FAP-BRIX:
A PRACTICAL SOLUTION TO LESSEN PLASTIC POLLUTION

All figures, tables, graphs, and photographs by Akshadha Mehta

Abstract

Nearly 300 million tons of plastic waste are produced every year and experts estimate it to grow at an annual rate of 9%. 73% of all litter on beaches worldwide is plastic. Most of these ends up in ocean killing 1 million marine animals due to plastic pollution every year.

Most plastics are made of polypropylene and polyethylene, that can take 500-1,000 years to degrade, adding million tons of plastic waste to the environment. Also, plastic production consumes higher energy and releases greenhouse gases. One possible solution is recycling plastic in the construction industry. The objective of this project is to efficiently recycle plastic waste with fly ash and lime to reduce the use of cement to create FAP-BRIX, an eco-friendly alternative to traditional bricks.

Plastic waste like newspaper bags, milk jugs, yogurt containers, water bottles, etc. were collected and cleaned. FAP-BRIX were created by mixing different proportions of shredded and melted plastic waste (0%,10%,20%,30%,40%), fly ash (60%,60%,50%,40%,30%), sand (18%), lime (12%) and cement (10%,0%,0%,0%,0%) respectively and cured for 21 days. To evaluate the efficiency of the FAP-BRIX, the manufacturing cost was derived, and various tests were conducted as per ASTM C67 procedures to determine the compressive strength, tensile strength, heat resistance, water absorption, and efflorescence.

Results showed that compared to traditional bricks, the FAP-BRIX has at least 4 times greater compressive strength, lower water absorption, at least 50% lower cost, and were lightweight.

FAP-BRIX is a groundbreaking concept that transforms plastic waste into a construction material, offering a sustainable alternative to traditional bricks. It is the most economical and environmentally friendly solution that will revolutionize the construction industry.

Introduction

- Consider the amount of plastic we trash or recycle every day. There's a lid to a coffee cup, a newspaper bag, a yogurt container, and plenty of packaging materials. These plastics, though convenient, pose a grave environmental challenge as they are non-biodegradable and can take millions of years to decompose, contributing to plastic pollution.
- Simultaneously, the construction industry heavily relies on cement, a material known for its environmental impact and costly production process. Also, fly ash, a waste product from burning coal in power plants, pollutes the environment by releasing harmful particles and toxins.
- To address these challenges, we need a sustainable solution that recycles plastic waste and benefits the construction industry while reducing environmental pollution.

Objectives

- To efficiently recycle plastic waste with fly ash to lower the usage of clay, cement, or sand to create an eco-friendly alternative to traditional bricks, thereby reducing toxic pollution in our environment.

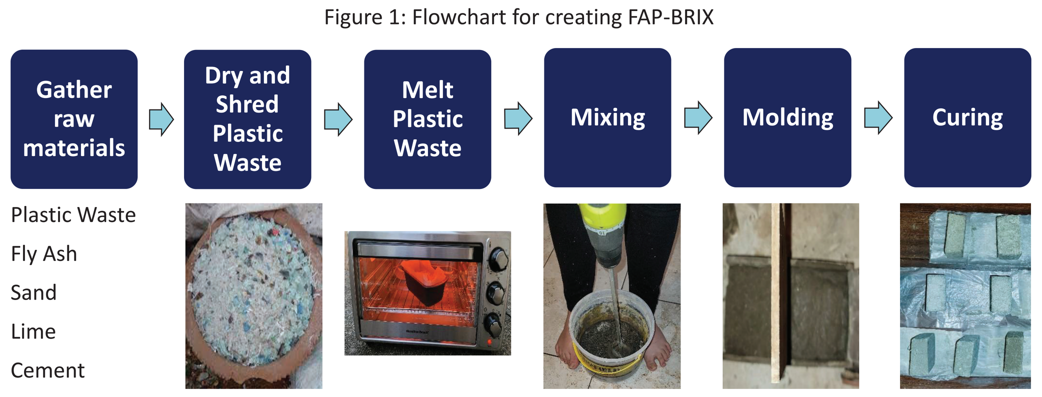
Hypothesis

- If environmentally friendly Fly Ash-Plastic Bricks (FAP-BRIX) are made using plastic waste, fly ash and lime by reducing the use of clay, cement, or sand then it will be cost effective, lightweight, durable, and less water-absorbent. I base this hypothesis on the fact that fly ash and plastic waste are lighter and when mixed with lime it creates high strength of the mix. Also, polypropylene and polyethylene will contribute to chemical stability, hardness, and moisture resistance.

Plan

- Brainstorm ideas on recycling plastic waste and their environmental impact.
- Determine the right proportion of materials to make efficient Fly Ash-Plastic Bricks.
- Create sample bricks using the flowchart below.

Figure 1: Flowchart for creating FAP-BRIX



Materials

- Plastic waste
- Fly Ash
- Lime
- Sand
- Cement
- Water, Distilled Water
- Stucco Mixer
- Weighing Scale
- Compression Testing Machine
- Burner/Stove/Oven

Variables and Constants

- **Independent Variables:**
  - Plastic waste
  - Fly ash
  - Cement
- **Dependent Variables:**
  - Compressive Strength
  - Tensile Strength
  - Water Absorption %
  - Bulk Density
  - Heat Resistance
  - Efflorescence Presence
  - Weight
- **Constants:**
  - Lime
  - Sand
  - Distilled Water
  - Stucco Mixer
  - Weighing Scale
  - Compression Testing Machine

Test Results

Tests Conducted

To evaluate the efficiency of the FAP-BRIX, thirty sample bricks were created with six samples for each proportion. The following tests were conducted as per ASTM C67 procedures at the 7th day and 21st day, and their mean data value was recorded:

- **Compressive Strength and Tensile Strength Tests:** These tests were carried out at the construction lab in Kennesaw State University. To test, the sample brick was placed in the compression testing machine and uniform load was applied continuously until it broke down.

$$\text{Compressive Strength} = \frac{\text{Applied Max Load} \times 1000\ (\text{N})}{\text{Cross Sectional Area}\ (\text{mm}^2)}$$

- **Water Absorption Test**: This test was carried out by taking the dry weight (W_1) and wet weight (W_2) after submerging the bricks in water for 24 hours. The water absorption percentage was calculated.

$$\text{Water Absorbtion in \% by Weight} = \frac{W_2 - W_1}{W_1} \times 100$$

- **Heat Resistance Test:** This test was carried out to determine the heat resistance of the FAP-BRIX brick by placing the sample in the Thermolyne Furnace at 650°C for 24 hours.
- **Bulk Density Test**: Bulk density of a brick is its mass per unit volume, where unit volume is calculated by multiplying the length, width and height of the brick.
- **Efflorescence Test**: This test was carried out to determine if there is any salt deposition on the FAP-BRIX brick's surface.
- **Weight Comparison Test**: The proportional weight of the traditional brick was compared with FAP-BRIX brick based on the unit volume of each sample brick.

Data

Table 1. FAP-BRIX Bricks Mix Proportion and Cost Analysis

Brick Sample Type	Plastic Waste %	Fly Ash %	Sand %	Lime %	Cement %	Material Cost	30% Overhead plus 20% Profit Cost	Total Cost
B1	0	60	18	12	10	$0.24	$0.13	$0.37
B2	10	60	18	12	0	$0.18	$0.10	$0.28
B3	20	50	18	12	0	$0.18	$0.10	$0.27
B4	30	40	18	12	0	$0.17	$0.10	$0.27
B5	40	30	18	12	0	$0.16	$0.09	$0.26

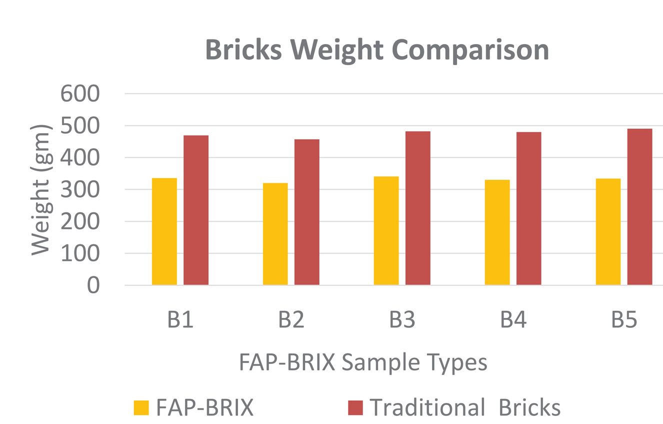
Table 2. Material Cost

Material	Weight (LB)	Cost
Fly Ash	2000	$25.00
Sand	50	$4.10
Lime	2000	$300.00
Cement	94	$12.15

- From Table 1, it is evident that the total cost to make FAP-BRIX is about $0.30 per brick. That is very cost effective as compared to traditional brick which cost between $0.50 and $1.

Table 3. FAP-BRIX Bricks Weight Comparison Data

Brick Sample Type	Dry Weight gm	Volume cm^3	Proportional Weight of Traditional Brick gm	% Lighter than Traditional Brick
B1	336	240.73	469.3	28
B2	320	234.59	457.33	30
B3	341	247.24	481.99	29
B4	330	246.15	479.86	31
B5	334	251.45	490.2	32



- Table 3 results indicate that the environmentally friendly FAP-BRIX bricks were about 30% lighter than the traditional bricks.

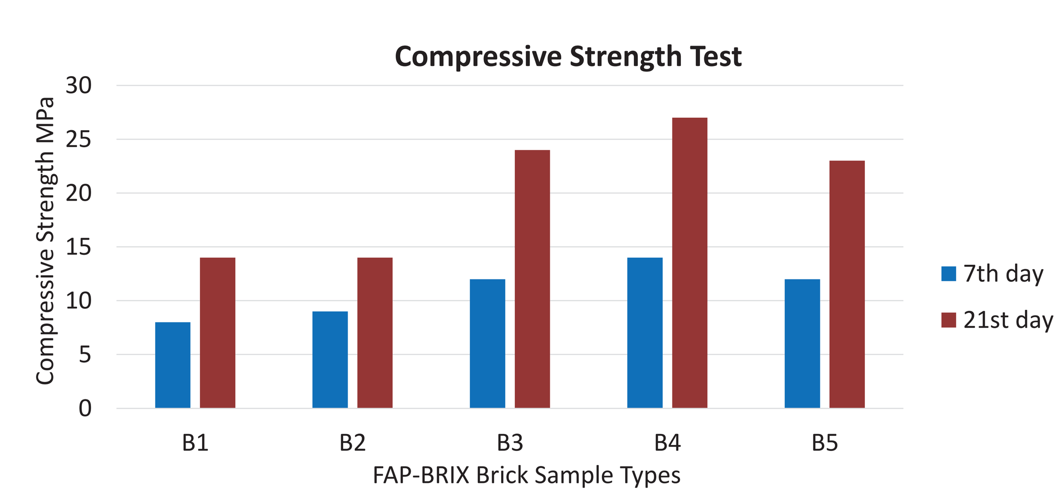
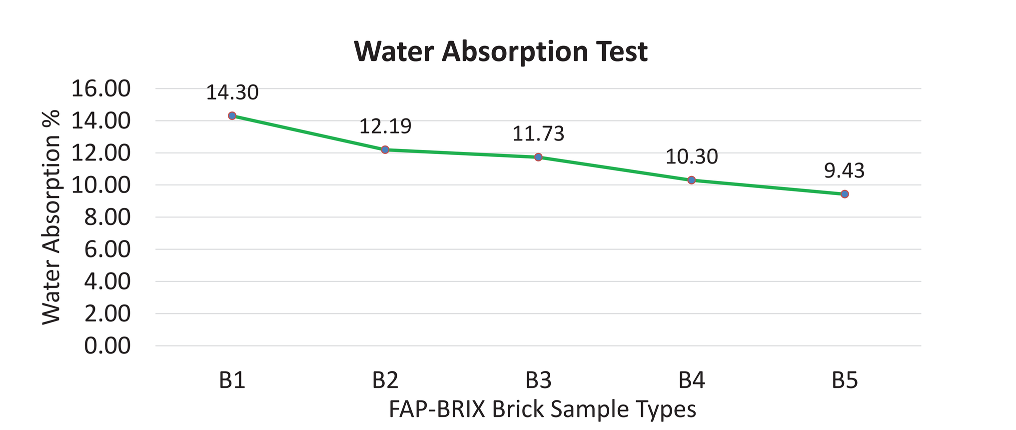


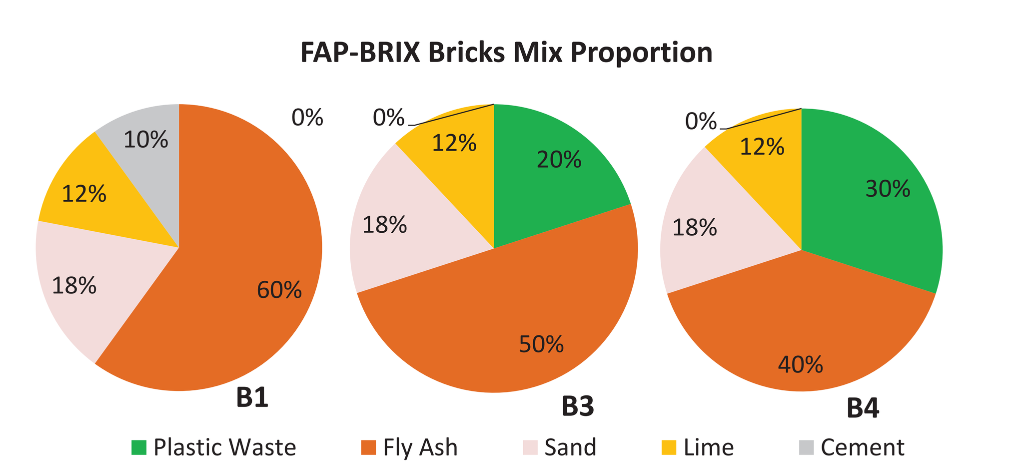
Table 4. Efficiency Test data for FAP-BRIX Brick Sample Type B3 and B5

Brick Sample Type	Dry Weight gm	Wet Weight gm	Volume cm^3	Compressive Strength MPa		Tensile Strength Mpa	Water Absorption %	Bulk Density gm/cm^3	Efflorescence %
				7th day	21st day				
B3-1	334	373	245.94	11	22	2.56	11.68	1.36	0
B3-2	349	387	248.64	13	24	2.80	10.89	1.40	0
B3-3	340	385	248.53	12	22	2.56	13.24	1.37	0
B3-4	346	385	247.27	12	24	2.80	11.27	1.40	0
B3-5	337	377	245.67	11	23	2.68	11.87	1.37	0
B3-6	341	380	247.36	14	24	2.80	11.44	1.38	0
MEAN (B3)	**341**	**381**	**247.24**	**12**	**23**	**2.70**	**11.73**	**1.38**	**0**
B5-1	334	366	251.45	10	18	2.13	9.58	1.33	0
B5-2	338	371	252.86	11	18	2.13	9.76	1.34	0
B5-3	341	376	257.49	10	17	2.01	10.26	1.32	0
B5-4	322	351	244.4	10	20	2.37	9.01	1.32	0
B5-5	336	366	252.32	9	16	1.90	8.93	1.33	0
B5-6	332	362	250.2	11	18	2.13	9.04	1.33	0
MEAN (B5)	**334**	**365**	**251.45**	**10**	**18**	**2.11**	**9.43**	**1.33**	**0**

Table 5. FAP-BRIX Bricks Efficiency Test data (Mean value from 6 tests of each sample type)

Brick Sample Type	Dry Weight gm	Wet Weight gm	Volume cm^3	Compressive Strength MPa		Tensile Strength MPa	Water Absorption %	Bulk Density gm/cm^3	Efflorescence %
				7th day	21st day				
B1	336	384	240.73	8	14	1.53	14.30	1.40	0
B2	320	359	234.59	9	14	1.70	12.19	1.36	0
B3	341	381	247.24	12	23	2.70	11.73	1.38	0
B4	330	364	246.15	14	25	2.80	10.30	1.34	0
B5	334	365	251.45	10	18	2.11	9.43	1.33	0





Method

- Collect the plastic waste, fly ash, sand, Portland cement, lime, and water.
- Determine the proportion of raw materials for FAP-BRIX bricks.
- Clean the plastic waste and dry them.
- Shred the plastic waste into small pieces using a shredding machine and melt them for 2 minutes at 230 °F.
- Mix the raw materials.
- After the raw materials are mixed, pour the mortar in the mold, and compact it.
- After 2 minutes, remove the brick sample from the mold and cure it for 21 days.
- Repeat these steps to create the other sample bricks.

Discussions

- The compressive strength of the FAP-BRIX brick increased after curing from 7 days to 21 days. The compressive strength of these bricks on the 21st day ranged from 14 to 25 MPa. It was at least 4 times more than traditional bricks, which is 3.5 MPa. Also, the tensile strength was more than 11% of the compressive strength as compared to the traditional bricks which is 8% to 11%. This indicates that these bricks are very sturdy.
- The FAP-BRIX bricks were able to resist heat of 650°C for 24 hours without melting or changing shape.
- Greater quality bricks absorb less water. The water absorption should be less than 12% of the brick's weight. Brick sample types B3, B4 and B5 with a high proportion of plastic waste (>20%) has the water absorption percentage less than 12%.
- Bulk density greater than 1.3 g/cm^3, which indicates that these bricks have less pores and are lightweight. Also, there were no white spots found and thus, no efflorescence.

Challenges

- Determining the right proportion of materials that works the best.
- To melt plastic and mix with other raw materials.

Conclusions

- My hypothesis was accepted. The FAP-BRIX made of plastic waste is highly efficient since the quality of any brick depends on its compressive strength, tensile strength, heat resistance, water absorption rate, and efflorescence.
- My results proved that compared to traditional brick, the FAP-BRIX brick have:
  - 4 times greater compressive strength
  - Lower water absorption.
  - Lighter weight
  - Lower cost: about $0.30 per brick as compared to traditional brick which cost between $0.50 to $1.
- Based on the brick efficiency test results, it can also be concluded that brick sample type "B4" has the optimal proportion of materials with plastic waste-30%, fly ash-40%, sand-18%, lime-12% and 0% cement for creating FAP-BRIX.

Significance

- The FAP-BRIX will benefit the construction industry and the environment by recycling plastic waste instead of sending them to landfills or oceans thereby reducing toxic pollution.
- It can be widely used as structural elements such as walls, retaining walls, pavements, driveways, etc. in construction. Thus, the use of these environmentally friendly FAP-BRIX will be a sustainable development and eco-conservation at the same time.

Future Work

- These FAP-BRIX give us hope and a way to further extend this study using nanotechnology to make construction materials more sturdier and durable that can be widely used thereby recycling more plastic waste.

References

- Books:
  - Solutions for a cleaner, greener planet : environmental chemistry
    Author: Zimmer, Marc
- Internet:
  - Plastic Waste Statistics: A Deep-Dive
    https://seedscientific.com/environment/plastic-waste-statistics/
  - Fly ash management and use in the United States
    https://www.gem.wiki/Fly_ash_management_and_use_in_the_United_States
  - A Study on Mechanical Properties of fly ash Brick with Waste Plastic Strips
    https://www.researchgate.net/publication/313030157_A_Study_on_Mechanical_Properties_of_fly_ash_Brick_with_Waste_Plastic_Strips
  - Plastic wastes to construction products: Status, limitations and future perspective
    https://www.sciencedirect.com/science/article/pii/S2214509520300024
  - Plastic-fly ash waste composites reinforced with carbon nanotubes for sustainable building and construction applications: A review
    https://www.sciencedirect.com/science/article/pii/S2211715622001242