PAPERCRETE RESEARCH

MOVES TOWARD PERFECTION AND CODE COMPLIANCE

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STEP ONE
MAKING PAPER SLURRY

1. The base ingredient: post-consumer paper

2. Jodi adds water to the paper in the tow mixer, a 200 gal. drum with a lawn mower blade mounted in the bottom.

3. The lawn mower blade is driven by a modified T-Bird transmission mounted to this trailer, which is towed by the Ford at a max. speed of 10 mph.

4. The paper slurry mix in progress. Water is added, unwanted trash removed, and trips repeated in the Ford until the desired consistency is reached.

5. A finished paper slurry mix ready for additives.

STEP TWO
MIXING IN ADDITIVES

1. We made several batches of papercrete, combining it with varying ratios of additives such as clay, lime, pumice, sand, and cement.

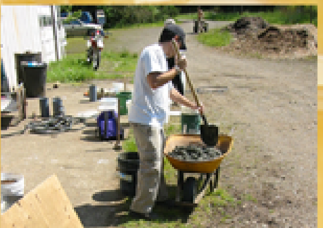
2. The paper slurry and additives are poured into this 55 gal. drum mixer and blended. To the left of the drum is the drainage bed, where excess water is removed and sand added to the mix by hand.

A giant blender: The interior of the 55 gal. drum mixer showing shortened lawn mower blade and drain pipe.

A rain gutter catches the excess water and routes it to a bucket set in a hole. This water is reused for subsequent batches. It also runs fairly clear, leaving desired solids behind.

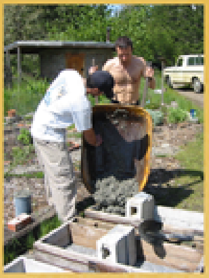
3. Pull the plug and the papercrete mix is released into the drainage bed.

4. Mixing in sand by hand. (Adding sand to the drum mixer creates premature wear on the lawn mower blade.



Trial and Error: Peter makes Jeff mix the hard way, which also proved to be less effective.

STEP THREE
POURING AND CURING



1. The finished papercrete mix is transferred into reusable forms made from scrapwood.

2. Care must be taken at this stage not to compress the mix too much. It diminishes air pockets thereby reducing insulative performance.

3. The Drying Kiln: The forms can be removed from the blocks in about one hour. Reused glass panels are then supported on concrete blocks to protect the papercrete from moisture and expedite the curing process.

These cylindrical samples will be used later for compressive strength testing.

BENEFITS OF BUILDING WITH PAPERCRETE

1. makes excellent use of post-consumer paper, still a major component of our country's landfills
2. extremely low embodied energy -- drying and hardening uses solar energy only
3. both paper and sand are sourced locally, minimizing transportation- related energy consumption
4. unused PC blocks or pieces can be pulped up again and reused on site
5. PC block or panel production happens at the grass-roots level, only a home-built mixer and rough forms are required (decentralized, local manufacturing)
6. PC demonstrates the necessary shift from energy-intensive to more labor-intensive methods (less environmental deterioration, more jobs)

ASHLAND FIELD TRIP

Yeti peers into a state-of-the-art, custom 300 gal. papercrete mixer. Peter is very impressed.

A vortex of papercrete oatmeal.

This mix was later poured (crudely) into the stick-framed walls and floor of an older structure for insulative purposes.

An addition to a house using papercrete as infill within post-and-beam construction. The infill consists of blocks and mortar bound with layers of papercrete stucco.

Ashland team's formwork with integrated mesh for drainage and ventilation.

Ashland's tow mixer.

A Green Beam consisting of four spindly bales of straw bound together and encapsulated with papercrete. (Load resisting characteristics were questionable)

WHERE WE GO FROM HERE

While a range of papercrete buildings have been erected in the US, very little systematic testing has taken place, keeping this grass-roots sustainable construction material from entering main stream construction. Now that we have a variety of papercrete samples, it is time to begin testing for the most critical data-- R-value and compressive strength. The building code requires much more testing in order for papercrete to be accepted as a legitimate building material. Our colleagues in Ashland have begun building a calibrated hot box needed for testing R-value, and are hoping to receive a grant that would allow them to pay for testing at a certified laboratory.

We have sought out a compression testing machine in the architecture department to do preliminary strength tests. However, the machine is dated and needs some mechanical assistance and calibrating before it can be of use. Subsequent testing will include flammability, shear, tensile, water resistance and durability.

Our goal is to find the best material composition which yields the highest strength and thermal performance, while minimizing the embodied energy associated with manufactured products. Therefore, we began experimenting with different mix ratios in order to find the best combination. A common ratio is 70% paper, 20% sand, and 10% cement.

Because cement is toxic and requires a significant amount of energy to produce, a fly ash/lime mix was substituted in some batches to lower the embodied energy. The fly ash/lime mix is a modern binding agent based on historic Roman cement. Other additives include clay, sawdust, hemp, and natural oils. Clay adds a stronger binding element to the mix and is often suggested in stucco mixes. Sawdust and hemp can be used in combination with paper to increase tensile strength. Natural oils, such as linseed, are natural waterproofing agents and are most often added to stucco mixes. These materials are just a few examples of how experimental papercrete "formulas" can be and demonstrates its potential as a green building material.

PAPERCRETE SAMPLES

SAMPLE 1

70% paper, 20% sand, 10% cement

A common mix used for infill purposes only. R-value has been tested at 2.8 per inch. Code requires a wall to be R-21, therefore an 8-10 inch wall is needed.

SAMPLE 2

45% paper, 45% sand, 10% cement

Higher sand content increases thermal mass and compressive strength, but makes for a much heavier block.

SAMPLE 3

67% paper, 16% sand, 8% clay, 8% lime

Lime and clay bond chemically to act as the binding agent in this mix.

SAMPLE 4

67% paper, 16% lime, 16% clay

Because this mix is more pure without sand or cement, it can be used as blown insulation.

SAMPLE 5

78% paper, 12% sand, 6% pumice, 6% lime

This mix produces a very crumbly block due to the excessive aggregate of both sand and pumice. (A mix not worth pursuing)

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