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The Effect of Recycled Aggregate Quality on Concrete Properties

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Abstract: Waste from construction and demolition are one of the main types of wastes produced worldwide. The aim of this study is to lessen the environmental problems produced by the dumping of waste from construction and demolition. This study presents a comparative analysis of the findings of the experiments conducted on the properties of fresh and hardened concrete with different replacement ratios of normal with recycled coarse aggregate. Recycled aggregate was produced by crushing the waste concrete from buildings. Two types of concrete mixtures were tested namely concrete made fully using normal aggregate as a control concrete and another type of concrete made using recycled coarse aggregate (25, 50 and 75% coarse recycled aggregate replacement were used). Twelve specimens were utilized for the testing compressive strength of the basic properties of hardened concrete. Flexural test of the concrete beams made from the concrete types were also tested. Irrespective of the replacement ratio used, recycled aggregate concrete had a satisfactory performance that did not significantly differ from the performance of control concrete in this experimental study. Nevertheless, it is vital to utilize quality recycled concrete coarse aggregate and to adhere to the specific rules for designing and producing this type of new concrete.

INTRODUCTION

Recycling is defined as processing the used material to create new products. Lately, there is an ever-growing concern over the large volume of wastes from construction sites that seem to be increasing yearly. Waste accumulation is a global issue. Most of waste materials are utilized as landfills or dumped illegally. On the other hand, making use of this waste in a more sustainable way can reduce the impact on environment[1]. Disposing waste material has posed a major problem, since, the last few decades. Using waste as landfills incurs high transportation cost and tipping fees. However, this waste material can be utilized as aggregate in concrete to lessen the cost of concrete and effect on the environment. When old and deteriorating buildings are demolished the waste

consists of stony pieces. After recycling these pieces are known as recycled aggregates. Recycled aggregates are granular materials obtained by processing inorganic materials utilized in construction and using them for construction purposes again.

Concrete is one of the main materials used in construction worldwide. It is utilized widely in all kinds of civil engineering works such as low and high-rise buildings, infrastructure, environmental protection facilities and defense mechanisms. Nevertheless, recycled materials can be used to produce concrete. During the last two decades, the usage of Recycled Aggregate Concrete (RAC) has been increasing gradually and currently it is used as lightweight aggregate, lightweight concrete, asphalt concrete, concrete exposed to high temperatures and in road constructions. Since the Second World War, the usage of crushed waste as aggregate in concrete has started in Europe[2]. After the Second World War, many buildings in Japan are built using crushed waste due to the need for cheap and swiftly built buildings. These buildings still remain functionally well till now. The usage of Recycled Aggregate Concrete (RAC) paves new ways for reusing materials in the building industry, Making use of Recycled Aggregate Concrete (RAC) can provide a solution for excessive waste materials as long as the final product fits the standard quality required. At the same time, use of recycled aggregate concrete can decrease environmental load and improve the ecology[3].

The findings revealed that construction waste can be changed into recycled aggregates which are useful through proper treatment. Strength of concrete is affected if unwashed recycled aggregates are utilized. If washed aggregates are used, the comprehensive concrete strength is higher than if unwashed recycled aggregates are utilized as the bonding is stronger[4].

Recycling involves the action of processing used material to be used in producing new products. Enhanced development in the area of infrastructure enables the use of natural aggregate to be more intensified. Both natural and recycled aggregate can be utilized as replacement materials. Recycled aggregate can consist of graded and crushed inorganic particles which have been obtained from construction waste and material used in construction.

In Libya, the aggregates are of poor quality and therefore recycled aggregate are not generally used in concrete. The aggregates have high absorption rate and low density. Hence, recycled aggregates are not utilized in structural buildings since there is a vast difference in their variation in quality[5]. In the present study, concrete wastes collected from demolished buildings were manually broken into small pieces of different standard sizes coarse aggregates. Recycled concrete coarse aggregates of different replacement ratios were used to cast standard specimens to examine the strength of the concrete produced.

Objectives of the study: The current study includes laboratory observations on using concrete waste from demolished buildings in construction. The following are the main objectives of this study:

- To highlight the importance of using recycled concrete
- To determine the compressive strength of recycled concrete at the age of 28 days
- To compare the difference in compressive strength of normal and recycled concrete
- To demonstrate the benefits of using recycled concrete

MATERIALS AND METHODS

Several tests were conducted to identify the properties of coarse aggregates and the concrete made using coarse aggregates so that the effect of replacing normal coarse aggregate with recycled aggregate concrete could be determined. In the current studies, only 25, 50 and 75% of stone aggregate were replaced with recycled aggregate concrete while all other elements were not changed. The test samples were divided into four groups namely M_1, M_2, M_3 and M_4. 'M' denotes 'concrete mix' and the subscript denotes the 'percentage of recycled aggregate concrete used to replace stone aggregate'. Twelve (150×150×150 mm) concrete cubes were made for each group to be tested for compressive strength. Another eight prisms (100×100×500 mm) were made for flexural test (Fig. 1).

Materials used in this study: Coarse aggregate contains concrete mixes that is made of ordinary Portland cement, crushed stones and sea sand. Replacement aggregate contains different percentage of recycled aggregate concrete and water. The use of ordinary Portland cement and local sea sand with a specific gravity of 2.66 fulfilled ASTM requirements. Crushed stones coarse aggregate has a specific gravity of 2.65 (Table 1). The sieve analysis of coarse aggregate was conducted according to ASTM regulations[6]. Waste recycled aggregate concrete was gathered. Next it was crushed in the laboratory to produce recycled concrete as coarse aggregates. The recycled concrete was then manually crushed and sieved into various sizes. The flaky particles were rejected and removed. Both coarse aggregates and replacement aggregates were screened to a maximum size of 14 mm.

Fig. 1: Recycled Concrete aggregate

Table 1: The obtained percentage of recycled concrete aggregate

Property	Natural aggregate (%)	Recycled aggregate (%)
Crushing value	26.5	29.5
Impact value	24.5	28.5

Table 2: Shows the mix proportion of concrete

Mix No	Cement (kg m^{-3})	Fine Agg (kg m^{-3})	Normal coarse Agg (kg m^{-3})	Recycle Agg (kg m^{-3})	Water (L)
M1	350	700	1050	0	157.5
M2	350	700	787.5	262.5	157.5
M3	350	700	525	525	157.5
M4	350	700	262.5	787.5	157.5

Mix design: The proportions were mixed randomly. The cement, sand and recycled coarse aggregate were weighed according to a mix proportion of 1:2:3. Mix proportions and characteristics of the concrete are presented in Table 2.

Experimental work: The experimental testing was conducted in the concrete laboratory of the Faculty of Engineering at BaniWaleed University, Libya. Twenty concrete samples were made with and without using recycled aggregate concrete. In this study, twelve 150 mm side cubes with a compressive strength of 30 Mpa and eight prisms with flexural strength of 2.65 Mps were used as samples (Fig. 2). The nominal mixing proportion utilized for making the samples (cement: sand: coarse aggregate) by weight with slump of (180±5) mm as a base to get constant workability for all samples were designed. The recycled aggregate concrete was submerged in water for 24 h and later dried to get saturated surface dry conditions. Sand, cement and normal coarse aggregate or recycled aggregate concrete were mixed in a dry state before the necessary amount of water (0.45%) was added and mixed thoroughly. Oil was brushed on the inner surfaces of the wooden mold before casting. Three layers of concrete were poured into the mold and compacted thoroughly using a standard compact Immersion Vibrators. The top surface was done using a trowel. The samples were removed from the mold after 24 h and then

Fig. 2: Flexural test

cured under water for 28 days. The samples were removed from the curing tank just before the test. Compressive strength test was carried out by utilizing a 3000 kn compression testing machine and flexural strength was conducted according to BS EN 12390-3[3]. The tests were carried out according to appropriate standard specifications.

RESULTS AND DISCUSSION

Several tests were conducted on fresh and hardened concrete. Slump test was carried out to evaluate fresh concrete workability while compressive and flexural strength tests were carried out on hardened concrete. Table 3 showed the results obtained for the slump test conducted on recycled aggregate concrete. The data recorded was used to detect the relationship between percentages of recycled aggregate concrete replacement of normal aggregate and slump. The values of slump for different percentages of recycled aggregate concrete mixes were plotted in a graph as displayed in Fig. 3. The graph showed slump for different percentages of recycled aggregate concrete mixes. The graph clearly revealed that slump increase slightly as the percentages of aggregate replacement increased.

Figure 4 showed the test results acquired from concrete cube samples with and without recycled aggregate concrete. The results displayed the average obtained by the 3 samples at age of 28 days which satisfied BS: 1881: part 3: 1970, 1881: part 4: 1970. This figure clearly showed that the usage of recycled aggregate concrete in concrete increased its compression strength. The increase in strength may be due to using higher strength recycled concrete. Figure 5 also revealed that the compressive strength had increased slightly when the ratio of the recycled aggregate concrete to coarse normal aggregate increased.

Nevertheless, the compressive strength of cubes made using recycled aggregate concrete labeled M_2, M_3 and M_4 had increased strength at 28 days. The compressive strength recorded were 30.89 (M_2), 31.06 (M_3) and 32.06 (M_4) Mpa compared to the control mix M_1. The compressive strength increased as the usage of recycled aggregate concrete was increased. The flexural

Table 3: Mechanical properties test results

Concrete Mix.	Aggregate replacement ratio (%)	Slump (mm)	Compressive strength (MPa) 28 days	Flexural strength (MPa) 28 days
M_1	0	185	30.08	2.65
M_2	25	190	30.89	2.67
M_3	50	190	31.06	2.96
M_4	75	200	32.06	3.42

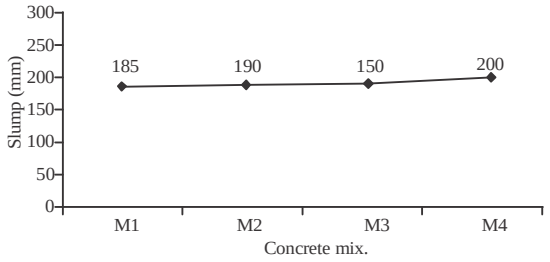

Fig. 3: Slump results for different percentage of recycled aggregate concrete

Fig. 4: Compressive strength for different percentage of recycled aggregate concrete

Fig. 5: Flexural strength for different percentage of recycled aggregate concrete

test revealed an increased flexural strength when the percentage of recycled aggregate concrete in concrete mix is increased. However, the increase in strength was gradual.

CONCLUSION

This study has proved that recycled aggregate concrete can be utilized satisfactorily as coarse aggregate for the production of concrete since the comparative analysis of test results showed the basic properties of concrete with three different percentages namely 25, 50 and 75% replacement of coarse recycled aggregate content offered both economic benefits and sustainability.

The way of preparing recycled aggregate for concrete mixtures affects the workability of the concrete. Concrete with normal and recycled aggregate has to achieve almost the same workability. The quality of recycled aggregate determined the compressive strength of the concrete. If good quality aggregate acquired by crushing higher strength concrete is utilized for the producing new concrete, the resulting recycled aggregate will affect the compressive strength, irrespective of the replacement ratio of normal coarse aggregate with recycled aggregate. The flexural strength of the concrete is also affected in the same way. The bond between the recycled aggregate concrete and normal aggregate is not significant because it is achieved through a new cement paste.

All the conclusions derived from this study on the tested properties of fresh and hardened concrete and subsequently the performance of beams subjected to bending are valid for recycled aggregate concrete made from quality recycled aggregate obtained from demolished concrete with good mechanical properties as used in this experimental research. This study revealed that the concrete from demolition site is a good source for concrete constructions. Economic and environmental factors further justify the suitability of recycled aggregate concrete usage as an alternative to normal concrete. Whenever normal aggregates made from new rocks are not available, recycled aggregate concrete can serve as an alternative for normal coarse aggregate in the production of concrete.

RECOMMENDATIONS

Further testing and studies on the recycled aggregate concrete is highly recommended to indicate the strength of recycled aggregates that can be utilized in concrete. The following are the recommendations for future studies:

- Even though reducing the cement/water ratio enables recycled aggregates to achieve higher strength and greater performance concrete it is recommended to add admixtures for instance and silica fume and super plasticizer into the mixture to improve workability
- More laboratory tests and investigations must be carried out to test the strength of recycled aggregate. Testing can be conducted on beams, walls and concrete slabs. Some mechanical properties such as creeping and abrasion were also recommended
- More testing should be done with recycled aggregate particles of different sizes and percentage of replacement to obtain different results and recycled aggregate concrete of good quality

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REFERENCES

01. Batayneh, M., I. Marie and I.M. Asi, 2007. Use of selected waste materials in concrete mixes. J. Waste Manage., 27: 1870-1876.
02. Swamy, R.N., 1983. New Concrete Materials. Surrey University Press, London, England, UK., Pages: 180.
03. Wang, X., 2012. Experimental study of the preparation of ecological concrete using waste fly ash. Master Thesis, Shandong Jianzhu University, Jinan, China.
04. Chen, H.J., T. Yen and K.H. Chen, 2003. Use of building rubbles as recycled aggregates. Cem. Concr. Res., 33: 125-132.
05. Alsadey, S., 2016. Properties of concrete using crushed brick as coarse aggregate. Int. J. Adv. Mech. Civil Eng., 6: 44-47.
06. ASTM C192/C192M., 2002. Standard practice for making and curing concrete test specimens in the laboratory. ASTM International, West Conshohocken, Pennsylvania, USA.