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Wood Chipping Concrete Strength improved by using aPlastic Waste Materials

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Abstract:
This paper presents the results of a testing program to examine the possibility of using plastic waste material to enhance the strength of wood chipping concrete. The plastic waste was cleaned and then cut to small pieces. On the other hand, the wood chipping was cleaned and passing from sieve of number 200 and was saturated in water for 24 hours. A total of 144 numbers of concrete specimens were cast at different replacement ratios of wood chipping with and without plastic waste of (0, 5, 10, and 15) % by weight of cement. All of the concrete mixtures were tested at room temperature. These tests include performing compression, split tension and flexural strength has per relevant British standard specifications. The results proved the arrest of the propagation of micro cracks by introducing plastic waste as coarse aggregate shapes on concrete mixture. The results of this study indicated an improvement in compressive, tensile and flexural strength of wood chipping concrete with(10, 9, 13)% comparing with normal concrete results of mechanical properties of (26.2, 2.3, and 0.44) at 7days age, and (39.3, 3.5, and 0.66) at 28 days age, respectively. This study insures that reusing plastic waste in wood chipping concrete gives a good approach to reduce the cost of materials and solve an environment problems of the solid waste materials.

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I. INTRODUCTION

In Iraq, most of the industrial activities have yielded plastic and solid wastes, the majority of which remain non-biodegradable. Globally, the consumption of plastic materials in each year has increased significantly, compared to the case of the 1950s, recent statistics point to about 100 million tons while the initial statistical value for the 1950s stood at five millions on average [1]. In a context such as Japan, the period after the Second World War saw many buildings established. This trend was in response to the need to realize rapid and low-cost construction. Up-to-date, the majority of the structures have remained effective. In Germany, the technology concerning material recycling or reuse was established as early as 1900 [2]. Recently, attention has been directed at the introduction of mechanisms through which concrete could be strengthened through the addition of certain amounts of polythene or recycled plastic waste [3]. From the outcomes, it has been established that when about 5% of sand contains plastic mixture, the flexural, tensile, and compressive strengths of the concrete tend to increase by 4.1% and reduce by 10.71% and 12.81%, respectively. These outcomes are observed in about seven days. In about 28 days, the decrease in concrete strength stands at about 23.6%, 28.6%, and 7.93%, respectively. In some studies [4], the use of plastic bottles causes a difference of 57% in

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material strength compared to situations where plain local concrete blocks are utilized. Also, additional studies suggest that when cellular fibres are used, the resultant mixtures into which the fibres are added tend to exhibit good durability, especially in coating and insulation applications [5].

In the study by Temba et al. [6], the main aim was to investigate wood chippings' physic-chemical properties and how they could aid in addressing the difficult regarding wood's high absorption rates. In another investigation, it was observed that when plastic waste is reused and applied as a substitution aggregate for sand in concrete, it yields better results in such a way that it causes a reduction in material cost and also address problems linked to solid wastes that arise from plastics [7]. In a similar investigation, YoucefGhernouti[8] reported that when waste material from plastic bags is used, the outcome is beneficial whereby there is likely to be a significant improvement in density and workability. The compressive strength of concrete with 10% and 20% of wastes was also observed to reduce significantly after mixing with waste material from plastic bags. The reduction was documented to be 10% and 24%, respectively. Thus, it was inferred that the decision to use these waste materials translates into improvements in mechanical strengths of the concrete, as well as ensuring that the concrete is developed in terms of lightweight materials.

II. EXPERIMENTAL WORK

The specimens considered in this study consisted of 48 numbers of 100mm side cubes, 48 numbers of 100mm diameter and 200mm height cylinders and 48 numbers of (100*100*400)mm prisms.The curing ages of 7 and 28 days for the concrete mixtures were depended in this work.

1. Preparationof Materials

1.1. Cement

The Ordinary Portland cement OPC manufactured by the United Cement Company (Tasulougeh - Sulaymaniyah) has a specific weight (3.15). Chemical analysis and its mechanical properties are shown in Table (I).

1.2. Aggregate

Uncrushed type obtained from natural deposits in Salah Aldine governorate.

1.2.1. Fine Aggregate

In accordance with British Standard No. 882, gradient area 2, its specific weight is in the case of saturated surface dry (2.56) and SO_3 ratio (0.05%). Table (II) shows the analysis of the fine aggregate.

1.2.2. Coarse Aggregate

In accordance with British specifications 882, its specific weight in the case of saturated surface dry (2.73) and the ratio of SO_3 was (0.01%) and the maximum aggregatesize(20mm). Table (III) shows the analysis of the coarse aggregate.

Fig.(1) shows the sieves used in sieve analysis of fine and coarse aggregate.

Table I
Physical and chemical properties of cement used

Description	Content %	Limit of Iraqi Specification No. 5/1984
Tri-calcium aluminate, C_3S	4.0	8.0 Max.
Sulphur Oxide, S_3O	2.5	2.8 % Max.
Iron Oxide, Fe2O3	3.31	6% Max.
Magnesia, MgO	2.3	5% Max.
Loss of Ignition, (L.O.I)	2.7	4% Max.
Insoluble material	1.15	1.5% Max.
Specific surface area, (m2/kg)	251	>250 m2/kg
Initial setting, hrs.: min Final setting, hrs. : min	0:80 6:00	>45 min <10 hrs.
3-day f'c MPa	15.2	>15 MPa

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Table II
Grading, chemical and physical properties of fine aggregate

Grading of coarse aggregate			
Sieve size	Cumulative passing %	Limit of B.S.882:1973	
37.5 mm	97.34	95-100	
20 mm	63.8	35-70	
14 mm	67.73	-	
10 mm	20.3	10-40	
5mm	2.45	0-5	
Chemical and physical properties of coarse aggregate			
Properties	Specification	Test Results	Limits of Specification
Specific gravity	ASTM C128-01	2.63	
Absorption %	ASTM C128-01	2.0	
Dry loose unit weight, lg/m³	ASTM C29/C29M/97	1610	
Sulphate content (as SO_3), %	(I.O.S)No.45-84	0.075	< 0.5
Material finer than 0.075 mm % sieve	(I.O.S)No.45-84	0.9	< 0.5

Table III
Grading, chemical and physical properties of coarse aggregate

Grading of fine aggregate			
Sieve size	Cumulative passing %	Limit of B.S.882:1973	
9.5 mm	100	100	
4.75 mm	93.5	90-100	
2.36 mm	82	75-100	
1.18 mm	57.6	55-95	
600 µm	43.4	35-59	
300µm	14.4	8-30	
150µm	3.8	0-10	
Chemical and physical properties of fine aggregate			
Properties	Specification	Test Results	Limits of Specification
Specific gravity	ASTM C128-01	2.60	
Absorption %	ASTM C128-01	2.2	
Dry loose unit weight, lg/m³	ASTM C29/C29M/97	1590	
Sulphate content (as SO_3), %	(I.O.S)No.45-84	0.08	< 0.5
Material finer than 0.075 mm % sieve	(I.O.S)No.45-84	1.3	< 0.5

Fig.1. Sieves Set

1.3. Water

Relative to BS: 1881, the guidelines governing the needed water for curing and concerting are met or satisfied by the college campus' available water.

1.4. Wood Chipping

The resulting sawdust was used as wood waste from the carpentry shops after cleaning it Fig.(2), and passing it from sieve No. 200, and then immersed in water for 24 hours to ensure that it was fully moistened and not absorbed the mixing water and was added to concrete mixtures by (5, 10 and 15%) of cement weight as shown below.

Fig.2.Wood Chipping

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1.5. PlasticWaste materials

The plastic waste was collected from the damaged plastic materials available in the garbage. It was cleaned and cut into small pieces and added to the concrete mix with 6% of the total concrete weight, Fig(3).

Fig.3. PlasticWasteMaterials

In this experimental work, the percentage of mixing used in the preparation of the specimens was 1: 2: 4: 0.5 (cement: fine aggregate: coarse aggregate: water/cement ratio) by weight, with a slump of 3.1 cm as a basis for obtaining stable workability of all specimens when designed according to US standard specifications[10] (ASTM C143). Manual mixing was used and the material was added according to the following sequence with continuous mixing:

1. Cement. 2. Fine Aggregate. 3. Wood chipping. 4. Waste Plastic. 5. Coarse aggregate. Water (gradually addition).

The main mechanical properties were examined (compression strength of cubes, indirect shear of cylinders and flexural of the prisms) at the age of (7,28) days. In dry state handy, there was the mixing of cement, fine aggregate, and coarse aggregate before adding some water amount as deemed appropriate and, in turn, ensuring that the content is mixed thoroughly. On the steel mold's inner surfaces, there was the smearing of oil prior to the casting stage. In turn, the mixture was introduced into the mold to undergo through compaction via the use of a standard compact system. This compaction process proceeded for two minutes [9, 10]. To finish the top surface, a trowel was used. Eventually, there was the removal of the specimens, a procedure that was completed after leaving the content for a day. The next step was curing, which lasted between one and four weeks. To test the specimen, it was removed from the curing system. In turn, its compressive strength was examined via a universal hydraulic compression test device. Also, the Wecup machine was used in examining the content's indirect shear strength. The process culminated into the examination of the flexural strength. Figure 4 demonstrates this experimental arrangement [9, 10].

Fig.4.CompressionMachine

III. RESULTS AND DISCUSSION

The concrete strengthis one of the most important properties for determining the quality, and the suitability of its use in the establishments, it is reflect a comprehensive behavior of the quality and of the mixtures as they related to the rigid cement paste structure. Therefore, it is necessary to study the compressive, tensile and flexural strength of the wood chipping concrete enhanced by plastic and compare them with reference mix.

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The compression, tensile and flexural strength depend mainly on water / cement ratio. Age can also be expressed by the percentage of gel / voids. The solid products of the hydration, gaps and the proliferation degree in the matrix also effectson the mixture strength.

Figs.(5) – (10),are shown for the compressive, tensile and flexural strength with different percentagesof plastic waste materials.Although the Figs. (5) – (8) denotes for the best enhancing of compressive and tensile strength for mixtureswith wood chipping of 5% from cement weight, while the Figs. (9), (10) denotes for the best enhancing of flexural strength for mixtures with wood chipping 15% from cement weight.

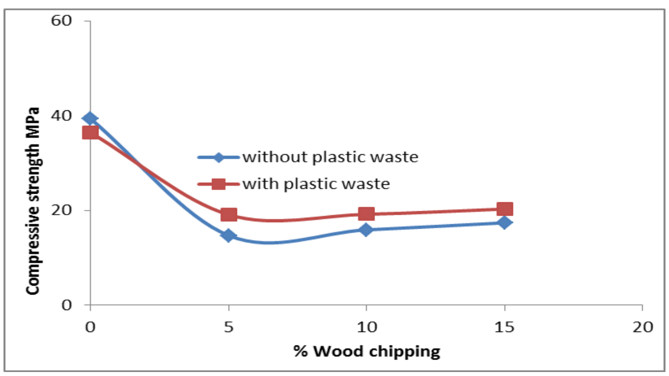

Fig.5. Effect of plastic waste on the compressive strength of wood chipping concrete at age of 7 days

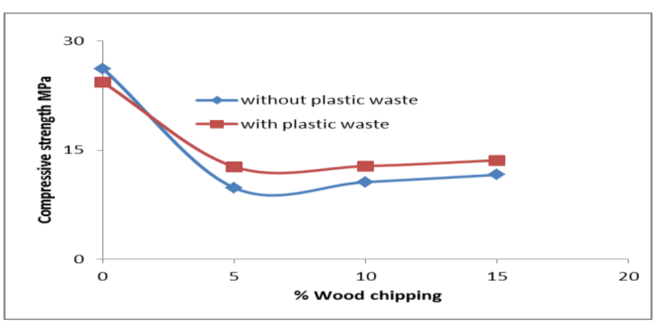

Fig.6. Effect of plastic waste on the compressive strength of wood chipping concrete at age of 28 days

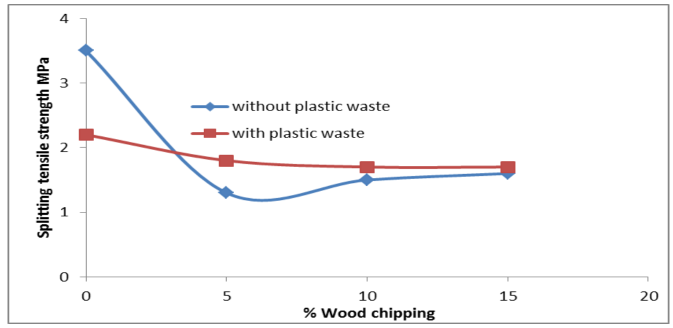

Fig. 7. Effect of plastic waste on tensile strength of wood chipping concreteat age of 7 days

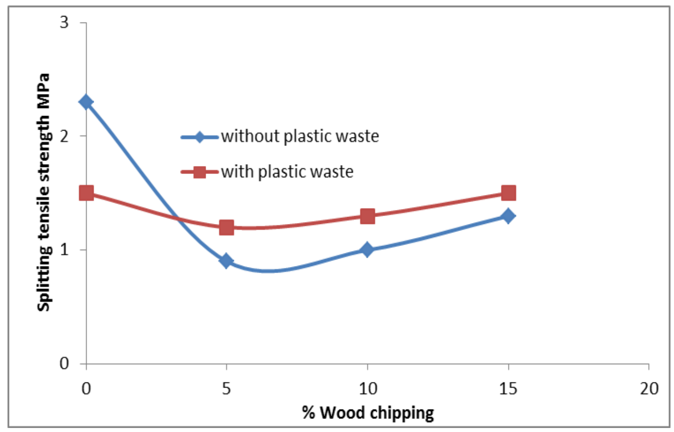

Fig. 8. Effect of plastic waste on tensile strength of wood chipping concreteat age of 28 days

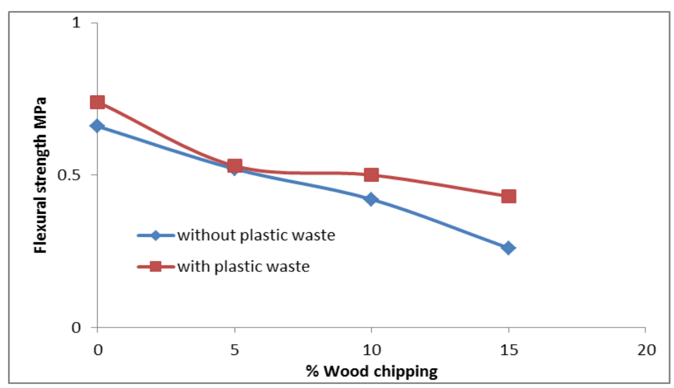

Fig. 9. Effect of plastic waste on flexural strength of wood chipping concreteat age of 7 days

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Fig.10. Effect of plastic waste on flexural strength of wood chipping concreteat an age of 28 days

The compressive strength, tensile strength and flexural strength are ranging from (4-9)%, (6-17)%, and (1-25)%at the ages of (7-28) days respectively.The marginal improvements in the strength of wood chipping concrete may be attributed to the reason that the plastic waste failed to develop proper adequate bond with concrete. The variation of dry and wet weights are shown in Figs. (11,12,13,14,15 and 16). The dry and wet weights are increased when adding the plastic waste, this is due to the heavy weight of plastic waste comparing with wood chipping. The results reported are average of 3 specimens.

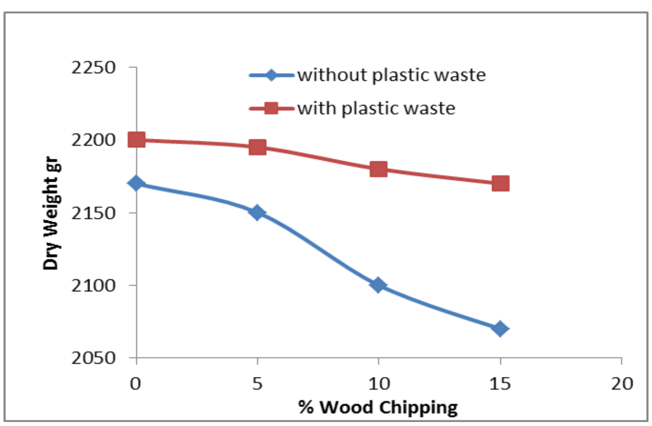

Fig.11. Effect of using plastic waste on dry weight of wood chipping concrete(cubic specimens)

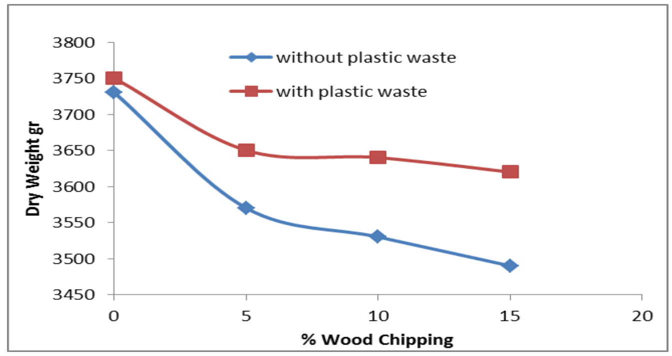

Fig.12. Effect of using plastic waste on dry weight of wood chipping concrete(cylindrical specimens)

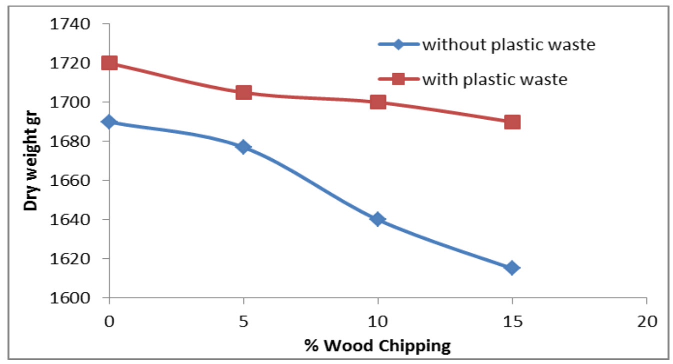

Fig.13.Effect of using plastic waste on dry weight of wood chipping concrete(prismatic specimens)

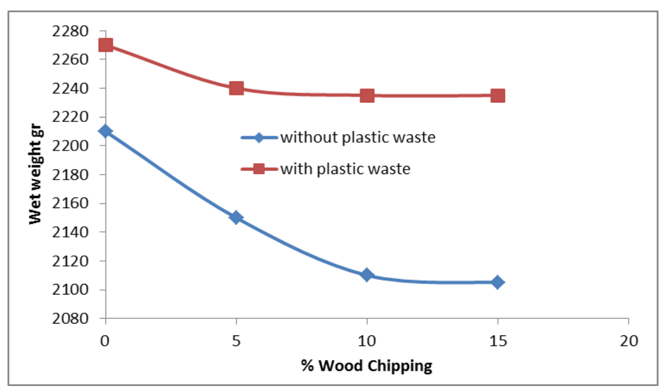

Fig. 14.Effect of using plastic waste on wet weight of wood chipping concrete(cubic specimens)

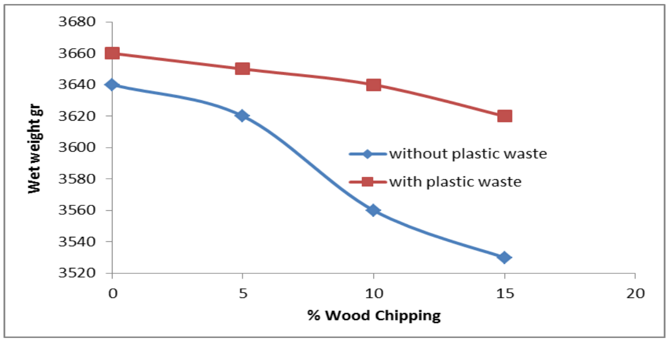

Fig.15. Effect of using plastic waste on wet weight of wood chipping concrete(cylindrical specimens)

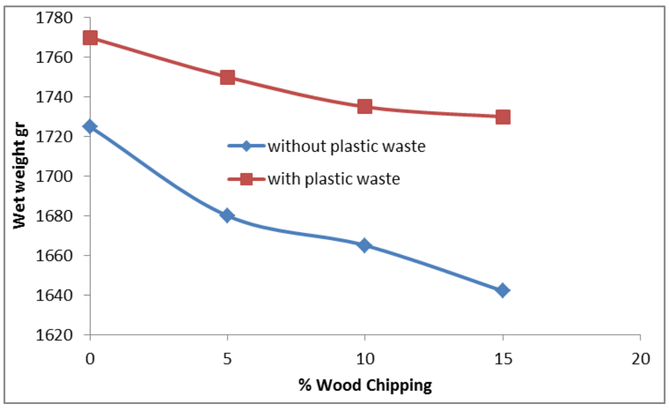

Fig.16. Effect of using plastic waste on wet weight of wood chipping concrete(prismatic specimens)

IV. CONCLUSIONS

The main conducted results of the present experimental work are:

1. The greatest difficulty in using wood chippingwas the high water absorption capacity compared to the conventional debris due to its porous matrix. This behavior was similar to the light weight types of aggregates. Due to its high absorption it was difficult to obtaining constant water / cement ratio during mixing, this case requires an addition of small amounts of water above the prescribed rate. Therefore, the wood chipping should be saturated in water for 24 hours before it used in mixing to ensure that the remaining water is not affected on cement to complete the process of hydration.

2. It is very convenient to use wood chipping concrete enhancing by plastic waste when the high strength of concrete is not a major consideration because it provides the advantage of reducing dead loads as well as reducing cost.

3. The presence of plastic waste in the concrete reduces the workability and the flow ratio compared to the normal mixture. It was noted that mixtures containing 15% wood chipping with plastic waste had less flow than the reference mixture and had lowworkability.

4. The variation in strength in wood chipping concrete specimens were asfollows:

4-1. The enhancingofcompressive strength when using the plasticwastewas about 10% on average, and the reduction in compressive strength achieved by replacing wood chipping with cement in the percentages mentioned earlier was (63, 56, and 60)% respectively at28 days age.

4-2. The enhancingoftensile strength when using the plasticwastewas about 9% on average,and the reduction in tensile strength achieved by replacing wood chipping with cementin the percentages mentioned earlier was (63, 55, and 56)% respectively at 28 days age.

4-3 The increasing in flexural strength when using the plasticwastewas about 13% on average, and the reduction in flexural strength achieved by replacing wood chipping with cement in the percentages mentioned earlier was (21, 36, and 61)% respectively at 28 days age.

The reduction in flexural strength is less than that of compressive andtensilestrengths, also increasing by using plastic waste in flexural and tensile strengths is better than of compressive strength. Concrete strength usually affected by all types of gaps and cracks in the mixture.

5. It could conducted that it is possible to use of wood chipping concrete because it is lightweight but as a unloaded cutouts, it can enhancing its strength by

using plasticwaste and it can be adopted as a good correlative material with suitable tolerances and low cost.

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