Final Presentation

Recycling Infrastructure & Education

Recycling Team
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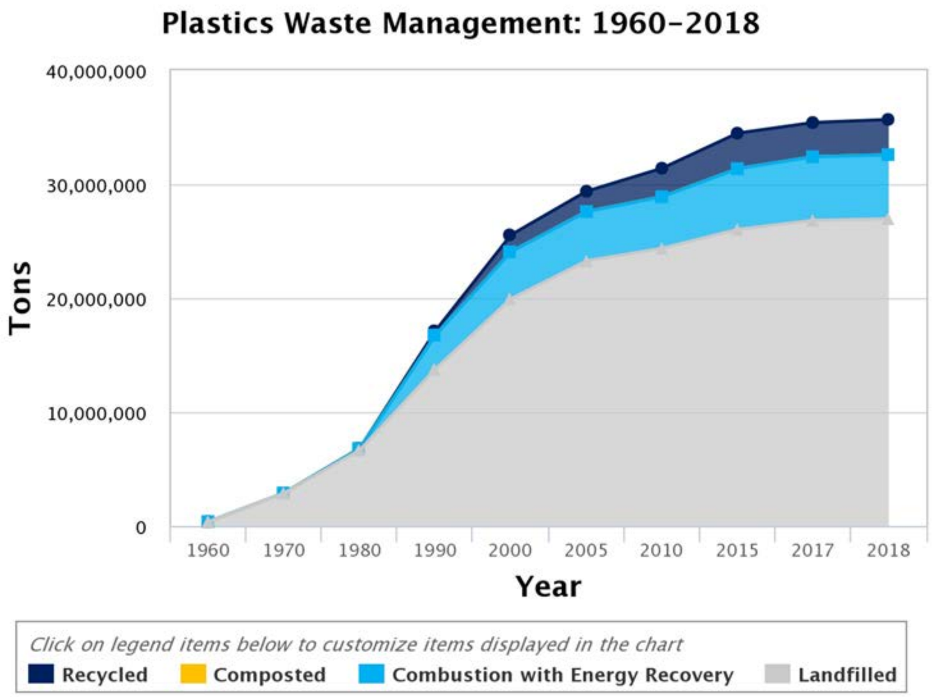
Motivation

- Majority of recycling does not actually get recycled
  - Sorting – Contamination
  - Economics – Demand for Recycled Material
- Major material of concern is plastic #3-7

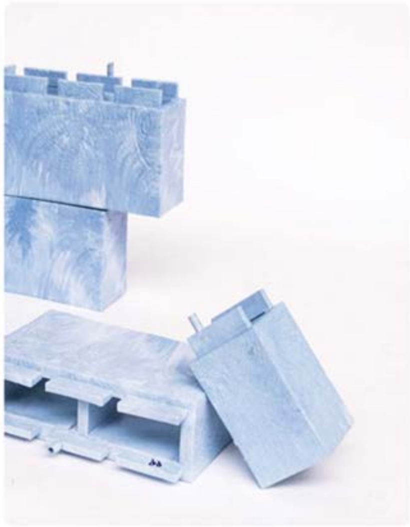


Concepts Considering

Using recycled plastic to create plastic bricks

Objective

- Identify specific waste material
- Test materials and low fidelity prototypes
- Human powered prototype
- Quantify environmental benefits
- Think of potential end users for brick



Factors to Consider: Plastics

USED FOR	RECYCLABILITY	HEALTH	NOTES
PLASTIC #1 - POLYETHYLENE TEREPHTHALATE (PET)			
01 PET • soft drink, water, and other beverage bottles • detergent and cleaning containers • peanut butter and other food containers and bottles	PET is recycled into: new bottles, polyester for fabrics and carpet, fill for bumper cars and fiberfill for sleeping bags and jackets.	No known health issues.	PET is one of the most easily recycled plastic.
PLASTIC #2 - HIGH DENSITY POLYETHYLENE (HDPE)			
2 HDPE • milk and water jugs • laundry detergents, shampoo, and motor oil containers • shampoo bottles • some plastic bags	Clear HDPE containers are easily recycled back into new containers. Colored HDPE are converted into plastic lumber, lawn and garden edging, pipes, rope, and toys.	No known health issues.	HDPE is easily recycled.
PLASTIC #3 - POLYVINYL CHLORIDE (PVC OR V)			
3 PVC • clear food packaging, cling wrap • detergents and window cleaner bottles • some plastic squeeze bottles, cooking oil and peanut butter jars • vinyl pipes • shower curtains • flooring, home siding, and window and door frames	PVC is one of the least recyclable plastic due to additives. Potentially harmful substances are also created by its disposal.	Many harmful chemicals are produced in the manufacturing, disposal, or destruction of PVC including: • Lead • DEHA (di(2ethylhexyl)adipate) • Dioxins • Ethylene dichloride • Vinyl chloride Effects of exposure to these chemicals may include: decreased birth weight, learning and behavioral problems in children, suppressed immune function and disruption of hormones in the body, cancer and birth defects, genetic changes.	Harmful chemicals created as a byproduct of PVC can also settle on grassland, where they can be consumed by livestock, and accumulate in meat and dairy products that are directly ingested by us.
PLASTIC #4 - LOW DENSITY POLYETHELENE (LDPE)			
4 LDPE • bread, frozen food, and grocery bags • most plastic wraps • some bottles	LDPE is not usually recycled.	No known health issues.	While no known health effects associated with the use of this plastic are known, organic pollutants are formed during manufacturing.
PLASTIC #5 - POLYPROPYLENE (PP)			
5 PP • deli soups, syrup, yogurt and margarine containers • disposable diapers • outdoor carpet • house wrap • clouded plastic containers, e.g. baby bottles, straws	PP is not easily recycled. Differences in the varieties of type and grade, mean achieving consistent quality during recycling is difficult.	No known health issues.	
PLASTIC #6 - POLYSTYRENE (PS)			
6 PS **Rigid Polystyrene** • CD cases • disposeable cutlery **Formed Polystyrene (Styrofoam)** • food containers • packaging • insulation • egg cartons • building insulation	Recycling PS is possible, but not normally economically viable.	Styrene can leach from polystyrene. Over the long term, this can act as a neurotoxin. Studies on animals report harmful effects of styrene on red-blood cells, the liver, kidney, and stomach organs[1]. [1] US Environmental Protection Agency (1992) "Styrene". Air Toxics Website. Retrieved on 31/1/2008 from http://www.epa.gov/ttn/atw/hlthef/styrene.html Styrene can be absorbed by food, and once ingested can be stored in body fat. It is thought that repeated exposure could lead to bioaccumulation[2]. [2] WHO International Programme On Chemical Safety. "Styrene". Environmental Health Criteria 26. Retrieved on 31/1/2008 http://www.inchem.org/documents/ehc/ehc/ehc26.htm	Try reusing styrofoam packing peanuts, and polystyrene cutlery where practical.
PLASTIC #7 - MIXED (OTHER)			
7 OTHER • lids • medical storage containers • electronics • most plastic baby bottles • 5-gallon water bottles • "sport" water bottles • metal food can liners • clear plastic "sippy" cups • some clear plastic cutlery	Mixed resin plastics like #7 are difficult, if not impossible, to recycle.	Health effects vary depending on the resin and plasticizers in this plastic that often includes polycarbonates. Polycarbonate plastic leaches bisphenol A (BPA) a known endocrine disruptor. By mimicking the action of the hormone, estrogen, bisphenol A has been found to: effect the development of young animals; play a role in certain types of cancer; create genetic damage and behavioral changes in a variety of species. bisphenol A is widespread--one study found BPA in 95% of American adults sampled[3]. [3] Calafat, A.M., Kuklenyik, Z., Reidy, J.A., Caudill, S.P., Ekong, J. & Needham, L.L. (2005) "Urinary Concentrations of Bisphenol A and 4-Nonylphenol in a Human Reference Population" Environmental Health Perspectives **113**: 391-395. Retrieved 31/1/2008 from http://www.ehponline.org/members/2004/7534/7534.html	The number of studies documenting the detrimental effects between BPA and health are increasing.

Picking Plastics to Work With

Plastic type	Accessibility (0.5)	Environmental Benefit (0.75)	Feasibility (shredding, extruding/melting) (1)	Energy Consumption (0.25)	**Score**
#1 PET/PETE	5	3	3	2	8.25
#2 HDPE	5	3	3	5	9
#4 LDPE	3	5	4	5	10.5
#5 PP	3	4	3	4	8.5
#6 HIPS	4	4	1	4	7

Low Fidelity Testing Procedure

Materials: scissors, aluminum foil, beaker, tin can, bunsen burner, metal stick, thermometer

Tested plastics: #2 (plastic bag, jug), #1 (bottle), #6 (solo cup, lid), #5 (yogurt container)

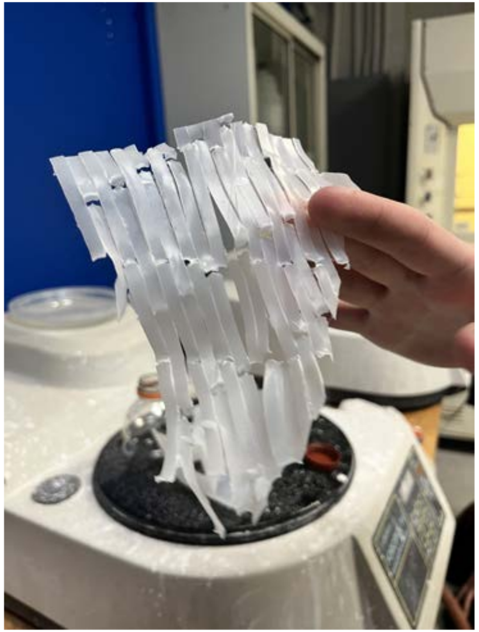
Method:

Melt small pieces of different plastic types over a hot plate in a fume hood.

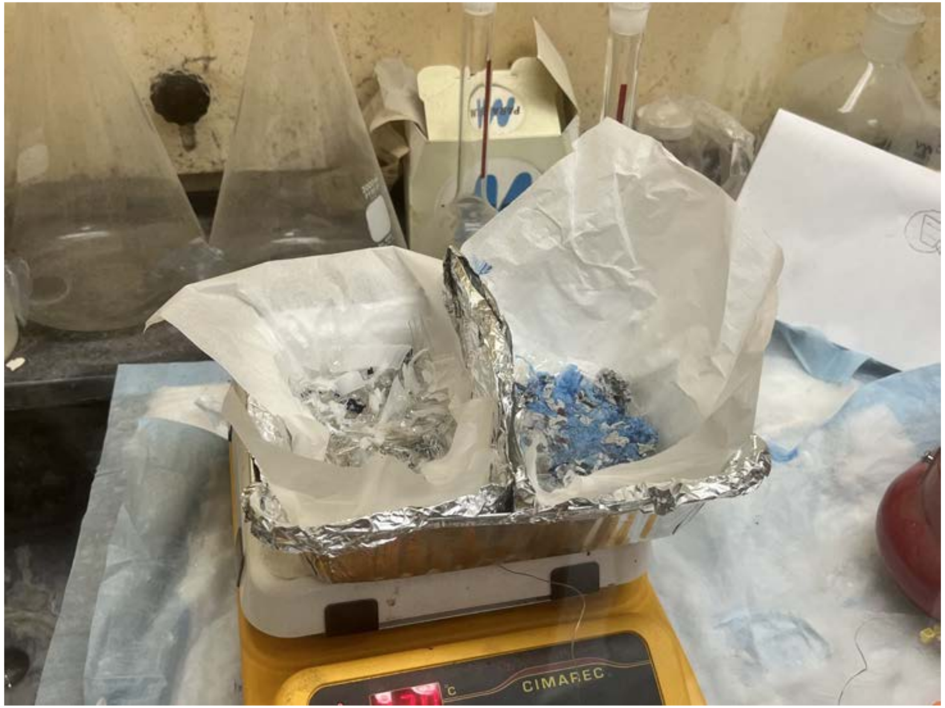
Observe melting time, malleability of material, create small brick.

Prototype Testing: Shredders

Credit Card Shredder ✓

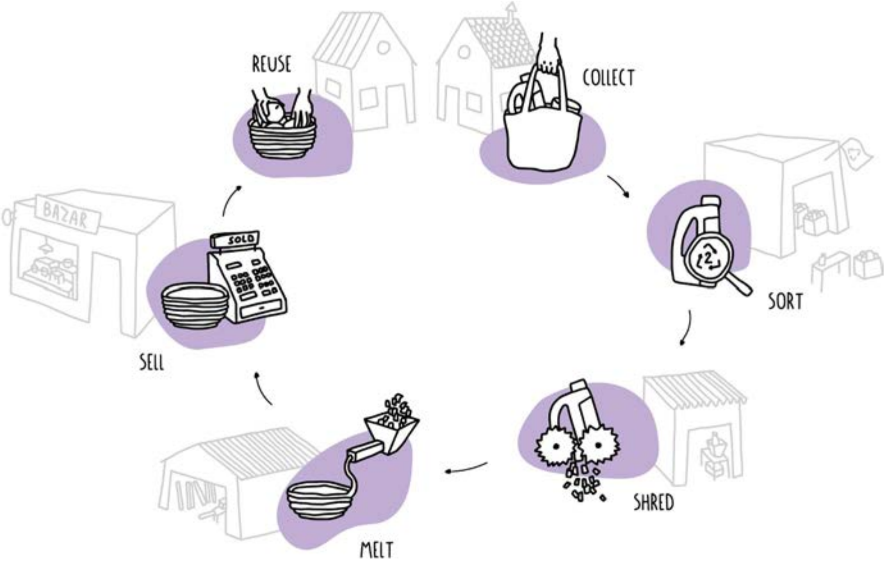


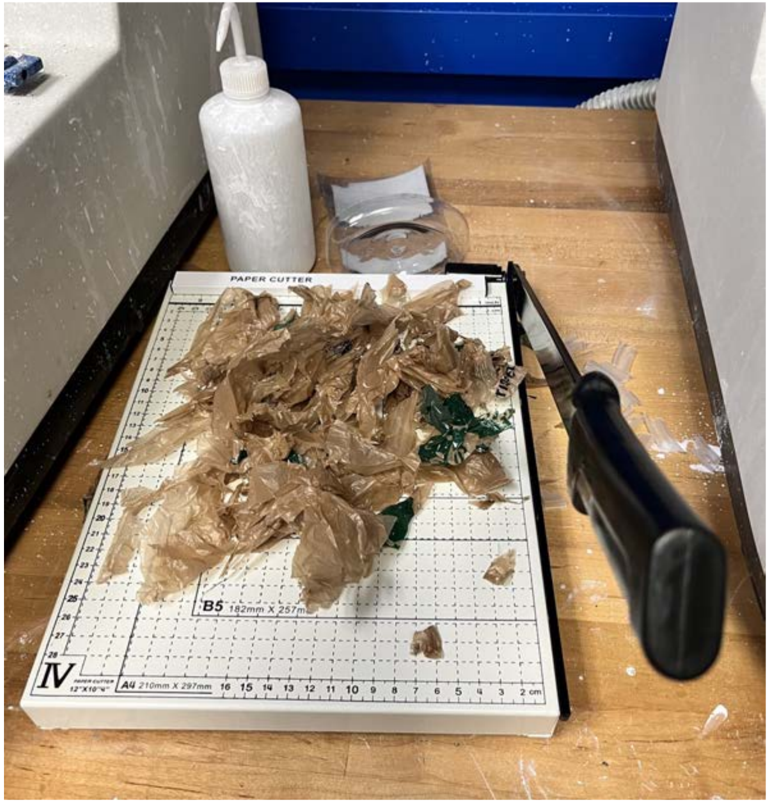
Melting Testing


CIMAREC

Factors to Consider: Required Materials

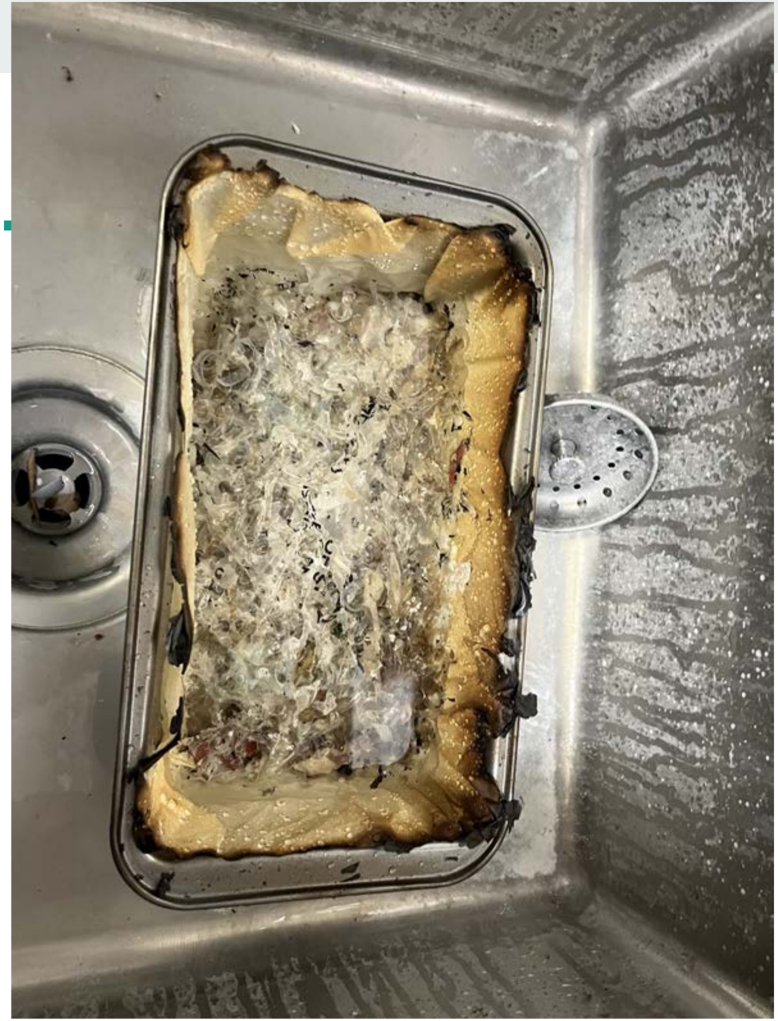
- Shredding
  - Low Fidelity: Scissors
  - High Fidelity: paper cutter & credit card shredder
- Extrusion/Melting
  - Low Fidelity: Hot plate
  - High Fidelity: Toaster oven
- Molding
  - Low Fidelity: Tin can
  - High Fidelity: Bread Pan
  - Aluminum foil, parchment/wax paper

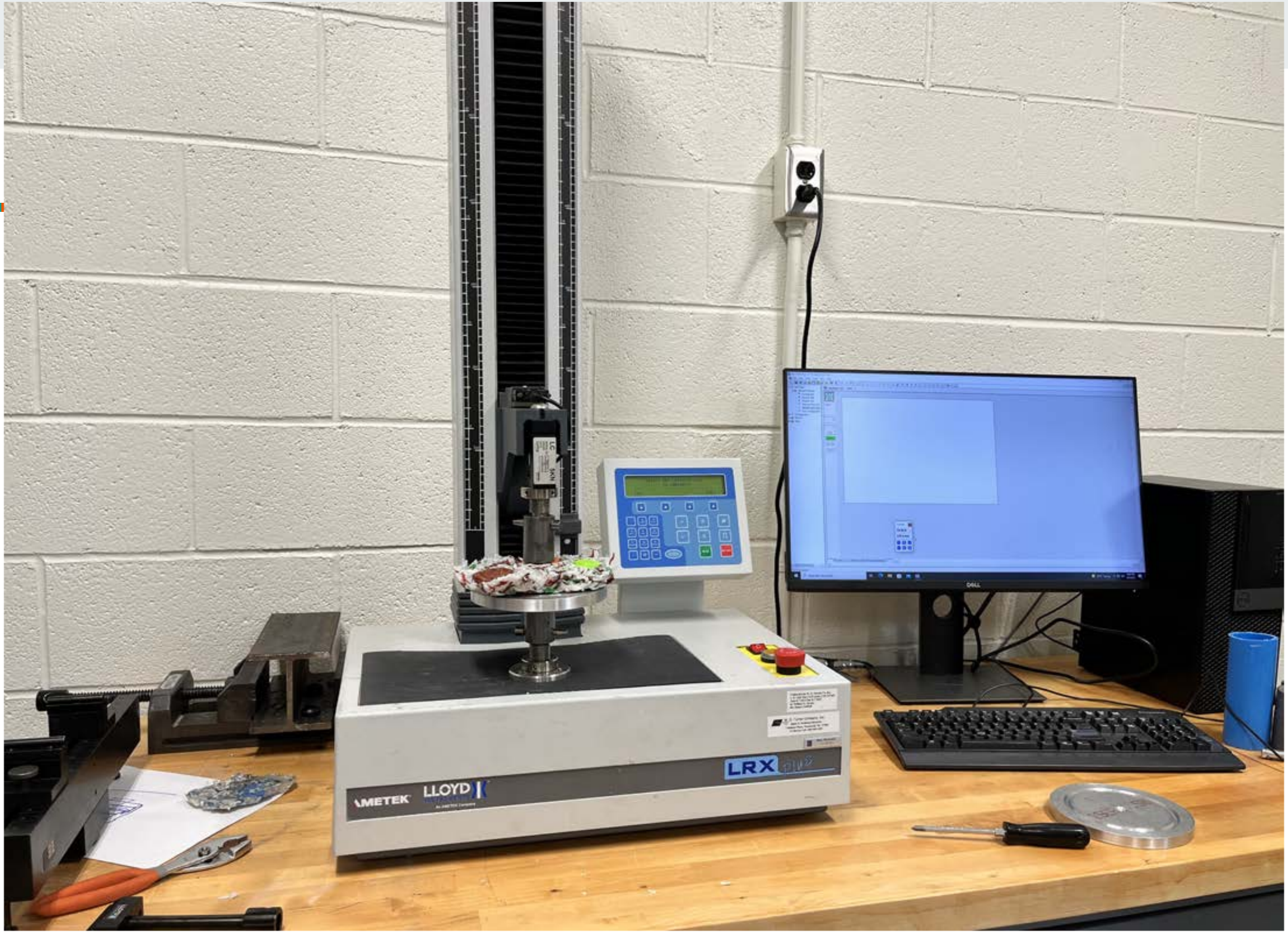



PAPER CUTTER
B5 182mm X 257m
IV
A4 210mm X 297mm


Cuisinart


METTLER TOLEDO
42.81





AMETEK
LLOYD
LRX

Brick 1

Brick 2

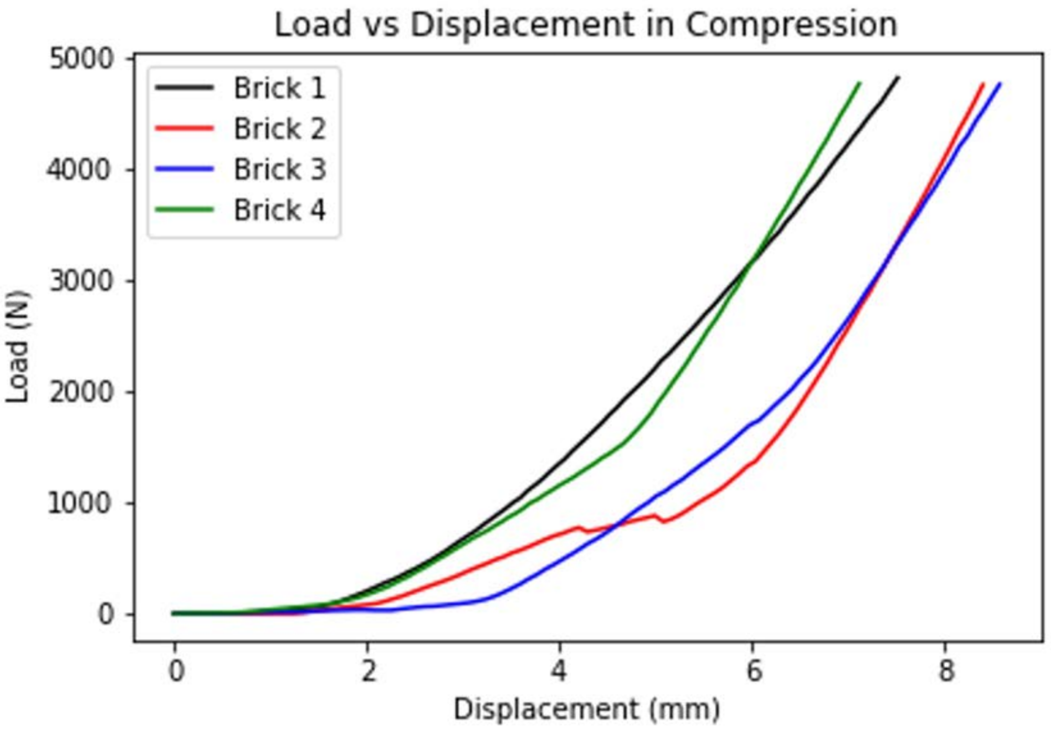
Brick 3

Brick 4

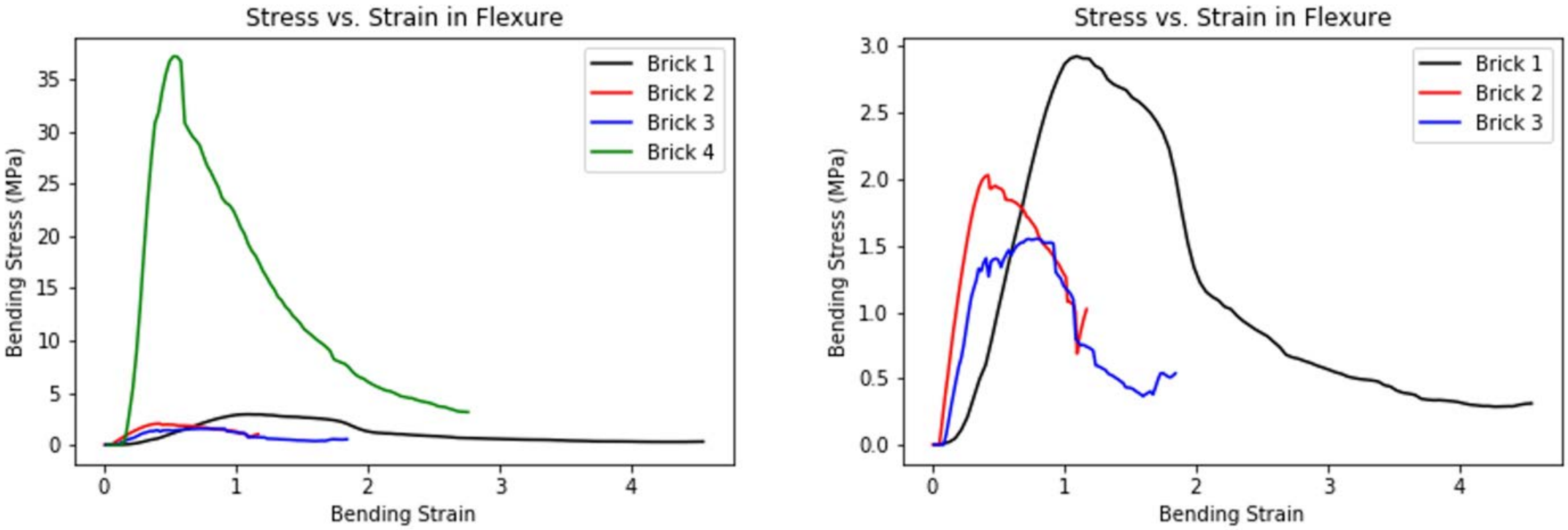
Results: Test Samples

Brick	Dimensions l x w x h (in)	Density (g/in^3)	Composition	Ultimate Flexural Strength (MPa)
1 (non-uniform)	8 x 4.5 x 1	5.83	Plastics #1,2,4,5, Mostly #1, 2	2.92
2 (uniform)	4.5 x 3 x .5	7.26	Plastics #1,2,4,5 (25% of each plastic)	2.03
3 (uniform)	4.5 x 3 x .5	7.11	Plastics #1, 2	1.55
4 (uniform)	8 x 4.5 x .5	12.5	Plastics #1,2,4,5, (Mostly #5, 1)	37.19

Results: Compressive Strength from Compression Test



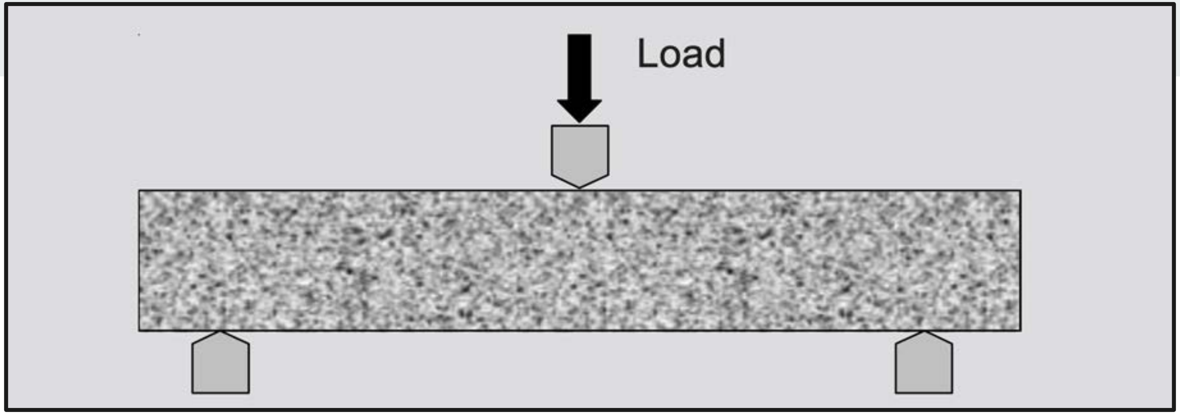
Results: Flexural Strengths from 3-Point-Bend Test



Results Compared to Standard Bricks

Material	Compression Strength - σ -		Tension Strength - σ -	
	psi	*MPa*	*psi*	*MPa*
Bricks, hard	12000	80	400	2.8
Bricks, light	1000	7	40	0.28
Brickwork, common quality	1000	7	50	0.35
Brickwork, best quality	2000	14	300	2.1
Granite	19000	130	700	4.8
Limestone	9000	60	300	2.1
Portland Cement, less than one month old	2000	14	400	2.8
Portland Cement, more than one year old	3000	21	500	3.5
Portland Concrete, 28 days old	5000	35	200	1.4
Portland Concrete, more than one year old	6200	43	400	2.8
Sandstone	9000	60	300	2.1
Slate	14000	95	500	3.5
Trap rock	20000	140	800	5.5

https://www.engineeringtoolbox.com/compression-tension-strength-d_1352.html



Characteristic compressive strength (MPa)	Flexural Strength (MPa)
20	3.13
25	3.50
30	3.83
35	4.14
40	4.43
45	4.70
50	4.95

Flexural strength of various grades of concrete as per IS code

Benefits: Environmental and Social

- Each brick uses ~200 g of plastic
  - Roughly 22 standard water bottles (16 oz)
- Plastics #1, 2, 4, and 5 were used
- Estimated life cycle of bricks:
  - Requires further research (effects of weather, sun, etc.)
  - Plastic bottle takes 450 years to decompose
- Presence of recycled bricks on campus encourages recycling

Environmental Benefits

- Energy consumption/emissions compared to concrete production
  - Concrete: 2775 MJ per m^3
  - Plastic: 3.24 MJ per brick (.0005 m^3)
  - ByBlock: creates 41% less emissions
- Emissions saved due to lack of transportation
- Environmental damage prevented by lack of mining

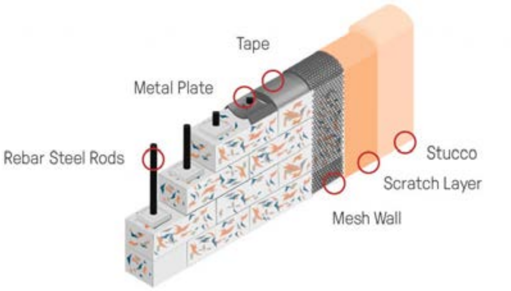
Costs

- The total cost of materials: $248.84.
- Total time to make: 90 min
- Precious Plastic Project’s kit for creating bricks: $10,200.

https://preciousplastic.com/starterkits/buy/bricks.html

Compared to Standard Bricks

- Clay/concrete bricks: $0.30-$0.90 per brick.
- What's better about plastic:
    - Thinner, lighter, have heat insulating properties 5x greater than standard bricks, are highly effective at noise insulation, and are better for earthquake zones due to the flexibility of the material.
- Added Profits
    - Plastic crediting, plastic offsetting, market incentives, and government funding will support the production of plastic bricks.



Potential End Users

- On campus/in local area
  - Pallets for K-Ville
  - Decoration/art (raising awareness for recycling)
  - Landscaping/gardening (no leaching)
  - Benches
  - Fences
  - Construction – Light/heavy structural loads, wall fillers
    - More research needed before heavy structural loads
- Outside of local area
  - Earthquake zones
  - Rural/low income areas

Conclusions & Successes

- We learned more about the difficulties of the recycling process.
- We created a cheap and accessible process for making plastic bricks.
- We found that multiple types of plastic can be used in one brick (#1, 2, 4, 5), which relieves the pressure of sorting.
- Limitation of mixing plastics: differing melting points and burning
- Our research can motivate people to continue recycling, push for the elimination of unrecyclable plastics (#3, 6, 7), and encourage mass production of recycled products (such as bricks).

Further Testing

- Differing percentages of each plastic and their corresponding strengths.
- Effects of additives (such as fire retardants).
- How they withstand heavy structural loads, exposure to sun, interactions with other materials and contamination.
- Handling/eliminating emissions from melting/burning.

Type	Composition (%)			Compressive Strength Average	
	Plastic	Cement	Sand	Kg/cm^2	N/nm^2
A	50	50	-	>100	>10
B	75	25	-	100-80	10-8
C	69	23	8	80-60	8-6
D	66	22	12		

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