Study the Recycling and use of Construction Waste in Concrete Mixtures in Yemen

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Abstract — The reuse of construction waste in the production of new concrete achieves two aims together, the first is the removal of large amounts of environmental pollution sources resulting from these wastes, and the second is to provide cheap sources of concrete aggregates. This study included testing the properties of a concrete mix equipped with coarse aggregate from the local natural concrete residues after removing the large pieces of gravel, meaning the use of mortar, these residues after grading and crushed and washed.
The results showed that this reused aggregate had a lower specific gravity and higher absorption compared to the usual aggregates used in Yemen. The results indicated that the blended concrete of this aggregate has acceptable compressive strength and absorption resistance. It also has good flexural strength and low dry density compared to the concrete of local natural aggregates. This concrete is suitable for use in the pavement of streets, squares, and corridors, parapet, as well as for the construction of concrete blocks.

Index Terms— Recycled Aggregate, Construction Waste, Pollution, Concrete Paving, Concrete Blocks, Flexural Strength, and Specific Gravity

1 INTRODUCTION

The Concrete waste is the debris resulting from the construction and demolition of the various installations. It is produced from the reparation of the existing structures, the demolition of the old ones or the construction of new buildings. These wastes are also produced from the precast concrete production factories as well as the prefabricated construction factories. It is composed of stones, blocks, concrete or mortar of different sizes. These wastes are dumped in waste collection sites and accumulate annually in large quantities because they are highly durable and do not decompose or moulder naturally and thus become a growing pollution problem annually throughout the world. In Poland, three million and a half million tons of wastes are produced annually. In addition, only 5% of the waste is reused, and the rest is dumped in landfill sites.

One of the methods of recycle of these wastes is to use them instead of the usual or partial aggregate for the production of new concrete by breaking the clean blocks that do not contain the wood pieces or reinforcing bars or gypsum product residues to sizes similar to the sizes of the gravel aggregate and then washing them and gradually separating them on sieves to sizes This is a cheap source of concrete aggregates especially in countries that do not have gravel or base course suitable for concrete.

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The use of this type of aggregate reduces the extraction of gravel layers or crushing rocks to form natural aggregates. Its operations cause the destruction of large areas of the natural environment in the world.

The reused aggregates, which are known as "Recycled Aggregate", which are produced from building and construction waste, have the characteristics of the concrete produced from them and contain the same compounds. It may be a mixture of different concrete, This affects the properties of the concrete produced from this aggregate, so it is common to pave roads or pour the corridors and squares or produce ready-made concrete pieces at the edges of the roads or to pave the places of people walking in the streets, It is not used for the production of concrete, as it does not use more than 20% of the total aggregate used in this concrete and is mixed with the natural aggregates for the production of this concrete if used. The selection of a well-reposted aggregate source can increase the properties of the resulting concrete. In Finland, concrete was produced from the reconstructed aggregates, which gave it two to three times more resistance than the concrete produced from local broken rocks.

Recycled aggregates are of less specific gravity, higher absorbability, and lower operating capacity because it has surface rough if compared to the natural aggregates used in Yemen, this requires larger quantities of water to obtain concrete that is capable of operating equally to that produced from natural aggregates. It absorbs water during and after the mixing process, so it is preferable to mix it, which is saturated with water when producing the concrete.

2 EXPERIMENTAL WORKS:

2.1 Materials used:

I. Cement: Ordinary Yemeni Portland cement from the Mukalla Cement Factory was used to comply with the Yemeni standard. Its physical characteristics were as shown in Table (1).

Table (1) cement user properties

No.	Test	Result	Specification limits
1	Standard ductility (%)	29.5	---
2	Primary coherence time (min)	80	Not less than 45
3	Final coherence time (min)	170	Not more than 600
4	softness (Kg/m^2)	260	Not less than 230
5	Resistance to compression		
	After 3 days (MPa)	18.4	Not less than 15
	After 7 days (MPa)	26.9	Not less than 23

II. Sand: Sand was used from the areas of liquids and watercourses located in the area of Mitem government of Ibb and after washing and cleaning it were listed in accordance with the British standard, within the average gradient area, as shown in Figure 1 that shows the gradation curve of the sand used in concrete mixtures and in the Table (2).

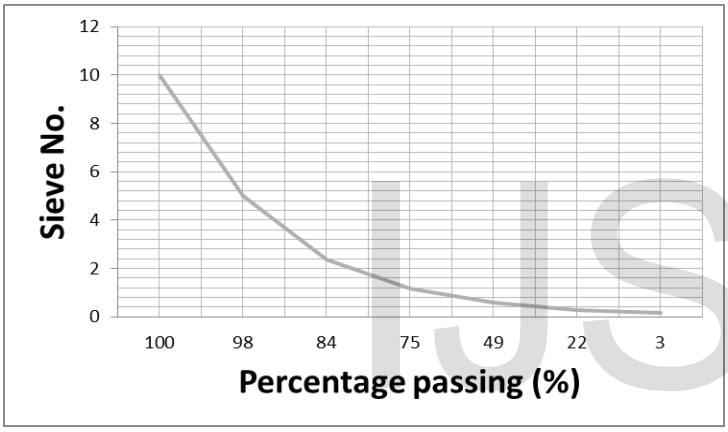

Figure 1 shows the gradation curve of the sand used in concrete mixtures

Table (2) Gradient of sand

Sieve hole (mm)	Percentage passing (%)	Specification limits
10	100	100
5	98	89-100
2.36	84	65-100
1.18	75	45-100
0.6	49	25-80
0.3	22	5-48
0.15	3	0-15

III. Water: Clean drinking water was used in the production of concrete.

IV. The coarse aggregate: The concrete blocks were examined after crushing them and the large pieces of gravel were removed. Their gradients were then tested to conform to the British standard with a maximum dimension of (20 mm), as shown in Figure 2 shows the granular gradient curve of recycled aggregates used in concrete mixtures and in the Table (3) shows the properties of this aggregate.

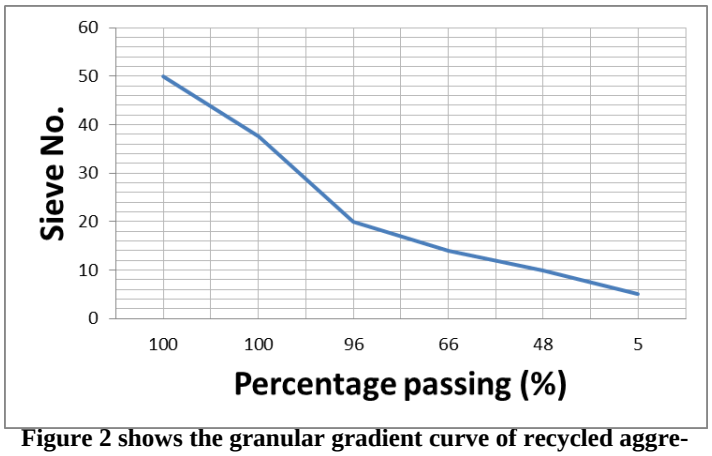

Figure 2 shows the granular gradient curve of recycled aggregates used in concrete mixtures

Table (3) coarse aggregate properties

Sieve hole (mm)	Percentage passing (%)	Specification limits
50	100	100
37.5	100	100
20	96	90-100
14	66	40-80
10	48	30-60
5	5	0-10
Specific gravity total (dry saturated surface)		2.124
Absorption		10.8%
Softness coefficient		6.85%

2.2 Concrete Mix:

Concrete mixture was mixed with 4: 2: 1 ratio with water/cement ratio (0.55). The aggregate was saturated and dry when the surface was weighed and mixed with cement and water at the concrete production stage.

2.3 Laboratory tests:

a) Test compressive strength:

Six concrete cubes were set apart (15 * 15 * 15 cm) and were manually put on layers and then processed by placing them in water for a certain period of time according to British specifications, as the test time according to the British standard specifications of the samples are as follows:

Three cubes are examined after seven days and the other three after 28 days of concrete, and the average is calculated for each period.

b) - Test of absorption of concrete:

Three cubes were prepared in the same way for the previous test. The absorption ratio was calculated for dry sample weight at 28 days and the average was taken for the three cubes.

c) Test of resistance to flexure:

Three concrete beams were prepared according to the British standard and were tested at 28 days in an axial loading point method. The average of the three beams was calculated.

d) Test of dry density:

Three cubes were prepared and processed by putting them in a standard temperature water basin, and then weighed and calculated density after the age of (28 days),

and finally, the average was calculated for the three cubes.

3 RESULTS AND DISCUSSION:

By examining the processed models of the concrete mix containing the coarse aggregate from the concrete residues results are shown in Table (4) were obtained, and from these values, we can obtain several results for these laboratory experiments.

1- By reading the table (3) of the properties of aggregate Recycled, we find that the specific gravity of the aggregate is (2.124) which is less than the specific gravity of the local coarse aggregates, which is almost specific gravity value (2.65) as well as the absorption of a proportion (10.8%) which is higher than the local natural aggregates that typically ranges from (0.5-1%) and the reason is that the percentage of porosity within the granules of this recycled aggregates are higher than in local natural aggregates, which reduces the specific gravity and increases the absorption ratio.
2- Special resistance to compression in the table values (4), we find that these values achieved the requirements of Yemeni Standard for mixing ratio (1: 2: 4) which must not be less than (14 MPa) after age (7 days) and not less than (21 MPa) after age (28 days).
3- By reading the value of the flexure strength of the concrete produced from recycled aggregates in Table (4) we see that it was higher than that of the concrete produced from the local natural aggregates, while the Portland Cement Association determined the flexural strength ratio to the compression resistance of the concrete with compressive strength which is about (20 MPa) about (0.16), the ratio of this concrete was approximately (0.42). This is due to the roughness of the used aggregate surface and its stronger bonding with the cement paste to the smoother surface.
4- By reading the dry density value in Table (4) for Recycled Concrete, we see that it is less than for the local natural aggregates ranging from (2200-2600 Kg/m3).
5- The value of absorbance according to Table (4) is considered acceptable if compared to the standard specifications of Yemen, the ratio of the absorbance of the concrete block, which must not exceed (10%) for the Block concrete type of (a) and also allowed that there will be higher rates for the rest of the type.

Table (4) properties of concrete containing concrete residues

No.	Test	Result	Specification limits
1	Compression of strength after (7 days) (MPa)	14.6	Not less than 14
2	Compression of strength after (28 days) (MPa)	21.3	Not less than 21
3	Compression of Flexure after (28 days) (MPa)	8.9	Not less than 3.36
4	Absorption ratio (%)	3.235	Not more than 10
5	Dry Density after (28 days) (MPa) (KN/m^3)	21.98	22.00 – 26.00

4 CONCLUSIONS

From the above we can conclude the following:

1- The recycled aggregate and its use from the concrete residues have a low specific weight and a high absorption ratio compared to the local rough aggregates (gravel).
2- The compressive resistance of the concrete produced from the recycled coarse aggregate and its use is within the limits of the Yemeni Standard for the specific mixing rate, but it is close to its minimum limits.
3- It was found that the flexure strength of the concrete produced from the recycled aggregate is high relative to the compressive strength achieved. These values were compared with the similar values of the concrete with the local natural aggregate.
4- It was also found that the concrete with recycled aggregates had a relatively dry density compared to the density of concrete with local natural aggregates.
5- The values of absorbance concrete with recycled aggregates higher than for concrete with local natural aggregates, but are acceptable for the specifications of precast concrete products such as blocks, side moldings, parapet.
6- It was found that the concrete with recycled aggregate and its use from the damaged concrete residues is suitable for use in constructions related to the pavement of concrete roads, parking, pavements, and corridors, as well as in the work of concrete blocks, parapet and templates, and others.

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