Behavior of Concrete Formulated with Plastic Waste

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***Abstract*—This study is about the behavior of concrete formulated with plastic waste. Two hundred and thirteen referenced values, were collected and analyzed. The collected samples are representative of the concretes produced by different researchers. The effects of the incorporation of plastic waste on the behavior of concrete in the fresh and hardened states were examined. It was noticed, that the behavior of the concrete depends on the rate of plastic waste incorporation.**

***Keywords*— Concrete, Plastic Waste, Strengths, Slumps, Densities, Modulus of Elasticity.**

I. Introduction

The world is faced with the problem of recovering and recycling plastic waste. This plastic waste, whatever its origin, is not biodegradable and today contributes to dangerous pollution. At the same time, demand for concrete is increasing. This demand for concrete leads to overconsumption of natural aggregates. In the short to medium term, this could lead to a scarcity of local natural deposits. The solution to this dual problem could be to replace part of the natural aggregates by plastic waste in the manufacture of concrete. This is the rationale behind this study. The aim is to analyze the effect of incorporating plastic waste on the mechanical behavior of concrete. To this end, two hundred and thirteen referenced test values were collected and analyzed. The samples collected are representative of the concretes produced by the various researchers.. The types of waste are listed as follows: (HDPE) for high-density polyethylene, (LDPE) for low-density polyethylene, (PET) for polyethylene terephthalate, (PVC) for polyvinyl chloride, (PP) for polypropylene, (WFSCC) for waste plastic bag fibers, (N.I) unidentified, (MPW) for metallized polypropylene fibers, and (HDPI) for high-impact polystyrene. Waste dimensions are quoted. The percentage of waste substitution incorporated is also listed.

II. Test Programs

For each study referenced, test programs have been organized to study the properties of the concretes in their fresh and hardened states. These concretes are formulated using waste plastics. Plastic waste is introduced, step by step, as a replacement for natural aggregates. The characteristics, morphology and substitution rates of plastic waste differ from one study to another. [1 to 13]

For all the tests analyzed, the characteristics of reference concrete with 0% plastic waste, formulated solely with natural aggregates, were first measured.

Next, concrete samples in which the natural aggregates were replaced by plastic waste were produced. Substitution rates are specific to each study. The mechanical characteristics of the concretes produced were thus established.

III. Effect of Incorporation Plastic Waste on Fresh Concrete Behaviour

Thirty-nine documented test values for slump were collected, analyzed and plotted in Figure 1. Similarly, thirty-five referenced test values were collected and analyzed for the study of density. The various values are shown in Figure 2.

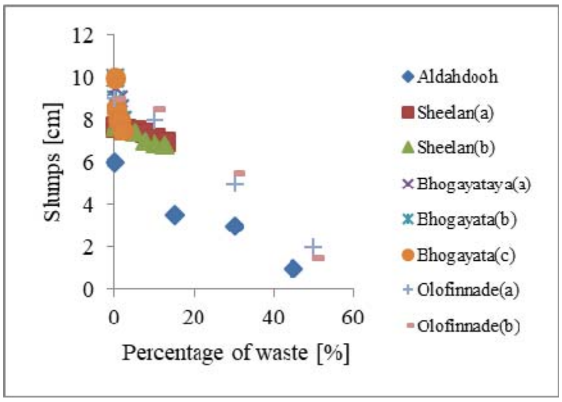

Fig. 1: Variation of slumps in referenced tests.

It was observed that the slump curves were decreasing. In the cases analyzed, the concretes became increasingly firm as the ratio of plastic waste increased. In fact, the slump of these concretes decreases as the ratio of plastic waste introduced increases. Slump decreases as the percentage of plastic waste increases.

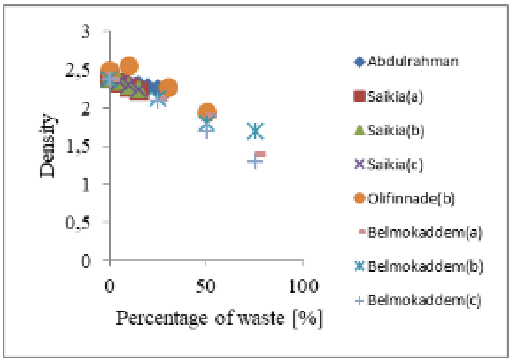

Fig. 2: Variation of densities in referenced tests.

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It was observed that the density curves were decreasing. The densities of the concretes considered decrease as the ratio of plastic waste introduced increases. The particle density of plastic aggregates, which is very low compared to that of natural aggregates, could explain this behavior

4. Effect of Incorporation Plastic Waste on Concrete Behaviour in the Hardened State

Fifty-seven documented test values were collected and analyzed for 28-day compressive strength. They are shown in Figure 3

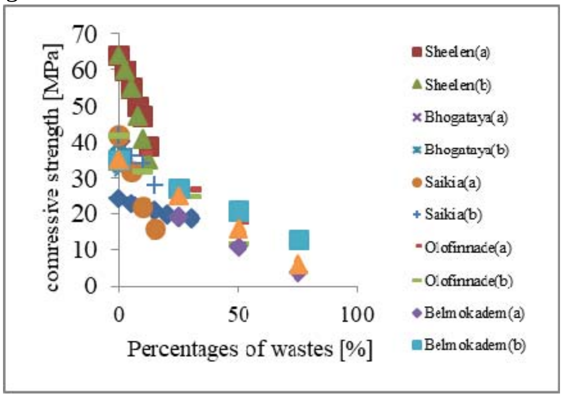

Fig. 3: Variation of compressive strengths in referenced tests.

Forty-three documented test values were collected and analyzed for 28-day tensile strength. The test valuesare shown in Figure 4

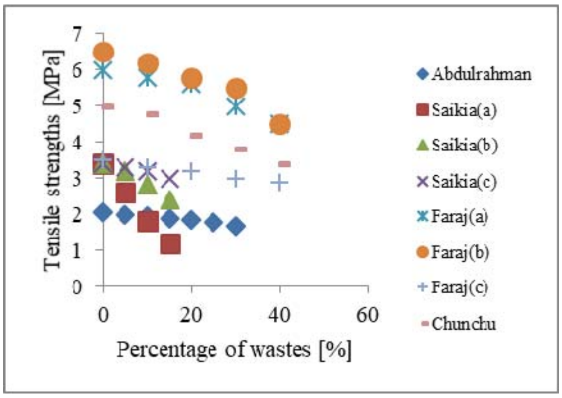

Fig.4: Variation of tensile strengths in referenced tests

Thirty-nine documented test values were collected and analyzed for modulus of elasticity. The test valuesare shown in Figure 5.

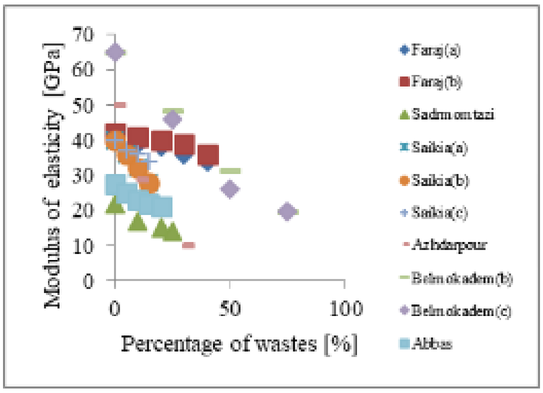

Fig.5: Variation of modulus of elasticity in referenced tests

The curves for compressive strength at 28 days, tensile strength at 28 days and modulus of elasticity are decreasing. In fact, the values of these properties decrease as the ratio of plastic waste introduced increases. These characteristics decrease as the percentage of plastic waste increases. There is therefore a loss of performance as the substitution ratio increases.

IV. Results Analysis

In the various investigations, it was found that concrete mixes containing plastic waste became increasingly firm as the substitution of natural aggregates by waste increased. These observations were confirmed by the slump values shown in Figure 1. The slump of concrete containing plastic waste therefore decreases as the wasteratio increases. In fact, the slump of the reference concrete is always higher than that of concrete containing plastic waste. The slump curves are decreasing (Figure 1). This observation was confirmed by the authors of the studies cited, who noted a reduction in water demand when plastic waste aggregates were substituted. They observed that the presence of waste prevents the dough from settling. This reduces workability but increases compactability.

It was observed that the density of fresh concrete decreases as waste plastics are substituted for natural aggregates. The density of fresh concrete is therefore inversely proportional to the rate of substitution of plastic waste. This trend can be clearly seen in Figure 2, where the density curve for concretes containing plastic waste decreases. In other words, the density of waste-containing concrete is lower than that of the reference concrete. This is because the density of plastic waste is lower than that of natural aggregates. This reduction in density was observed by all the authors. They correlated the density of the various aggregates with the density of the resulting concretes.

The results shown in figures (3 to 5) demonstrate that compressive strength, tensile strength and modulus of elasticity decrease with increasing plastic waste content.

This loss of performance was explained by the authors cited, by analyzing the microstructure of concretes containing plastic waste. The existence of micro-cracks in the vicinity of the waste explains the drop in the mechanical properties of these concretes. They deduced that plastic waste in general has a harder time regaining strength than natural aggregates, and tends to formulate porous, lightweight concretes. Belmokaddem et al, and Alqahtani et al, reported that the reduction in strength of concretes formulated with plastic waste is due to the presence of pores and poor adhesion between the plastic waste and the cement matrix

IV. Conclusions

In the cases analyzed, the concretes became increasingly firm as the ratio of plastic waste increased. Regardless of the morphology and dimensions of the plastic waste aggregates:

Densities of fresh concrete decrease as the plastic aggregate content increases, as the particle density ofplastic aggregates is very low compared to that of natural aggregates.

The compressive and tensile strengths and modulus of elasticity of concrete containing plastic aggregate are lower than those of reference concrete. These properties decrease with increasing plastic aggregate content.

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