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Strength Properties of Concrete Including Waste Plastic Boxes

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Abstract. Iraq beside other countries generates tonnes of waste plastic boxes delivered from fruits and vegetable plastic boxes. In the construction sector, an alternative disposal is required for sustainable development of this material. The reducing of this plastic waste can be achieved by adding it in concrete as replacement of coarse aggregate. The investigations of this study carried out at the age of 7, 28, 56 days by testing concrete with and without of plastic coarse aggregate. Five sets of concrete mixtures were cast with percentages of 0%, 20%, 40%, 60%, and 80% of waste plastic boxes as replacement of gravel. Fresh and hardened Properties were tested at a specific age and compared with reference concrete (RC). Concrete with plastic considerably enhanced concrete properties. Results of the study indicated that depending on the quantity of plastic replaced gravel, plastic may effect on strengths. However, the test results demonstrated that this replacement in concrete is promising by comparing results with reference mixtures concrete.

Keywords: waste plastic boxes, disposal, fresh and hardened properties

1. Introduction

The significant increase in the use of concrete in recent years which is estimated at around 30 billion metric tons annually in the world is offset by a shortage of quantity raw materials on our land[1]. The concrete industry consumes a huge amount of natural raw materials and this has a direct impact on the environment energy consumption and economic effect a huge accumulation of industrial waste. As a result, we have two issues. The first is a shortage of raw materials for the production of new concrete. The second is how disposal of these plastic waste. Hence the idea of reuse in the production of new concrete went a long way in some countries. Researchers have been experimenting and continue to use with the best promising technologies in solving practical and technical problems associated with reusing of plastic waste in concrete[2].

Iraq as a nation with a populace of more than 37 million individuals, it imports a considerable package of various fruit and vegetables stored in plastic boxes. All these waste plastic boxes are being disposal in landfill locales. It takes years to decompose making an issue to our environment and create serious risk, thus increasing the danger to our environment[3]. It should be focused on studies that investigate from reusing of these plastic boxes. In this study, these waste plastic after grinning can be used in the generation of normal concrete as replacement of coarse aggregate. However, previous studies did not use plastic at high percentages replacement of coarse aggregate in concrete. Thus, due



to this lack, this study is considered as an essential development toward of reusing waste plastic boxes in concrete as coarse aggregate to minimize its disposal issue. This study may be helping us to promote an alternative way of reusing waste plastic boxes delivered from fruits and vegetable plastic boxes.

2. Materials

Cement: Ordinary Portland cement (Cresta) from a region in the north of Iraq was used with 3.1 and fineness of 317 kg/m^2 . **Sand:** The fine aggregate was sand local sources in Iraq with a specific gravity 2.68. **Coarse aggregate:** Gravel Maximum size of 20 mm and specific gravity of 2.75 was used as coarse aggregate. **Waste plastic boxes (WPB):** percentages of (0%, 20%, 40%, 60% and 80%) were used as a replacement of the gravel after washing and grinding with a specific gravity equal to 1.34. **Mixing and curing water:** Fresh water from the tap in the concrete laboratory was used.



Figure 1. Waste plastic boxes (a) before grinding (b) after grinding

3. Experimental work

The experimental program was including fresh and a hardened state. In fresh state, the slump test was done directly after mixing the raw materials in the mixer by using a slump cone according to cone according to the BS 1881:102 standard[4]. After that, standard cubes of (150×150) mm was used to cast concrete, besides that, cylinder and beam also used to investigate the hardened properties[5]. After 24 hours of casting, the moulds were de-moulded taken out in tank water for testing at a specific age. The compressive strength test with British Standard (BS EN 12390-3:2009)[6] was conducted at 7 and 28 days.

3.1. Mix proportion

As shown in Table 1, six cubes for the M30 grade of concrete with five different weight percentages of waste plastic boxes (0%, 20%, 40%, 60% and 80%) were cast. Sizes of cube specimens are 150mm × 150mm × 150mm, and sizes of cylinders specimens are 300mm × 150 mm.

Table 1. Mix proportion (kg/m^3)

Specimens	OPC	WPB	Sand	Gravel	w/p
RC	460	0	540	1080	0.45
WPB 20%	460	216	540	864	0.45
WPB 40%	460	432	540	648	0.45
WPB 60%	460	648	540	432	0.45

WPB 80%	460	864	540	216	0.45
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RC= Reference concrete; WPB= Waste plastic boxes

4. Results of Tests in Fresh State

4.1. Slump test results

As shown in Figure 2, the slump values are clearly decreased, and the mixture becomes stiffer as percentages of replacement increased. The slump test showed that reference concrete has workability better than rest mixes.

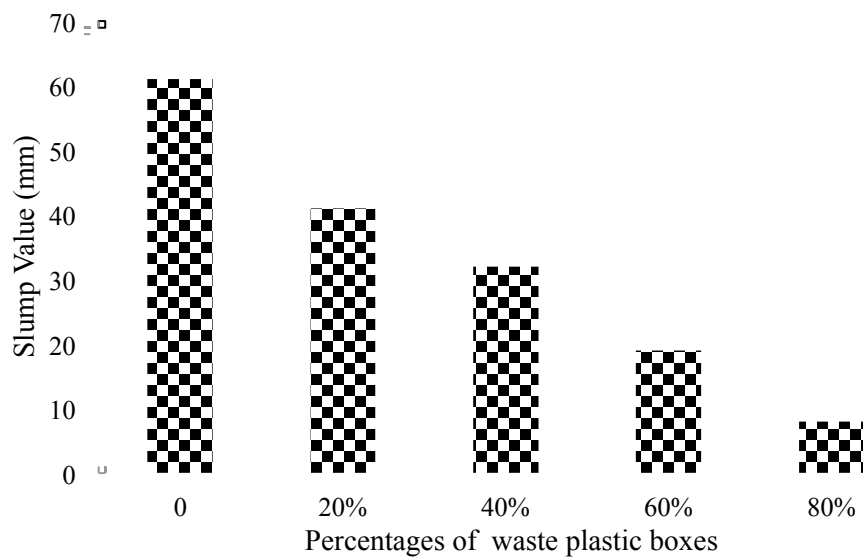


Figure 2. Results of the slump test

5. Results of Tests in Hardened State

5.1. Density of samples

The utilization of the plastic in concrete mix led to reducing the weight of samples up 26.5%. The weighted of dry density for waste plastic boxes mixes concrete and reference mix are graphed in Figure 3. It is obvious that, at 28 days curing age, the lowest dry density was 1.83 kg/cm³). The structural lightweight concrete has a density of range 1.440 to 1.840 kg/cm³ that mean the dry density of samples study exceeds the range of structural lightweight concrete[7-9]. The reducing in the dry densities of all mixtures increased with increase in the waste plastic ratio replacement of coarse aggregate. It may be attributed to the lower specific gravity of plastic compared to the specific gravity of gravel which was 1.34 and 2.75, respectively.

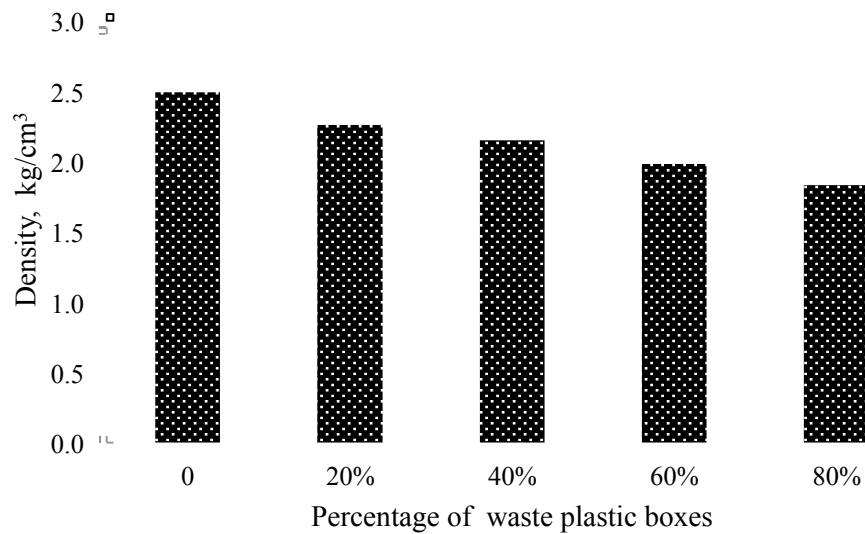


Figure 3. Results of dry densities at 28 days

5.2 Compressive test

Table 1 shows the average compressive strength of concrete incorporating grinding plastic boxes at 7 days, 28 days and 56 days. Results from above table indicated that the suitable percentage replacement of WPB was 20% up to 40% which showed that decreasing in compressive strength was 7.37% and 17.68% compared to reference concrete. It was also observed that the decreasing in compressive strength of concrete mixes with WPB 60% and WPB 80% was 38.6% and 46.65%, respectively. Satisfy of acceptance criteria depends on the grade of concrete that concrete design for it[10]

Table 2. Compressive strength test results

Mix Design	Compressive Strength (Mpa)		
	7 days	28 days	56 days
Reference mix	24.36	30.36	31.44
WPB 20%	21.09	27.19	28.68
WPB 40%	18.54	24.89	25.44
WPB 60%	16.09	18.99	19.3
WPB 80%	13.27	16.16	16.8

5.3 Splitting tensile

The results of splitting tensile test were graphed in Figure 2. It is clear that when increasing the percentage of waste plastic boxes in concrete as replacement of aggregate the splitting tensile decreases.

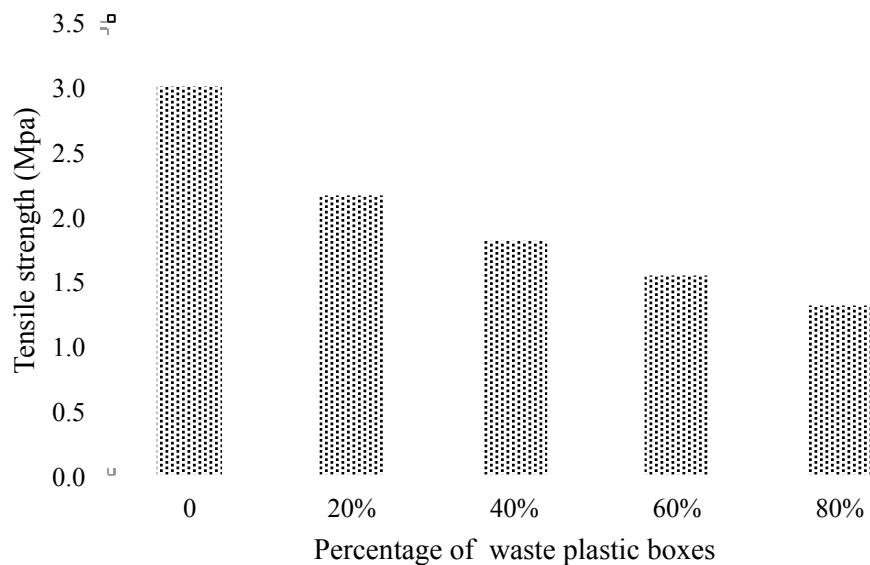


Figure 4. Results of splitting tensile strength

6. Conclusion:

The huge amounts of waste plastic boxes make its disposal a very critical problem. The current study was conducted to pay attention the feasibility of using plastic boxes in normal concrete. The obtained results gave positive indicator about using this waste in concrete and the possibility of developing the properties of concrete. However, there has been a decline in strength properties, and therefore further studies are needed on WPB reuse to demonstrate field application.

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