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Recycling of Concrete Debris using aggregate: a pathway for environmental sustainability

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Abstract- Recycling of Concrete debris can contribute to reducing the total environmental impact of the building sector. To increase the scope for recycling in the future, aspects of recycling must be included in the design phase. Besides, aggregate sources near Metro Manila are almost depleted, so aggregates must be brought from far quarries. Consequently, reclaiming aggregates from concrete debris would lead to environmental and economic benefits. Recycling of waste concrete is done to reuse the concrete rubble as aggregates in concrete. The recycled aggregates have less crushing strength, and impact resistance and have more absorption value as compared to fresh aggregates.This experimental study aimed to use crushed concrete debris as an alternative fine aggregate in a mortar mixture. A conventional mortar mixture will be compared to a concrete debris mixture for the same proportions.

Keywords- Concrete debris**,** aggregate, strength, recycled waste.

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I. INTRODUCTION

Recycling Concrete debris can contribute to reducing the total environmental impact of the building sector.Construction and demolition (C&D) particles are the waste fabric that affects the construction, renovation, or demolition of any structure, which includes buildings, roads, and bridges[1]. Typical waste components include Portland cement concrete, asphalt concrete, wood,drywall, asphalt shingles, metal, cardboard, plastic, and soil. This waste fabric has received interest as its environmental effect has developed these days [2].One of the matters builders, builders, and contractors should don't forget all through construction, maintenance or demolition is wherein to place all of the particles[3]. As what maximum humans do withinside the upkeep of the surroundings and for financial purposes, studies, research, and experiments are being accomplished to find out new methods on a way to locate answer thinking about wherein else to place those particles and what may be accomplished to reduce its disposal to landfills and in view that there's a growing environmental hassle concerning the waste disposal to landfills [4, 5], it's far essential to think about viable methods on a way to keep away from those issues and on the equal time steady protection and convenience, and that is, to recycle [4-6].

Recycling of waste concrete is finished to reuse the concrete rubble as aggregates in concrete [7]. The recycled combination has much less crushing strength, effect resistance, and particular gravity and has a greater absorption cost in comparison to clean aggregates [8]. Millions of heaps of waste concrete are generated each year-round in the sector because of the following reasons: (a) Demolition of a vintage structure. (b) Destruction of homes and systems at some stage in earthquakes and wars(c) Removal of useless concrete from structures, buildings, road pavements,*etc*. (d) Waste concrete generated because of concrete dice and cylinder trying out, detrimental techniques of trying out of present systems and so on [6-9].To increase the scope for recycling in the future, aspects of recycling must be included in the design phase. Besides, aggregate sources near Metro Manila are almost depleted, so aggregates must be brought from far quarries [10]. Consequently, reclaiming aggregates from concrete debris would lead to environmental and economic benefits[11]. This experimental study aimed to use crushed concrete debris as an alternative fine aggregate in a mortar mixture. A conventional mortar mixture will be compared to a concrete debris mixture for the same proportions. This study aimed to look for development withinside the manufacturing and allocation of properly great production merchandise out of recycled materials. It additionally aimed to expand a layout combination of recycled concrete particles as a mortar mix.

This research targeted designing concrete particles in combination with a purpose to meet the

necessities of the ASTM for mortar mix.These include
(1) the mix proportion ofconcrete debris as mortar mixture,
(2) the workability of the mixture in terms ofconsistency, mobility, and compactness as mortar,
(3) the factors which affect theconsistency and instability of the concrete debris mixture.

II. MATERIALS AND METHOD

A flow chart is shown to fully illustrate the activities covered in this research. The following are the step-by-step procedures utilized in the design of the concrete debris mixture as mortar mix shown in Figure 1.

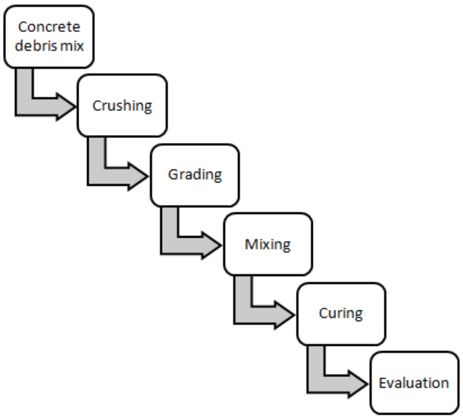

Fig. 1 Designing of concrete debris mix

According to the ASTM standard size of the mortar with sieve no. 4 (100% passing) and sieve no. 2 (10% passing) the collected concrete debris mix is crushed and graded [4]. Then the collected particle of concrete debris mixed with cement and water in different ratios. Then the samples were cured for 7 days, 14 days, 21 days, and 28 days until complete hydration took place, and then a compression test was done. For the slump test, curing is not necessary therefore slump test can be performed directly after mixing. The slump test helps in determining the plasticity of the collected sample and the penetration test helps in determining the compressive strength of the concrete debris mix.

III. RESULTS AND DISCUSSION

Initially, 70% crushed debris, 10% water and 20% cement which constitutes the mortar mix is used for compression and penetration test. For the slump test to be conducted, the water content is increased from 10% to 55% so that the slump of the mixture can be found easily and the content of crushed debris and cement is 20% and 25% respectively. The experiments were conducted to investigate the effect of mix proportion (crushed debris, water, cement) in the cement material, and the graph is plotted as shown in Figure 2. The graph shows that the amount of water for every 250g for cement is 46.5 g and for crushed debris is 37.8 g which is applicable for 2-in cube specimens for compression and penetration tests.

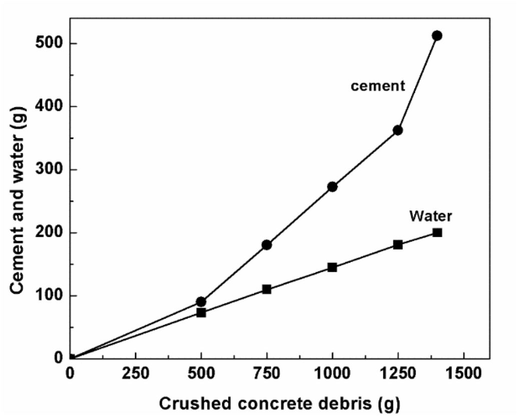

Fig. 2 Water and cement ratio to concrete debris

3.1 Sieve Analysis

The sieve analysis test is done to find out the particle size of the coarse aggregate in which the sample aggregate is passed through an appropriate sieve to find out the particle size. The crushed concrete debrispasses through the 100% passing sieve no. 4 and 10% passing sieve no. 200 according to the ASTM C144, standard specification of sand and mortar, and the results obtained are shown in Table 1.

Table 1. Sieve analysis of concrete debris mix

Sieve size (mm)	**Mass retained (g)**	**Cumulative**			**% passing**
		Mass passing (g)	% passing	% retained	
3.95	9.15	1362.12	96.19	0.67	100
2.56	60.32	1310.54	95.88	4.41	95-100
1.25	96.01	1215.84	93.64	8.39	70-100

0.80	390.24	826.52	70.12	7.21	40-75
0.35	531.36	298.54	36.75	4.13	20-40
0.11	230.21	59.62	20.23	4.21	10-25
0.05			1.00	8.00	0-10

3.2 Slump Test

The slump of the standard mix is 7.2 inches and at the same time, the concrete debris mix has a slump of 7.3 inches (Table 2). In this test, the distinction of slump values is 0.1inch. However, the slumps of the mixtures have been acquired with the addition of water from 11% to 60%. The required slump for mortar is from 5-8 inches. Therefore, the slump of the combination of the concrete particle exceeded the required slump for mortar.

Table 2. Slump pf Concrete and debris mix

Slump of standard mix In	**Slump of concrete debris In**
7.8	7.9

3.3 Compression Test

The compressive strength of standard and concrete debris for at 7 days, 14 days, 21 days, and 28 days is shown in the tables given below. The area (mm^2), weight (g), maximum load capacity (kN), and the compressive strength (MPa) of standard and concrete debris mix are mentioned in the respective tables.The average compressive strength of the standard mix is more than the average compressive strength of the concrete debris mix for 7 days. It is also clear from the respective tables that the average compressive strength at 28 days is more than the average compressive strength at 7 days for the standard mix. The average compressive strength of concrete debris mix at 28 days is slightly more than the average compressive strength at 21 days of concrete debris mix. It is also observed that the average compressive strength of both the mixtures is higher than the allowable compressive strength of the mortar.

Table 3. Compressive strength of standard and concrete debris mix for 7, 14, 21 and 28 days

Standard and concrete debris mix (7 days)

No. of standard mix specimen	**Area (mm^2)**	**Weight (g)**	**Load (kN)**	**Compressive Strength (Mpa)**
1	3000	283.2	56.54	25.91
2	3000	287	59.68	18.35
3	3000	286	46.32	16.58
4	3000	275	55.87	22.65
5	3000	267	40.65	15.38
Average				19.77
No. of concrete debris mix specimen	**Area (mm^2)**	**Weight (g)**	**Load (kN)**	**Compressive Strength (Mpa)**
1	3000	264	37.5	13.8
2	3000	256.7	33.5	10.6
3	3000	262.9	40.6	15.2
4	3000	248	32.9	10.1
5	3000	253.9	41.5	14.9
Average				12.92

Standard and concrete debris mix (14 days)

No. of standard mix specimen	Area (mm^2)	Weight (g)	Load (kN)	Compressive Strength (Mpa)
1	3000	323.1	49.85	21.85
2	3000	338	45.25	17.53
3	3000	326.5	51.3	14.84
4	3000	327	48.9	20.12
5	3000	318.6	47.5	11.23
Average				17.11
No. of standard mix specimen	**Area (mm^2)**	**Weight (g)**	**Load (kN)**	**Compressive Strength (Mpa)**
1	3000	315	33.8	18.5
2	3000	308.7	35.6	15.4
3	3000	311.9	31.5	11.6
4	3000	305	29.8	13.9
5	3000	307.5	36.8	10.6
Average				14

Standard and concrete debris mix (21 days)

No. of standard mix specimen	Area (mm^2)	Weight (g)	Load (kN)	Compressive Strength (Mpa)
1	3000	316.5	42.5	19.85
2	3000	327	40.5	22.6
3	3000	316.5	45.3	17.54
4	3000	307	42.9	16.12
5	3000	319.5	47.5	18.23
Average				18.86
No. of standard mix specimen	**Area (mm^2)**	**Weight (g)**	**Load (kN)**	**Compressive Strength (Mpa)**
1	3000	298	37.6	17.9
2	3000	304.7	33.2	14.9
3	3000	291.9	30.1	16.6
4	3000	286	27.8	18.9
5	3000	283.8	34.7	15.6
Average				16.78

Standard and concrete debris mix (28 days)

No. of standard mix specimen	Area (mm^2)	Weight (g)	Load (kN)	Compressive Strength (Mpa)
1	3000	306	49.5	25.5
2	3000	315.8	53.5	19.65
3	3000	311.4	55.1	15.6
4	3000	299	52.9	23.8
5	3000	295.5	57.6	21.89
Average				21.28
No. of standard mix specimen	**Area (mm^2)**	**Weight (g)**	**Load (kN)**	**Compressive Strength (Mpa)**
1	3000	286	45.8	18.5
2	3000	291	43.2	15.1
3	3000	278.9	47.6	14.6
4	3000	280.8	41.8	16.9
5	3000	283.8	48.3	19.6
Average				16.94

Figure 3shows the differences in the average stress of the standard mix and the concrete debris mix cured for 7 days, 14 days, 21 days, and 28 days. It was observed that the higher compressive strength of both standard mix and concrete debris mix is obtained at 28 days i.e. 21.28 MPa and 16.94 MPa respectively.

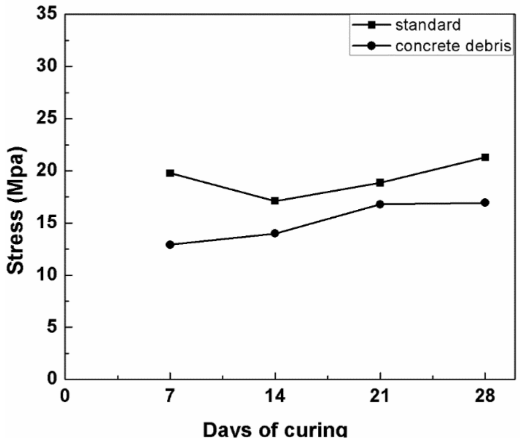

Fig 3. Average compressive strength of standard mix and concrete debris mix

Table 4 shows the compressive strength of the cement-sand-gravel at 28 days at two different ratios. The compressive strength at ratio 1:3:6 is 15.6 MPa and at ratio 1: 2 $^{3}/_{4}$: 6 $^{1}/_{4}$ is 18.89 MPa.

Table 4. Compressive strength of cement-sand-gravel mix and cement-debris-water mix

	Cement	sand	gravel	Strength (Mpa)	Cement	Concrete debris	Water	Strength (Mpa)
ratio	1	3	6	15.6	1	2 $^{3}/_{4}$	6 $^{1}/_{4}$	18.892

IV. CONCLUSION

Concrete is the most effective material that doesn't face sizeable opposition from different recycled materials. Its foremost competitor is overwhelmed stone, which is abundant in nature. However, crushed stone is not used widely, therefore there is a need for aggregates that might get replaced via way of means of recycled concrete. Thus, there is enough potential to recycle all the concrete generated.Based on the observations of the experiments performed, the researcher concludes the following: (a) The proportions of the concrete debris particles influence cement and water in a way that it absorbs a maximum of the water withinside the combination. (b) The concrete particle combination acquired a high slump and low compressive strength on its 7th day of curing. (c) The quantity of water withinside the concrete debris mixture influences the consistency of the mortar combination. (d) The concrete particles blend, with a 1:3 ratio of cement to concrete debris particles with considerable slump and penetration, has suitable mobility as the same old mortar blend of the identical cement to sand ratio. (e)The concrete particles having a 1:2¾ cement to debris concrete particles ratio of 2-in cubes is as compact as the same old mortar blend of the identical cement to sand ratio and (f) Its blend percentage influences the consistency or workability of a mortar blend having 1:2¾ cement to overwhelmed concrete particles ratio.

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