Plastic Based Cost-Effective Interlock Paver Blocks

Shahla Al Balushi[1], Nawar Al Siyabi[1], Maryam AL Hasani[1], Al Monther Al Titi[1] and Sachin Kuckian[1#]

[1]Middle East College, Muscat, Oman
[#]Advisor

ABSTRACT

Plastic trash is a big environmental issue; hence several steps have been taken to recycle it into construction materials. Plastic garbage pavers create engineering and environmental challenges. Because plastic is non-biodegradable, developing countries' trash management is problematic. Interlocks made from plastic waste are promising. According to the Portland Cement Association, this project solves two issues. The Portland Cement Association says this effort addresses CO_2 emissions from cement. Melted plastic waste is tested as a binder for pavement interlocks. 7 mixes are used. M1 is a typical mix, and M2–M4 uses different sand and plastic ratios. Sand, plastic, and coarse aggregate were combined at M5–M7. Mixing sand and plastic (1:3) and (1:1) increased compressive strength compared to conventional interlocks. When blended 3:2:3, sand, coarse aggregate, and plastic had good compressive strength. Plastic interlocks are cheaper than regular ones. According to the study, plastic should be mixed at a similar or higher amount than other materials. The lower plastic percentage would cause a less sudden mix and lower compressive strength. Thus, this study encourages a greener atmosphere.

Project Introduction

Standard sizes allow interlocks to be updated quickly and cheaply. Concrete pavers are great for roads and sidewalks, whereas concrete spreaders are preferable for industrial applications. Interlocking tiles, which come in many shapes and sizes, are ideal for flat outdoor settings like patios. OCP bonding panels are concrete blocks used for roadways and low-traffic areas. They are attractive, require little construction equipment, and can be paved in simple or complex places (Hanson, 2022).

Synthetic plastics are made of polymers. They can mould, extrude, and form plastic due to their plasticity and other qualities. Modern manufacturing uses renewable plastics instead of fossil fuels. Corn and cotton derivatives are used. Between 1950 and 2017, 9.2 billion tonnes of plastic were manufactured, and 400 million tonnes are expected by 2020. By 2050, consumption trends will produce over 1,100 million tonnes of plastic (Sharma, 2022).

Plastic in the waters suffocates or starves turtles, seabirds, and other marine species. We shouldn't pollute Oman's unspoiled beaches. We need to promote awareness by prosecuting offenders, educating kids, and forcing bottled water and dairy companies to use glass bottles and supermarkets to stop using plastic bags (Abdulraheem, 2016).

The objective of the project thus focused on the use of plastic in the interlock paver blocks with the complete elimination of the cement.

Literature Review

Since 1950, the world has created 6.3 billion tonnes of plastic, yet only 9–12% is recycled. Thus, plastic pollution and waste have increased. Plastics with phthalates, heavy metals, and bisphenol A are used in medical equipment, food packaging, and water bottles. Alabi, O. A., Ologbonjaye, K. I., Awosolu, O., & Alalade, O. E., 2019).

Ethylene, a petroleum byproduct with two carbons and four hydrogens, is an organic gas (Ahmed, J., & Varshney, S. K., 2011). Molten HDPE and LDPE are used exclusively as binders in new construction materials, and PWC may be made with less energy. (Thiam, M., & Fall, M., 2021).

Concrete pavers are inexpensive, easy to build, low maintenance, and versatile. They operate effectively in low, moderate, severe, and extreme traffic. Variable block strength and occasional failure due to extreme surface wear are key issues (Sharma, P., & Batra, R. K., 2016).

Fly ash was tested in interlocking paver blocks by Kuckian and Dalvi (2020). The study recommends 20% fly ash. This focused on a greener interlock manufacturing procedure. Waste and recyclable materials are added to paver block concrete mixes to minimize these concerns. Bitumen can bind plastic trash to pave roads, according to Mir, A. H. (2015). (Ghuge, J., Surale, S., Patil, B.M., & Bhutekar, S.B., 2019) Even though non-biodegradable plastics is one of the biggest environmental problems, merging waste plastic bags does not affect concrete mass strength or other properties. Even if it does not affect other attributes or concrete mass strength.

Ghana's plastic waste pavement blocks have higher compressive strength and lower water absorption. In 2003, the Central Road Research Institute (CRRI) approved a 25-kilometer plastic road in Bangalore due to its smoothness, uniformity, and low rut count. Aggregates made from recycled plastic and rubber could be utilized to create environmentally friendly building materials. Plastic and rubber aggregates are easier on the body and lighter than natural aggregates; nonetheless, they dilute the matrix and degrade its mechanical qualities. Because of their low levels of thermal, acoustic, and electrical conductivity, these composite aggregates are ideally suited for use in the production of concrete that is both thermally and acoustically insulating.

Methodology

Modern civil engineers help the environment by using eco-friendly materials, recycling, or reducing greenhouse gas emissions like carbon dioxide and methane. The current initiative replaces cement in interlocks with primarily plastic rubbish, which is hard to recycle and affects marine life and the ecosystem. Seven interlock mixes were generated at 200°C and tested, including sieve analysis for sand and coarse aggregate.

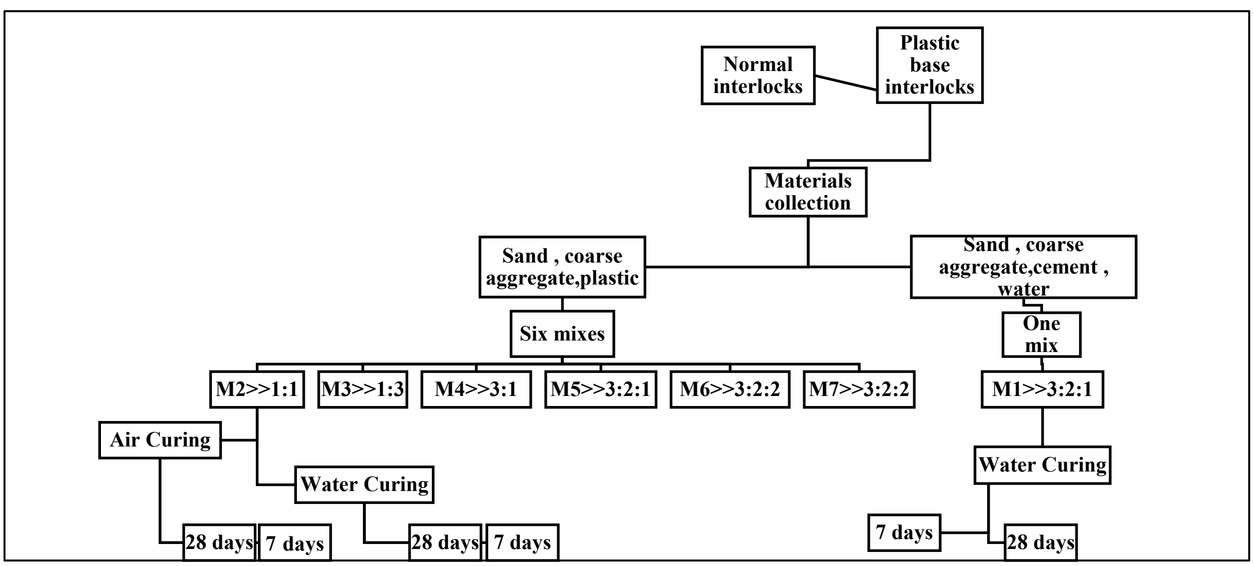

Figure 1. Project Work Steps.

Result & Discussion

The results include the compressive strength, cost analysis of normal and plastic based interlocks.

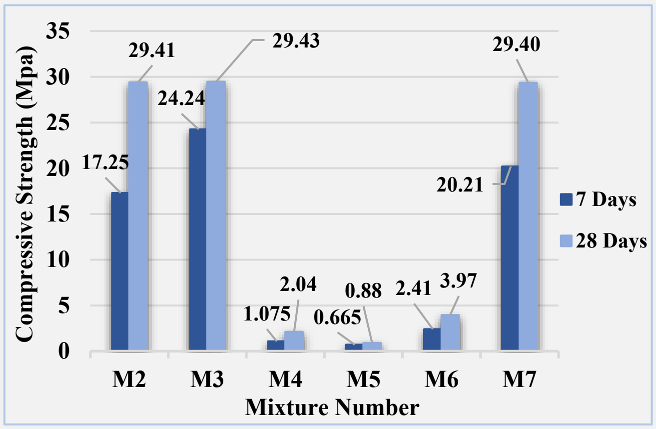

Figure 2. Compressive Strength of different mixes under air curing condition.

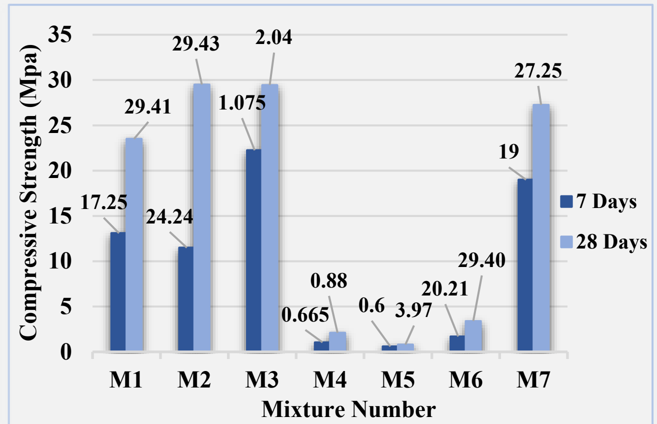

Figure 3. Compressive Strength of different mixes under water curing condition.

Table 1. Quantities and weights of different mixes under air and water conditions.

Mixture No.	Ratio	Quantities (kg) Air Curing	Weight (kg) Air Curing		Quantities (kg) Water Curing	Weight (kg) Water Curing	
			7 days	28 days		7 days	28 days
M_1	3:2:1 Sand: Coarse Aggregate: Cement	-----	-----	-----	Sand = 20 Coarse Aggregate = 15 Cement = 7	4.75	5.05
M_2	1:1 Sand: Plastic	Sand = 10.10 Plastic = 10.10	2.70	2.70	Sand = 10 Plastic = 10	3.15	3.20
M_3	1:3 Sand: Plastic	Sand = 5.10 Plastic = 8.90	1.95	1.95	Sand = 5 Plastic = 8.8	1.85	1.95
M_4	3:1 Sand: Plastic	Sand = 15.10 Plastic = 3.10	2.70	2.70	Sand = 15 Plastic = 3	3.75	3.85
M_5	3:2:1 Sand: Coarse Aggregate: Plastic	Sand = 11.50 Coarse Aggregate = 7.40 Plastic =1.96	2.95	2.95	Sand = 10 Coarse Aggregate = 7.5 Plastic = 1.95	3.45	3.55
M_6	3:2:2	Sand =8.60	3.60	3.60	Sand = 8.57	3.45	3.67

	Sand: Coarse Aggregate: Plastic	Coarse Aggregate=6.425 Plastic = 6.425			Coarse Aggregate = 6.425 Plastic = 6.425		
M₇	3:2:3 Sand: Coarse Aggregate: Plastic	Sand=8.20 Coarse Aggregate=6.15 Plastic=8.20	2.22	2.22	Sand = 10 Coarse Aggregate = 7.5 Plastic = 10	3.91	3.93

Cost Analysis

Table 2. Cost analysis for different mixes.

Mixture No.	Material Type	Price per 1000 (kg)	Price (kg)	Amount Required For 1 Interlock (kg)	Amount Required For 1000 Interlock (kg)	Total Price for Each Material (OMR)	TOTAL PRICE (OMR)
M_1	Sand	5 OMR	0.005 OMR 5 baizes	2.5	2.5*1000=2500	12.5	43
	Coarse Aggregate	3 OMR	0.003 OMR 3 baizes	1.875	1.875*1000=1875	5.625	
	Cement	2.8 OMR	0.028 OMR 28 baizas	0.875	0.875*1000=875	24.5	
	Water	0.923 OMR	0.000925 OMR	0.4125	0.4125*1000=412.5	0.38	
M_2	Plastic	-	-	1.47	1.47*1000=1470	0	12.5
	Sand	5 OMR	0.005 OMR 5 baizes	2.5	2.5*1000=2500	12.5	
M_3	Plastic	-	-	2.2	2.2*1000=2200	0	12.5
	Sand	5 OMR	0.005 OMR 5 baizes	1.25	2.5*1000=2500	12.5	
M_4	Plastic	-	-	0.725	0.725*1000=725	0	18.75
	Sand	5 OMR	0.005 OMR 5 baizes	3.75	3.75*1000=3750	18.75	

M_5	Plastic	-	-	0.49	0.49*1000=490	0	18.125
	Sand	5 OMR	0.005 OMR 5 baizes	2.5	2.5*1000=2500	12.5	
	Coarse Ag-gregate	3 OMR	0.003 OMR 3 baizes	1.875	1.875*1000=1875	5.625	
M_6	Plastic	-	-	1.2	1.2 *1000=1200 kg	0	14.5
	Sand	5 OMR	0.005 OMR 5 baizes	2	2*1000=2000	10	
	Coarse Ag-gregate	3 OMR	0.003 OMR 3 baizes	1.5	1.5*1000=1500	4.5	
M_7	Plastic	-	-	0.838	0.838*1000=838	0	15.3
	Sand	5 OMR	0.005 OMR 5 baizes	2.1	2.1*1000=2100	10.5	
	Coarse Ag-gregate	3 OMR	0.003 OMR 3 baizes	1.6	1.6*1000=1600	4.8	

Discussion

As shown in figures 2 and 3, the M_3 mixture, which contains more plastic than sand (1:3) was the highest compressive strength under both air and water curing conditions, as the compressive strength reached approximately 29.43 MPa after curing for 28 days. In addition, after 28 days of curing, the compressive strength of M_5, a combination with a ratio of (3:2:1), was only 0.88 MPa. Furthermore, M_4, M_5, and M_6 mixes had the weakest compressive strength because they had a higher proportion of sand and coarse aggregate than plastic. The compressive strength of the interlock is low when the proportion of sand and coarse aggregate exceeds the proportion of plastic, as shown by (Al-Sinan & Bubshait, 2022).

As demonstrated in tables 1 and 2, the M_6 mixture, which contains a ratio of (3:2:2) was the heaviest weight under both air and water curing conditions. As the weight reached approximately 3.5 kg after curing for 28 days. Furthermore, despite its high plastic content (1:3), the lightest combination is M_3, which weighs only 1.95 kg. The M_3 combination is the best since it has the lowest weight and the highest compressive strength. The weights of the various configurations measuring 200 millimeters by 170 millimeters by 65 millimeters increase after 7 and 28 days of water curing, respectively. Normal interlock and plastic-based interlock both see an increase due to water molecules penetrating their pores (Rasidi et al., 2020). After 28 days, the heaviest of the mixtures, M_1 (Normal Interlock), had a weight of 5.05 kg thanks to its (3:2:1) ratio.

As indicated in figure 4, M_2, M_3, and M_4 mixes have the same moisture content (%) after seven and twenty-eight days of curing. Additionally, other combinations like M_5 and M_7 have shown a rise in moisture content after being submerged in water for seven days. The moisture percentage in the M_6 mix decreased after being stored for a week. Water absorption is the lowest (10.5 percent) in the M_4 mix, which has a ratio of (3:1). After 28 days, the M_1 (Normal Interlock) mix had the highest moisture content, equaling 34.05.

Conclusion

The team's basic concept of creating inexpensive interlocking expanded into a sizable undertaking as they sought out answers to the root causes of Oman's environmental woes. Due to the high volume of plastic trash generated every day in Oman, we first investigated the possibility of using recycled plastic in place of cement in the interlock. With the help of Al-Hayat Company, we conducted trials in the field to develop the original idea into a workable scenario, and subsequent testing yielded encouraging and fruitful results.

This project's findings also demonstrated that cement may be replaced with plastic waste without compromising safety or strength. In addition to bolstering Oman's economy, this project offers a long-term answer to the country's environmental issues caused by plastic trash.

It also appears that by combining sand and plastic in the ratios of (1:3) and (1:1), a stronger interlock can be produced. Sand, coarse aggregate, and plastic mixed in a ratio of (3:2:3) yields an interlock with a higher compressive strength, corroborating and resembling the findings of (Sahani et al., 2022).

However, economically speaking, its execution is fantastic because its production is so much less expensive than that of a standard interlock. The cost to manufacture 1000 plastic interlocks at a ratio of (1:1) or (1:3) is 12.5 OMR, while the same quantity manufactured at a ratio of (3:2:3) is 14.5 OMR. Clearly, a plastic interlock is far more affordable than a traditional interlock.

References

1. Hanson Last Modified Date: December 19, G. (2022). *What are the different uses for paving blocks?* Home Questions Answered. https://www.homequestionsanswered.com/what-are-the-different-uses-for-paving-blocks.htm
2. Sharma, B. (2022). *Everything you need to know about paver blocks*. 99acres.com. https://www.99acres.com/
3. Abdulraheem, M. (2016). *What a waste 2.0*. Tackling Increasing Plastic Waste. https://datatopics.worldbank.org/what-a-waste/tackling_increasing_plastic_waste.html
4. Alabi, O. A., Ologbonjaye, K. I., Awosolu, O., & Alalade, O. E. (2019). Public and environmental health effects of plastic wastes disposal: a review. *J Toxicol Risk Assess*, *5*(021), 1-13.
5. Thiam, M., Fall, M., & Diarra, M. S. (2021). Mechanical properties of a mortar with melted plastic waste as the only binder: Influence of material composition and curing regime, and application in Bamako. *Case Studies in Construction Materials*, *15*, e00634.
6. Ghuge, J., Surale, S., Patil, B. M., & Bhutekar, S. B. (2019). Utilization of waste plastic in manufacturing of paver blocks. *System*, *6*(04), 1967-1970.
7. Kuckian, S., & Dalvi, A. (2020). Strength Possibilities on Fly ash Based Interlock Pavers. In Applied Mechanics and Materials (Vol. 897, pp. 12-19). Trans Tech Publications Ltd.
8. M. Al-Tayeb, M., M. Zeyad, A., Dawoud, O., & Tayeh, B. A. (2021). Experimental and numerical investigations of the influence of partial replacement of coarse aggregates by plastic waste on the impact load. *International Journal of Sustainable Engineering*, *14*(4), 735-742.
9. Al-Sinan, M. A., & Bubshait, A. A. (2022). Using plastic sand as a construction material toward a circular economy: A review. *Sustainability*, *14*(11), 6446.

10. Rasidi, N., Rochman, T., Sumardi, S., & Purnomo, F. (2020). Structural behavior of lightweight interlocking brick system. In IOP Conference Series: Materials Science and Engineering (Vol. 732, No. 1, p. 012026). IOP Publishing.