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# Recycling of Waste Plastic for the Production of Road Interlocking Paving Stone in Nigeria

**Praise Onimisi Dawodu [a*], Apata Akindele [a] and Udeme Imoh [a]**

*[a] Department of Civil Engineering, University of Lagos, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. Author POD helped in conceptualization, performed methodology and wrote the original draft of the manuscript. Author AA reviewed the article. Author UI wrote and edited the original draft of the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

As the demand for construction materials increases, the need to find alternative construction materials that are readily available and cheaper is imperative. This research attempts to explore the recycling of waste plastic as a complete replacement for the Portland cement used in the production of pavement interlocking paving stones.

Three specimens were produced, by varying the ratio of the waste plastic with the fine and coarse aggregates. The content of melted waste plastic in specimens A, B, and C was 33%, 29%, and 20% respectively. The specimens were crushed to determine their compressive strength. Specimen A having 33% melted waste plastic had the highest compressive strength of 25.7 $N/mm^{2,}$ For effective binding with the aggregates, the melted waste plastic should not be less than 30% of the mixture.

**Corresponding author: Email: praisedaw@gmail.com;*

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## 1. INTRODUCTION

Interlocking paving stones are made from Portland cement, fine and coarse aggregates, and these interlocking stones are used for the construction of roads. Pavements made from interlocking stones though made of rigid pavement materials, function as flexible pavement, this is primarily because the vehicular load on the pavement is transferred to a smaller surface area of the subgrade while rigid pavements transfer loads to a smaller surface area on the subgrade and this has shown it to be relatively durable [1].

Some other benefits of interlocking paving stones include their environmental sustainability, due to their porous nature, it allows surface water easily drain off, and as such can be used in marshy areas, the construction process is also easy and faster, compared to other pavements it requires low maintenance.

Interlocking paving stones are used for car parks, walkways, driveways, arterial roads, and collector and local roads [2].

Of the main components of interlocking paving stones, Portland cement plays a major role in binding the other components together and also is responsible for the chemical reaction that forms the paving stone and defines its strength.

In Nigeria, cement is one of the heavily used construction materials that are not readily available and thus making it expensive, and hence the need for readily available alternatives.

This research attempts to proffer an alternative to Portland cement using melted waste plastics for the production of interlocking paving stones. The waste plastic being considered are thermoplastics such as polyethylenes, and nylons, which can be melted and remolded, owing to their elastic property and ability to be melted and solidify thereafter, they can serve as a binder for interlocking paving stone aggregates.

Presently, about 400 million tonnes of waste is produced yearly, throughout the world [3].

One of the most crucial measures available to lessen the environmental effect of plastic waste is recycling, which also stands for one of the most dynamic sectors to lessen the volume of disposed trash and their associated gas emissions. Numerous programs have been devised to recycle post-consumer products, such as plastic trash, into various construction materials [4].

Generally, the use of plastics for civil engineering may have so negative impacts on the environment, which could include pollution, fire, toxic and other hazards [3].

Recycling plastic waste to produce interlocking paving stones would be a plus to the construction industry as it will significantly reduce the cost, and subsequently promote a healthier, sustainable environment [5].

## 2. METHODOLOGY

### 2.1 Research Flow Chat

Fig. 1 shows the research flow.

### 2.2 Materials and Tools

Materials used for this work include sand, granite, waste plastic (empty cement bags), Tools: steel mold, tamping rod, trowel, shovel, weighing scale, steel drum, head pans, and fire setup.

### 2.3 Batching

Three specimens were prepared, of which specimen A, specimen B, and specimen C contained 33%, 29%, and 20% melted waste plastic respectively. The batching of the specimens was done in the ratios of; melted waste plastic to sand to granite, of which specimen A was in the ratio of 1:1:1, specimen B in the ratio of 1:1:1.5, and specimen C in the ratio of 1:1.5:2.5. Fig. 2 shows the component materials used.

### 2.4 Procedure

The melted waste plastic, sand, and granite were measured using a digital scale to the defined weights by the mix ratio, after which the heating setup was made and the steel drum was placed on it to heat up. Then the waste plastic bags are placed in the drum to melt, thereafter the sand and the granite are added, then this is mixed thoroughly till it forms a molten paste. The paste is then placed into steel molds of dimensions (200mm x 100mm x 80mm) that have been oiled, then it is compacted, and left to cure for a few hours before demolding. [6] Fig. 3 show interlocking paving stone made from waste plastics.

## 2.5 Curing

This was allowed to air dry for 3 days, although it attains optimum strength when it cools completely, which is usually between 24 hours. [6].

## 2.6 Compressive Strength Test

The compressive strength test was conducted to obtain the strength of each of the three specimens. This test was carried out when the specimens were fully cured. Fig. 4 shows the test setup.

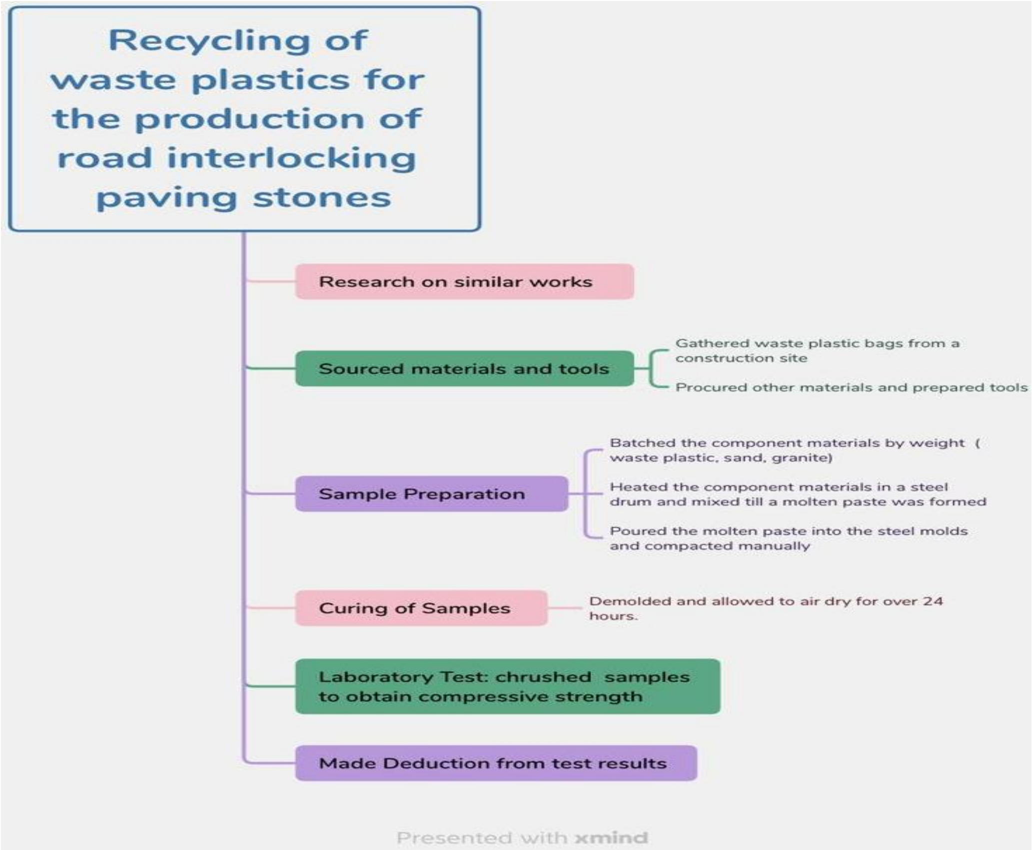


**Fig. 1. Research flow chat**

**Fig. 2. Component materials: From left to right: sand, melted waste plastics, and granite**

## 3. RESULTS AND DISCUSSION

Compressive strength determination of the specimens is pivotal to this research because it is the index by which the deductions of the research will be drawn. Fig. 5 shows that as the percentage of the melted waste plastic in the specimen is reduced, the compressive strength also reduces, the compressive strength of specimen A reduced from 25.7 N/mm2 to 10.6 N/mm2 when the ratio of melted waste plastic was reduced from 33% to 29%, the strength further reduced to 7.9 N/mm2 when the percent of the melted waste plastic was reduced from 29% to 20%. Concrete cement Interlocking paving stones usually have a compressive strength that varies from 15 N/mm2 to 28 N/mm2 for international standards [7], specimen A has a compressive strength of 25.7 N/mm2 and thus is within the limits. These results are consistent with results obtained by the study carried out by Lukman Salami on the mechanical performance of interlocking paving stones using dissolved waste plastics [8].

**Fig. 3. Interlocking paving stone made from waste plastics**

**Fig. 4. Crushing of specimens**

**Table 1. Compressive strength results**

| Specimen | Percentage of melted waste plastic (%) | Mix ratio (melted waste: plastic:sand:granite) | Weight (KG) | Compressive strength (N/mm$^2$) |
|---|---|---|---|---|
| Specimen A | 33 | 1:1:1 | 3.05 | 25.7 |
| Specimen B | 29 | 1:1:1.5 | 3.95 | 10.6 |
| Specimen C | 20 | 1:1.5:2.5 | 4.03 | 7.9 |

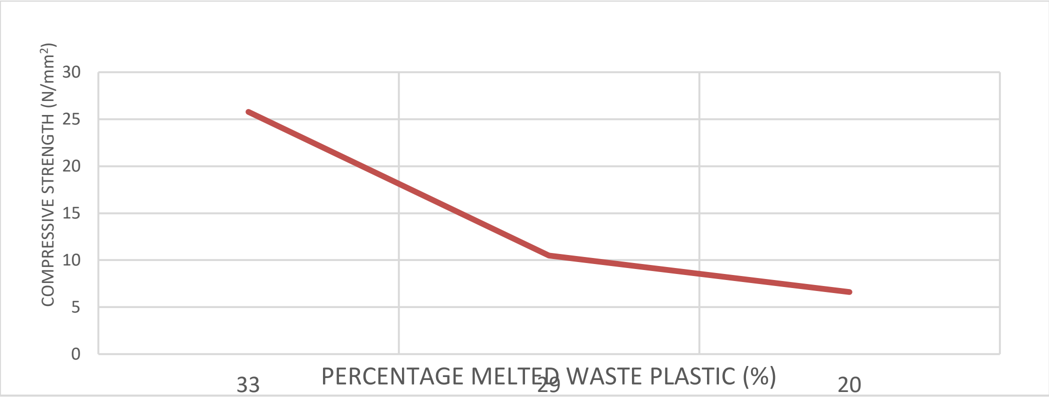


**Fig. 5. Compressive strength of interlocking paving stones made from melted waste plastic**

## 4. CONCLUSION

The purpose of this research is to explore the use of melted waste plastic as an alternative to the use of Portland cement for the production of interlocking paving stones, in the bid to recycle plastic. The following conclusion was drawn from this study;

1. As the percentage of melted waste plastic increases, the strength of the interlocking paving stone increases.
2. Interlocking paving stones made from 33 % of melted waste plastic give a compressive strength of 25N/mm2 which can be used for road pavements expected to carry light to medium vehicular traffic, cycleways, and pedestrian ways. [9,10].

Recycling waste plastic for the production of paving stones will protect the environment, conserve natural resources and also positively influence the cost of construction.

## 5. LIMITATION

This research has some limitations within which the findings need to be interpreted. Of which are; firstly, a local method of production of the interlocking paving stone was adopted.

Secondly, this research did not examine the effect of fire on the specimens.

Thirdly, the test done was limited to compressive strength test, and the specimens produce are between 20% to 33% replacement of the Portland cement in interlocking paving stones.

## 6. RECOMMENDATION

This research employed a crude method for the production of interlocking paving stone specimens, however, it is recommended that for best results, advanced techniques are used for the production of these interlocking paving stones. Also, there is a need to consider other aspects as water absorption, resistance to abrasion, and the effect of fire, on the interlocking stones made from this method.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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