Utilisation of Plastic Waste Bags as Concrete Additives

John Bentil, John Jackson Nsiah

Abstract - The study is an exploratory research work aimed to find out the possibility of plastic waste bags as additive to improve the performance of concrete mix in the construction industry. Fifteen (15) concrete cubes measuring 150 mm * 150 mm * 150 mm were made from concrete mix prepared by adding 0.00 %, 0.20 %, 0.40 %, 0.60 % and 0.80 % plastic waste bags. The workability of the mix was evaluated using the slump test. The water absorption rate was observed by curing for the 28 day period while the compressive strength was determined by the crushing test. It was observed that the compressive strength gradually decreases with increasing percentage of plastic waste. The workability of the concrete decreases with increasing percentage of plastic waste. The water absorption rate of the concrete decreases with increasing percentage of plastic waste. Although the compressive strength was lower than the recommended value (32.5N/mm2), it could be used for a variety of applications including concrete paving blocks and pre-cast concrete wall elements.

Keywords - Compressive Strength, Concrete, Plastics Bags, Waste, Workability

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1.0 INTRODUCTION

Waste management despite the numerous technological innovations in recent years is still a global phenomenon. Ghana, a developing country is not left out of the environmental degradation phenomena resulting from the improper handling of solid waste. Solid waste, which is the non-liquid and non-gaseous by-products of human activities, poses a hydra-headed challenge beyond the scope of waste management practitioners. One of such is the plastic waste bags. Since the import of the selling of "hygienic water" popularly known as sachet water in Ghana, and the use of plastic bags for packaging, plastic bags have increased tremendously in quantities in our society. Plastic waste especially 'sachet water bags' appear in very high proportion in the municipal solid waste stream in most part of the country especially in the urban and peri-urban centers. Recycling and reusing of plastic waste require vast manpower and huge processing cost thus a very small amount of plastic waste is recycled and reused whiles the rest go into landfills, incinerators and illegal dump sites finding their way into our environment and consequentially clogging drains and causing flooding. Recent year has witnessed the search for alternative raw materials in the construction industry due to the escalating cost of building materials and the need to provide affordable housing to cater for the housing deficit in the country. Many studies have been emerging worldwide highlighting the reuse of plastic waste in construction technology with the view that plastic can be used in concrete mix to improve on its properties. Thus, recycling and reusing of wastes equally can save the materials that should have been used for the same purposes, saved energy that could have been used to process virgin materials and reduce emissions produced in processing virgin materials.

This study is an exploratory research work that aimed to find out if plastic waste bags can improve the performance of concrete with plastic waste bags as additive in concrete production. The study also intend to add on to the existing knowledge on plastics re-utilization and on the on-going researches to find alternative raw materials for construction; and environmentally sound disposal means for plastic waste in Ghana.

2.0 MATERIALS & METHODS

2.1 Materials

Cement: Ordinary Limestone Portland Cement (CEMI II/B-L32.5R) conforming to GS 914:2007 was obtained from GHACEM Limited, Takoradi in Ghana. The characteristic strength of the cement is of class grade 32.5R.

Fine aggregate: The natural sand from a local river source was used. It was sieved to make it free from debris. It had a specific gravity of 2.53, bulk density of 1720 kg/m3, a silt content of 0.61 % with a water absorption ratio of 1.2 %.

Coarse aggregate: Crushed stone aggregate of size ranging between 10 and 20 mm was used. This was also obtained from a local quarry site.

Water: Potable water from a flowing tap was used in the mixing and curing of the concrete cubes.

Plastic waste bags (PWB): Ordinary plastic bags (single brand) of thickness less than 20 microns were sorted out of municipal solid waste. The bags were manually shredded into pieces and sieved to a size range of between 5 and 20 mm. The specific gravity was 1.35 and water absorption of 0.00 %.

2.2 Methods

2.2.1 Mix Proportion for Concrete Cubes

For durability studies, the British Standard mix proportion used in the mixes of conventional concrete was fixed as (1:2:4) after several trials. The water/cement ratio for the mixes was also 0.55%. The amount of plastic waste as additive was varied to assess its effects on the performance of the derived concrete. Materials were batched as shown in table 1.0.

Table 1.0: Concrete batching with varying percentages of plastic waste and their corresponding aggregate weights.

Cube samples (%)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water quantity (kg)	Plastic waste (kg)
Cube A (0%)	1.40	2.56	4.88	3.850	0.00
Cube B (0.2%)	1.40	2.56	4.88	3.850	1.62
Cube C (0.4%)	1.40	2.56	4.88	3.850	3.24
Cube D (0.6%)	1.40	2.56	4.88	3.850	4.48
Cube E (0.8%)	1.40	2.56	4.88	3.850	6.49

2.2.2 Casting and Curing

The River sand used was first air-dried and sieved to remove clumps and debris. Known weights of the sand and cement were then mixed with PWB. The mixing lasted for about 10 minutes to ensure an even distribution of the materials in the mix. It was spread evenly to receive coarse aggregate. Water content up to the optimum moisture content was gradually added to the mix, during the mixing. Since the mixture was planned to be compacted, to avoid adhesion of concrete, the internal faces of the moulds were coated with thin layer of oil.

Fifteen (15) concrete cubes were cast and compacted in three layers. The compaction was done manually by subjecting each layer to 25 blows form the tamping rod making sure that the rod does not forcibly strike the surface below.

After casting, the samples were labelled with identifications and kept in their moulds for 24 hours. The samples were then removed from their moulds and immediately placed in the curing tank after their weights were taken. The effects of the plastic waste bags additive were assessed to determine the effects of the increase in the plastic on the slump test, water adsorption and the compressive strength. The slump test, water adsorption and the compressive strength were determined in the laboratory using the BS 1881 Part 116:1990, BS 1881, Part 122:1990 and BS 1881, Part 102; 1990 respectively.

3.0 RESULTS AND DISCUSSIONS

A comparative analysis of the concrete mix is made to evaluate the effect of compressive strength and workability with varying percentages of plastic waste by volume. The compressive strengths of concretes cured at 7, 14 and 28 days are presented in Table 2 and Figures 1 and 2.

Table 2: Compressive strength result with varying percentages of plastic waste cured for 7, 14 and 28 days

Mix Description					
% of Plastic	0.00	0.20	0.40	0.60	0.80
7 days	16.65	14.26	12.47	11.02	9.78
14 days	21.3	20.65	18.58	16.44	14.32
28 days	24.65	22.76	21.1	20.64	19.34

It was observed that the compressive strength gradually decreases with increasing percentage of plastic waste. This conforms to the result of Raghatate [1] who attributed the reduction to the weak bonding formed as a result of the introduction of the plastic waste. Similarly, Rahman et al. [2] reported of a reduction in specific compressive strength and density with the addition of plastic waste. A clear reduction in compressive strength was also reported by Sadiq and Khattak [3] with increasing percentages of plastic waste aggregate replaced with crushed aggregate at 7, 14 and 28 days curing.

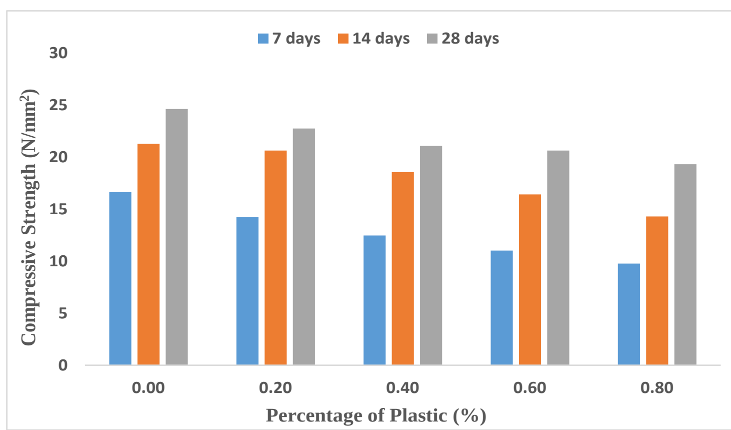

Figure 1: Compressive strength test result for varying percentages of plastic and curing periods

It can be seen in table 2 that the concrete cube with 0.2% plastic waste recorded the highest compressive strength of 22.76N/mm2 after 28 days curing. Also, the addition of

0.8% plastic waste causes about 22% reduction in the compressive strength after 28 days.

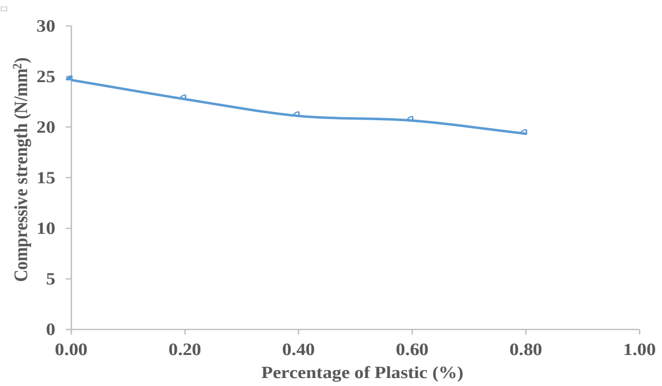

Figure 2: The 28 day compressive strength test result with varying percentages of plastic waste.

Kumar et al., [4] and Nibudey et al., [5] on the other hand observed reduction in compressive strength at percentage of plastic higher than 1%. They also attributed it to the weak bonding between the concrete constituents due to the presence of the plastic waste.

3.1 Workability test result

Workability is related to the compatibility, mobility and stability of fresh concrete. It is the property of a freshly mixed concrete that determines the ease with which it can be mixed, placed, compacted and finished. Table 3 shows the variation of the slump heights with varying amount of water-cement ratio and varying percentage of plastic waste.

Table 3: Slump test result with varying percentages of plastic waste and weights of water-cement ratio.

Plastic weights	Water-cement ratio				
(%)	0.45	0.50	0.55	0.60	0.70
0.00	30	30	29.5	27	26
0.20	30	29	28	26	25
0.40	30	28.5	27	24.5	23
0.60	28.5	27	25	23.5	21
0.80	27	26.5	25	22	19.5

Although the additions of plastic waste result in a mix of substantial workability, it is observed that the slump height decreases with increasing water-cement ratio. The slump heights also decreases with increasing percentage of plastic waste. This may be due to the use of super plasticizer which acts as retarder to some extent [4].

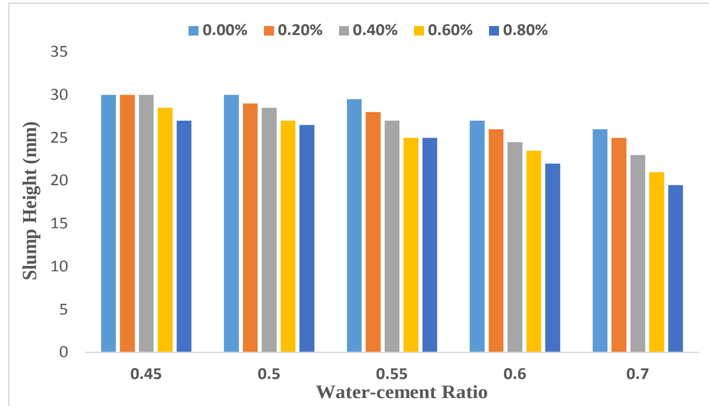

Figure 3: The slump test result for varying percentages of plastic waste and water-cement ratio by weight

The slump test result as indicated in figure 3 shows that the workability of the concrete decreases with increasing percentage of plastic waste and water cement ratio. This confirms the result of Nibudey et al. [5] who reported that the workability of green concrete decreases as fiber content increases. They attributed it to the introduction of fiber by the plastic waste. This is because plastic is not a material that absorbs water and so excess water content is not absorbed therefore making a shear slump.

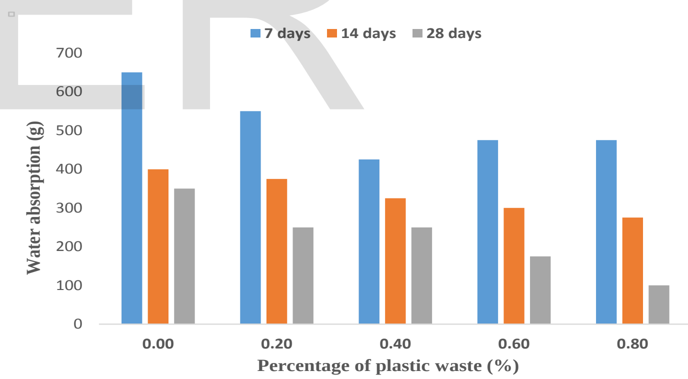

Figure 4: Water absorption rate for varying percentages of plastic waste and curing periods.

The water absorption test results as indicated in Figure 4 shows that the amount of water absorbed decreases with increasing percentage of plastic waste and curing period. This is indeed true because plastic has 0.00 % absorption rate [6] and so little or no amount of water will be absorbed. More so, as the curing days increases, the concrete is not able to absorb water due to the presence of the plastic waste.

4.0 CONCLUSIONS

Although the additions of plastic waste result in a mix of substantial workability, it is observed that the slump height decreases with increasing water-cement ratio. It also decreases with increasing percentage of plastic waste. Thus,

- The workability of the concrete decreases with increasing percentage of plastic waste and curing period.
- The water absorption rate of the concrete decreases with increasing percentage of plastic waste.
- The compressive strength of the concrete with 0.2% plastic waste recorded the highest compressive strength of 22.76N/mm2 after 28 days curing.
- Addition of 0.8% plastic in the concrete causes about 22% reduction in the compressive strength after 28 days.

Although the compressive strength was lower than the recommended value (32.5N/mm2), it could be used for a variety of applications including concrete paving blocks and pre-cast concrete wall elements.

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