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Investigate about Some Mechanical Properties of Hardened Concrete with Plastic and Metal Trash

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Abstract: Many research works went to investigate about concrete properties contains metal and plastic trash, to improve some mechanical properties of concrete in tension and flexural in addition, to use this trash as an admixture to improve its properties, its work to clearance the environment from harmful waste. The main goal of this research is to investigate some important mechanical properties like compressive strength, splitting tensile strength, flexural strength and load-deflection test. Reference concrete used by mix proportion 1:1.5: 3 and water to cement ratio 0.45. The results of tests show that increase in compressive strength, splitting tensile strength, flexural strength of concrete contains plastic trash due to reference concrete (14, 48, 19%), (9, 20, 6%) for ages 28 and 56, respectively and increase in compressive strength, splitting tensile strength, flexural strength of concrete contain metal trash due to reference concrete (13.3, 60, 31%), (12.3, 0.0, 8.6%) for ages 28 and 56, respectively. The results of tests show that increase in capability of loading of samples due to deflection (23, 35%) between concrete contains plastic, metal trash and reference concrete.

Key words: Compression resistance, compressive strength, mechanical properties, polypropylene, deflection, metal trash

INTRODUCTION

Microfiber filaments of polypropylene were used to shorten the cement or mortar to be used as an alternative to asbestos cement (Sunzilint and Hanant, 1998). Attempts were made to improve bonding with the material by surface treatment and tearing of fiber edges to increase contact surface and overlap between material and fiber. In order to improve the adhesion, the fibers were produced in the form of buttons. Sunzilint and Hanant (1999) suggested using multiple layers of open fiber polypropylene networks and using them in the concrete with the addition of a quantity of fiber, so that, the composite resistance is much more resistant than the material called Netcem.

It has also, published encouraging results by Gardiner and Currle on the use of corrugated polypropylene fabric in cement compounds. The best advantages of using corrugated cloth are the ease of arming and the ease of blending with cement materials and preliminary tests indicate that such compounds can produce good properties. In the flexural resistance of those compounds made by open networks of fibrous fibers. Gardiner *et al.* also, reported on the manufacture and inspection of a number of products in civil engineering in laboratory containing polypropylene textiles in cement material and the results were very encouraging.

Walton and Majmadar (1975) took into consideration the composition of fiber, low-grade labs, short polymer fibers, polypropylene and nylon with high-factor fibers such as asbestos, glass and carbon. The basic benefit of the structure is the upper resistance to the shock due to the fiber with the lowest coefficient.

Based on Kobayashi and Chi (1982), it is possible to obtain a fiber reinforced concrete with improved strength by dispersing short fiber, fibers with polyethylene fibers in a random distribution in the concrete. In the practical application, the optimum structure was obtained by mixing 1% of the volume of the ferric fiber with 3% polyethylene volume. Hughes (1980) has installed a continuous Kevlar wire with reinforced concrete in glass fiber to overcome tensile resistance and increase the refractive speed over time of reinforced glass fiber reinforced concrete. The AGRC was named for the production of light weight construction units such as thin wall sections. The performance of the Kevlar wire is the same as standard reinforcement bars and provides reinforced concrete with fiberglass resistance to shear and improved impact resistance compared with non-reinforced materials, although, the impact resistance is less than time.

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MATERIALS AND METHODS

Experimental: In order to study the characteristics of the concrete used in the research, fiber or plastic and metal strips were added to know the extent of their effect on the concrete in terms of mechanical characteristics. These characteristics were examined such as plastic and metal additives, Compression resistance, indirect tensile strength, bending resistance, deviation relative to loading. Mixing and ratio mixing methods also studied.

Materials

Cement: Use salt resistant cement. In the tests carried out and the details of the chemical examination in Table 1 in the appendix tables and details of the physical examination in Table 2, the results were compared with (Iraqi Standard No. 5 of 1984) (Anonymous, 1984).

Sand: Sand was used in the laboratory tests of the sand of Najaf with a maximum size of 4.75 mm which is identical to Iraqi Standard No. 45 of 1984 (Anonymous, 1984). The second gradient area and Table 3 and 4 showing the properties of used sand.

Gravel: The fractured gravel was used for a maximum of 10 mm and was identical to Iraqi Standard No. 45 of 1984 (Anonymous, 1984) and Table 5 and 6 in the appendix to the tables showing the properties of the used gravel.

Water: Regular drinking water was used (tap water) for all mixtures as well as in the maturation and processing of samples.

Plastic waste strips: Strips of plastic waste length 7 cm and width 2 cm were used with a volume of 0.5% of the cement weight (added).

Metal waste strips: Strips of metal waste 7 cm and width 2 cm were used with a volume of 0.5% of the cement weight (added).

Mixtures and laboratory test

Mix concrete: Sand was mixed with cement and gravel by (1:1.5:3). Metal and plastic bands were also added as shown in Table 5 according to the specifications of the American Concrete Commission (ACI, 2002). Where the mixing process was carried out in the laboratory under the Iraqi Standard (SASO/280/1992), a horizontal electric mixer was used for laboratory work. After the preparation and weight of the mixtures, the mixture is moistened to prevent absorption of the water and change the mixing rates. The mixture is placed in the mixer and then the gravel. Then add the cement and mix with the sand and gravel in a dry way for two minutes. Then mix the mixture and add the mixing water. The mixture will continue for 2 min, followed by stopping the mixer. The mixer is operated for another 2 min to obtain a homogeneous mixture. In mixtures that add metal and plastic strips, the same method is applied in the mixing of dry materials. After that the mixer is activated. Mixing water is added. Mixing and lifting of the materials is continued in the same way above and the mixing continues for another 5 min in order to ensure the required homogeneity and operation.

Laboratory tests

Compressive strength: The standard specification (ASTMC109-81 1989) (Anonymous, 1989a, b) was adopted in this examination. Compression resistance was determined at ages 7, 28, 56 days from the beginning of casting and for each mixture. The compressive resistance of the models and each age was shown as an average compressive strength of three cubic cubes of concrete length, 150 mm in length and tested with a regular load by a laboratory test machine (200 kN) with a loading speed of 15 net/mm^2/min where the load was placed on 2 side of the face sided and perpendicular to the direction of its molding and the saturated and dry surface condition.

Table 1: Chemical composition and main compounds of cement

Oxide composition	Abbreviation	Content (%)	Limits of Iraqi specification No. 5/1984
Lime	CaO	62.44	---
Silica	SiO_2	20.25	---
Alumina	Al_2O_3	4.73	---
Iron oxide	Fe_2O_3	4.32	---
Magnesia	MgO	1.90	≤5.0%
Sulfate	SO_3	1.88	≤2.8% If C_3A>5%
Loss on ignition	LOI	3.50	≤4.0%
Insoluble residue	IR	0.80	≤1.5%
Lime saturation factor	LSF	0.93	0.66-1.02
Main compounds (bogue's equations)			
Tricalcium silicate	C_3S	56.90	---
Dicalcium silicate	C_2S	15.21	---
Tricalcium aluminate	C_3A	5.23	---
Tetra calcium alumino-ferrite	C_4AF	13.13	---

Table 2: Physical properties of the cement

Physical properties	Test results	Limits of Iraqi specification No. 5/1984
Specific surface area (Blaine method) (m^2/kg)	372	≥230
Soundness (Auto clave) (%)	0.01	≤0.8
Setting time (Vicat's apparatus)		
Initial setting time (h: min.)	3:58	≥45 min
Final setting time (h: min.)	4:50	≤10 h
Compressive strength		
3 days (N/mm^2)	29.80	≥15
7 days (N/mm^2)	34.84	≥23

Table 3: Grading of fine aggregate

Sieve size (mm)	Cumulative passing (%)	Limits of Iraq specification No. 45/1984, zone 2
4.75	95.90	90-100
2.36	84.60	75-100
1.18	66.60	55-90
0.60	44.20	35-59
0.30	21.60	8-30
0.15	3.80	0-10
Fineness modulus = 2.83	-	-

Table 4: Some properties of fine aggregate

Physical properties	Test results	Limits of Iraq specification No. 45/1984
Specific gravity	2.60	---
Sulfate content (%)	0.1	≤0.5
Absorption (%)	2.05	---
Dry-loose density (kg/m^3)	1595	---
Materials finer than (0.075 mm) (%)	2	≤5

Table 5: Grading of coarse aggregate

Sieve size (mm)	Cumulative passing (%)	Limits of Iraq specification No. 45/1984
20	97.60	95-100
14	---	---
10	31.09	30-60
5	3.10	0-10

Table 6: Some properties of coarse aggregate

Physical properties	Test results	Limits of Iraqi specification No.45/1984
Specific gravity	2.66	---
Sulfate content (%)	0.06	≤0.1
Absorption (%)	1.09	---

Indirect tensile strength: ASTM49496-86 (1996) (Anonymous, 1996) examined cylindrical molds with dimensions of 100×200 mm at ages 7, 28 and 56 days from the beginning of casting and for each mixture. They were placed horizontally in the laboratory examination machine and between 2 planks of thickness no more than 3 mm thick. The loading speed of the test was 1.5 nm/mm^2/min and the tensile strength of the models was confirmed and for each age, the average of 3 samples. The indirect tensile strength is calculated under Eq. 1:

$$F_t = \frac{2P}{\pi d l} \quad (1)$$

Where:

- Ft = Indirect tensile strength (N/mm^2)
- P = Maximum load of failure (N)
- d = diameter examination mold (mm)
- l = Length of examination mold (mm)

Flexural strength with one point load: This test was performed on 500×100 mm models according to the British standard (BS 1881:PART118) (Anonymous, 1989a, b) using the 300 m test machine. The loading method was adopted at one point and the maximum load was taken as an average of three models. The flexure impedance was calculated at a single point of loading under Eq. 2:

$$Fr = (3PI)/2bd^2 \quad (2)$$

Where:

- Fr = Flexural strength (N/mm^2)
- P = Maximum load of failure (N)
- l = The distance between the cushions (mm)
- b = Display the mold section (mm)
- d = Depth of the mold section (mm)

Loading-deflection test: The examination was done on rectangular Prisim with dimensions 45×20×5 cm reference samples of 6 where pregnancy was examined at the age of 7 and 28 days from the beginning of casting and for each mix and samples with plastic strips number 6 and metal strips with 6 and 7 and 28 days the models are installed with the loading of the load centrally on the surface of the tile and the load reading is taken from the instrument scale and the deviation in the middle of the tile by a dial gauge (0.001 mm).

RESULTS AND DISCUSSION

In this laboratory work, several tests were carried out in the laboratory. The results obtained after adding plastic waste strips and metal waste strips showed improvement in most mechanical tests (stress resistance, examination, indirect tensile resistance test, bending test, the pregnancy test-deviation). To the results obtained.

Compressive strength: (Ref, PM, PMM). The results of the compressive resistance of the ref and the plastic tape (PM) and the metal bearing tapes (PMM) of the cubes showed an increase in compressive resistance in the mixing of the plastic strips mix the reference by 5, 14, 9% for reconstruction 7, 28, 56, respectively. As well as an increase in compressive strengthfor mixing the metal slices from the reference mixture by (0.6, 13.3, 12.3%) for the reconstruction 7, 28, 56, respectively as shown in Table 7.

Table 7: The results of compressive resistance of mixtures (7, 28.56) days

	Material content			Compressive strength (MPa)		
Symbol of mix	Cement (kg/m^3)	Plastic and metal content (%)	w/c	7 days	28 days	56 days
Ref*	420	0.0	0.45	15.4	20.0	23.4
PM**	420	0.5	0.45	16.2	22.8	25.6
PMM***	420	0.5	0.45	15.5	22.7	26.3

*, **, ***; Reference, PM bearing; PMM bearing

Table 8: The results of indirect tensile resistance of mixtures with age (56, 28.7) days

	Material content			Splitting tensile strength (MPa)		
Symbol of mix	Cement (kg/m^3)	Plastic and metal content (%)	w/c	7 days	28 days	56 days
Ref	420	0.0	0.45	3.0	3.3	4.0
PM	420	0.5	0.45	4.1	4.9	4.8
PMM	420	0.5	0.45	3.4	5.3	4.0

Table 9: The results of the flexural strengthof mixtures (56, 28.7) days

	Material content			Flexural strength (MPa)		
Symbol of mix	Cement (kg/m^3)	Plastic and metal content (%)	w/c	7 days	28 days	56 days
Ref	420	0	0.45	3.9	4.1	4.6
PM	420	0.5	0.45	4.2	4.9	4.9
PMM	420	0.5	0.45	4.9	5.4	5.0

Table 10: The results of the load with deflection for mixing reference and mixing of plastic and metal slides

Tile 500×250×50 mm P.M (Armed with plastic strips)				Tile 500×250×50 mm P.M.M (Armed with metal bands)				Tile 500×250×50 mm ref.			
7 days		28 days		7 days		28days		7 days		28days	
Load (N)	Def (mm)	Load (N)	Def (mm)	Load (N)	Def (mm)	Load (N)	Def (mm)	Load (N)	Def (mm)	Load (N)	Def (mm)
0	0	0	0	0	0	0	0	0	0	0	0
250	0.35	250	0.26	250	0.4	250	0.33	250	0.21	250	0.11
568	-	611	-	493	-	587	-	352	-	457	-
0	0	0	0	0	0	0	0	0	0	0	0
250	0.3	250	0.29	250	0.36	250	0.31	250	0.0	250	0.19
464	-	503	-	485	-	682	-	415	-	481	-
0	0	0	0	0	0	0	0	0	0	0	0
250	0.32	250	0.25	250	0.35	250	0.3	250	0.11	250	0.0
562	-	692	-	562	-	717	-	323	-	523	-

Indirect tensile resistance: The results showed an increase in indirect tensile resistance for mixing plastic strips by reference 36, 48, 20% for the reconstruction of the plastic and plastic waste 7, 28, 56 a day in a row.

There was also, an increase in indirect tensile resistance for mixing the metal bands from the reference mixture by 13.3, 60.6, 0.0% for reconstruction 7, 28, 56 days, respectively.

The reason for the increase in indirect tensile resistance is due to the presence of plastic strips and metal strips that increase the cohesion of concrete components and prevent the separation of molecules from each other easily, causing resistance to tensile tension above Mehta and Mehta (1986) (Table 8).

Flexural strength: About 7, 28, 56 the results showed an increase in the flexure resistance of the mixture containing the plastic strips for the reference mixture by 7, 19, 6% of the reconstruction 7, 28, 56 a day in a row.

An increase in bending resistance of the metal bonding was also achieved by 25.6, 31.1, 8.6% for reconstruction 7, 28, 56 days, respectively. The reason for the increased resistance to bending is the reason for the presence of plastic and metal strips that resist the tensile resistance resulting from loading more than the concrete and thus increase resistance to bending Caldaron *et al*. (1994) as shown in Table 9.

Load-deflection: Load-deflection of cement slabs 500*250 mm, thickness 50 mm, plastic and metal straps, 28.7 days, loading and loading with one dot. The results of the impact test showed an increase in pregnancy of the plates containing plastic and metal strips from the reference mixture 23, 35% at the age of 28 days. The result of this increase in endurance is the presence of plastic and metal strips which increase the tensile strength due to pregnancy, thus, increasing the loss of pregnancy. The results of the pregnancy test also showed an increase in the tolerance of the plates on the plastic strips on the metal tape containers by 9% (Table 10).

CONCLUSION

The presence of plastic slides in the concrete mix resulted in an increase in compressive resistance by 5, 14, 9% for the reconstruction 7, 28, 56, respectively, to the mixture. The presence of plastic slides in the concrete mix led to an increase in indirect tensile resistance by 36, 48, 20% for reconstruction 7, 28, 56, respectively, to the reference mixture. The presence of plastic slides in the concrete mix led to an increase in resistance to bending by 7, 19, 6% for reconstruction 7, 28, 56, respectively to the ratio of the reference. The presence of metal slats ledto an increase in compressive resistance to concrete mixing by 0.6, 13.3, 12.3% for reconstruction 56, 28, 7, respectively to the ratio of the mixture. The presence of metal slats led to an increase in indirect tensile strength by 13.3, 60.6, 0.0% for the reconstruction 56, 28, 7, respectively, relative to the mixture. The presence of metal slices led to an increase in resistance to bending by 25.6, 31.63, 8.6% for reconstruction 56, 28, 7, respectively, to the ratio of the reference. The presence of plastic slides in the concrete mix led to an increase in pregnancy by (23%) at the age of 28% to the mixture. The presence of metal slices in the concrete mixture led to an increase in pregnancy by 35% at the age of 28 percent to the mixture.

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