Effect of Using Crushed Limestone in Concrete Mixes as Fine Aggregate on Compressive Strength and Workability

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***Abstract*—**Crushed limestone is a waste material generated from cutting large stones in (Hillan factories) in Mosul and other towns north of Iraq. These wastes needs very large areas to gather them and cause big complaint for owners of these factories, so for the increasing demand to protect the normal environment, especially in buildup areas, the needs to use these wastes is very important.
In this paper two types of concrete mixes were prepared with three different mixes (rich, normal, poor) for each type. Type A mix: Concrete mixes with crushed limestone as fine aggregate.
Type B mix: Concrete mixes with river normal sand as fine aggregate.
Three results have been found:

1- Concrete mix, of type A needs more water-content than those of type B to get the same workability.

2- Concrete mix of type A gave more compressive strength than those of type B about (2-8) MN/m^2.
The increase of compressive strength depend on water/cement ratio, type of concrete mix, and the age of concrete in days.

3- Crushed limestone can be used for producing good quality of concrete that was suitable for concrete paving blocks for footpaths, gardens, passengers waiting sheds ,bus stops, , industry and other public places.

***Keywords*—** Crushed limestone , Paving blocks , concrete , compressive strength

I. Introduction

CONCRETE is a constructional material, which consists essentially of aggregate and binding agents. Aggregate form (75%-80%) by volume of concrete. In Iraq the most common aggregate naturally was sand and gravel. The binding agents was cement. [3]. In east of Asia and Europe natural materials such as river sand and crushed fine stone are generally used in concrete as fine aggregates. In India, Chinese cities, Hong Kong ,Malaysia, few studies have been done on exploring the feasibility of using crushed fine stone in concrete mixes for examples:
In 2005 Raman [9] studied the effect of quarry dust and found replacement of river sand with quarry dust without the inclusion of fly ash resulted in a reduction in the compressive strength of concrete specimen. Reddy and Reddy 2007 [10] reported on increasing compressive strength by use of rock flour as fine aggregate instead of river sand.

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Ilangovana at 2008 [8] reported strength of quarry rock dust concrete was (10-12%) more than that of similar mix of conventional concrete. Hameed and Sekar 2009 [5] studied effect of crushed stone dust as fine sand and found the flexural strength increases than the concrete with natural sand but the values decreases as percentage of crushes dust increases. Similarly water absorption found to be more in the concrete containing crusher dust.
The overall workability value of quarry rock dust concrete in terms of slump as well as compaction factor was less in comparison to conventional concrete (Ilangovana *et al.*, 2008) [8]. As reported by (Hameed and Sekar. 2009) [5] the slump value increases (workability increases) if concrete is mixes with quarry dust as well as marble sludge due to presence of marble sludge powder. A parametric experimental study for producing paving blocks using crusher dust is presented [8]. Some of the physical and mechanical properties of paving blocks with fine aggregate (sand) replaced by various percentages of crusher dust are investigated.[8].The test results shows that the replacement 50% by weight has a negligible effect on the reduction of any physical and mechanical properties while there is a saving of 56% of money. The percentage of saving was less but highly beneficial for mass production of paving blocks. The shaving would be more if the sand availability is at a greater distance. This also reduces the burden of dumping crusher dust on earth which reduces environmental pollution[9].

II. Experimental Work

A. Material Used

1- Cement: Iraqi ordinary Portland cement which complies with Iraqi standard specification No. 5. 1984 was used.

2- Coarse and fine aggregate: gravel and sand from Salahia aggregate in Mosul was used gradation of coarse aggregate (gravel) and fine aggregate (sand) according to B.S. 82-1973 as shown in Tables (1, 2) .

TABLE I
GRADATION OF GRAVEL USED (COARSE AGGREGATE)

B.S. sieve size	Percentage passing	
	Natural gravel	Standard requirement according to B.S. 882-19
1/2 in (38mm)	100	100
3/4 in (19mm)	100	95-100
3/8 in (9.5mm)	33.5	30-60
3/6 in (4.75mm)	4	0-10

TABLE II
GRADATION OF SAND (FINE AGGREGATE) USED

B.S. sieve size	Percentage passing	
	Natural sand	Standard requirement according to B.S. 882-19
3/8 in (10mm)	-	-
No. 4 (5mm)	-	-
No. 8 (2-3mm)	74	65-10
No. 16 (1.18mm)	66	45-100
No. 30 (0.6mm)	80	25-80
No. 50 (0.3mm)	33	5-48
No. 100 (0.15mm)	5	-
No. 200 (0.074mm)	-	-

3-Limestone: crushed limestone as fine aggregate was used. Specifications of limestone used are given in Tables (3 , 4) below.[2]

TABLE III
CHEMICAL ANALYSIS

CaO%	MgO%	Fe_2O_3%	Al_2O_3%	SiO_2%	SO_3%	P_2O_5	K_2O
45.3	0.43	0.78	0.41	1.25	0.32	0.12	0.04

TABLE IV
PHYSICAL PROPERTIES

Specific gravity		Absorption capacity %	Compressive strength kg/cm^2	Impact resistance cm
Bulk	Apparent			
1.95-2.56	2.04-2.56	0.47-0.52	190-373	8-12

III. PREPARE MODELS

Two basic types of concrete mixes were carried out:

Mixes type A Concrete mix made with crushed rock as fine aggregate, gravel as coarse aggregate.

Mixes type B; Concrete mix made with natural sand as fine aggregate and gravel as coarse aggregate.

For each type three mixes were carried out:

Rich mix with 1 cement: (1 fine agg.): 2(Coarse agg-) by weight.

Poor mix with 1 cement: 2(fine agg.): 4 (coarse agg.) by weight.

Poor mix with 1 cement: 3 (fine agg.): 6 (coarse agg.) by weight.

Mixture models developed in cubes (15cm × 15cm × 15cm),
after casting concrete specimens with different mixes curing and ripening was according to B.S. 1881 part (111, 114, 116) 1983 [13].

IV. TESTS AND RESULTS

The following tests were done:

1- Workability was investigated by two test:

a. Slump test.

b. (V.B. Consistometer test).

2- Compressive strength according to B.S. 1881. part 116 1983.

Also for each cement / aggregate ratio three or four water/cement ratio were selected to give arrange of workability
from (no slump-0 -to-high slump).

Results of all various tests are given in tables (5 , 6 , 7) with a note:

TABLE V
IRAQI STANDARD SPECIFICATION FOR COMPRESSIVE STRENGTH IN (1985) [12]

Age in days	Compressive strength MN/m^2
7 days	14MN/m^2
28 days	21MN/m^2

TABLE VI
WORKABILITY AND COMPRESSIVE STRENGTH FOR MIXES TYPE (A) WITH CRUSHED LIMESTONE AS FINE AGGREGATE

Mix design weight		Slump	V.B.	Comp. Str. In MN/m^2 at ages:			
C/agg.	W/C	Am	Sec	7 days	28 days	56 days	90 days
Rich mix	0.35	0	20	42.7	54.3	59.2	62.3
1:1:2	0.40	85	4.0	39.7	46.5	54.2	57.8
	0.45	150	1.0	25.2	42.8	48.7	54.2
Normal	0.45	0	34	29.1	41.1	47.1	50.1
mix	0.5	21	11	25.9	39.2	46.8	48.9
1:2:4	0.55	47	5.0	19.5	33.3	40.2	43.2
	0.6	125	2.0	16.3	28.3	35.0	36.1
Poor mix	0.6	0	18	17.3	29.8	34.5	36.8
1:3:6	0.65	13	7.5	15.1	27.8	33.8	36.0
	0.70	47	3.0	11.2	22.2	28.2	32.0
	0.75	145	1.5	10.3	20.9	23.2	27.9

TABLE VII
WORKABILITY AND COMPRESSIVE STRENGTH FOR MIXES TYPE (B) WITH SAND AS FINE AGGREGATE

Mix design weight		Slump	V.B.	Comp. Str. In MN/m^2 at ages:			
C/agg.	W/C	Mm	Sec	7 days	28 days	56 days	98 days
Rich mix	0.3	0	30	36.5	48.5	52.0	54.0
1:1:2	0.35	45	12	34.2	42.2	50.1	52.3
	0.4	150	1.5	30.3	40.1	47.3	51.2
Normal mix	0.45	0	23	22.5	32.2	39.3	42.5
1:2:4	0.5	20	10	21.3	30.3	36.2	40.1
	0.55	110	3.0	18.2	28.3	35.1	38.2
	0.6	150	1.2	14.5	26.1	33.5	35.0
Poor mix	0.55	0	25	15.2	26.3	31.1	33.2
1:3:6	0.625	10	9.0	12.3	24.3	25.2	30.1
	0.7	50	5.0	10	21.2	23.1	28.3
	0.75	150	1.2	7.1	18.9	20.2	25.3

V. RESULTS AND DISCUSSION

The use of crushed limestone as fine aggregate in concrete effect properties of both fresh and hardened concrete, such as workability and compressive strength, with comparison of concrete made with natural sand. The reason for such influences is due to difference in properties of two types of fine aggregate. Crushed rock fine aggregate had rough surface texture more angular shape and was more absorptive than natural sand [3]. The workability of mixes type A, was near to that of mixes type B, when cement content was rather low. The reason may be due to high cement paste in rich mixes (about 35% of concrete mixture) which coats the aggregate and provides better lubricating action and also reduces the effect of absorption[I], while the difference of angularity between crushed rock and natural sand still plays a major part in workability [5].

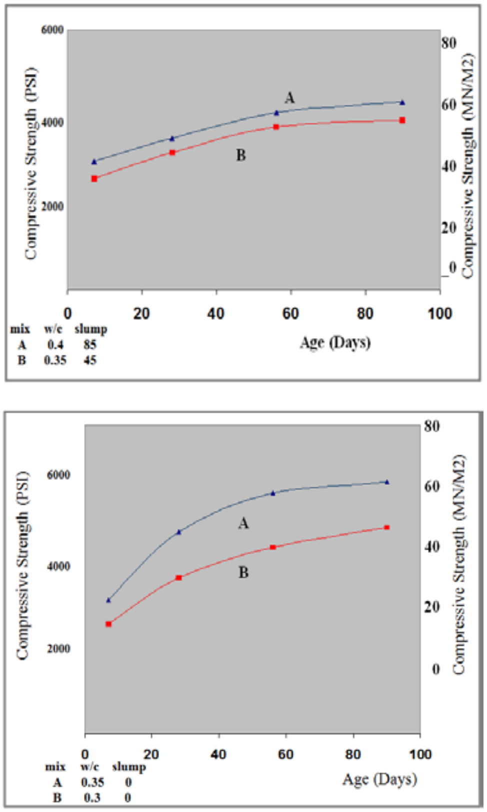


Fig. 1 Relationship between age and compressive strength at the indicated workability (rich mix 1:1:2)

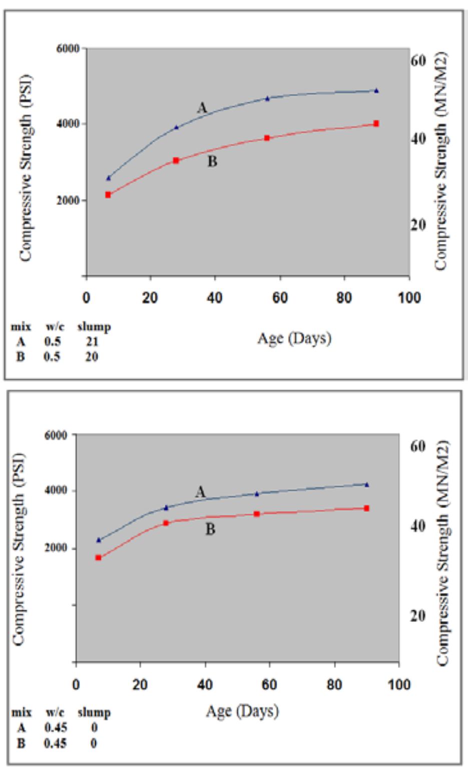


Fig. 2 Relationship between age and compressive strength at the indicated workability (normal 1:2:4)

In leaner mix (poor mix) the percentage of cement paste is less (18% of concrete mixture) so earlier absorption of fine aggregate may be more effective than rich mixes. From Table 6 & 7 it can be observed that for the same cement/aggregate and water/cement ratio, compressive strength of mix of type A was more than that of type B. furthermore the fine aggregate used in mixes type A had rough surface texture and more angular shape than that of fine aggregate (sand) used in mixes B, because of that having stronger bond between cement paste and fine aggregate [1], [2], [4]. So at last, it can be stated that the effect of surface texture and angularity are more significant parameters in increasing flexural strength.[11,6]. For all mixes also the highest compressive strength was at the age of 90 days as shown in fig.(1, 2, 3, 4, 5 & 6.)

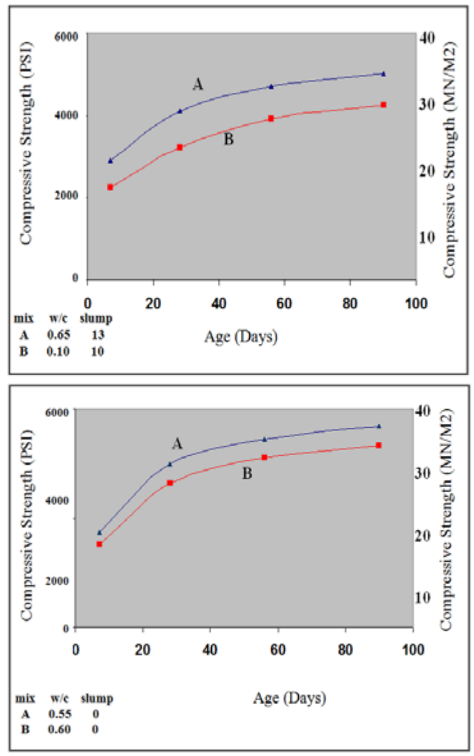
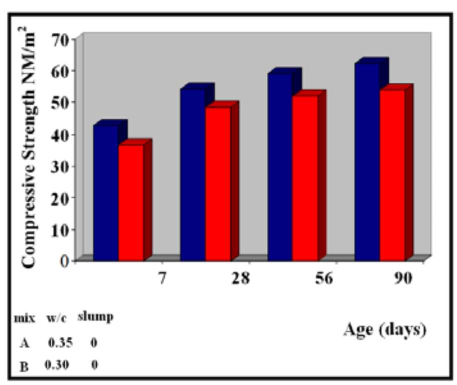
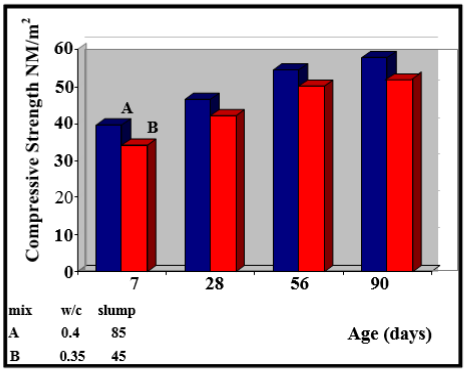


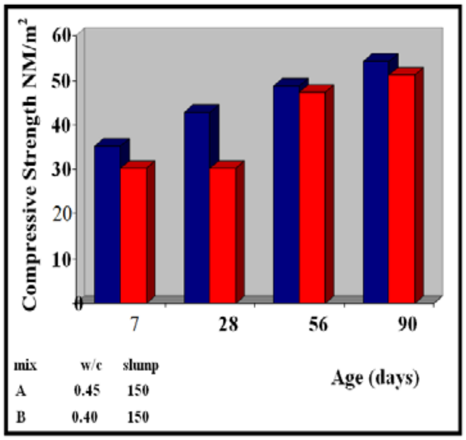
Fig. 3 Relationship between age and compressive strength at the indicated workability (poor mix 1:3:6)



Rich mix 1

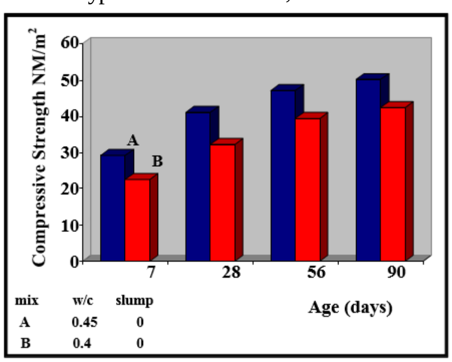


Rich mix 2

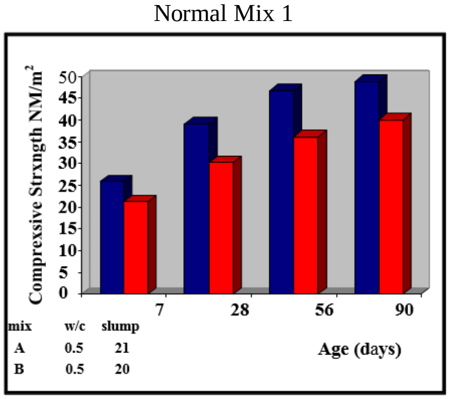


Rich mix 3

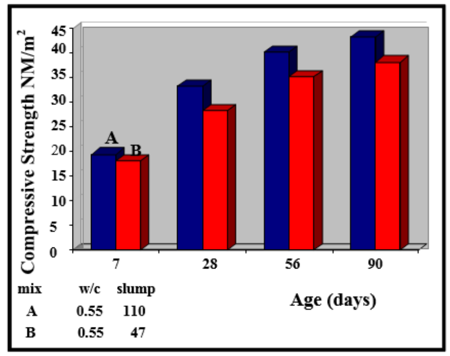
Fig. 4 Relationship between compressive strength and age in days for two types of mixes A& B, Rich mix 1:1:2



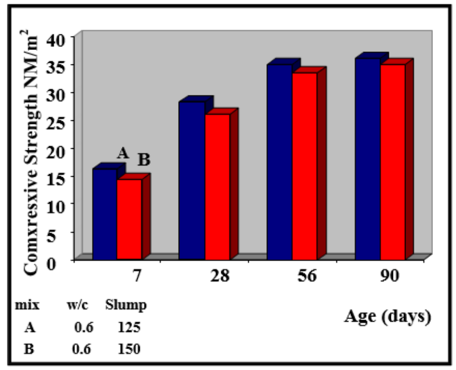
Normal Mix 1



Normal mix 2

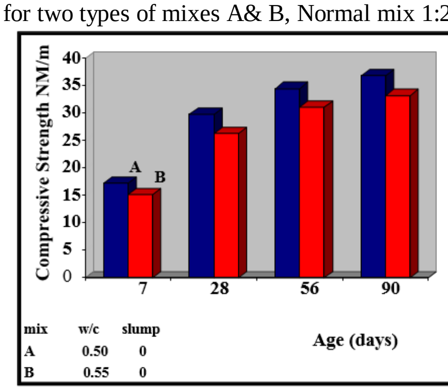


Normal mix 3

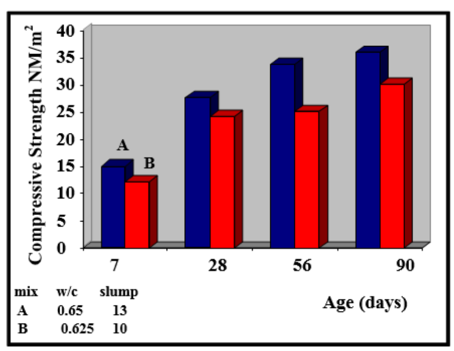


Normal mix 4

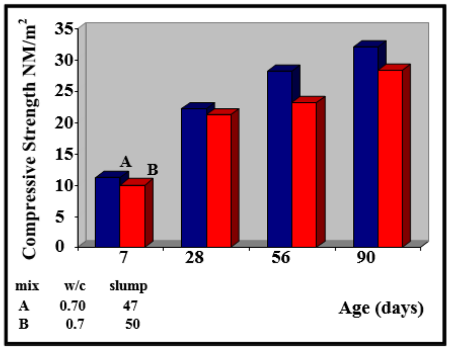
Fig. 5 Relationship between compressive strength and age in days for two types of mixes A& B, Normal mix 1:2:4



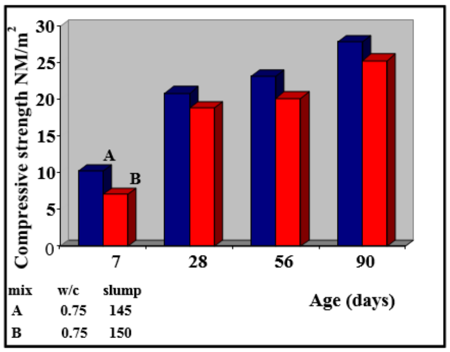
Poor Mix 1



Poor mix 2



Poor mix 3



Poor mix 4

Fig. 6 Relationship between compressive strength and age in days for two types of mixes A& B Poor mix 1:3:6

VI. Conclusion

1 Replacement fine aggregate by crushed limestone reduces workability of concrete mixes especially in leaner mixes (poor).

2 Concrete mixes with crushed limestone fine aggregate needs more water to maintain the same workability than that of natural sand. The amounts of needed water are rather not high ranging about (5-10)% of cement quantity.

3 Concrete made with crashed limestone gave more compressive strength than that made with natural sand. The increase was (2-8)MN/m2 in compressive strength.

4 The concrete produced from crushed limestone as fine aggregate have good quality of concrete and was suitable for producing concrete paving blocks.

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