

PaperStone/PanelTech

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Recycled Paper to Stone

Course Number 1

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Recycled Paper to Stone

There are more than 5000 products made from paper and paper-making by-products.



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Learning Objectives

Understand the basic properties of paper and wood fiber

Consider recycled paper and the options for reuse

Learn about phenolic resin – naturally occurring and man-made

Develop a new understanding of the durability of composite countertops

Ultimately – learn how to turn paper into stone!



What
architectural
purpose?



Commercial













Residential











What is paper?

- Paper is primarily wood fibers formed into a sheet.
- In paper, the wood fibers are held together with relatively weak hydrogen bonds at the points where the fibers make contact. Think of a random pile of round straws that are held together only at the points where fibers come in contact with each other.



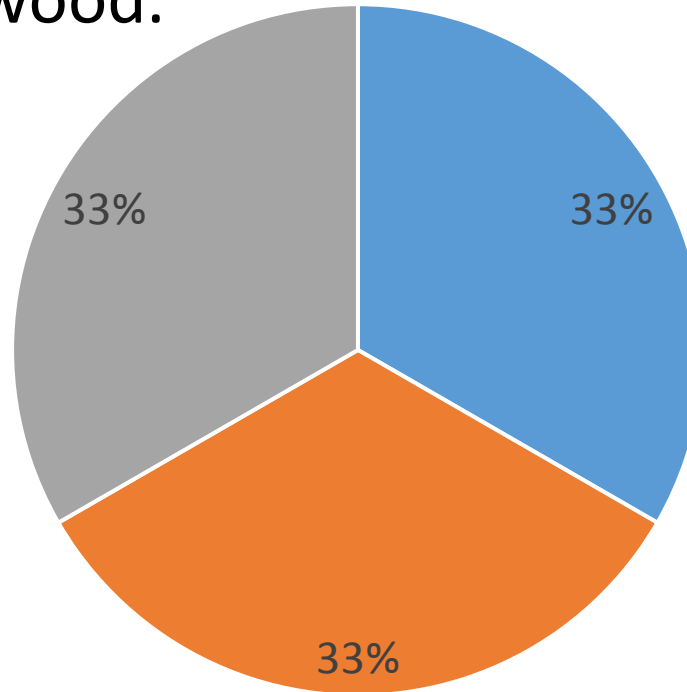
What are wood fibers?



- Wood is comprised of natural fibers called cellulose and a natural glue called lignin.
- A cellulose fiber is an organic polymer (chain of molecules) of glucose shaped in a hollow tube like the straw in the previous example. A fiber is actually very durable, comparable in many ways to a hard bone cell in an animal.
- Lignin is a natural phenolic cross linked polymer that hold the fibers together in wood. Lignin is what makes wood stiff and hard.
- Polymers can be formed in nature such as wood, or man-made such as nylon.

Average raw material source for paper in US

- 33% Trees and other plants.
- 33% Residual from lumber, plywood.
- 33% Recycled Paper.



Source: EPA

How is wood prepared to make paper?

- Wood chips are most commonly cooked with chemicals to liquefy the lignin and liberate the fibers.
- The amount of lignin removed depends on the type of paper. Lignin has a brown or red color. White paper has more lignin removed than brown paper.
- A bleaching agent is required to obtain white.



How do virgin and recycled papers differ?

Recycled fibers come from consumers, offices, manufacturing

Reduces landfill and gets multiple use of same fiber.

Typical recycle before re-processing



Virgin paper fibers come from trees or from solid wood “chips” produced as a by-product of lumber and plywood.

Some sources are non-native species grown in foreign lands – worth checking by discerning consumers.

Wood Chips



Eucalyptus plantation in Brazil – Virgin Fiber



Recycle sources of fiber to make paper

Sorted office paper. A mix of papers collected for recycling that includes white and pastel copy, writing, and printing paper, letterhead and envelopes, notepads, advertising booklets, and fliers. The raw material for white recycled paper.

Old corrugated containers. Cardboard from shipping boxes. Raw material for brown recycled paper.

Box clippings. Cut off pieces from box manufacturing. Additional raw material for brown recycled paper.

Where is recycled paper made?

- **In America!**
- What was this movie filmed in Port Townsend, WA?
- Port Townsend Paper is a maker of recycled paper and the fictional employer of Paula.



Lorimar Film Entertainment, Paramount Pictures

How much paper is recycled in US

- Of the 69 million tons total annual usage, 64% or 44 million tons per year is recycled.



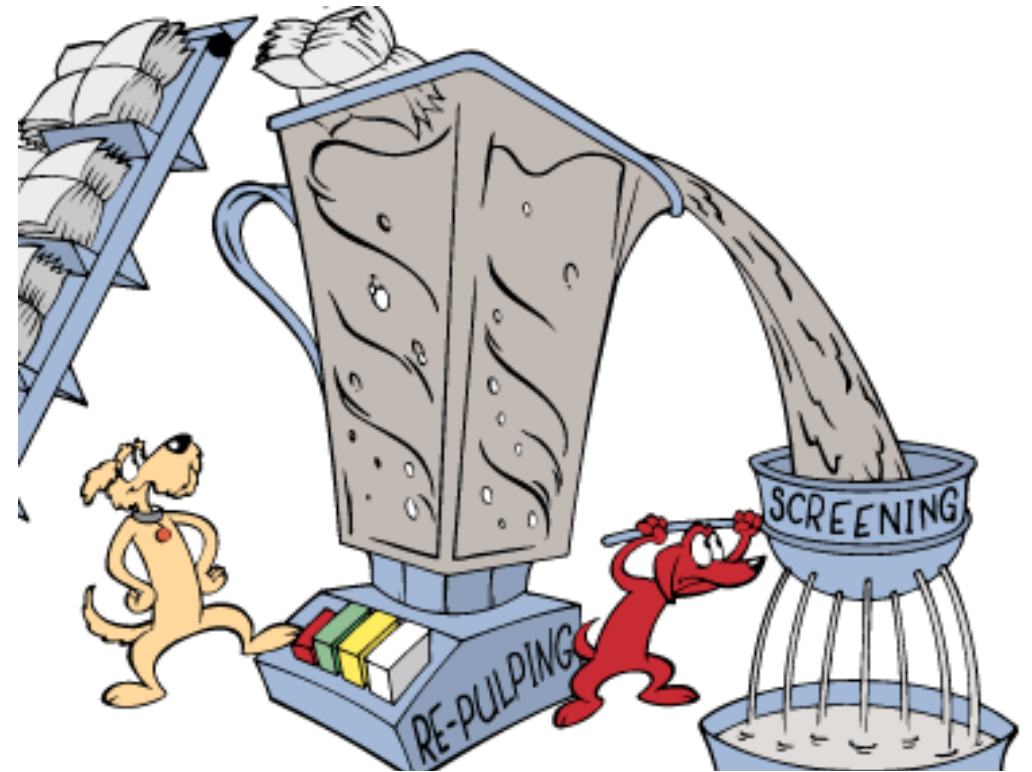
2,200,000
truckloads

What is recycled paper used for

- 53% is used for domestic paper
 - 5% is used for other products
 - 42% is exported
-
- Paper can be recycled 5-7 times. Each time the fibers get shorter, eventually becoming too short to be useful.

How is recovered paper prepared to make new recycled paper

- Recovered paper is mixed with water into a fiber slurry and cleaned in several steps.



Source: Tappi

How are paper fibers formed into paper

- A slurry of wood fibers, water, and other additives is sprayed onto a moving screen.
- Water drains through the screen forming a mat.
- A series of drums and dryers firm and dry the sheet.
- A winder winds the sheet into rolls.



Old style headbox and forming table. A wood fiber/water slurry is metered onto a moving screen belt.

What can be added to paper to make it more durable

- Starch, wax, or other sizing for water resistant bags, cardboard.
- Tar for roofing shingles, roofing felt, tar paper.
- Melamine resin for laminate surfaces.
- Phenolic resin for solid surfaces.

What is phenolic resin?

- Phenolic resin was developed by Belgian-born chemist Leo Baekeland in New York in 1907, to find a replacement for shellac which was made by Lac bugs from tree sap (lignin). Many applications followed.
- There are many different formulas for phenolic resin designed for different purposes.
- Phenolic resin can be purchased from chemical companies or custom manufactured by the consumer with equipment and knowhow.



Flask containing phenolic resin

Properties of phenolic resin

- Extremely durable
- Heat resistant, non-conductive
- Combine with fabrics – organic and inorganic, paper, fiberglass, Kevlar
- Thermoset – when fully cured it retains its shape when reheated unlike thermoplastic materials



Light bulb socket



Carburetor heat shield

Uses of phenolic resin

- circuit boards and electric insulators
- pool balls
- laboratory countertops
- Commercial and residential countertops and vanities
- Restroom partitions
- Building cladding
- coatings and adhesives
- Kitchenware
- Pipe Stems
- Jewelry
- Toys
- Vehicle and structure armor
- saxophone mouthpieces
- Whistles
- Cameras
- solid-body electric guitars
- machine guns, pistol grips
- Soviet heat shields for ICBM warheads and spacecraft reentry

Recycled paper–phenolic composite

- The combination of recycled paper and phenolic resin makes an extremely attractive, durable product.
- A high value re-purpose for recycled paper.
- Recycled paper creates a unique appearance.
- Recycle adds manufacturing challenges.

Bokken – traditional Japanese training sword made from recycled paper – phenolic composite

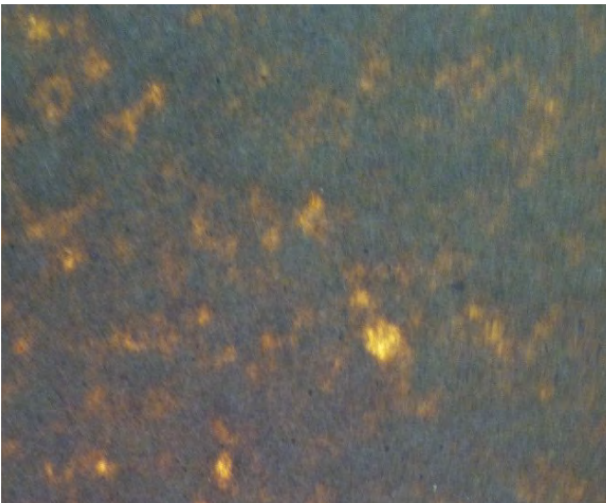




How do virgin and recycled papers look different?

- Recycled paper has fiber clumps and particles of various materials. Much more effort is required to produce a quality product.
- Virgin produces a much more “plastic” appearance.

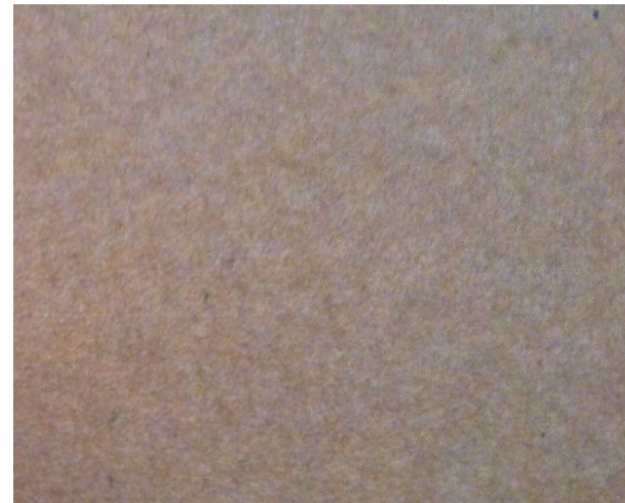
Recycled Cardboard Paper
saturated with phenolic resin



Recycled Office Paper
saturated with phenolic resin



Virgin Paper saturated with
phenolic resin



Virgin
Bleached
over
Recycled
Core

Recycled
Office
Paper



Virgin
Natural
Kraft

Recycled
Natural
Kraft



Paper-Phenolic Products in Construction

- MDO (medium density overlay) and HDO (high density overlay) are extremely durable paper-phenolic surfaces used in concrete forming.
- Have been engineered to stand up to extreme PH levels present in today's concrete mixes which contain fly ash.
- Fly ash is a waste product of energy generation and steel smelting; the repurpose of it is beneficial to the environment.



Shared Intellectual Capital

- Architectural paper-phenolic composite products can benefit from the science and engineering of construction products if both are made by a single manufacturer.
- Paneltech, the maker of PaperStone, is one of the leading suppliers of concrete forming surfaces.



How to make a recycled paper-phenolic composite – Step 1

- First, acquire phenolic resin from one of the three mega chemical companies. Or, make your own using raw materials and formulas that best meet your needs and business objectives.
- The resin properties, such as hardness when cured, are extremely important.



Valves and pipes feeding into a resin reactor

How to make a recycled paper-phenolic composite – Step 2

- Acquire recycled paper stock and other materials that are required to make the desired products.
- There are many grades and density (weight and thickness) of paper. The grade needed is called saturating grade.
- Thickness is important to provide adequate workable surface for sanding, finishing.
- FSC (Forest Stewardship Council) is the third party that certifies the recycle claims are true.



FSC label on a roll of raw saturating grade recycled cardboard paper

How to make a recycled paper-phenolic composite – Step 3

- Soak the recycled paper with partially cured, liquid phenolic resin. The saturated web of paper is then run through a heated oven where the curing of the resin is further advanced. The resin is no longer liquid.



To Ovens



Metering Rolls



Resin Bath



Raw Paper

Paper color

- Colorants can be added to the raw paper by the paper supplier (see Step 2) or to the resin in the saturating step (see Step 3).
- Paper suppliers need larger batch runs to offer colorant. OCC type recyclers generally will not add colorant.

Paper Color

- Saturator added colorant reduces batch size, affords more flexibility in colorant type (pigments, dyes) color selection and quality.
- A choice of bleached vs unbleached has an impact on the environment and it is often made through color selection or manufacturer selection.



How to make a recycled paper-phenolic composite – Step 4

- The web of resin saturated paper is cut into sheets.
- Sheet sizes vary to fit customer needs and/or production constraints. Widths generally 4'-5', lengths 8-12'. Some are limited to 4'x8'.



How to make a recycled paper-phenolic composite – Step 5

- The sheets are stacked on top of each other in the correct quantity to achieve the desired thickness.



How to make a recycled paper-phenolic composite – Step 6

- The stack is held in a hot press under pressure until the resin is fully cured into a three dimensional solid mass surrounding the cellulose fibers. Think of the earlier random pile of straws encased in a solid block of stone, able to easily withstand heat, water, and physical punishment.



Paper Stones!



How do you use paper-phenolic composites

- Cut and fabricate the sheet for the desired application using typical solid surface dry tooling.



- Example applications
(see next 3 slides)

Commercial surfaces













Residential surfaces and wall treatments















Other applications



Thank You