Using of Waste Materials for Production of High Performance Concrete [+]

Nadia Salim Ismael [*] **Mohammed Abdulla Baker** [**]

Abstract

High performance concrete with compressive strength (40 – 120) MPa and other perfect properties is a new type of cementitious materials.
The research deals with the use of industrial by-product waste material as partial replacement of sand to produce high performance concrete with compressive strength higher than 40 MPa.

The result indicate that partial replacement of sand by industrial waste material (Brass) in addition of use of admixtures (Superplasticizer) and powder of pure silica gives high strength in comparative with reference mix.

Key Words: High performance concrete, compressive strength, waste materials, superplasticizer.

المستخلص

الخرسانة عالية الاداء التي لها مقاومة انضغاط بين (٤٠–١٢٠) ميكاباسكال بالاضافة الى خصائص اخرى تعتبر احد انواع الخرسانة الحديثة.

يتضمن البحث استخدام بعض المخلفات الصناعية كاستبدال جزئي للركام الناعم (الرمل) لانتاج خرسانة عالية الاداء ذات مقاومة انضغاط اكثر من (٤٠) ميكاباسكال . النتائج المختبرية توضح ان الاستبدال الجزئي للرمل بمادة البراص (Brass) الذي يعتبر احد الفضلات الصناعية والتي تتخلف بكميات كبيرة بالاضافة الى استخدام عامل مقلل للماء (Superplasticizer) والسليكا النقية تعطي مقاومة انضغاط عالية مقارنة بالخلط المرجعية .

Introduction

The construction industry has taken considerable strides forward over the last two or three decades with regard to many materials in particular – High strength concrete (HSC) and generally Higher performing concrete materials or High performance concrete (HPC).

HPC define as “concrete which meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional

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[*]Assistant Prof./ Technical College / Mosul
[**]Lecturer/ Technical Institute / Mosul

materials and normal mixing, placing, and curing practices. The requirement may involve enhancement of characteristics such as placement and compaction without segregation, long – term mechanical properties, early age strength, toughness, volume stability, or service life in severe environments" [1, 2].

High performance concrete is a new cementitious material with strength more that 40 MPa and other perfect properties.

The use of chemical admixtures has become one of the essential parts of modern concrete technology. Added to concrete mixture in relatively small amounts, the chemical admixtures change significantly the required parameters and behavior of fresh or hardened concrete. Developed from industrial waste, requiring utilization in to special formulations engineered for the optimal interaction with concrete modern admixtures can offer the right remedy for overcoming almost any problematic property of concrete [3, 4].

According to wide scale investigations [5, 6], the performance of concrete with controlled volumes of industrial by-products and waste can be significantly improved. well-investigated of waste, or mineral additives include granulated blast furnace slag, fly ash and silica fume, such by-product and waste brings about not only improved concrete properties and economical effectiveness, but it also improved the eco-and energy- balances of these materials .

By far the greatest potential in achieving the goals of sustainable development is the capacity of the concrete industry to reuse various industrial by products and absorb large amounts of recycled materials that otherwise would most likely and up in landfills.

Usually the attempt is to improve concrete properties by addititives to concrete or by replacement part of cement by other materials waste or natural materials as pozzolana. This paper reports the effect of replacement of part of sand by waste material (Brass), besides describing the influence of superplasticizer and mineral admixtures (Silica powder) on the compressive strength of concrete.

Brass used for manufacture of cartridge and shell cases, this manufacture produce waste, large in amount about (2 – 3)% of other waste, but there is no real computing of this by-product .

Experimental program

The objective enhancment of compressive strength of high performance concrete produced with only locally available, conventional constituent materials and normal production and curing procedures.

Materials used:

1. Cement: Ordinary portland cement Turkish cement (Adana) was used. Table (1) and (2) show the chemical and physical properties of the used cement .
2. Fine aggregate: Natural sand with grading limit Iraqi specification 45/ 1984. Table (3) illustrate the sieve analysis of sand grading.
3. Coarse aggregate: Aggregate of grading (5-20 mm) was used, Table (4) shows the grading of coarse aggregate which conforms to the Bs 822/1992.

Table (1): Chemical composition and main compounds of cement

Oxide composition	Abbreviation	Content percent	Limit of Iraqi specification No. 5/1985
Lime	CaO	63	-
Silica	SiO_2	20.8	-
Alumina	Al_2O_3	6.66	-
Iron Oxide	Fa_2O_3	2.12	-
Sulphate	SO_3	2.3	≤ 2.8 %
Magnesia	MgO	2.8	≤ 5.0 %
Potash	K_2O	0.24	-
Soda	Na_2O	0.12	-
Loss on ignition	L.O.I.	1.16	4.0 %
Insoluble residue	I.R.	0.8	1.5 %
Lime saturation factor			0.66 – 1.02
Main compounds (Bogue's equation)			
Tricalcium Silicate	C_3S	44	-
Dicalcium Silicate	C_2S	26.52	-
Tricalium Aluminate	C_3A	14	>5.0 %
Tetralcium aluminoferrite	C_4AF	6.44	-

Table (2): Physical properties of cement

Physical properties	Test results	Limits of Iraqi specification No. 5/1984
Specific surface area Blain method, m^2/kg	261	230
Soundness (Auto clave method)	0.26	0.8 %
Setting time (vicat's apparatus) Initial setting, hr : min **Final setting, hrs : max**	2:05 3:15	> 1 hr < 10 hrs
Compressive strength **3 days, N/mm^2** **7 days, N/mm^2**	 23 29	 15 23

Table (3): grading of fine aggregate (Iraqi Specification No.45 / 1984)

Sieve size	Cumulative passing %	Limits of % passing Zone 2
10 mm	100	100
4.75 mm	93	90 – 100
2.36 mm	84	75 – 100
1.18 mm	64	55- 90
600 μm	45	35 – 59
300 μm	17	8 –30
150 μm	6	0 – 10
75 μm	3	0 – 5

Table (4) grading of coarse aggregate (B.S: 882: 1992)

Sive size	Cumulative passing %	Limits of % passing B.S: 882/1992
40 mm	100	100
20 mm	95	90 – 100
14 mm	60	40 – 80
10 mm	45	30 – 60
5 mm	0	0 – 10

4. Superplasticizer: A superplasticizer type Rheobuild 800 was used to produce high performance concrete by reducing the w/c ratio while maintaining equal workability. Table (5) shows physical description / properties of Rheobuild 800.

Table (5): properties of Rheobuild 800

Appearance	Cement gray powder
Boiling point (C̊)	> 200
Melting point (C̊)	Not available
Specific gravity	1.5 approx.
Solubility in water	Insoluble
pH (1:1 mixture)	> 11

5. Brass: The replacement of sand by waste materials (Brass), which is industrial by – product. Brass used is an alloy consist of 70 % Cu, 30% Zn. Brasses containing between 10 and 35 % Zinc are widely used for deep-drawing and general presswork, the maximum ductility being attained in the case of 70 – 30 brass , commonly known as "cartridge metal". Brass used particularly for the manufacture of cartridge and shell cases, which produce a large amount of waste. Figure (1) show the copper-zinc thermal equilibrium diagram[10] . Brass had resistance to corrosion particularly under marine conditions. The brass waste were converted into fine particles by grinding. The grinding of brass were affected by a grinding well for a period of 9 hours , after grinding the brass used passing sieve No.4 (4.75 mm).

6. Powder silica: powder of pure silica SiO_2 > 99.8 % were used.

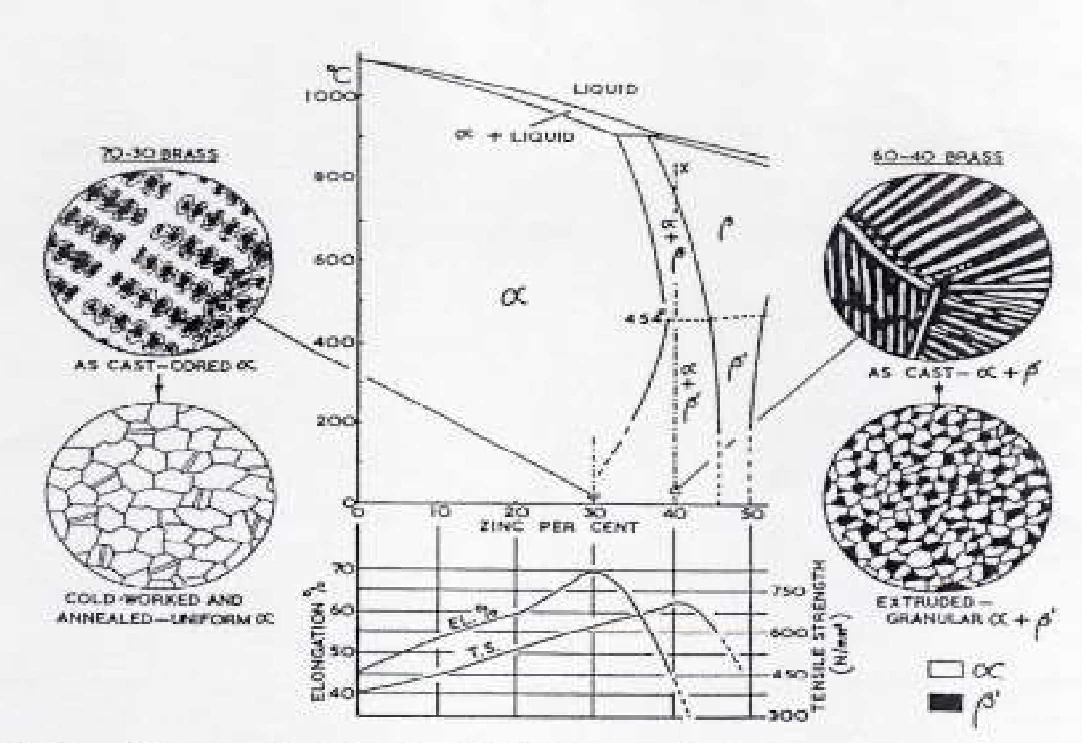

Fig. 1 *The copper–zinc thermal equilibrium diagram, showing representative structures and properties of the two main classes of brass—70–30 and 60–40 alloys.*[10]

Mixtures

A total of (24) cube specimens with dimension (100 * 100 mm) were batched for which 4 different mixture proportions were selected.

Manually casting was carried out for two equal layers without vibration, the specimens were covered to prevent evaporation of water from concrete. In the next day all specimens were demoulded and stored in water as curing condition to the time of testing.

The compressive strength test was determined according B.S. 1881, part 116:1983, 100 mm cubes were using testing machine with capacity of 1000 KN, at loading rate of 15 N/mm^2 per minute, the average of three cubes was adopted at each test.

Results

Compressive strength of the concrete made, is given in Table (6) and Fig (1). From test results the following observations and discussions can be noticed:

1. The best 28- days compressive strength value of 51 Mpa was obtained by mix 4 (concrete with 10% brass partial replacement) .
2. It is clear that the 28 – days compressive strength investigated that the percentage of increase in strength for concrete with superplasticizer and with partial replacement of sand compared with reference concrete mix are (29%, 79%, 112.5%, 70%, 62.5%) for mix2, mix3, mix4, mix5, mix6, respectively.
3. The reduction in w/c ratio causes an increase in strength due to the high range water reduction admixtures, where modification of hydration reaction is obtained.

Conclusion

The following conclusions can be made :

1. The suitable percentage of industrial by-product (Brass) as partial replacement of sand was (10%) which gave the higher compressive strength.
2. The use of (7 kg/m^3) Rheobuild 800 made possible to reduce w/c ratio (with slump 23 cm), and made significant increase in compressive strength, at 7- days age the compressive strength increase from 20 MPa to 26 MPa and at 28 – days increase from 20 to 31 MPa.
3. The combined use of superplasticizer, powder of pure silica and 7.5% , 10% , 20% , 30% as partial replacement of sand by brass, produce higher compressive strength than reference concrete at 7-days age from 20 Mpa to 34 Mpa and at 28-days from 24 Mpa to 51 Mpa .
4. Powder of pure silica increase strength of concrete and improved mix workability.
5. By-products of industrial processes which would have negative value if they were be land filled but that they also add value to the concrete end product because they improve certain properties.

Table (6): details of concrete mix and results

	Cement kg/m^3	**Silica / cement**	**Brass replacement of sand %**	**Mix proportion**	**W/c**	**Superplasticizer kg/m^3**	**7 day MPa**	**28 day MPa**
Mix 1.	700	-	-	1:1.6:1.6	0.34	-	20	24
Mix 2.	700	-	-	1:1.6:1.6	0.290	7	26	31
Mix 3.	700	1%	7.5%	1:1.6:1.6	0.290	7	30	43
Mix 4.	700	1%	10%	1:1.6:1.6	0.290	7	34	51
Mix 5.	700	1%	20%	1:1.6:1.6	0.290	7	28	41
Mix 6.	700	1%	30%	1:1.6:1.6	0.290	7	26	39

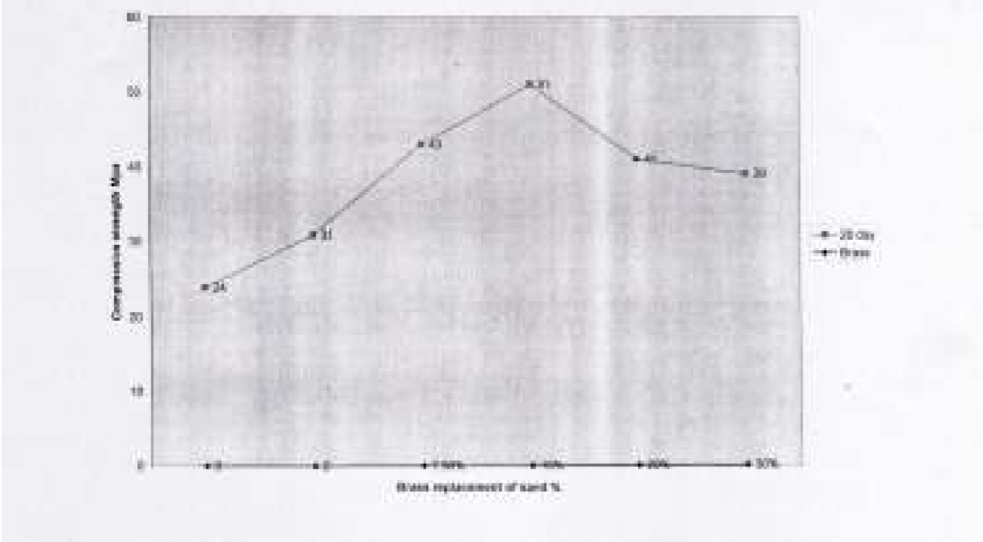

Fig (1) Relation between compressive strength and Brass replacement

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