INFLUENCE OF ADMIXTURES ON PLASTIC WASTES IN AN ECO-FRIENDLY CONCRETE

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Abstract*: The project was to assessing the effect of partial replacement of coarse aggregates in concrete used in suspended slabs with recycled plastic-waste palates. The properties of concrete studied include both fresh and hardened properties. The independent variable in this project is the partial replacement of course aggregate with plastic palates. The dependent variable in this case is the properties of concrete such as workability, compressive strength and the weight of the cubes at different percentage replacement. Since it was a partial replacement, the replacement of coarse aggregates with plastic palate was from 0% to 75%. The results of the project were as follows. The average weight of concrete cubes at 28days was 7.894Kg for 0% replacement and 5.904Kg for 75% replacement of coarse aggregates with the plastic waste palates. The decrease in the weight of the concrete with the increase in the replacement of the coarse aggregates with plastic waste palates could have been due to the fact that the plastic palates were not as heavy as the natural course aggregate. The workability of the concrete was 50mm at 0%, 53mm at 25%, 56mm at 50% and 60mm at 75% replacement of coarse aggregates with plastic palate.The results showed an increase in slump with the increase the replacement of coarse aggregates with plastic palate which could be due to the fact that plastic waste palates had less or no absorption of water in the concrete mix which increased the water content in the mix that resulted into a high workability. The plot compressive strength against plastic percentage replacement shows steady decrease in compressive strength between 0 and 50% and later drastically decreases with increase in plastic replacement. This could have been due to the fact that in the process of preparing the plastic palate aggregate, the palates were cut with shape and smooth which hindered the adequate bonding with the other concrete constituents hence lowering the compressive strength.The plastic percentage of 50% with compressive strength of 11.2kN/mm2and weight of 6.370Kg is our optimum percentage replacement of course aggregates with plastic waste palates because the weight had reduced but the compressive strength was not so much compromised.

INTRODUCTION

Background

Concrete is a construction material composed of cement, aggregates, water, and admixtures.The aggregates may be classified as fine or course aggregates basing on the particle size fromthe sieve analysis. It offers stability and design flexibility for the residential marketplace and environmental advantages through every stage of manufacturing and use. There are many advantages of concrete as a building materials such as built-in fire resistance, high compressive strength and low maintenance(Praveen, 2013).

The importance of using the right type and quality of aggregates should be given much consideration since they provide the compressive strength of concrete. The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) andstrongly influence the concrete's freshly mixed and hardened properties, mixture proportionsand economy. Coarse aggregates consist of one or a combination of gravels or crushed stonewith particles predominantly larger than 5 mm and generally between 9.5 mm and 37.5 mm.Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed.

Crushedstone is produced by crushing quarry rock, cobbles, or large-size gravel. Crushed air-cooled blast-furnace slag is also used as fine or coarse aggregate. The aggregates are usually washedand graded at the pit or plant. Some variation in the type, quality, cleanliness, grading, moisture content, and other properties is expected. Ghernouti, Y., &Rabehi. (2011).

Naturally occurring concrete aggregates are a mixture of rocks and mineral and are a non- renewable source that has to be partially or completely replaced with a material that has almost the same properties in the construction industry before its depletion from the naturalreserves.

Today, you can hardly look around you and not spot some item that is made entirely from plastic or has some plastic ingredient. This only proves that from its inception up to now plastichas managed to become a popular material with millions of useful items, but it is not perfect.Plastic has become a nuisance to the environment and has created the need for its use in theconstruction industry as a way of controlling its negative effects on the environment. Since ittakes long to get biodegraded, the partial replacement of aggregates of concrete used in theconstruction of suspended slabs with plastics will help to save our environment from this non-biodegradable element.

Problem Statement

The aggregates in concrete are quite expensive and contribute greatly to the self-weight ofthe concrete members in any concreting works. Therefore, their replacement with lighter plastic palates from the abundant waste plastic materials in the environment would reducethe self-weight of the concrete used in suspended slabs and to provide an environmental friendly plastic waste management strategy(Ramesan,2015).

Objectives

Main Objective

To assess the effect of partially replacement of coarse aggregates in concrete with recycledplastic-waste palates.

Specific Objectives

i. To study the effect of replacing natural aggregate with plastic palates on workabilityof concrete.
ii. To study the effect of replacing natural aggregate with plastic palates on thecompressive strength of concrete.
iii. To study the effect of replacing natural aggregate with plastic palate on weight ofconcrete.
iv. To compare and analyze the results
v. To give recommendations based on the results.

Justification and significance.

Due to rapid increase of the population in the world, the amount of waste products such as waste plastic is also increasing rapidly and these wastes remain in the environment for hundreds of years. The inclusion of this waste plastic in concrete may reduce the environmental problems up to a certain extent. It's a possibility of disposal of these wastagesin mass concrete such as in heavy mass concreting in PCC in pavements where the strength of concrete is not a major criterion under consideration(Ghernouti & Rabehi, 2011).

The waste plastic is one component of Municipal Solid Waste (MSW). The disposal of the waste plastic which cause the big problems to the environment because the plastic is very lowbiodegradable material (Singh, 2007). As from many years the research concern that the useof by-products from industry may augment the properties of concrete. In the modern decades,the use of by-products such as silica fume, glass culvert, fly ash, ground granulated blast

2 .LITERATURE REVIEW

INTRODUCTION

The effect of the replacement of coarse aggregates with various percentages (0% to 40%) ofplastic aggregate on behaviour of concrete was experimentally investigated by (Anju Ramesan, 2015) and the optimum replacement of coarse aggregate was found to be at 25%.The results showed that the addition of plastic aggregate to the concrete mixture improved the properties of the resultant mix. The present study investigated the partial replacement ofthe coarse aggregates in concrete used in suspended slabs with recycled plastic waste palatesat percentages of 0%, 25%, 50% and 75% to create an in-depth study and investigation on the optimum replacement of the coarse aggregates by plastics in the concrete. The plastics used in the study were waste plastic and the concrete mixing ratios used was (1:2:4).

According to (Aginam C. H. Nwakaire C, 2016) a study was carried out about the suitability ofquarry dust as a partial replacement of coarse aggregates in concrete making. Samples of concrete cubes were made with varying proportions of quarry dust replacing the coarse aggregate. Some physical properties of the concrete constituent materials that are relevant to the experiments were determined. The mix design of 1:2:4 by volume was adopted and two brands of Ordinary Portland cement (OPC) were used for comparative purposes. Particlesize distribution analysis, slump test, and compressive strength test were carried out on the materials, the fresh concrete, and the cured concrete cubes respectively. The results disclosedthat replacing 10% of the required amount of gravel with quarry dust and using the Ibeto brand of Portland cement yielded the highest amount of compressive strength of 32.3N/mm^2.It was also observed that using the Ibeto brand of OPC, the concrete cubes made with inclusion of quarry dust up to 25% all performed better than the zero-replacement level in terms of their compressive strengths. The strengths achieved with the Dangote brand of OPCwere satisfactory up to 15% replacement level. This suggests that the quarry dust can be utilized as a partial replacement of the coarse aggregates in concrete within the satisfactory levels. However, this study looked at the partial replacement of the coarse aggregates in concrete with plastic palates from the recycles plastic wastes.

, 14 and 28 days of age.

3. METHODOLOGY

The successive steps that were followed to complete the study are as follows:

- Collection of plastics materials.
- Preparation of recycled plastic palate aggregate.
- Casting of Concrete Cube with control mix using natural aggregate
- Cubes casting for varying percentage replacement 0% to 75% of natural aggregateby plastic aggregate.
- Workability and the compressive strength tests.
- Determining the weights of the concrete at different percentage replacement.

Making of plastic aggregate

Generally, the process involved use of a series of materials and equipment ranging fromfuel, cutting equipment among other apparatus as per the figure 3-1 below. The plastic recycling was completed through 5 steps which included;

- collecting
- Sorting
- Shredding
- Washing
- Heating and,
- Molding as shown in figure 3-2.

Collecting: The plastics that were used and are ready for recycling were collected from their respective and different places of disposal. They particularly included empty vegetable-oil jerry-cans, water bottles and old plastic Tv sets.
Sorting: This was basically done for the plastic materials collected from areas of disposalto sort the recycled plastic from the non-recycled that could have been collected from the disposal areas.
Shredding: The plastic materials were prepared for melting by cutting them into smallpieces using knives.
Washing plastic: The residues of products contained in the plastic materials and variousother contaminants were removed by washing them out using any local detergents. Theseresidues ranged from vegetable oil to paints and soils.
Heating: This involved exposing the plastics to high temperatures till their melting point using local charcoal stoves/fire place, briquettes/fire wood and saucepans.as shown in figure3-1.
Moulding: This was the second last stage and it involved pouring the molten plastics into a metallic mould and left to harden to form palates. The mould measured 300mm by 120mm by 20mm for length, breadth and height respectively. The width was further sub-divided into6 rows each of 20mm as compartments into which the molten plastic was poured. The molten plastic was left to cool for about three hours after which it was removed from the moulds by controlled re-heating of the mould as the plastic had a tendency of sticking to thesides.

Briquette and firewood as fuel Saucepan and metallic mould

Figure 2-2Material and equipment used in making plastic pallets.

Compressive strength test

This test was done to determine the compressive strength of the concrete according to BS4550-3.4: 1978 on the cubes after their respective days of curing. It involved the followingsteps;

- The specimen blocks were removed from the water after the specified curing time andthe excess water wiped away from the surface.
- The dimensions of the specimens were taken to the nearest 0.2m
- The bearing surface of the testing machine was cleaned
- The specimen was placed in the machine in such a manner that the load was appliedto the opposite sides of the cube cast.
- The specimen was aligned centrally on the base plate of the machine.
- The movable portion of the machine was rotated gently by hand so that it touched thetop surface of the specimen.
- The load was applied gradually without shock and continuously at the rate of140kg/cm^2/minute till the specimen failed
- The maximum load was recorded and noted.

4. RESULTS AND DISCUSSION

Slump test results and analysis

Slump tests at various percentage replacements were done and results tabulated as shownin table 4-10 below.

Table 0-1 slump test results

Cube plastic composition (%)	Slump (mm)
0	50
25	53
50	56
75	60

A trend of variation of workability of concrete with increasing plastic percentage replacementwas thus plotted as shown in the figure 4-5 below.

Analysis of weight results of concrete cubes

Consider the tables 4-1 and 4-2 below with results of weights of the concrete cube weights at 7 and 28 days of curing respectively

Table 0-4 Average densities of the cubes at 7 and 28 days of curing

Cube plastic composition (%)	Average Cube weights in kg		Average density of the cubes(Kg/m³)	
	7 days	28days	7 days	28days
0	7.659	7.894	2269.3	2339.0
25	7.485	7.104	2217.8	2104.9
50	6.724	6.370	1992.3	1887.4
75	6.120	5.904	1813.3	1749.3

These average density values in table 4-3 above were used to obtain a trend of variation of density with percentage replacement as shown in figure 4-1 below.

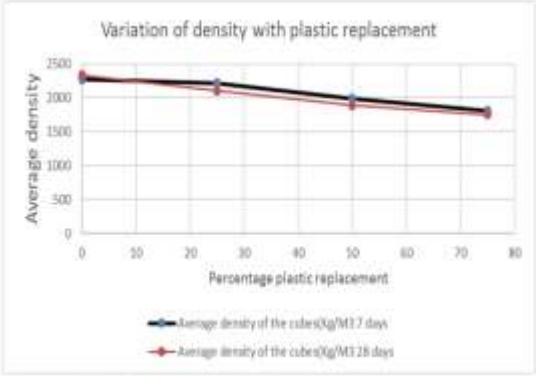

Figure 0-2 Variation of Average density with plastic replacement

Compressive strength results

The compressive loads and strengths at which the different cubes failed were as shown inthe tables 4-4 and 4-5 overleaf;

Table 4-5 Compressive strengths after 7 days

Plastic replacement	Maximum loads (KN)			Compressive strengths (kN/mm^2)			Average compressive strength (kN/mm^2)
	Sample I	Sample II	Sample III	Sample I	Sample II	Sample III	
0	120	125	125	5.3	5.6	5.6	5.5
25	80	95	60	3.6	4.2	2.7	3.5
50	75	90	80	3.3	4.0	3.6	3.6
75	70	75	65	3.1	3.3	2.9	3.1

were plotted and it was observed that there was a general decrease in compressive strength with increase in plastic percentage in each cube as shown in figure 4-2overleaf. This is due to the fact that natural aggregates have a higher crushing value than HDPE plastic used in some cubes and this has an overall effect of decreasing strength of concrete with increase in plastic replacement. replacement were plotted and it was observed that there was a general decrease in compressive strength with increase in plastic percentage in each cube as shown in figure 4-3overleaf.

A plot of compressive strength against plastic percentage replacement shows steady decreasein compressive strength between 0 and 50% and later drastically decreases with increase in plastic replacement.This could have been due to the fact that in the process of preparing theplastic palate aggregate, the palates were cut with shape and smooth which hindered the adequate bonding with the other concrete constituents hence lowering the compressive strength.

Furthermore, in comparison to the trends obtained at 7 days of compressive strength test, there are no anomalies of a rapid decrease between 0-50% at 28 days of curing. This could be explained in a way that concrete at 28 days of curing has or has almost attained the required strength and at this point, a conclusion can be drawn on the best percentage for replacement of natural stone aggregate. For this matter therefore, plastic percentage of 50%with compressive strength of 11.2kN/mm^{2}and the weight 6.370 at 28days is our optimum percentage replacement of coarse aggregates with plastic waste palates which varied from the control mix of 0% by 0.8kN/mm^{2}in compressive strength and 1.524Kg in the cube weight.

CONCLUSIONS

Quite a number of obstacles were faced during execution of this project ranging from finance,time, hands-on execution of works among others as outlined below.

1. The project was so demanding since it involved collecting plastic materials from the different disposal points. Also costs of transportation of sand, cement, and naturally existing stone aggregates was so tedious.
2. There was a challenge of a tedious slow process of making plastic pallets to be used in concrete. It involved operation in risky environment of hot temperatures which at times caused painful burns despite the personal protective equipment PPE used duringthe venture.
3. There was no machinery to use for quickly making plastic pallets. This slowed the rateat which the project activities progressed.
4. During lab tests, we encountered a financial problem to facilitate the testing of the cubes for compressive strength and weights using commercial laboratory.
5. In addition to the above we were not allowed to conduct the tests with the laboratorytechnicians.

Slump test.

Basing on the results obtained from the slump test, the concrete mix is completely workable at all percentage replacements. The slump test results ranged from 50mm to 62mm at 0% and 100% respectively. Generally, the slump tests showed an increasing trend in workabilityas more plastic palates were used instead of natural stone aggregates which is due to the limited absorption of water by the plastic pallet. According to research, the medium workability, is between 50-90mm and thus the obtained workability at 25% plastic replacement which is 53mm can be used for normal reinforced concrete placed with vibration

Compressive strength

It was generally observed that the compressive strength decreased with increase in plastic replacement. Considering the compressive strength of the cubes after 28 days of curing, it can be observed that at 25% plastic replacement, the value of compressive strength ($12.7kNmm^{-2}$) does not vary greatly from the compressive strength at 0% replacement ($12.0kNmm^{-2}$) which in this case was our reference. It is further observed that at 50% plasticreplacement, a compressive strength of $11.2kNmm^{-2}$ is also a close value to the compressivestrength at 0%. Conclusively, a plastic replacement between the range of 0% and 51% will give the required strength. For this particular experiment, we considered a 50% plastic replacement which was of compressive strength 11.2kN/mm^{2}and which

is below the referenceby 0.8kN/mm^2 .

Recommendations

Based on the compressive strength test, the concrete with 50% replacement of coarse aggregates with plastic waste palates is recommended to be used in low strength concrete like blinding and road solders.

I recommend carrying out the same test, that's to say slump and compressive strength usingdifferent forms of materials other than plastic like quarry dust but maintaining the same mixingratios.

I also recommend investigations on different mixing ratios with the different percentagereplacementof coarse aggregates with plastic palates waste.

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