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Enhancement Conventional Concrete using locally available Waste Material

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Abstract: Concrete is a nifty construction material. Concrete has some attractive properties when it is newly mixed, it is plastic and malleable, but when it is hardened it becomes very strong and durable. These qualities make concrete unique from other materials. For the reason that concrete is the main construction material across the world and widely used in all kinds of civil engineering works, such as for building skyscrapers, dams, bridges,barrage, highways, and houses. As we know that aggregate represents about 70-80% of concrete elements, so it will be useful to recycle the aggregate for construction works and also to solve the environmental problems. Iraq is suffering a lot of the problem of rubble(debris) as a result of the wars that occurred during the past years, on the other hand in some places have been converted buildings from residential buildings to commercial buildings, so these destroyed buildings constitute the problem of environmental pollutants. To minimize the trouble of excess of waste material it is suitable steps to utilize the recycled aggregates provide that the desired final product will meet the standards. In the present investigation adjustments to traditional mix designs of concrete using locally available waste material was studied experimentally.The experimental program consisted of nine mixes with mix proportions [1:2:4] and constant slump equal to (13) cm were constructed and tested. These nine mixes classified into three groups based on the types of sand and gravel used in all mixes.The experimental results showed that, the optimum mix was Mix_2 in Group (B) with (cement : 50% naturally sand and 50% crushed recycled concrete as sand : crushed boulder as gravel), which enhance the properties of the existing concrete , such that, increasing compressive strength by (18.6%), flexural strength by (8.3%) and splitting strength by (28.9%), as comparing with Mix_1 (Reference mix).

Keywords: Conventional concrete, Concrete locally waste material, Compressive strength, Flexural strength, Splitting strength

Introduction and Liteature Review

The environmental effect of the production of the raw components of concrete (such as cement, coarse and fine aggregate) is large (Buck 1977 & Hansen1984). Generally concrete is the main construction material in the world and the widely used in all kinds of civil engineering works. Amount of aggregate in concrete is about 70-80% of concrete components so it will be useful to recycle the aggregate for construction works as well as for the purpose of solving the environmental problems. The scale of the problem makes it prudent to investigate other origins of raw materials in order to reduce the consumption of energy and available natural origins, and to obtain a more ''green'' concrete. Crushing concrete to produce aggregate for the production of new concrete is one common mean for obtaining a more environment-friendly concrete. This reduces the consumption of the natural resources as well as the consumption of the landfills required for waste concrete (Rahal 2007).

Concrete destruction waste has been proved to be an excellent origin of aggregate for new concrete production. There are abundant studies proved that concrete made with this kind of aggregate can have mechanical

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properties similar to those of conventional concrete is nowadays a possible goal for this environmentally sound practice(Buck 1977 & Hansen1984).

Iraq is suffering a lot of the problem of rubble(debris) as a result of the wars that occurred during the past years, on the other hand in some places have been converted buildings from residential buildings to commercial buildings, so these destroyed buildings constitute the problem of environmental pollutants. To reduce the surplus of waste material it is a suitable step to use the recycled aggregate provide that can be meet the standards to provide the desired final product.

Experimental Work

In the present investigation adjustments to traditional mix designs of concrete using locally available waste material was studied experimentally as shown in plate (1).The experimental program consisted of nine mixes with mix proportions [1:2:4] and constant slump equal to (13) cm were constructed and tested. These nine mixes classified into three groups based on the types of sand and gravel used in all mixes, as follows:

Group (A) was divided into three mixes depending on the types of gravel [Mix_1 "Reference mix", included (cement : sand : gravel), $Mix_{2,}$ included (cement : sand : crushed boulder as gravel) and $Mix_{3,}$ included (cement : sand : crushed recycled concrete as gravel)].

Group (B) was the same as in Group (A) divided into three mixes except types and percentage of sand [$Mix_{1,}$ Mix_2 and Mix_3 are included 50% naturally sand and 50% crushed recycled concrete as sand].

Group (C) was the same as in Group (A) except type of sand [$Mix_{1,}$ Mix_2 and Mix_3 are included 100% crushed recycled concrete as sand].

Plate 1. Locally Concrete available waste material

Materials

Cement

Ordinary Portland cement (OPC) produced by Badoosh cement factory.Tables(1 and 2) showed the physical properties and chemical compositions of cement. Both physical and chemical properties are with compliance to Iraqi standard specification "IQS: 5/1984".

Table (1) physical and mechanical properties of ordinary portland cement

Physical properties	Test results	Limits of Iraqi specification No.5/1984
Specific surface area, Blain's method, m^2/kg	290	≥ 230
Soundness, Autoclave's Method, %	0.03	< 0.8
Setting time, Vicat's method Initial setting hr:min Final setting hr:min	 1:49 3:25	 ≥ 45 min ≤ 10 hours
Compressive strength 3 days N/mm^2 7 days N/mm^2	 22 30	 ≥ 15 ≥ 23

Table (2) Chemical Composition of Ordinary Portland Cement

Main oxide	Cao	Sio2	Fe2o3	Al2o3	So3	Mgo
%	62.2	21.31	2.67	5.89	2.6	3.62
(IIS No.5/1984)	___	___	___	___	Max 2.8%	Max 5 %

Fine aggregate

Natural fine aggregate: it obtained from Kanhash region (Mosul). This type of sand is identical with british standard (B.S.)882:1992.Its sieve analysis is shown in table (3) .The grading limits with compliance to ASTM C 33-02.

Recycled fine aggregate: it obtained from the destroyed building in the engineering technical college in (Mosul/Iraq).This type of sand is passing from sieve no.4(4.75mm).

Table 3. Sieve analysis of the natural sand

Sieve size (mm)	**Total limit**	**Percentage passing**			
			Grading zone limit		
		Percentage passing of the sand used	**Coarse**	**Medium**	**Fine**
4.75	89-100	100	-	-	-
2.36	60-100	87	60-100	65-100	80-100
1.18	30-100	70.4	30-90	45-100	70-100
0.6	15-100	56.8	15-54	25-80	55-100
0.3	5-70	13.2	5-40	5-48	5-70
0.15	0-15	3	-	-	-

Coarse aggregate

Crushed boulder Coarse aggregate: it obtained from Zako city in Iraq with M.A.S (19) mm. This gravel is in compatible with ASTM C33-03.The sieve analysis was performed, Table (4) show the results of the sieve analysis.

Table 4. Sieve analysis of the crushed boulder aggregate

Sieve size (mm)	Weight passing (%)	Total limits (ASTM C33-3)
37.5	100	100
25	100	100
19	100	90-100
12.5	60.8	35-80
9.5	29.3	20-55
4.75	6.6	0-10
2.36	2.9	0-5

Natural coarse aggregate: it obtained from the Tigris river (Mosul/Iraq) with M.A.S(19)mm. Table (5) shows the sieve analysis of the gravel according to ASTM C33-03

Table 5. Sieve analysis of the natural coarse aggregate

Sieve size (mm)	Weight passing (%)	Total limits (ASTM C33-3)
37.5	100	100
25	100	100
19	100	90-100
12.5	58.4	35-80
9.5	28.8	20-55
4.75	7.2	0-10
2.36	2.6	0-5

Recycled Coarse Aggregate: obtained from the destroyed building in the engineering technical college in (Mosul/Iraq) with M.A.S(19)mm. Table (6) shows the sieve analysis of the gravel according to ASTM C33-03.

Table 6. Sieve analysis of the recycled coarse aggregate

Sieve size (mm)	Weight passing (%)	Total limits (ASTM C33-3)
37.5	100	100
25	100	100
19	100	90-100
12.5	63.3	35-80
9.5	32.1	20-55
4.75	5.2	0-10
2.36	3.3	0-5

Water

Tap water was used in this research for both mixing and curing the concrete specimens in accordance with ASTMC1602.

Results and Discussion

Compressive strength

Compressive strength of the concrete mixtures obtained in this paper are shown in table(7) and Figure (1).The optimum mix was Mix_2 in Group (B) with (cement : 50% naturally sand and 50% crushed recycled concrete as sand : crushed boulder as gravel), which enhance and increase the compressive strength by (19%), as comparing with Mix_1 (Reference mix).

Table 7.Compressive strength of the concrete mixtures

Mix no.	Compressive strength (Mpa)	
	7 days	28 days
Mix 1	23.8	40.37
Mix 2	25	41.42
Mix 3	21.192	34.27
Mix 4	23.195	36.695
Mix 5	29.241	42.11
Mix 6	20.22	31.328
Mix 7	22.124	35.165
Mix 8	23.575	32.82
Mix 9	13.789	22.91

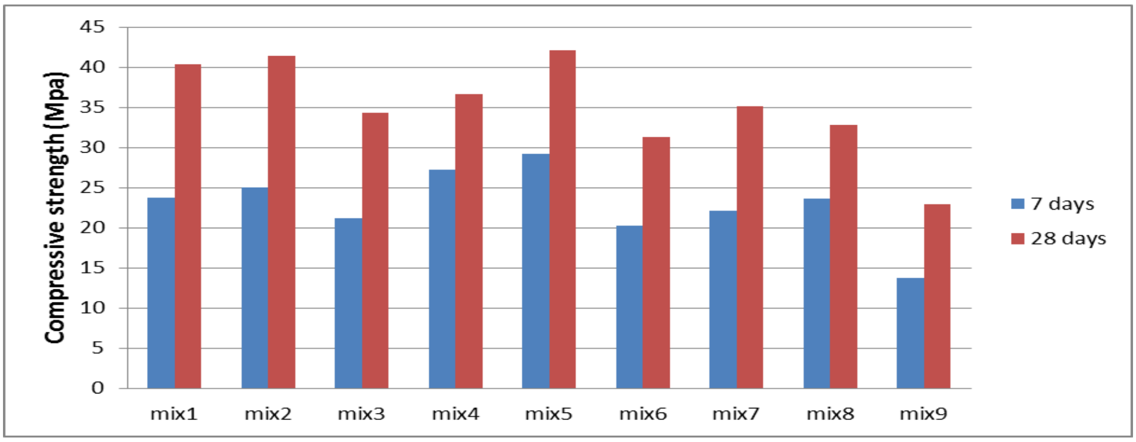

Figure 1. Compressive strengths of the concrete mixtures.

Flexural strength

Flexural strength of the concrete mixtures obtained in this paper are shown in table(8) and Figure (2).The optimum mix was Mix_2 in Group (B) with (cement : 50% naturally sand and 50% crushed recycled concrete as sand : crushed boulder as gravel), which enhance and increase the flexural strength by (8%), as comparing with Mix_1 (Reference mix).

Table(8) Flexural strength of the concrete mixtures

Mix no.	Flexural strength (Mpa)	
	7 days	28 days
Mix 1	4.11	4.65
Mix 2	4.136	4.72
Mix 3	4	4.22
Mix 4	4.377	4.57
Mix 5	4.481	4.81
Mix 6	3	3.44
Mix 7	3.32	3.63
Mix 8	3.56	3.74
Mix 9	2.9	3.284

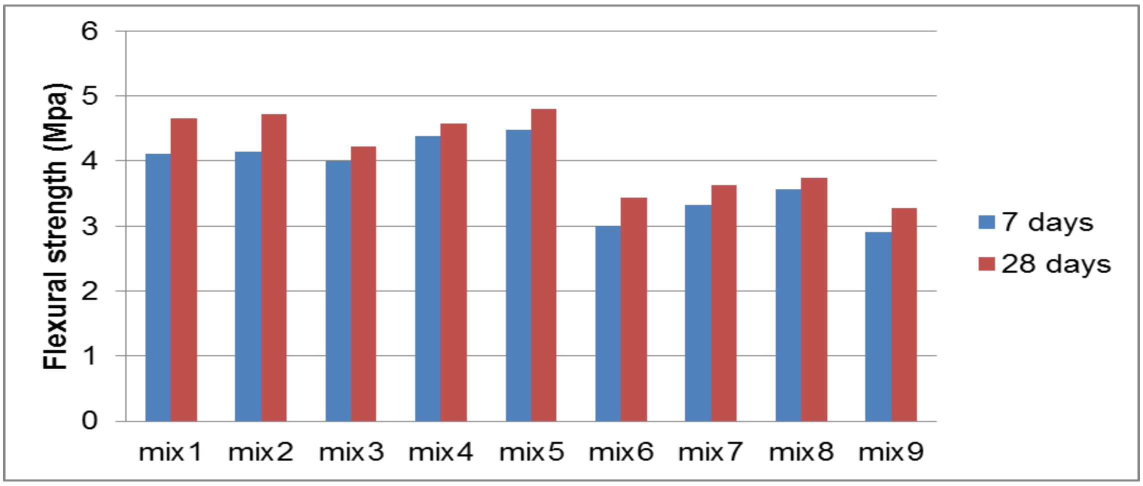

Figure 2. Flexural strengths of the concrete mixtures

Splitting tensile strength

Splitting tensile strength of the concrete mixtures obtained in this paper are shown in table(9) and figure (3).The optimum mix was Mix_2 in Group (B) with (cement : 50% naturally sand and 50% crushed recycled concrete as sand : crushed boulder as gravel), which enhance and increase the splitting tensile strength by (29%), as comparing with Mix_1 (Reference mix).

Table(9) splitting tensile strength of the concrete mixtures

Mix no.	Splitting tensile strength (Mpa)	
	7 days	28 days
Mix 1	2.051	3.68
Mix 2	2.368	3.82
Mix 3	2.757	3.46
Mix 4	2.741	3.39
Mix 5	2.884	3.96
Mix 6	2.1	2.38
Mix 7	1.9	2.68
Mix 8	2.275	2.91
Mix 9	1.44	1.83

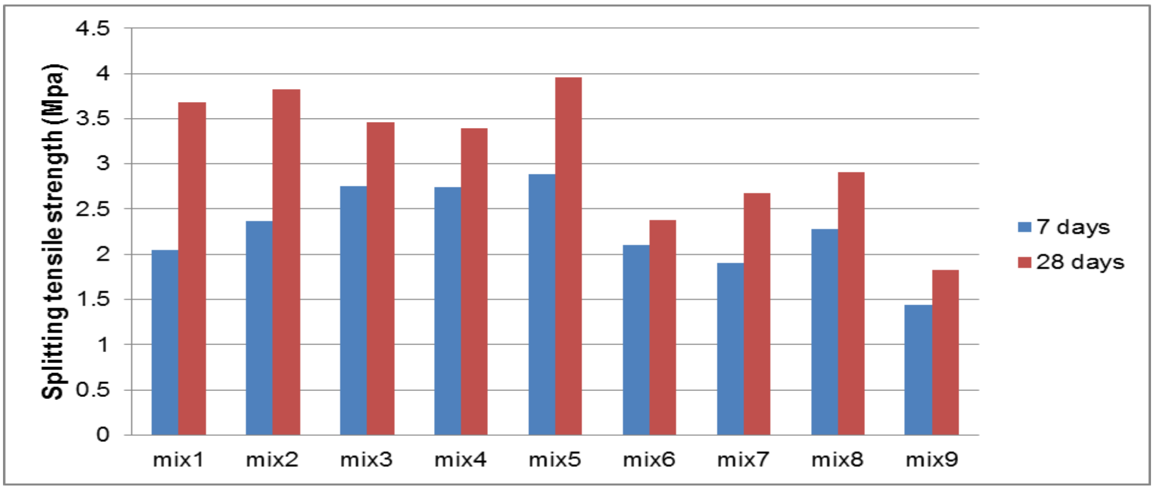

Figure 3. Splitting tensile strengths of the concrete mixtures

Conclusion

The experimental results showed that the optimum mix was Mix_2 in Group (B) with (Cement : 50% naturally sand and 50% crushed recycled concrete as sand : crushed boulder as gravel), which enhance the mechanical properties of the existing concrete , such that, increasing compressive strength by (19%), Flexural strength by (8%) and Splitting strength by (29%), as comparing with Mix_1 (Reference mix), The use of recycled concrete aggregate reduced the density of the new concrete, Recycling waste concrete aggregate in concrete production may help to solve the problem of the environment.

Recommendations

It is not recommended to use fine or coarse recycled aggregate as a ratio of 100% because they are reduced the strength of concrete.

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