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MECHINICAL PROPERTIES OF SUSTAINABLE CONCRETE WITH WASTE PLASTIC BAGS

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ABSTRACT: Disposal of waste material like plastic bags is a large problem in a developing country such as Iraq. Waste plastic bags (WPB) is a gentle of non-degradable material which leads to environmental pollution. The present study covers the use of WPB as a volumetric alternative for fine aggregates for the purpose of producing sustainable concrete. Three various percentages 10%, 20% and 30% of WPB had been utilized like a volumetric alternative for fine aggregates within concrete. The features for concrete mixes that include water absorbing, dry density, ultrasonic pulse speed, compressive strength as well as flexural strength had been studied. The outcomes show that the inclusion of WPB makes a decrease within compressive strength, flexural strength, dry density and ultrasonic pulse speed by 7 plus 28 days. Furthermore, the outcomes refer to an increase within water absorbing at 7 days plus 28 day. The reducing ratio of compressive strength to concrete comprising 10%, 20% plus 30% of WPB is 42.2%, 56.6% and 83.03% respectively at 7 days, and 48.9%, 61.2% and 80.8% respectively at 28 days. The reducing ratio of flexural strength to concrete comprising 10%, 20% plus 30% of WPB is 14.9%, 38.8% and 56.4% respectively at 7 days, and 31.9%, 52.2% and 61.4% respectively at 28 days. The use of WPB gives different benefits, among such benefits is the use of WPB which produces a lightweight concrete and that depends upon WPB's ratio being utilized.

Keywords: Waste plastic bags, Mechanical properties, Sustainable concrete, Experimental work.

1. INTRODUCTION

For a considerable length of time, environment contamination has been there yet just began to be noteworthy after the revolution in industry in the nineteenth century. Contamination happens as the common environment couldn't demolish a component with no hurt or harm is done to itself.

There are many causes for pollution like fuel combustion, incinerators and industrial plants, these causes a production of several pollutants such as carbon monoxide and carbon dioxide. Because of these sources, sustainability has become the world's attention.

Ismail et al.[1] studied utilizing waste plastic within concrete mixture like aggregate alternative which involved experimental work for determining the competence of using again the wasted plastic to produce concretes. Waste plastic of fabric form shape had been utilized to be a partial alternative for sands via weight of 0%, 10%, 15%, and 20%. The results show that the compressing force value for entirely mixes made of waste plastic concrete incline to reduce under the values for mixes the reference concrete along with the increase in the waste plastic rate of entire ages of cure. Likewise, the flexural force value for mixes made of waste plastic concrete incline to reduce due to the increment in the waste plastic contents.

Choi et al. [2] studied the advancement of lightweight total concrete utilizing fine aggregates which had been fabricated from reused wasted polyethylene terephthalate (PET) bottles. The examinations on wasted PET lightweight aggregates cement incorporated the assessment of properties of wasted plastic lightweight aggregate (WPLA) and the investigation of mortar properties when WPLA was utilized as fine total. The outcomes explain that WPLA having a thickness of 1390 kg/m3, a water absorbing of 0% and a mass thickness of 844 kg/m^3. Mortar containing WPLA shows increase in flowing value, whereas the compressing force reduced as the content of 25%, 50%, and 75% with elapsed time.

Usman et al. [3] presented the use of polythene bags to replace the coarse aggregates with different contents of 0%, 2%, 5%, 7% by volume. The effect of mixing of polythene bags on the strength of the concrete mix was observed and it was found that there is increment within the compressive strength as amount of polythene wastes increased up to certain limit but decreases thereafter. The 7 days' strength of the mix is found to be sufficient and within the permissible limit. The polythene in waste up to 5% by weight of coarse aggregates, weight of concrete becomes about 8% less on mixing about 2% of the polythene mix.

Jibrael et al. [4] investigated a strategy for reinforce concrete via the incorporation of various substance of reused wasted plastic (polyethylene). Very nearly 126 samples of cement were made ready, the concrete force (compressing, split tensile and flexural force) had been examined along a period interim of 7 to 28 days utilizing 1%, 3% and 5% of fine aggregates reused wasted plastic (polyethylene) as volumetric substitution for sands. It had been discovered that when wasted plastic aggregates substance expanded from zero to 5% as a substitution of the sand in the mixture, the compressive, tensile and flexural forces of cement diminished by the proportions of 12.81%, 10.71% and increment by 4.1% separately at the age of 7 days, similarly, such concrete strengths reduced by rates of 7.93, 28.6, and 23.6% at 28day age.

Subharti [5] investigated the effectiveness of using waste plastic bags as fine aggregate replacement with ratio of 1%, 3%, 5% and 10% by volume in concrete mixes. The compressive and tensile strength of different concrete samples had been tried to decide the way of replacing fine aggregates via wasted plastic sacks that would influence the improvement of mixes strengths. The utilization of wasted plastic sacks in the concrete blend prompts the decrease in the compressive strength while it expands the tensile strength, this implies that progressively concrete blend would be needed if the plastic pack was utilized in the concrete blend and the adaptability would increment in the structure as the tensile had been expanded and it could resist the impacts of earthquakes.

The main scopes of this investigation are to study the different properties (workability, dry density, water absorption, compressive strength, flexural strength as well as ultrasonic pulse speed) for sustainable concrete comprising various contents of waste plastic bags (10%, 20% plus30%) replacement to sand to reduces the consumption of the non-renewable resources and increase the environmental performance.

2. EXPERIMENTAL WORK

2.1 Materials

2.1.1 Concrete ingredients

In this research, Al-Mass factory Ordinary Portland cement has been used in all concrete mixes. This cement is conformed to the requirements of Iraqi Specification No.5/1984 [6] according to the Chemical and physical test results. Natural sand (Al-Ukhaider) was used as a fine aggregate with maximum size of 4.75 mm. it is satisfying Iraqi specifications limits No. 45/1984 [7], it's classified as zone No.2 according to the Iraqi Specification.

Local normal crumpled rough aggregates of maximum size 12.5 mm were used. The grade and sulfate contented of the adopted rough aggregates comply with standards of No.45/1984 Iraqi Specification [7]. In general, it is necessary to use superplasticizers in order to obtain satisfied workability for concrete mixes. Therefore, a high ranging water reduce admixture (HRWRA) had been utilized to fabricate better performance concrete mix. HRWRA is commercially recognized as Top Flow SP703.

The experiment outcomes for the current study point to that the optimal dose of superplasticizer equals 2.5 liters for each 100 kg of cement, this can make the maximum compressive strength approximately 32 MPa and 51MPa at 7 days and 28 day age respectively. This admixture conforms to ASTM C494 [8] requirements.

2.1.2 Waste plastic bag (WPB)

The waste plastic bag is used spare sling, torn into random shapes, distributed as evenly as possible in the concrete.

The physical properties of the waste plastic bags are shown in Table 1, and a specimen of WPB is shown in Fig.1.

Table 1 Physical properties of the waste plastic bags

physical properties	Waste plastic bags
Apparent density (g/cm^3)	0.53
Specific gravity	0.835
Visual equivalent (%)	-
Fineness modulus	4.7

Fig.1 Waste plastic bag used in this investigation

2.2 Concrete Mixes

The mixing ratios of reference concrete mixtures are 1:1.19:1.8 (cement: sands: gravels) by weight along with cement contents equal 552 kg/m^3, w/c proportion of 0.36, HRWRA of 2.5 liter/100 kg of cement as well as slump value of 114 mm.

Four concrete mixtures are prepared in the present study for examining the properties of concrete having waste plastic bags (WPB). Table 2 shows the details of concrete mixtures that prepared in the current study.

Table 2 Details of concrete mix design

Mix designation	Cement (kg/m^3)	WPB (%) by volume of fine aggregate	Fine aggregate (kg/m^3)
0% WPB	552	0	657
10% WPB	552	10	591.3
20% WPB	552	20	525.6
0% WPB3	552	30	459.9

2.3 Mixing and Curing

For achieving the functional and homogeneity necessities of the concrete mixture, the blending strategy is a significant manual. Concrete had been blended in a blender with a limit a capacity of 0.05 m³. Blending strategy exhibited as follows: The aggregate had been added to the concrete blender with (1/3) of blending water, then blended for 1 min; the cement and(1/3) blending water had then been included, and blended for 1 min; later on, the wasted plastic sacks along with the last (1/3) blending water had been included with (1/3) of the superplasticizer and blended for (1.5) min, at that point the mix had been left for (1.5) minutes so as to rest; The remaining two-third of the superplasticizer had been included after that and blended for (1.5) min. and the mix of cement was then cast, the entire blending period lasted for 5 min.

The specimens were demolded and laid in water tank with a temperature of 22 C°. Then, the specimens were left in laboratory till the date of testing. Fig.2 shows the casting of the specimens.

Fig.2 Casting of some specimens

3. RESULTS AND DISCUSSION

3.1 Dry Density

The dry densities of the reference mix and mixes containing WPB at 28 days are shown in Table 3 and Fig.3. The use of waste plastic bag reduces the dry densities of all mixtures besides increasing the waste plastic ratio. Such reducing within dry density can be attributed to the low density for WPB compared with the density of natural fine aggregates [1]. The decreasing ratio in dry density for concrete with 10%, 20% and 30% WPB is 4.1%, 10.6 % and 23.21% correspondingly in comparison to the reference concrete**.**

Table 3 Dry density and water absorbing results for different concrete mixtures

Mix designation	Dry density at 28 day (kg/m³)	Water absorption at 7 day (%)	Water absorption at 28 days (%)
0% WPB	2221.2	2.48	2.5
10% WPB	2130.9	2.55	2.65
20% WPB	1986.2	4.95	3.33
30% WPB	1705.6	10.26	9.6

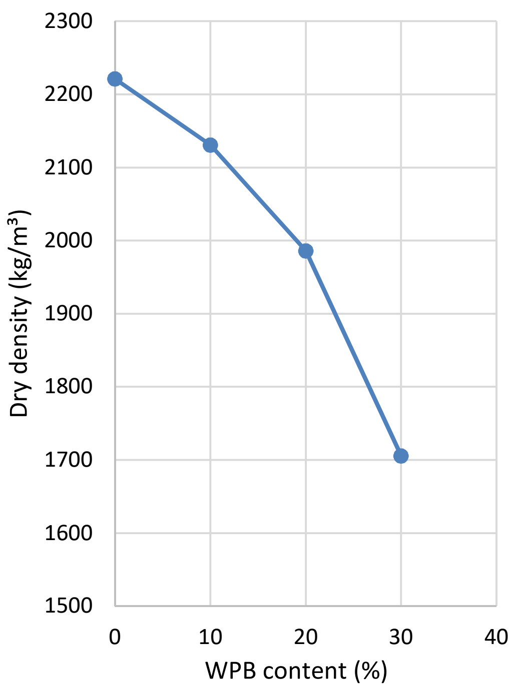

Fig.3 Influence for waste plastic bags content on dry density of sustainable concrete at 28 day

3.2 Water Absorption

Table 3 and Fig.4 show the water absorbing for various concrete mixes that including different ratios of WPB at 7 and 28 days. It can be noticed that the water absorbing for concrete having 10%, 20% and 30% WPB increased compared to the reference mix (without WPB).
The water absorbing for the concrete containing 10% WPB shows a slightly increase; while concrete mixes containing 20% and 30% WPB have a significant increase in water absorption in comparison with the reference mixture (having no WPB).
Such increase can be attributed to the angular shape for the waste plastic bags, this causes larger absorption of concrete in comparison with reference concrete [9]. The water absorbing of mixes having 10% and 20% WPB at 28 day age is less than 10%, so it is classified as good concrete and it is recommended for constructions [10].

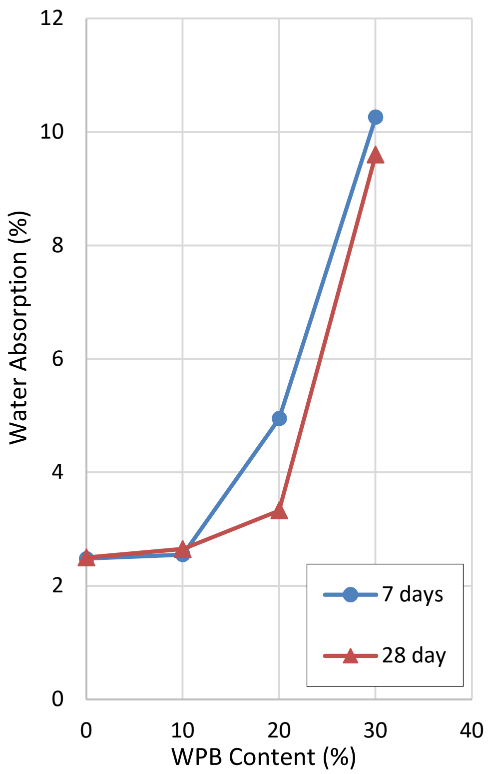

Fig.4 Waste plastic bags content influence upon water absorbing of sustainable concrete

3.3 Compressive Strength

Table 4 and Fig.5 show the various ratio influences for WPB used partially as alternative by volume of fine aggregate (10%, 20% and 30%) upon the concrete compressive strength during the age of 7 plus 28 days.

The outcomes illustrate that the reference concrete (having no WPB) is having a high strength of 51.33 N/mm^2 at 28 day. At the age of 7 as well as 28 days, the compressive strength of concrete having various ratios of WPB get decrease in comparison with reference samples.
The decrease ratio of compressive strength for the concrete mix comprising 10%, 20% and 30% of WPB is 42.2%, 56.6% and 83.03% respectively at 7 days, and 48.9%, 61.2% and 80.8% respectively during the age of 28 days. The reduction within the compressive strength of concrete having WPB is because of decreasing the adherent strength of wasted plastic surfaces with the cement paste, also waste plastic bags is hydrophobic material which may restrict the hydration of cement [1].
The outcomes of dry density as well as compressive strength illustrate that concrete with 20% and 30% of WPB are distinguished as non-structural lightweight concrete. Typical failing manners of concrete samples containing WPB below compression loading can be seen in Fig.6.
It is clear that the inclusion of WPB in concrete alters the failing manner of concrete samples starting with a fragile to a more ductile failing which is important for certain critical situation such as accident, earthquake ect. to enhance the resistance of the structure to cracking [11].

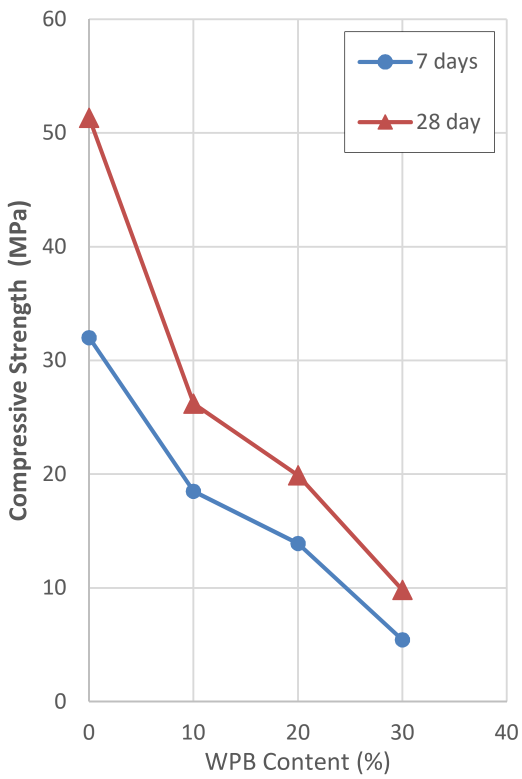

Fig.5 Wasted plastic bags content influence upon the compressive strength of sustainable concrete

(a) 0% WPB

(b) 10% WPB

(c) 20% WPB

(d) 30% WPB

Fig.6 Typical failing manners for concrete samples with various contents of WPB under compression

Table 4 Compressive strength plus ultrasonic pulse speed outcomes for concrete mixes

Mix designation	Compressive strength at 7 days* (MPa)	UPV at 7 days (m /sec)	Compressive strength at 28 days* (MPa)	UPV at 28 days (m /sec)
0% WPB	32	4.6	51.33	5.33
10%WPB	18.5	3.74	26.2	4.26
20%WPB	13.9	3.28	19.9	3.81
30%WPB	5.43	1.99	9.83	2.66

*100 mm cube specimen

3.4 Ultrasonic Pulse Velocity (UPV)

The obtained outcomes of the ultrasonic pulse speed for different concrete compositions can be seen within Table 4. The nondestructive testing has extreme usefulness for investigating the homogeneousness of concrete having waste plastic bags, i.e. more homogeneousness indicates increment transmitting of speed via the concrete. It is noted that the velocity is much higher for reference concrete (without WPB), while concrete with WPB shows a decrease in UPV.

This decrease is due to the angular form of waste plastic which increases the volume of voids in the microstructure of concrete [12], similarly the plastic can be deemed so week for transiting wave in comparison with normal aggregates [9].

3.5 Flexural Strength

Table 5 and Fig.7 show the flexural strength test results for the reference concrete samples and sustainable concrete specimen having different ratios of WPB. These results show that the flexural strength of sustainable concrete containing WPB decreases with the increase of WPB.

This trend may be attributed to the decrease within adherent strength amid the surface of plastic wasted particles with the cement pasting [1], and because of the incorporation of waste plastic bags, that considerably changes the failure behavior for the resulting concrete [13].

The percentage of decrease in flexural strength is about 14.9%, 38.8% and 56.4% at 7 days, and 31.9%, 52.2% and 61.4% at 28 days for specimens with 10%, 20% and 30% of WPB respectively. Regular failing manners of reference concrete sample and samples having WPB are shown in Fig.8. Concrete samples having only natural fine aggregates exhibit brittle failure under flexural, the concrete samples had been divided to two pieces. Concrete samples having various contents of WPB witnessed a failure as a ductile mode. Just a single straight crack had been seen within concrete samples having different contents of WPB fine aggregate and the cracking breadth reduces along with the increasing of WPB content.

Table 5 Flexural strength test results of concrete mixes

Mix designation	Flexural strength at 7 days (MPa)	Flexural strength at 28 days (MPa)
0% WPB	3.35	4.85
10% WPB	2.85	3.3
20% WPB	2.05	2.32
30% WPB	1.46	1.87

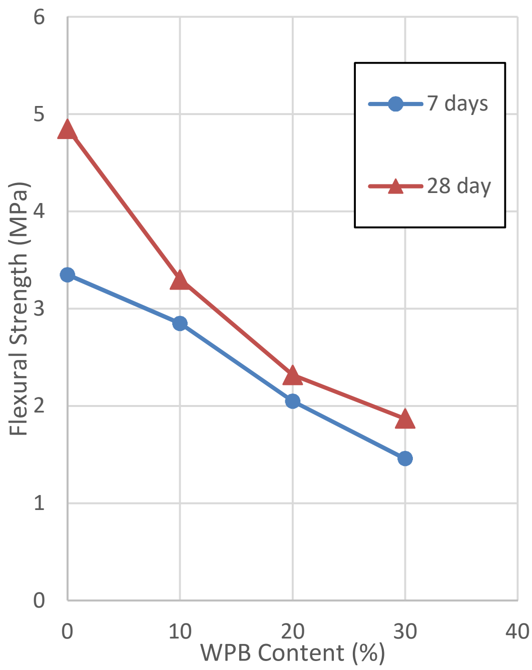

Fig.7 Effect of waste plastic bags on flexural strength of sustainable concrete

(a) 0% WPB

(b) 10% WPB

(c) 20% WPB

(d) 30% WPB

Fig.8 Regular failing modes of concrete samples with WPB under flexural

4. CONCLUSIONS

According to the findings of the experiment works done during the current study, the coming points are concluded:

1. The inclusion of waste plastic bags reduces the dry density of concrete. The percentage reduction is about 4.1%, 10.6% and 23.21% for concrete having 10%, 20% and 30% WPB as a volumetric alternative to fine aggregate respectively.
2. Water absorption for concrete having various contents of WPB increases in comparison with reference concrete (having no WPB).

3. The compressive strength reduces along with increasing of WPB contents. The reducing ratio within compressive strength is 42.2%, 56.6% and 83.03% at 7 days and 48.9%, 61.2% and 80.8% at 28 day for concrete containing 10, 20 and 30% volumetric replacement of WPB respectively.
4. Utilizing the WPB decreases the flexural strength of concrete. The percentage of reduction increments along with increasing WPB content. The percentage reduction is about 14.9%, 38.8% and 56.4% at 7 days and 31.9%, 52.2% and 61.4% at 28 day of concrete having 10%, 20% and 30% WPB respectively like volumetric alternative for fine aggregates.
5. An important reducing in ultrasonic pulse speed along with increasing of WPB contents.
6. Structural normal weight sustainable concrete can be produced by using 10% or less of WPB like volumetric alternative for fine aggregates.
7. Non-structural lightweight sustainable concrete can be produced using 20% and 30% WPB like volumetric alternative for fine aggregates.
8. Generally, the results of this research indicate that it is possible to produce structural and nonstructural sustainable concrete with accepted strength, water absorption and reduced dry density by the inclusion of WPB waste.
9. The use of WPB waste as fine aggregate in concrete industry can consume huge quantities of this waste material and solve both problems of aggregate lack on construction sites, and environmental pollution.

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