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# The Production of the Sustainable Concrete by using Different Types of Plastic Waste

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**Abstract:** In recent years, concrete is widely used in the construction field, the materials used in the production of concrete are cement, sand and gravel, its mean increasing consumption of the natural resources and this is one of the most important reasons emersion for the concept of sustainability in the production of concrete. The aim of this study is the keeping of natural source and providing alternatives for fine aggregate and coarse aggregate by using different types of plastic waste. The three types of recycling plastic waste were used in this studying, type A (flaky) minced was partially replaced for coarse aggregate with the ratio (2.5, 5, 7.5%), two types B and C of granules minced were partially replaced for fine aggregate with the ratio (2.5, 5, 7.5%), results indicated that the compressive strength decreasing with increasing the plastic waste for type A (flaky) and type B. The compressive strength of type C decreasing 26% with the ratio 2.5 and 12% with the ratio 7.5%.

**Key words:** Pole propylene, plastic waste, sustainable concret, construction field, cement, recycling

## INTRODUCTION

The definition of sustainability was in the Oxford dictionary where it defined a sustainable word: keeping environmental balance by avoiding depletion of natural resources. While, the United Nations Environment Program (UNEP) defined it as sustainable development is a development that provides the needs of the present time without compromising the ability of future generations to provide their own needs. Sustainable concrete can be defined is the concrete that uses sustainable materials in production to reduce consumption of natural resources and reduce waste production (Ammash *et al*., 2017).

Plastic waste management is one of the main topics that are attracting increasing attention around the world in 2012, it has been producing 280 million tons of plastic all over the world and half of this amount remains as waste in the rivers, lakes, oceans and in the ground, the disintegration of plastic waste have a harmful effect on the environment and needs a long time (Bandodkar *et al*., 2011).

Tafheem *et al*. (2018) have done an experimental study about using the plastic waste strip with length (10-30 cm) and fixed width of 5 cm as an addition of cement weight with the ratio (1-3%). The results showed increased compressive strength, tensile force and fracture factor of 20%.

Anonymous (1984) were examined using Polyvinyl Chloride bags (PVC) and Polyethylene Terephthalate (TEP) bottles as partial replacement for fine aggregate after pulverizing with a ratio (2, 5, 10%) they were observed the 28 day compressive strength reduction 13.5% with partially replacement ratio 10%.

ISS. No 5 (1984) carried out an investigation about using Polyethylene Terephthalate (PET) and High-Density Polyethylene (HDPE) plastic as partially replaced for stone coarse aggregate, the results of this studying were decreasing in compressive strength 35% with 10% PET plastic replaced and 45% with 10% (HDPE) and 40% with (5% PET+5% HDPE).

In the present study, three types of Polypropylene (PP) plastic waste have been used as a partial replacement for sand and gravel, flaky was replaced for coarse aggregate and two types of grains were replaced for fine aggregate (ISS. No 51984; Vanitha *et al*., 2005).

## MATERIALS AND METHODS

### Experimental programs

**Cement:** Ordinary portland cement has been used in this study, physical properties of the cement are shown in Table 1.

**Fin aggregate:** Fine aggregate within the zone 3 has been used, the results of the sieve analysis of fine aggregate is shown in Table 2.

**Coarse aggregate:** The coarse aggregate has been used within zone 4, Table 3 it shows, the results of the sieve analysis of coarse aggregate.

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Fig. 1: Plastic waste (PP) type A

Table 1: Physical properties of the cement

| Physical properties | Iraqi specification (No. 5/1984) | Tests rustles |
|---|---|---|
| Initial setting time | 45 (min) | 49 |
| Final setting time | 10 (h) | 7.5 |
| Fineness of cement | 301.5 (kg/m$^2$) | 305 |

Table 2: The results of the sieve analysis for fin aggregate

| Sieve size | Iraqi specification No. 5/1984 (%) | Total passed (%) |
|---|---|---|
| 4.75 (mm) | 90-100 | 97.92 |
| 2.36 (mm) | 75-100 | 89.82 |
| 1.18 (mm) | 55-90 | 82.33 |
| 600 (μ) | 35-59 | 55.22 |
| 300 (μ) | 8-30 | 78.60 |
| 150 (μ) | 0-10 | 1.26 |

Table 3: The results of the sieve analysis for coarse aggregate

| Sieve size (mm) | Iraqi specification (%) | Total passed (%) |
|---|---|---|
| 37.5 | 100-90 | 100 |
| 20.0 | 75-100 | 70 |
| 9.50 | 30-6 | 22.8 |
| 4.75 | 0-10 | 4 |

**Plastic waste:** Propylene is one of the most important materials that used in the petrochemical industry and produces many intermediate products, many products is made by using polypropylene and widely using as packaging, shopping bags, pipes, plastic toys, containers, lab fittings, speakers and car parts, three types of the plastic waste Polypropylene (PP) has been used in this study produced from recycling.

**Plastic waste type A:** Figure 1 shows, the type A of plastic waste has been produced by recycling containers, plastic chairs and different machine parts after collection plastic waste has been wished and crushed by the special machine.

**Plastic waste type B:** Figure 2 is shown, the type B of plastic waste has been produced with the same material in type A but less than the size of particles.

**Plastic waste type C:** Figure 3 is shown, the type C of plastic waste has been produced by recycling shopping bags and pipes by special machines after thermal treatment.

Fig. 2: Plastic waste (PP) type B

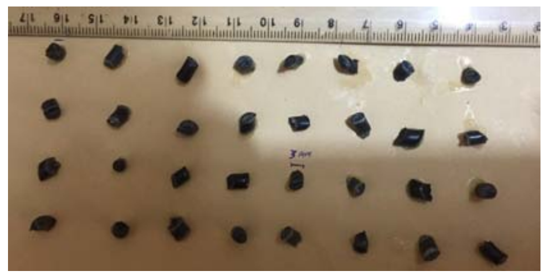

Fig. 3:Plastic waste (PP) type C

**Laboratory work:** The three types of plastic waste have been collected and washed, the results of the sieve analysis for all types of plastic waste (A-C) were showed that type A (flaky) was totally remain in sieve 4.75 mm and replaced for coarse aggregate, type B and C (granules) were totally passing from the sieve 4.75 and replaced for fine aggregate. Ten mixes have been casted in the laboratory with different ratios of plastic waste, Table 4-6 were shown the proportion of all mixes, some laboratory tests have been done to find the strength of concrete and workability.

## RESULTS AND DISCUSSION

Table 4 and Fig. 4 and 5 shows that, the compressive strength for plastic waste type A reduction 21% with ratio 2.5% when has been replaced for coarse aggregate and workability increasing with ratio 2.5 and 5% and decreasing with 7.5%.

Table 5 and Fig. 6 and 7 shows that, the compressive strength for plastic waste type B reduction 11% with ratio 2.5% when has been replaced for fine aggregate and workability increasing with ratio 2.5 and 5% and decreasing with 7.5%.

Table 6 and Fig. 8-10 show that, the compressive strength for plastic waste type B reduction 21% with ratio 2.5 and 11% with ratio 7.5% when has been replaced for fine aggregate and workability increasing with ratio 2.5 and 5% and decreasing with 7.5%.

Table 4: Mixes proportion materials (kg) with flaky plastic waste type A

| Mix | Cem. | Fine (Agg.) | Course (Agg.) | Plastic waste | Ratio (PW) (%) | W/C | Slump (mm) | Compressive strength (28 days) |
|---|---|---|---|---|---|---|---|---|
| Refer. | 340 | 729 | 1110.00 | 0.00 | 0.0 | 153 | 20 | 34.454 |
| M 01 | 340 | 729 | 1082.25 | 27.75 | 2.5 | 153 | 32 | 27.000 |
| M 02 | 340 | 729 | 1054.50 | 55.50 | 5.0 | 153 | 38 | 25.373 |
| M 03 | 340 | 729 | 1026.75 | 83.25 | 7.5 | 153 | 15 | 24.000 |

Table 5: Mixes proportion materials (kg) with grains plastic waste type B

| Mix | Cem. | Fine (Agg.) | Course (Agg.) | Plastic waste | Ratio (PW) (%) | W/C | Slump (cm) | Compressive strength (28 days) |
|---|---|---|---|---|---|---|---|---|
| Refer. | 340 | 729.000 | 1110 | 0.000 | 0.0 | 153 | 20 | 34.454 |
| M 11 | 340 | 710.775 | 1110 | 18.225 | 2.5 | 153 | 35 | 30.000 |
| M 12 | 340 | 692.550 | 1110 | 36.450 | 5.0 | 153 | 45 | 28.500 |
| M 13 | 340 | 674.325 | 1110 | 54.675 | 7.5 | 153 | 33 | 24.900 |

Table 6: Mixes proportion materials (kg) with grains plastic waste type C

| Mix | Cem. | Fine (Agg.) | Course (Agg.) | Plastic waste | Ratio (PW) (%) | W/C | Slump (cm) | Compressive strength (28 days) |
|---|---|---|---|---|---|---|---|---|
| Refer. | 340 | 729.000 | 1110 | 0.000 | 0.0 | 153 | 20 | 34.454 |
| M 21 | 340 | 710.775 | 1110 | 18.225 | 2.5 | 153 | 35 | 25.217 |
| M 22 | 340 | 692.550 | 1110 | 36.450 | 5.0 | 153 | 45 | 26.851 |
| M 23 | 340 | 674.325 | 1110 | 54.675 | 7.5 | 153 | 30 | 30.155 |

(a)

(b)

Fig. 4: a, b) The compressive strength test

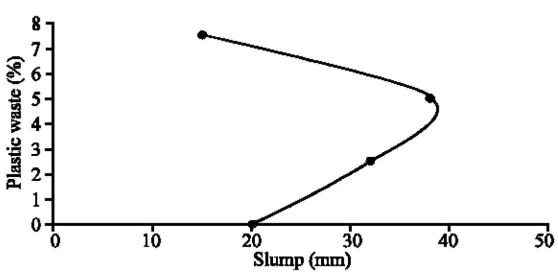


Fig. 5: Slump test with concrete content (PP) plastic waste type A

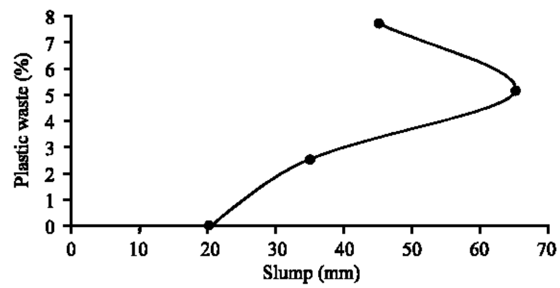


Fig. 6: Slump test with concrete content (PP) plastic waste type B

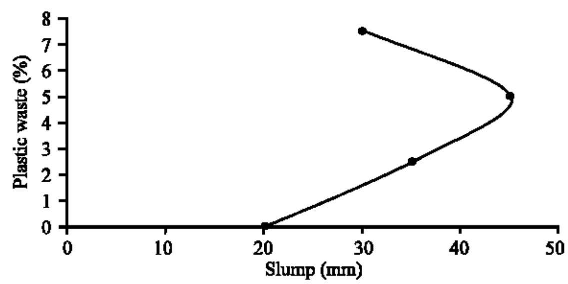


Fig. 7: Slump test with concrete content (PP) plastic waste type C

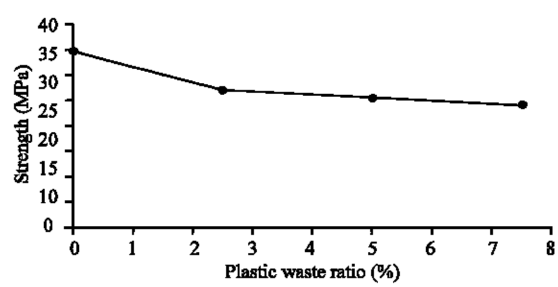


Fig. 8: Compressive strength with plastic waste (PP) type A

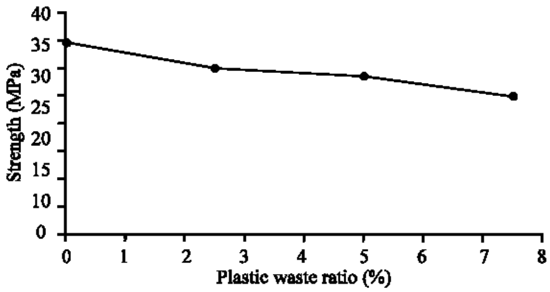


Fig. 9: Compressive strength with plastic waste (PP) type B

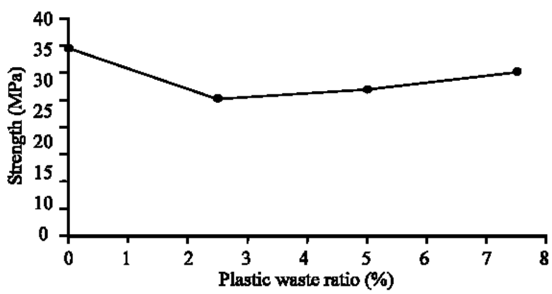


Fig. 10: Compressive strength with plastic waste (PP) type C

## CONCLUSION

In present study, ten concrete mixes have been investigated. The three types of plastic waste with different ratios partially replacement for sand and gravel were parametric. Some laboratory tests have been done to evaluate compressive strength and workability. From the results of the test, the following points can be concluded:

- Using plastic waste in the concrete mixes is good method to disposal the plastic waste
- Generally, compressive strength for concrete mixes that content plastic waste was decreasing with increasing ratio of plastic waste
- The workability of concrete mixes was decreasing with increasing plastic waste ratio


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