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Investigate Some Properties Types of Concrete that Contain Crump Rubber and Ordinary Concrete

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Abstract: In this study a many mixes of concrete was produced by using the materials which are available locally. A full gradient of course aggregate was used. Three main types of mixes were made in addition to reference mix. First mix depended on absence sand from the parameters in the second mix sand was absence and crump rubber presence in the mix by many replacement percents from coarse aggregate. While in the third mix sand and crump rubber was presence. The results of compressive strength in this study showed decrease compressive strength of (C+G)* mix. The percentage of decrease in compressive strength was 30.9% at 28 days from the reference mix. In the second mix the results showed decrease in compressive strength of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively. The percentage of decrease in compressive strength was (52.7, 50.1 and 57.5%) at 28 days, respectively from the reference mix. In the third mix, the results showed decrease in compressive strength of ((C+S+G) with 5% CRmix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage of decrease in compressive strength was (33.5, 42.1 and 54.6%) at 28 days respectively from the reference mix. The results of absorption in this study showed increase in absorption of (C+G) mix .The percentage of increase in absorption was 237.5% at 28 days from the reference mix . In the second mix the results showed increase in absorption of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively. The percentage increase of Absorption was (183.8, 129.1 and 120.8%) at 28 days, respectively from the reference mix. In the third mix, the results showed increase absorption of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage increase in absorption was (170.8, 145.0 and 150.0%) at 28 days, respectively from the reference mix. The results of permeability in this study showed increase in permeability of (C+G) mix. The percentage of increase in permeability was 450.7% at 28 days from the reference mix. In the second mix the results showed increase in permeability of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix) respectively . The percentage of increase in permeability was (426.7, 395.7 and 304.2%) at 28 days, respectively from the reference mix. In the third mix , the results showed increase in permeability of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage of increase in permeability was (188.8, 138.1 and 115.5%) at 28 days, respectively from the reference mix.

Key words: R: Refrence mix, C: Cement, S: Sand, G: Gravel, CR: Crump Rubber, parameters

INTRODUCTION

The term "Permeable concrete" describes a substance with a slump approaches to zero, a substance consisting of Portland cement and coarse aggregate and a small or zero of fine aggregates, additives and water (Neville and Brooks, 2006). A combination of these components will produce a solid with pores that are between 2-8 mm in size to allow water to pass through them easily.

The permeable concrete has gained a lot of attention as it has various environmental benefits such as controlling rainwater discharge, recharge groundwater and reducing water and soil pollution which have been identified as focal points in many regions around the world.

The first use of concrete was in 1800 in Europe as berths and retaining walls (Nimityongskul *et al*., 2002). Cost efficiency was the main driver of its use because of the low cement content. It was used again in 1920 for bunk houses in Scotland and England. It became increasingly applicable in Europe after the Second World War because of the scarcity of cement (Lea, 1971). In India, its use was widespread in 2000.

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Experimentel: In order to study the characteristics of the concrete used in the study, Crump rubber were replacement to know the behavior and its effect on the concrete permeability and Absorption in terms of mechanical characteristics. These characteristics were examined, compressive strength, permeability and Absorption.

MATERIALS AND METHODS

Cement: Ordinary Portland cement (Type I) produced at Iraqi cement factory, commercially known (Kufa) was used throughout this work. The cement is kept in air-tight plastic containers to avoid undue exposure to the atmosphere. The chemical composition and physical properties of the cement are presented in Tables 1 and 2, respectively. The results indicate that the used cement conforms to the Iraqi specification No. 5/1984.

Sand: The used fine aggregate was AL-Ekhaider natural sand. Tests are carried out to determine the grading, fineness modulus, Absorption, specific gravity, density, sulfate content. The test results show that these characteristics are conforming to Iraqi specification No. 45/1980 (Table 3 and 4).

Gravel: Crushed gravel of 20 mm maximum size was used as coarse aggregate. It was obtained from AL-Nebai source. The grading of coarse aggregate is given in Table 5. The specific gravity, sulfate content and Absorption of coarse aggregate are listed in Table 6. The test results show that these characteristics are within the limited specified by Iraqi standard specification No. 45/1980.

Water: Tap water is used for mixing and curing for substrate concrete and repair materials specimens.

Crumb rubber: Crumb rubber with the particle size (2-4 mm) particularly manipulated to pave a rubber runway was nominated as the substituent material as revealed in Table 7. The bulk density was 1.15. Conforming studies designated that the concrete encompassing (2-4 mm) crumb rubber had superior properties (Pittolo, 1985).

Mixing and casting

Mix of concrete: Sand was mixed with cement , gravel and crump rubber according to the specifications of the American Concrete Commission (ACI 318-02 2002 (Teychenne *et al*., 1997)). Where the dry constituents of

Table 1: Chemical composition and main compounds of cement

Oxide composition	Abbreviation	Content (%)	Limits of Iraqi specification No. 5/1984
SLime	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%IfC$_3$A>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	---
Tetracalcium alumino-ferrite	C_4AF	13.13	---

Table 2: Physical properties of 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		
3days (N/mm^2)	29.80	≥15
7days (N/mm^2)	34.84	≥23

Table 3: Grading of fine aggregate

Sieve size (mm)	Cumulative passing (%)	Limits of Iraqi specification No. 45/1980 (zone 2)
4.75	95.9	90-100
2.36	84.6	75-100
1.18	66.6	55-90
0.60	44.2	35-59
0.30	21.6	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 Iraqi specification No. 45/1980
Specific gravity	2.60	---
Sulfate content (%)	0.10	≤0.5
Absorption (%)	2.05	---
Dry-loose density (kg/m^3)	1595	---
Materials finer than (0.075 mm) (%)	2.00	≤5

Table 5: Grading of coarse aggregate

Sieve size (mm)	Cumulative passing (%)	Limits of Iraqi specification No. 45/1980
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.45/1980
Specific gravity	2.66	---
Sulfate content (%)	0.06	≤0.1
Absorption (%)	1.09	---

Table 7: Characteristics of crumb rubber used in this study

Characteristics	Test results
Bulk density	1.15
Sulfur content (%)	1.74
Polymer base (N/S/B)	60/20/20
Rubber (%)	65.82
Carbon black (%)	28.77
Ash (%)	5.41
Total (%)	100.00

Table 8: Types of mixes and mix proportions used in this study

Symbol	Mix proportions
R*	1:1.5:3
C+G*	1:3
(C+G) with 5% CR	(1:3) with 5% CR**
(C+G) with 7% CR	(1:3) with 7% CR**
(3:1) with 10% CR	(1:3) with 10% CR**
(C+S+G) with 5% CR	(1:1.5:3) with 5% CR**
(C+S+G) with 7% CR	(1:1.5:3) with7% CR**
(C+S+G) with 10% CR	(1:1.5:3)with10% CR**

*R: Refrence mix, C: Cement, S: Sand, G: Gravel, CR: Crump Rubber
**CR Percent used as a partial replacement by the weight of coarse aggregate

concrete placed in the mixer and then the required quantity of water was added directly which requires only the addition of water to produce all types of concrete in this study after addition of water, the mixture was mixed for two minutes, up to the homogeneity of the mix (Table 8).

Casting of concrete: Before casting, the molds were well cleaned and the internal faces were thoroughly oiled to avoid adhesion with the concrete after hardening. The concrete was cast by means of scoop in layers for all specimens. Each layer was compacted using vibrating table for about 25-30 sec to remove any entrapped air. Finally, after the top layer had been compacted it was smoothed and leveled with the top of mold by using steel trowel.

Laboratory tests

Compressive strength: The compressive strength test was made according to, B. S. 1881: part 116 (Anonymous, 1989) using 150 mm cubes. The compressive strength cubes were tested using a standard testing machine with capacity of 2000 kN. The loading was applied at a rate of 15 MPa/min. The average of three specimens was recorded for each testing age.

$$f_{cs} = P/A \quad (1)$$

Where:
f_{cs} = Compressive strength (MPa)
P = The maximum load sited up to failure (N)
A = Initial cross section area of specimens (mm^2)

Absorption test: This test was carried out according to ASTM C642-97 (Anonymous, 1997) on 100 mm cube specimens. Firstly, the specimens were weighed and then dried in oven at temperature of 100-110°C for a period of 24 h. After that they were removed from the oven and allowed to cool in dry air to a temperature of 20-25°C and reweighed. The above procedure was repeated until the difference between two successive weights did not exceed 0.5% and the final weights were considered as oven dried weights. Then, the specimens were immersed in water at a temperature about 21°C for 48 h. After that the surfaces of specimens were dried with cloth and weighed. This procedure was repeated until the difference between two successive weights of surface dried specimens at intervals of 24 h shows an increase in weights <0.5% of the heavier weights. The final weights were considered surface dried weights after immersion. Absorption of each specimen is calculated as the increase in weight resulting from immersion is expressed as a percentage of the weight of the dry specimen:

$$\text{Absorption\%} = B\text{-}A/A*100 \quad (2)$$

Where:
A = The weight of the dry specimen (gm)
B = The weight of the immersed specimen (gm)

Permeability test: The method of permeability used in this test is inflow-out flow method by pressure according to ACI 522R-10 (Anonymous, 2010). Where concrete cylinders prepare and test depend on recording the quantity of water inflow throughout the concrete due to time.

RESULTS AND DISCUSSION

In this laboratory work, several tests were carried out in the laboratory. The results obtained after adding crumb rubber with the mixes showed in the results of tests below:

Compressive strength: The results of compressive strength test showed decrease in compressive strength of (C+G) mix. The percentage of decrease in compressive strength was 30.9% at 28 days from the reference mix. Decrease in compressive strength of (C+G) mix may affected by absence of sand from the mix .

The results of compressive strength test showed, also, decrease in compressive strength of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix) respectively. The percentage of decrease in compressive strength was (52.7, 50.1, 57.5%) at 28 days respectively from the reference mix. Decrease in compressive strength of ((C+G) with 5% CR mix (C+G).

Table 9: The results of compressive strength of mixes at age (7 and 28) days

Type of mix index	w/c	Cement content (kg/m^3)	Compressive strength 7 days	Compressive strength 28 days
R	0.45	350	22.7	31.3
C+G	0.45	350	17.8	21.6
(C+G) with 5% C.R	0.45	350	13.5	14.8
(C+G) with 7% C.R	0.45	350	14.3	15.6
(C+G) with 10% C.R	0.45	350	11.8	13.3
(C+S+G) with 5% C.R	0.45	350	14.5	20.8
(C+S+G) with 7% C.R	0.45	350	14.9	18.1
(C+S+G) with 10% C.R	0.45	350	13.3	14.2

with 7% CR mix and (C+G) with 10% CR mix) may affected by absence of sand and presence of crump rubber in the mix (Mehta and Paulo, 2006).

The results of compressive strength test showed, also, decrease in compressive strength of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage of decrease in compressive strength was (33.5, 42.1 and 54.6%) at 28 days, respectively from the reference mix. Decrease in compressive strength of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix) may affected by presence of crump rubber in the mix. The results of the compressive strength test showed in Table 9.

Absorption test: The results of Absorption test showed increase in absorption of (C+G) mix. The percentage of increase in absorption was 237.5% at 28 days from the reference mix. Increase absorption of (C+G) mix may affected by absence of sand from the mix . The results of absorption test shows, also, increase absorption of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively . The percentage increase of Absorption was (183.8, 129.1 and 120.8%) at 28 days, respectively from the reference mix. Increase absorption of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix) may affected by absence of sand and presence of crump rubber in the mix.

The results of Absorption test showed also increase absorption of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage increase in absorption was (170.8, 145.0 and 150.0%) at 28 days, respectively from the reference mix. increase in absorption of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix) may affected by presence of crump rubber in the mix. The results of absorption test showed in Table 10.

Table 10: The results of absorption test of mixes at age (7 and 28) days

Type of mix index	w/c	Absorption 28 days
R	0.45	2.4
C+G	0.45	5.7
(C+G) with 5% C.R	0.45	4.4
(C+G) with 7% C.R	0.45	3.1
(C+G) with 10% C.R	0.45	2.9
(C+S+G) with 5% C.R	0.45	4.1
(C+S+G) with 7% C.R	0.45	3.5
(C+S+G) with 10% C.R	0.45	3.6

Table 11: The results of permeability test of mixes at age 28 day

Type of mix index	Permeability (L/min/m^2)	Permeability limit ([0]L/min/m^2)
R	71	81-730
C+G	320	
(C+G) with 5% CR	303	
(C+G) with 7% CR	281	
(C+G) with 10% CR	216	
(C+S+G) with 5% CR	134	
(C+S+G) with 7% CR	98	
(C+S+G) with 10% CR	82	

Permeability test: The results of permeability test showed increase in permeability of (C+G) mix. The percentage of increase in permeability was 450.7% at 28 days from the reference mix. Increase permeability of (C+G) mix may affected by absence of sand from the mix.

The results of permeability test showed, also, an increase in permeability of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively. The percentage of increase in permeability was (426.7, 395.7 and 304.2%) at 28 days, respectively from the reference mix. increase in permeability of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix) may affected by absence of sand and presence of crump rubber in the mix.

The results of permeability test showed also an increase in permeability of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage of increase in permeability, was (188.8, 138.1 and 115.5%) at 28 days, respectively from the reference mix. increase in permeability of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix) may affected by presence of crump rubber in the mix (Neville and Broks, 2006). The results of permeability test showed in Table 11.

CONCLUSION

Decrease in compressive strength of (C+G) mix. The percentage of decrease in compressive strength was 30.9% at 28 days from the reference mix. Decrease in compressive strength of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively. The percentage of decrease in compressive strength was (52.7, 50.1 and 57.5%) at 28 days respectively from the reference mix. Decrease in compressive strength of ((C+S+G) with 5% CRmix

(C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage of decrease in compressive strength was (33.5, 42.1 and 54.6%) at 28 days, respectively from the reference mix.

Increase in absorption of (C+G) mix. The percentage of increase in absorption was 237.5% at 28 days from the reference mix. Increase in absorption of ((C+G) with 5% CR mix (C+G) with 7% CR mix and (C+G) with 10% CR mix), respectively. The percentage increase of absorption was (183.8, 129.1 and 120.8%) at 28 days, respectively from the reference mix. Increase absorption of ((C+S+G) with 5% CR mix (C+S+G) with 7% CR mix and (C+S+G) with 10% CR mix), respectively. The percentage increase in absorption was (170.8, 145.0 and 150.0%) at 28 days, espectively from the reference mix.

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