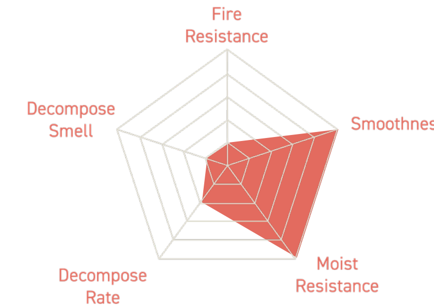
This evaluation system is designed to compare the selected fabrics to know their properties on five characteristics: the fire and moist resistance, the rate and smell for decomposition, and tactility level, which meet outdoor-use material needs for further research.

100% WOOL

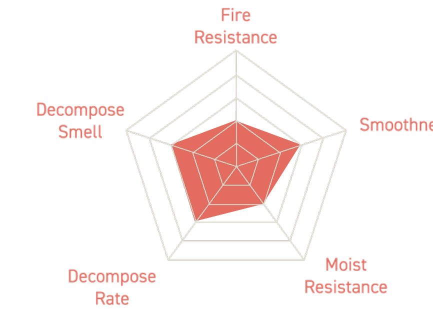




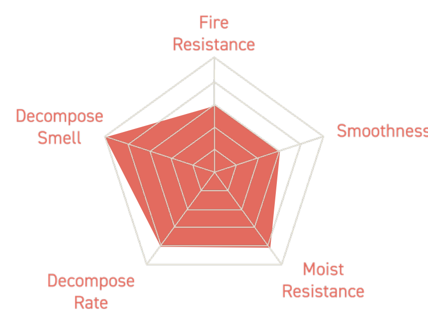
100% NYLON



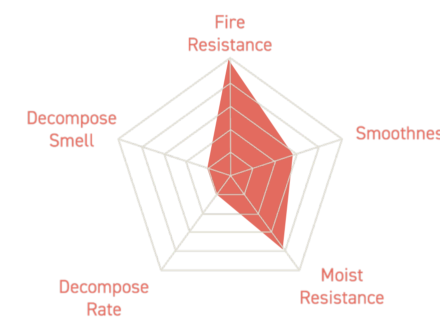
80% RAYON
20% NYLON



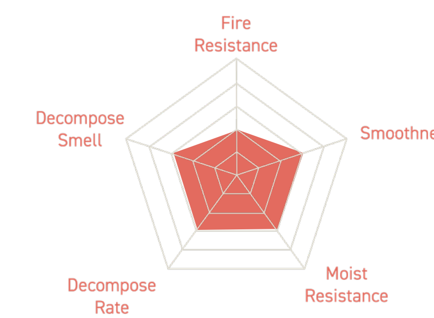
100% COTTON



100% POLYESTER

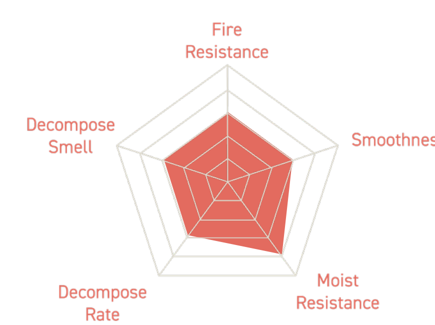


85% COTTON
15% NYLON



100% RAYON

85% COTTON
15% POLYESTER



50% COTTON
50% POLYESTER

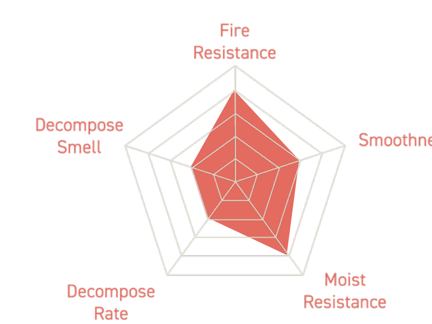


Figure 2-24
Evaluations for Selected Fabrics
Evaluation System:
Fire and Moist Resistance: Inner - Low, Outer - High
Smoothness: Inner - Tough, Outer - Smooth
Decompose Rate: Inner - Slow, Outer - Fast
Decompose Smell: Inner - Pungent, Outer - Neutral

Chapter 03

Investigation of the New Materials

How can we carefully investigate the materials through hand-on experiments? How do the proposed materials reveal and function in the landscape practice?

3-1

Figure 3-1
The Collection of New Material Tests

Material Investigation

After the material studies described in Chapters 01 and 02, the research was directed to seeking the most approachable testing methods. Through physical and chemical material tests, the investigation strategies engaged in transforming natural, synthetic, or blended fabrics into new materials. Textile waste either replace certain materials such as sand in concrete or is used alone as a soft material on or under the ground surface.

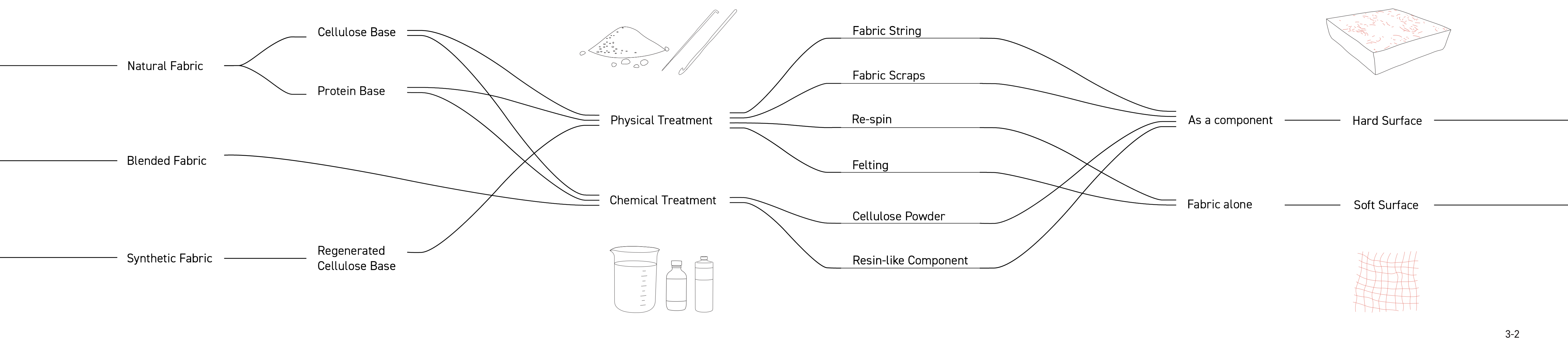
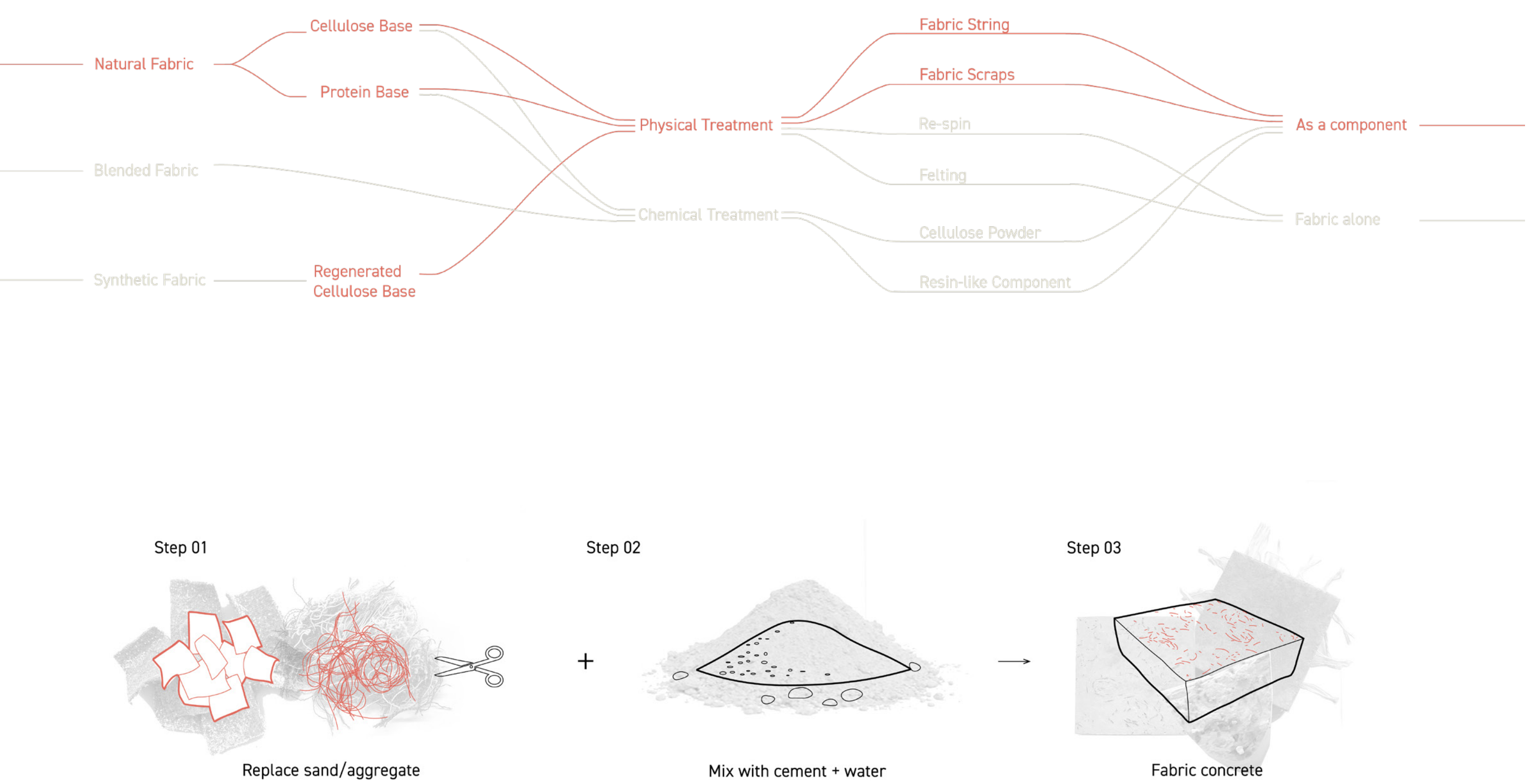


Figure 3-2
The Investigation Strategies

Investigation Strategy 01 - Physical Treatment

This strategy uses fabric as a component by replacing certain materials in existing material manufacture, such as sand and aggregate in concrete or sand and fiber in bricks. The tests aim to understand if the fabric can be used as a strong bounding in hard surface materials.



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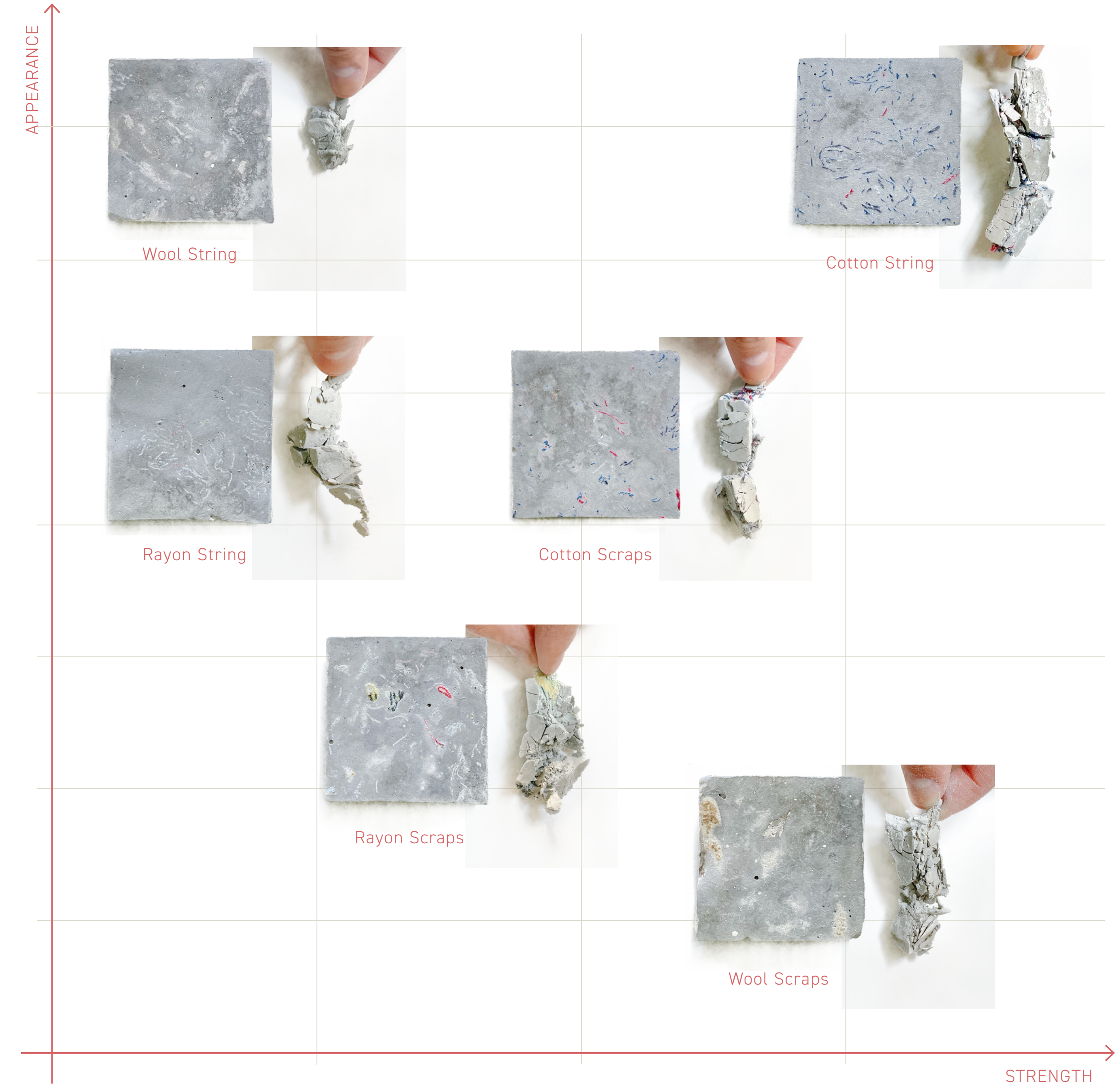


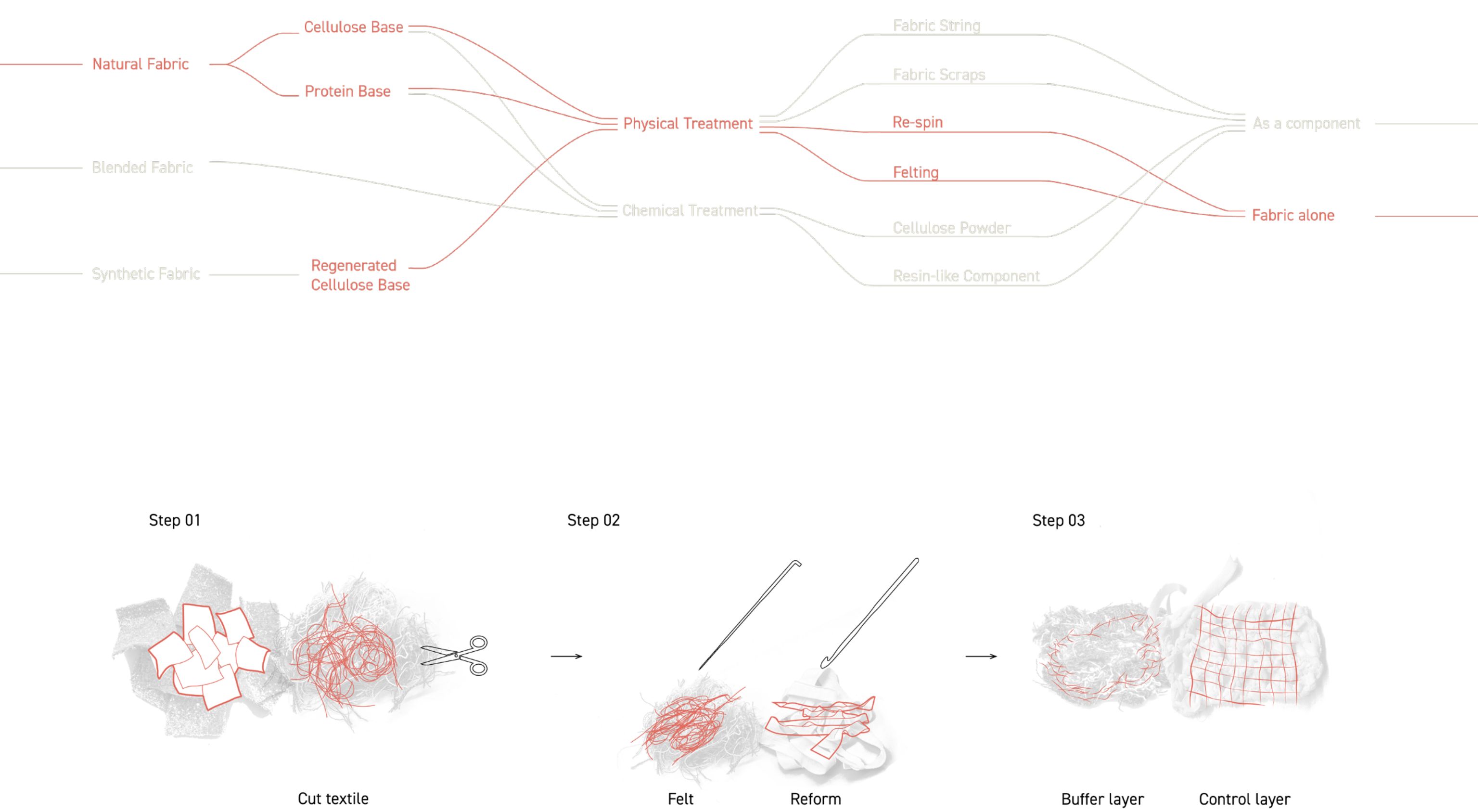
3-4

Figure 3-3
Strategy 01 - Physical Treatment - Textile as a Component

Figure 3-4
Strategy 01 Material Comparison
The material samples are ranked by their appearance and the strength of holding cement together. The strength level of the concrete samples could be tested further by Compressometers.

Investigation Strategy 02 - Physical Treatment

This strategy uses fabric itself as a surface material. Utilizing the methods of re-spinning, waving, and felting, the fabric scraps and strings were transformed into soft ground surface materials, which could eventually be used as a buffer layer in playing areas or as a control mat to prevent mulch and sand loss in the playground.



3-5

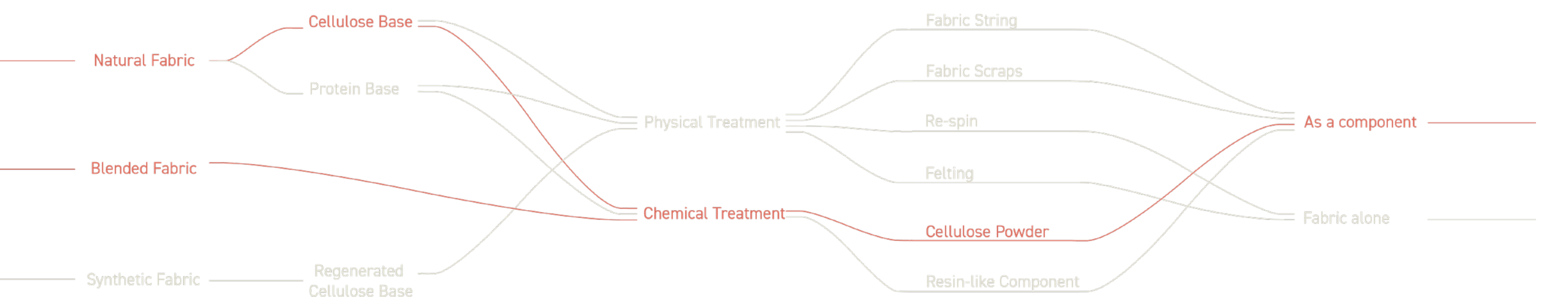
Figure 3-5
Strategy 02 - Physical Treatment - Textile Alone

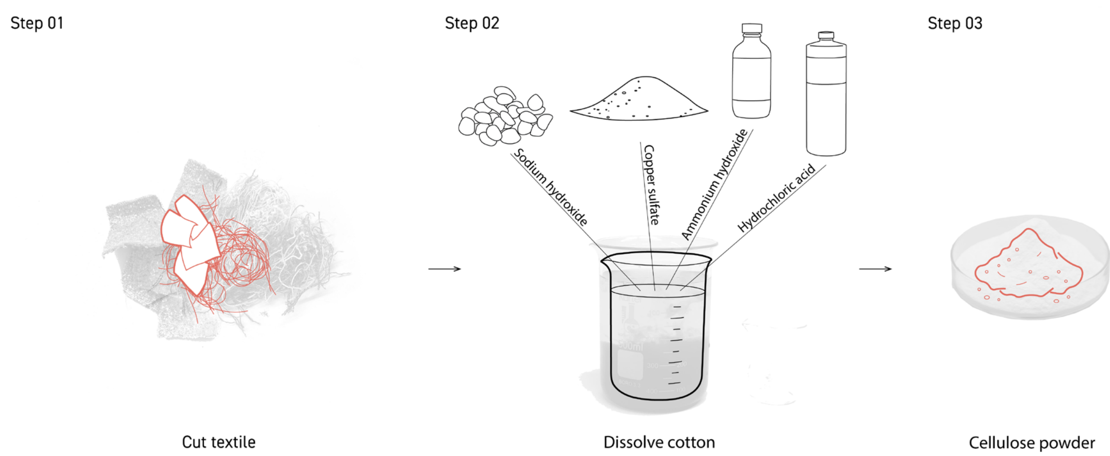
3-6

Figure 3-6
Strategy 02 -Material Comparison
The material samples are ranked by their tactility and elasticity level. The strength level of the soft material samples could be tested further by a tensile tester.

Investigation Strategy 03 - Chemical Treatment

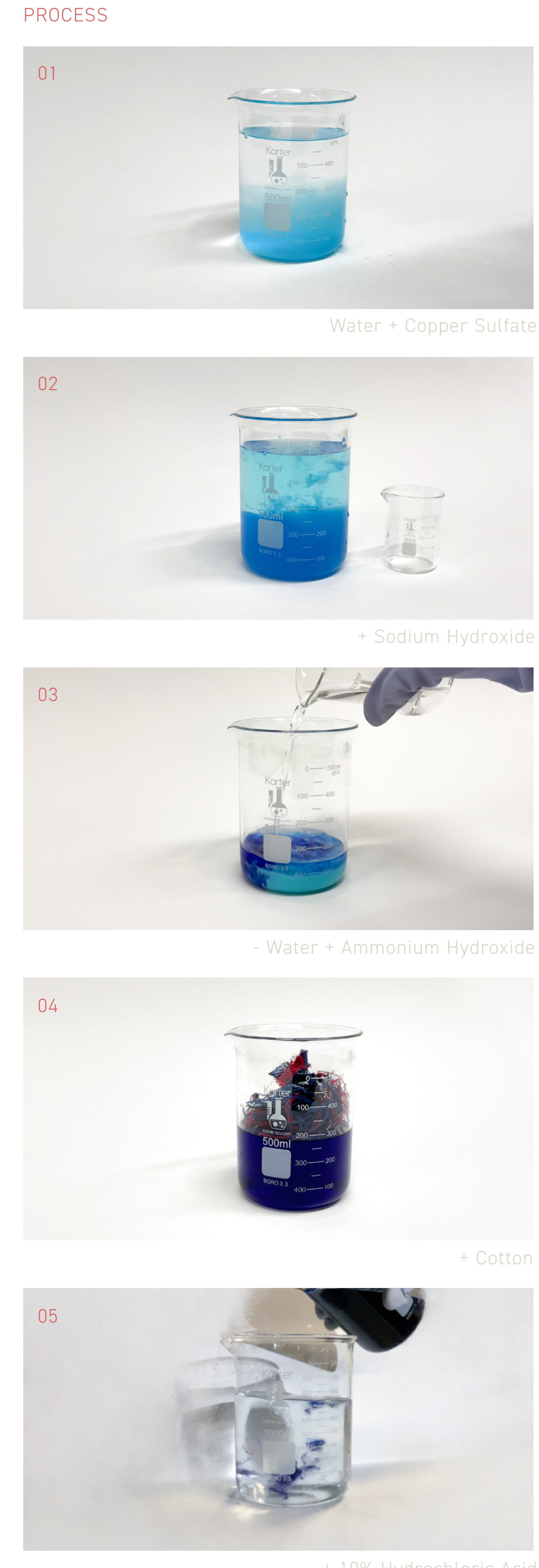
This strategy separates the natural and synthetic components in the blended fabric. The purpose is to reuse the natural portion in new material making and recycle synthetic parts, such as polyester. After chemical treatment, the natural fiber is transformed into cellulose powder, which could be used as a bounding and thickening agent due to its stable property.

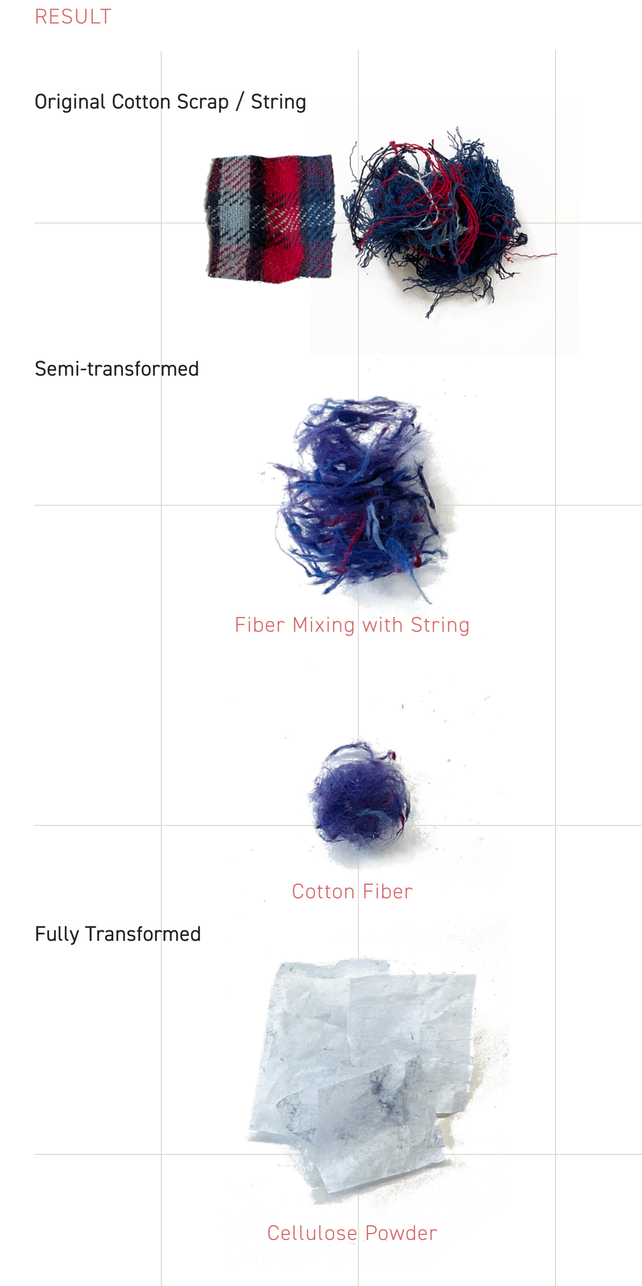




3-7

Figure 3-7
Strategy 03 - Chemical Treatment - Textile as a Component





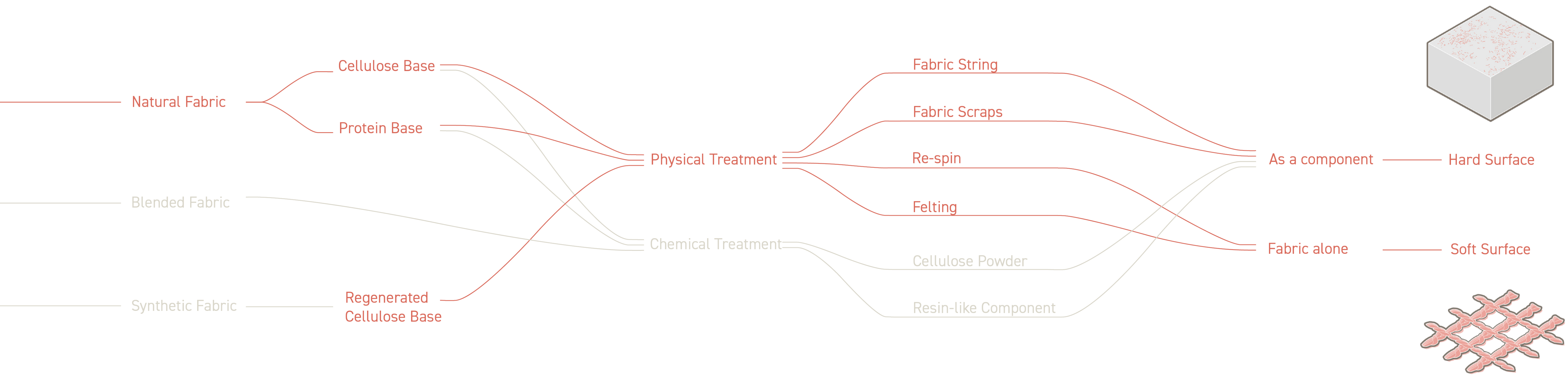
3-9

Figure 3-8
Strategy 03 - Chemical Treatment Process

Figure 3-9
The Result from Chemical Treatment
For the chemical treatment strategy, the input of time, chemicals, and money is higher than the amount of produced cellulose powder. Using this strategy requires an extensive industrial-scale production line instead of small local production.

Materials Design Directions

After the experiments with three strategies of disassembling and reassembling selected fabrics, this thesis is directed to physical material designing and making for hard and soft surfaces in the following chapter. In outdoor material design, synthetic fabrics will not be considered because there will have microplastic issues in the ecosystem during the degrading process. Secondly, using the chemical treatment to separate blended fabrics should be researched further if it is under the situation of a large industrial-scale production line.



3-10

Figure 3-10
The Directions of Materials Design

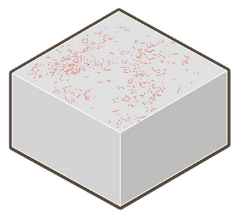
Figure 3-11
1-1 Prototype of Material Design

Ground Surface Material Design

Playgrounds are environments designed specifically for play. Typically, separate play areas are offered with intended purposes, and more than two ground surface materials are used in the playground. Hard surfaces are used for paths, parking lots, or lounges; soft surfaces are used for safety zones around equipment and areas with potential falls or planting areas. The material design will be looking for the most suitable method to upcycle textile waste into hard and soft surface materials.

3-11

Dimension and Pattern Design

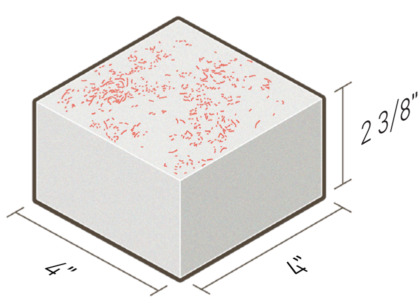


CONCRETE PAVER
Hard Surface

PEDESTRIAN PAVER

VEHICULAR PAVER

Dimension



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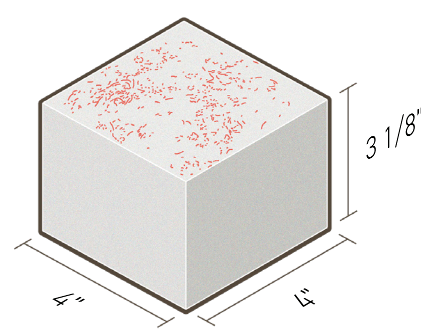
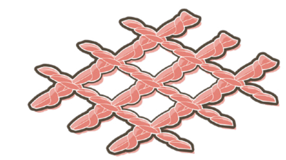


3-13

1-1 Prototype

3-15

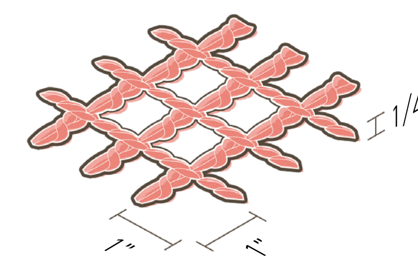
3-16



GEO-TEXTILE
Soft Surface

GEO-TEXTILE

Dimension



3-14

1-1 Prototype

3-17

Figure 3-12
The Dimension of Pedestrian Paver
Pedestrian paving for areas limited vehicular use is 2 3/8" thick minimum.

Figure 3-13
The Dimension of Vehicular Paver
Areas used by cars or maintenance services need the pavers to be a minimum thickness of 3 1/8".

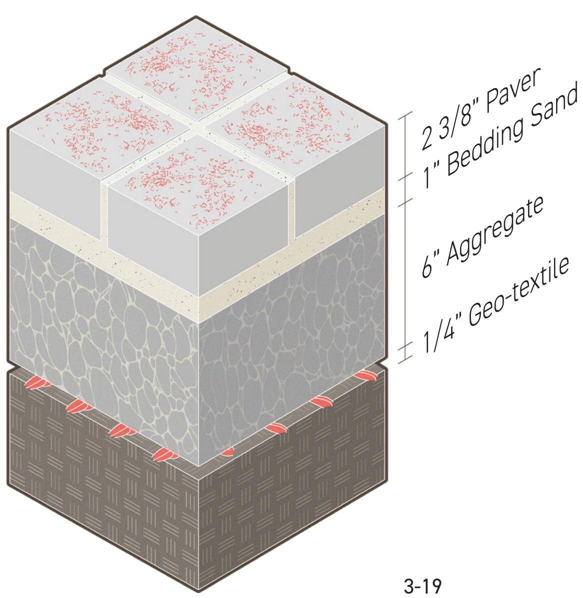
Figure 3-14
The Dimension of Geo-textile
The grid size for geo-textile is flexible depending on the location of the material used. Recommend 1"x 1" as the minimum size for areas with mulch or soil.

Figure 3-15
The Pattern of Proposed Paver
This pattern was created with cotton strings mixed with cement.

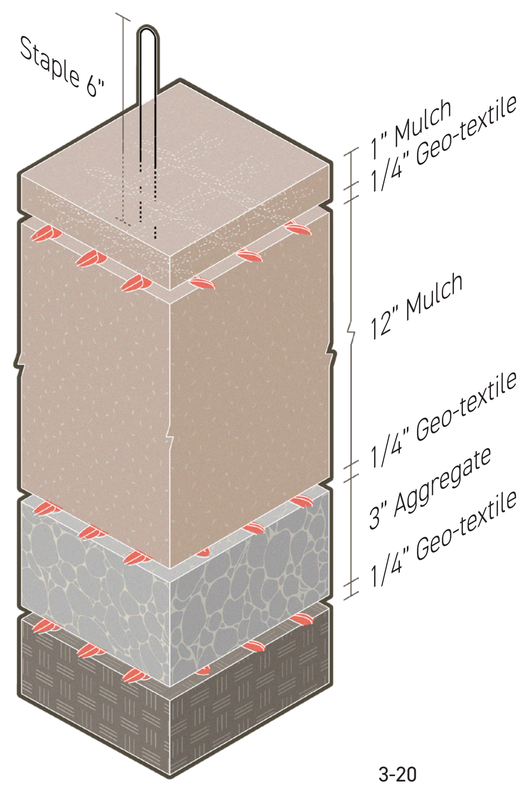
Figure 3-16
The Potential Pattern of Proposed Paver after Weathering
Mimicking the pattern after the paver is worn out, with holes and more textile exposed on the surface

Figure 3-17
The Geo-textile in Mulch and Soil

Material Installation Design



3-19



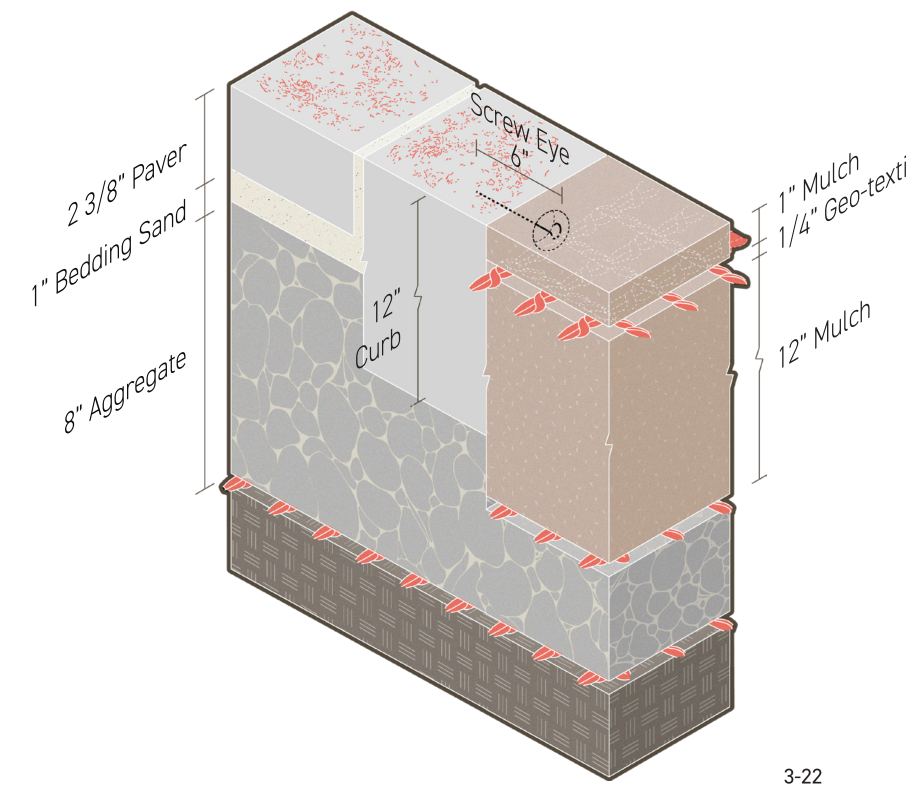
3-20

Figure 3-18
The Photo of Designed Surfaces

Figure 3-19
The Image of Pavers Installation

Figure 3-20
The Image of Geo-textile Installation
The designed Geo-textile can be placed on the playing area with mulch, and between two layers of different materials.

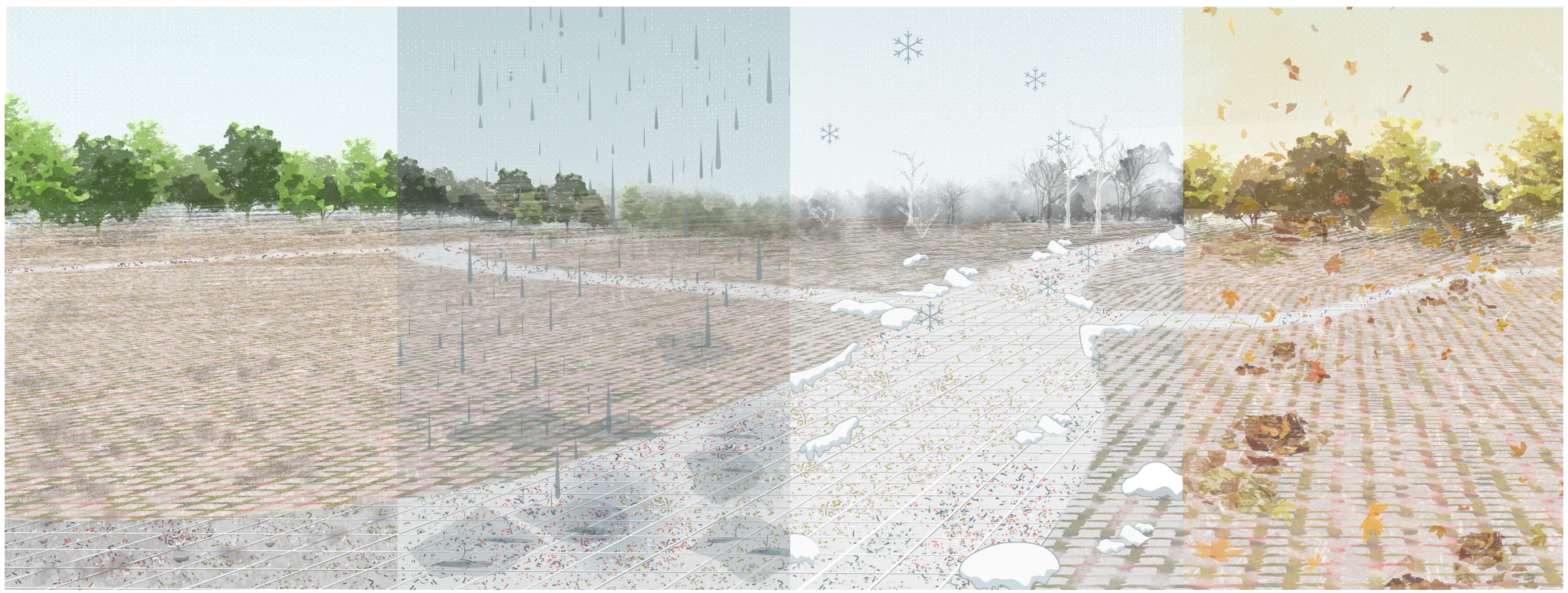
Material Connection Design



3-22

Figure 3-21
The Photo of Connection System

Figure 3-22
The Image of Connection System between Hard and Soft Surfaces



4-1

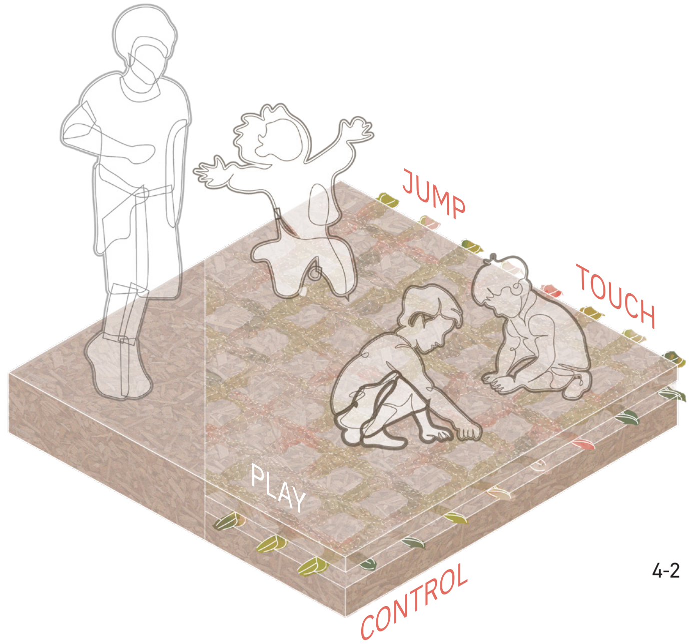
Chapter 04
Proposed Materials Reflection

How do the proposed materials impact the environment of playgrounds, socially and economically, throughout weathering?

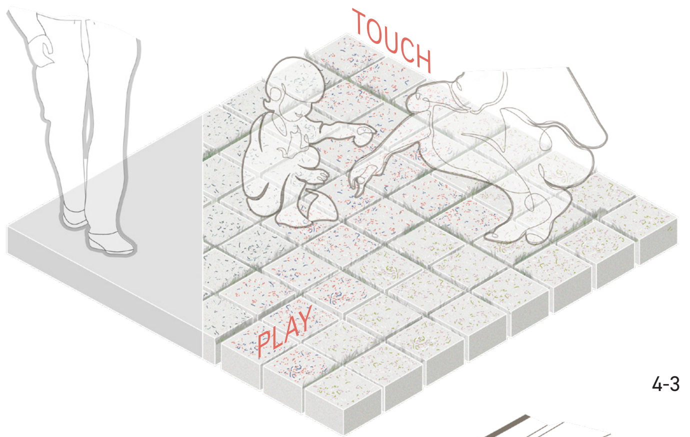
Figure 4-1
The Image of Proposed Material under Different Conditions

User Experience

The proposed materials have the versatility to be arranged into different color palettes due to the variety of colored fabric options. This colorful ground surface material can offer a memorable experience for the users, allowing the surface itself to act as a playful tool in the playground. Compared to standard concrete paving, the added fabric can bring a new opportunity for hard surface materials. Additionally, the elastic property of the textile offers opportunities for unexpected play from the mulch as it can bounce when interacted with by outside forces.



4-2



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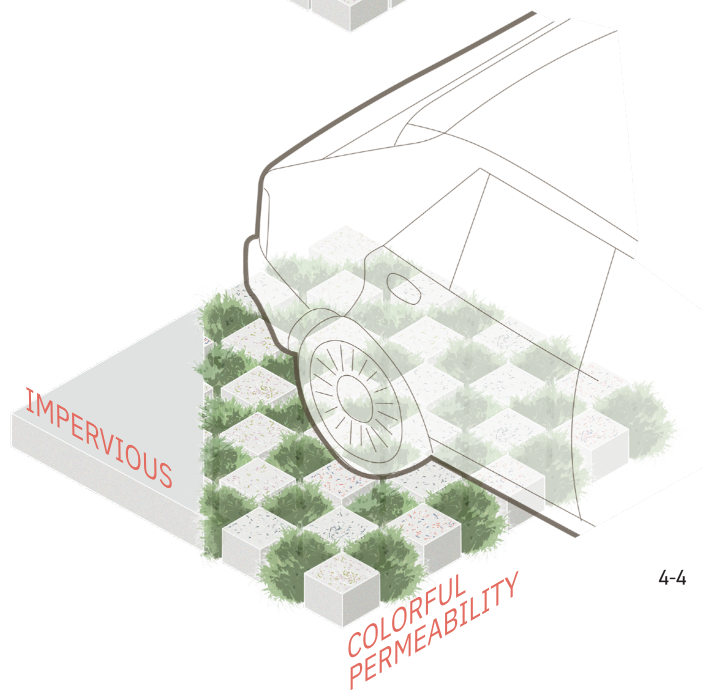


4-4

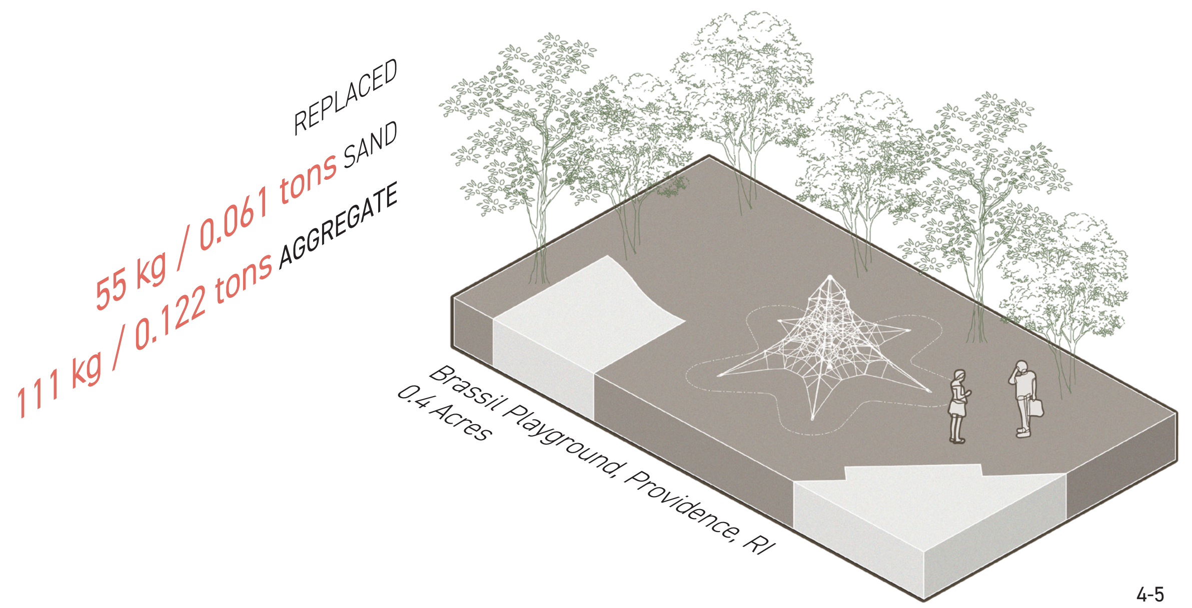
Figure 4-2
The Image of Geo-Textile Use
The geo-textile can help with the loss of mulch or soil from heavy rains.

Figure 4-3
The Image of Pedestrian Pavers Use

Figure 4-4
The Image of Vehicular Pavers Use

Economic Impacts

How might the proposed materials influence the landscape environment from an economic standpoint? In the practical aspect, it is necessary to know how much textile waste is upcycled while replacing existing surface materials with the proposed surfaces. In order to visualize the number, a playground in Providence, Rhode Island, has been selected as the site of interest.



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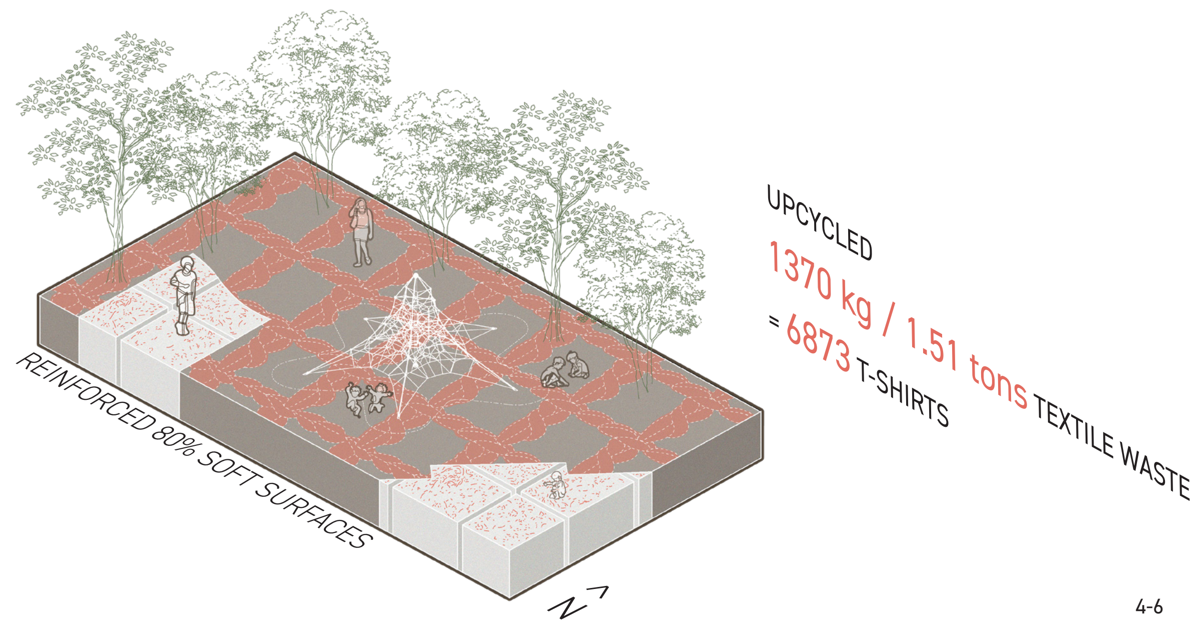


4-6

Figure 4-5
The Image of Before Using Proposed Materials

Figure 4-6
The Image of After Using Proposed Materials

Proposed Concrete Pavers under Various Conditions

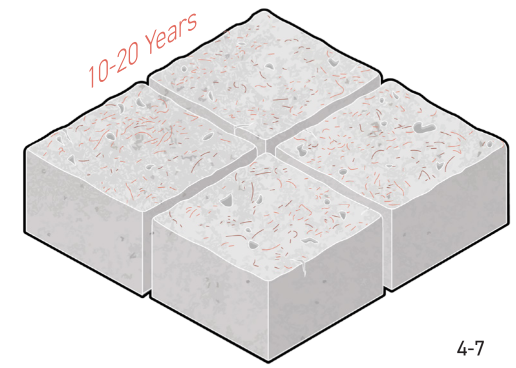
Due to the unique degradable properties of certain fabrics, it is valuable to consider and design with weathering in mind. The edge of the proposed pavers will become chipped; the surface will be worn, and pitting might occur on the surface from external variables. Except for functioning as existing materials within the service life, how will the users' experience with the proposed materials change or be different after the materials are weathered?

Figure 4-7
The Service Life of Proposed Paver
The edge and surface will be worn over time.

Figure 4-8
Proposed Paver under Wet Condition
Water will be collected in the wearing holes. The color of paver and textile will change.

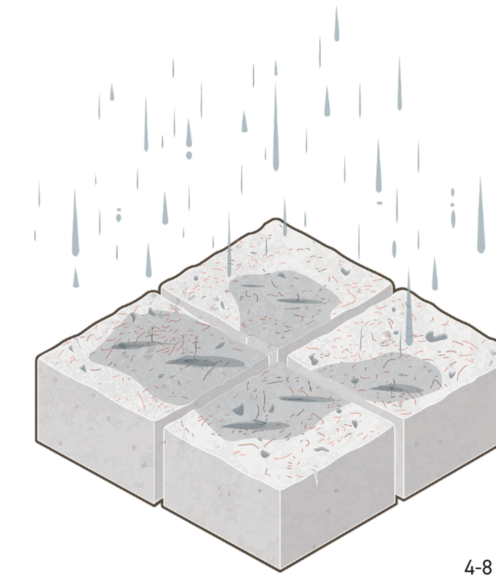
Figure 4-9
Proposed Paver under Snowy Condition
The contrast between snow and colorful fabric strings.

Figure 4-10
Proposed Paver in Fall Season
The contrast between leaves and colorful fabric strings.



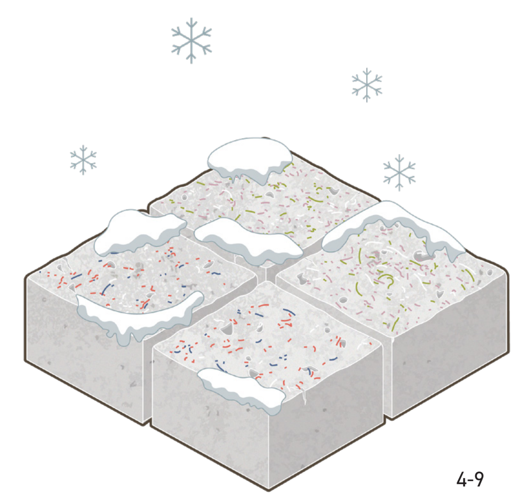
4-7

Service Life



4-8

Wet Condition



4-9

Snowy Condition

4-10

Fall Season

Proposed Geo-textile under Various Conditions

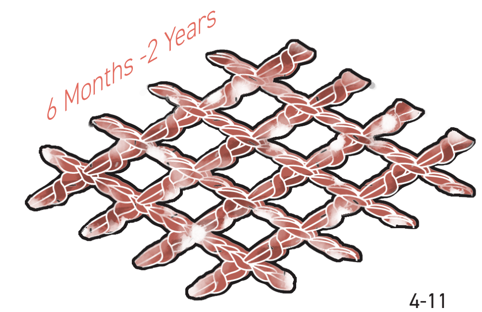
Due to the degradable property, the geo-textile needs to be replaced every six months to two years. Like the existing geo-textile, the proposed material can function for separation, filtration, reinforcement, protection, and drainage. Additionally, the elastic property of the textile offers unexpected play from the mulch as it can bounce with leaves when interacting with outside forces. The grid pattern can also create unexpectedly visual play through snow accumulation.

Figure 4-11
Service Life of Geo-textile

Figure 4-12
Geo-textille under Wet Condition
Separation, filtration, reinforcement, protection, and drainage.

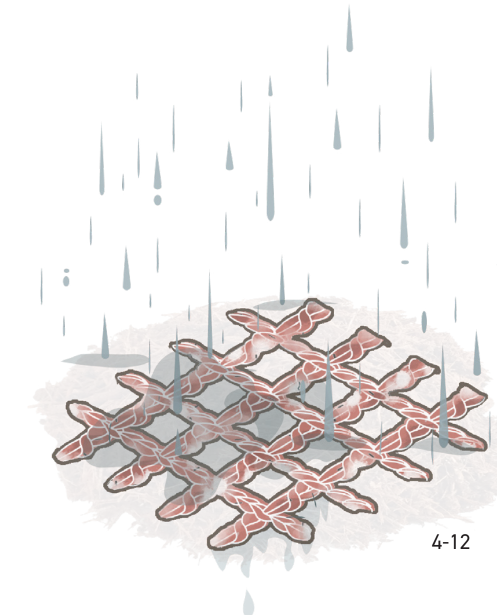
Figure 4-13
Geo-textille under Snowy Conditio
Unexpectedly accumulated snow from the grid pattern.

Figure 4-14
Geo-textille in Fall Season
Unexpected play as it can bounce with leaves when interacting with outside forces.



4-11

Service Life



4-12

Wet Condition

4-13

Snowy Condition

4-14

Fall Season

4-15

Figure 4-15
Playground with Proposed Surface Materials under various conditions

Alternative Uses

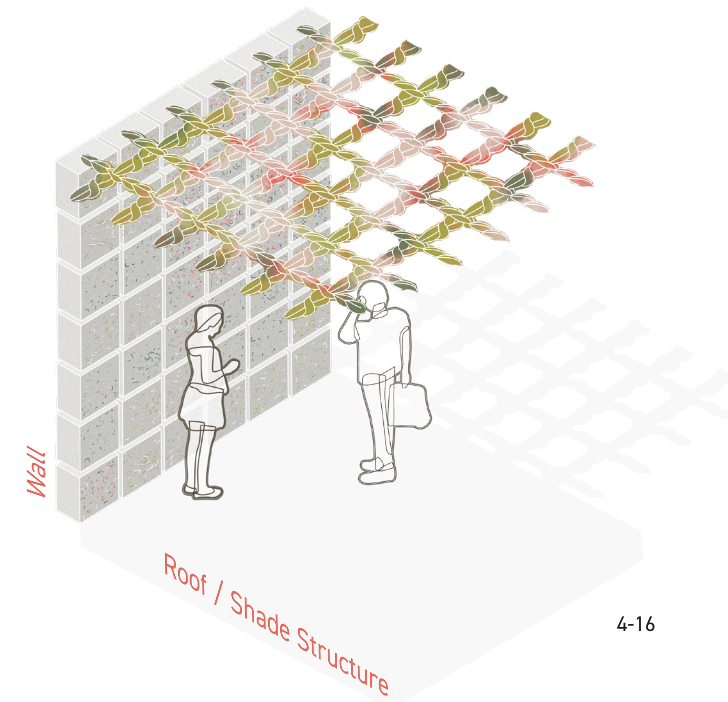
The proposed materials have a wide range of opportunities to be scaled up for other uses, thinking outside the box.

Figure 4-16
Different Dimensionality Use of Proposed Materials
As building fabrics, both proposed hard and soft materials can be considered for vertical and horizontal uses in construction, walls, roof structures, playing equipment, etc., in outdoor and indoor applications. Adding synthetic textiles to the indoor pavement could be the potential for further research.

Figure 4-17
Geo-textile inPlanting Area
Utilizing the common applications for geotextile in the landscape architecture practices, the proposed soft surface system could be positioned underground as a tool for separation, filtration, reinforcement, protection, and drainage.

Figure 4-18
The Possibility of Layering Geo-textile
Layering the proposed soft surfaces or fabricating them into 3-dimensions should be explored further. The performance of bounce and elasticity could make the soft surfaces become the playing equipment without additional playing structures installed.

Figure 4-19
Material Making in Industrial Scale
Explore transforming textile waste into a mold for hard material-making such as concrete casting or brick forming.



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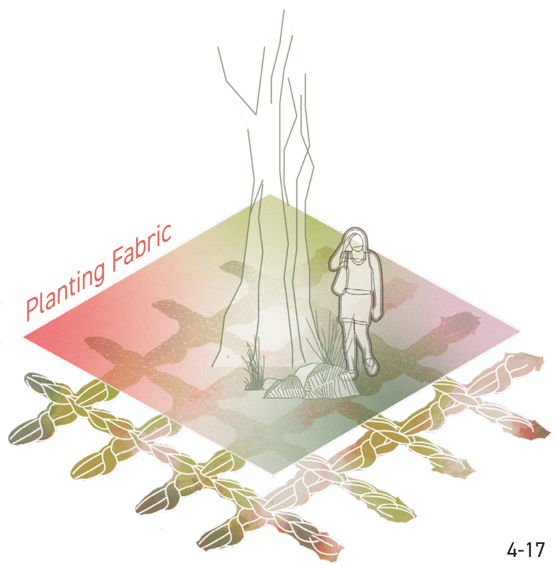

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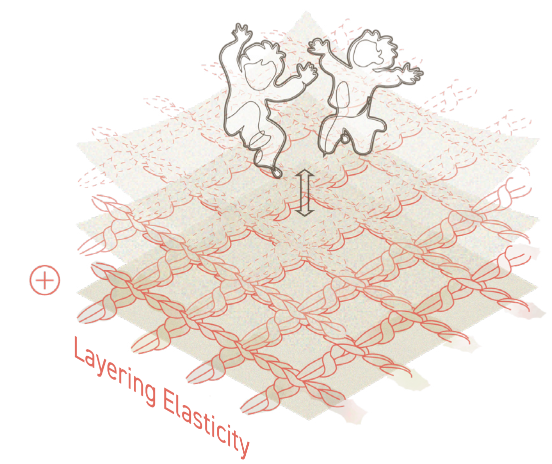

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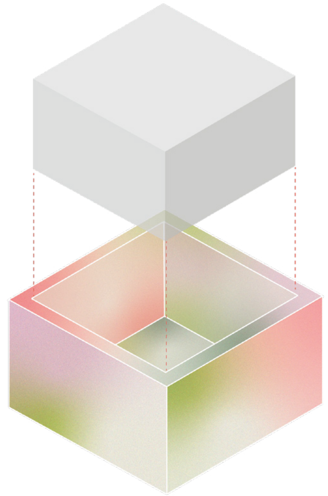


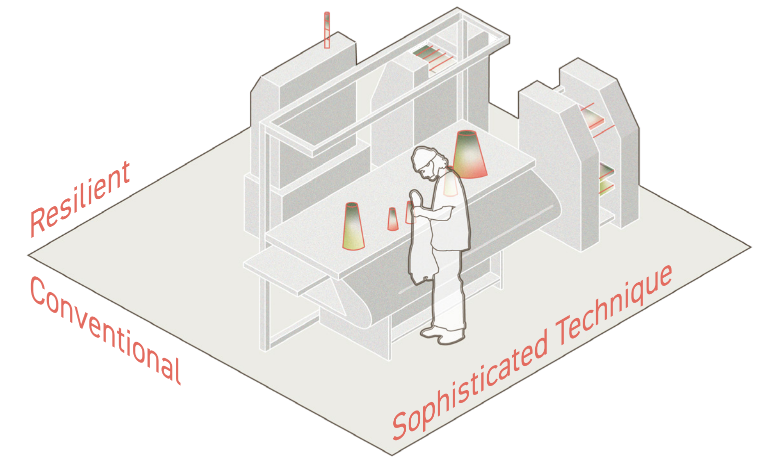
4-19

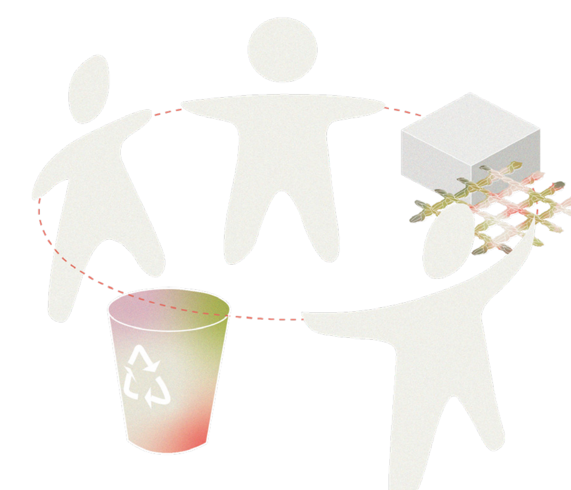
Thesis Reflection

Industrial or community-based production is foreseen for further practical directions of this thesis. Due to the high requirement of recycling textile waste from communities and the goal of improving users' awareness of the value of upcycling, community-based production could be the early phase of the proposed materials making.

The next stage could be reaching out to manufacturers and relevant research teams for more extensive and complex materials production. In the research process, I found a program called Garment to Garment (G2G) from the Hong Kong Research Institute of Textiles and Apparel (HKRITA). They have a relevant production line to recreate objects from textile waste on a larger scale. Connecting with this team and studying their upcycling methods will be a meaningful step for this thesis research.

Figure 4-20
Directions of Further Production Line for Proposed Materials





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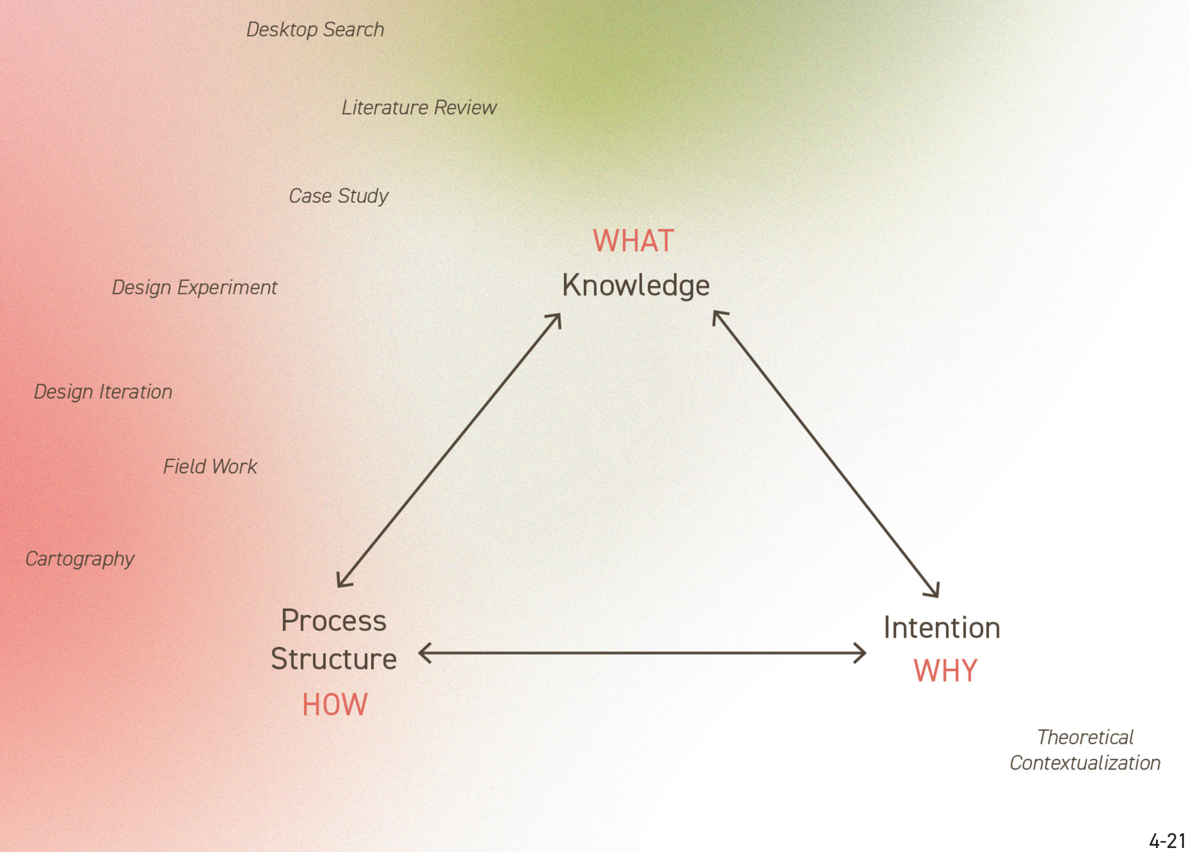

Figure 4-21
Thesis Research Structure Diagram

THESIS CONCLUSION

Recalling the Fall seminar for thesis preparation, Research / Theory / Design, this thesis began with a clear and firm intention: to design a sustainable surface material from textile waste that could be degradable, easy, and affordable to maintain. This initial aim came together from the desire to bring a new sensorial experience from the color and tactility of the textile in order to begin to change and shift away from the prevalent "take-make-discard" culture of the modern world by upcycling waste matter. The thesis research seeks to examine what types of knowledge are required and how the investigation structure for new materials could be stable. All three indispensable elements – intention, knowledge, and research structure – inform this thesis work.

At the end of the thesis, I want to record the meaningful lessons I have learned in the past year, which are valuable for a deeper understanding of landscape architecture. The priority of the focal point could be changed or shifted in a project or research; this is common as long as the changes are rational and coherent. This thesis heavily focused on designing degradable and eco-friendly materials, but it slowly shifts towards users' experiences from the proposed materials. Both goals are crucial for different stages of this research; just the priority group is switched due to the design purposes. Second, changing a system is not always necessary; instead, trying to compromise and find a method to improve the system might be more efficient. At the beginning of the blueprint for this research, I expected to fully transform the textile as a surface material to replace existing ground surfaces. However, I realized that the commonly used materials, such as concrete, have unique properties. Hence, the research shifted to focusing on finding better ways of working with existing materials instead of replacing them. In a landscape architecture project, the design often can not solve all the problems; instead, the project goals are seeking to improve methods and executing the design to meet the priority goals.

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Appendix

Re-use the fabrics

The unneeded fabrics are repurposed into a dog bed for the cover and stuffing.

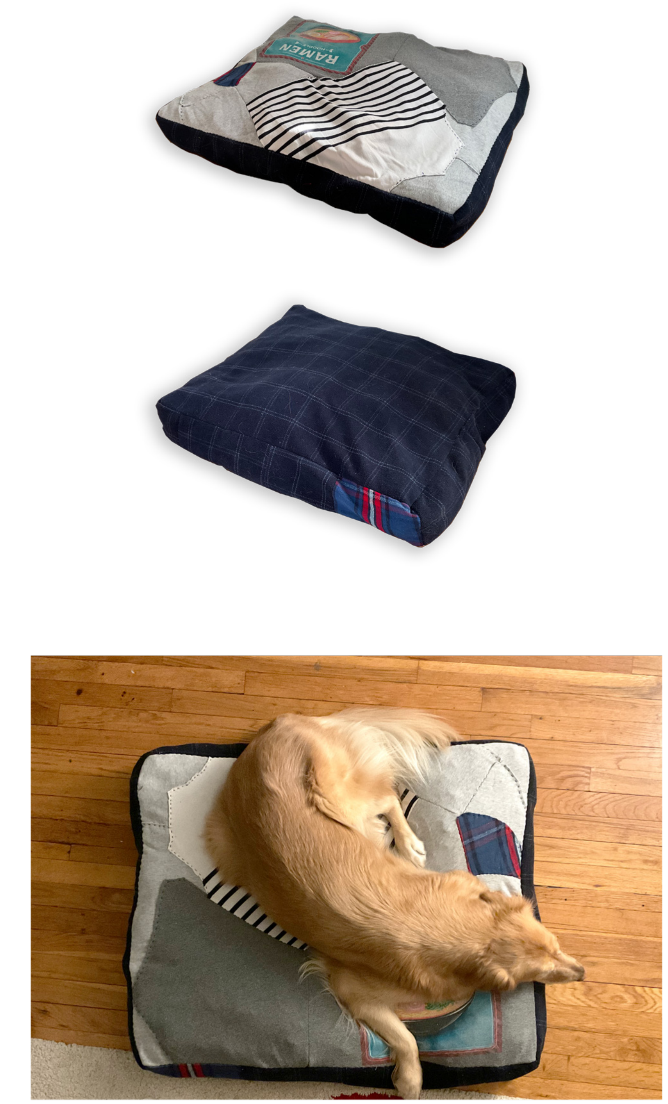

Figure 5-1
Photos of the reformed bed

The Documentation of Fabric Test 03 - Indoor Control Tests

The following images are from the set of open petri dish tests.

The Documentation of Fabric Test 04 - Indoor Control Tests

The following images are from the second sealed petri dish test with richer organic soil.