Compressive strength improvement for recycled concrete aggregate

Dhiyaa Mohammed[1], *Sameh* Tobeia[1], *Faris* Mohammed[1] and *Sarah* Hasan[1]

[1] Building and Construction Engineering Department, University of Technology, Baghdad, Iraq

Abstract. Increasing amount of construction waste and, concrete remnants, in particular pose a serious problem. Concrete waste exist in large amounts, do not decay and need long time for disintegration. Therefore, in this work old demolished concrete is crashed and recycled to produce recycled concrete aggregate which can be reused in new concrete production. The effect of using recycled aggregate on concrete compressive strength has been experimentally investigated; silica fume admixture also is used to improve recycled concrete aggregate compressive strength. The main parameters in this study are recycled aggregate and silica fume admixture. The percent of recycled aggregate ranged from (0-100) %. While the silica fume ranged from (0-10) %. The experimental results show that the average concrete compressive strength decreases from 30.85 MPa to 17.58 MPa when the recycled aggregate percentage increased from 0% to 100%. While, when silica fume is used the concrete compressive strength increase again to 29.2 MPa for samples with 100% of recycled aggregate.

1 Introduction

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infra-structure, low and high-rise buildings, defense installations, environment protection and local/domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these aggregates and, inert granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic prices and of qualities to suit all purposes [1]. However, in recent years the wisdom of the continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection. In light of this, the availability of natural resources to future generations has also been realized [2].

In fact, many countries throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing the use of recycled aggregates as a partial or full alternative (if any possible) of natural aggregate to produce recycled aggregate concrete, where it is technically, economically, and environmentally acceptable [3].

2 Aim of work

This work aimed to experimentally investigate the recycling old demolished concrete into recycled coarse aggregate and the effects of this aggregate on concrete properties, especially compressive strength and the possibility to improve it by using certain admixtures like silica fumes.

3 Recycled concrete aggregate productions

Waste concrete sources represented by, demolition of old and deteriorated buildings and traffic infrastructure, and their substitution with new ones, is a frequent phenomenon today in a large part of the world. The main reasons for this situation are changes of purpose, structural deterioration, rearrangement of a city, expansion of traffic directions and increasing traffic load and, natural disasters (earthquake, fire and flood) [3,4].

Recycled aggregate is generally produced by two-stages, the first one represented by crushing of demolished concrete, while the second is the screening and removal of contaminants such as reinforcing steel and other embedded items, and care must be taken to prevent contamination by other materials that can be troublesome, such as asphalt, soil and clay balls, chlorides, glass, gypsum board, sealants, paper, plaster, wood, and roofing materials. The quality of concrete with recycled aggregate is very dependent on the quality of the recycled material used [5-8].

4 Experimental work

In this work, several concrete cubes have been made

by using natural coarse aggregate as well as recycled coarse aggregate, cured and tested in order to investigate the effects of recycled aggregate on concrete compressive strength. Admixtures used also to improve recycled concrete aggregate performance.

4.1 Materials

4.1.1 Cement

Ordinary Portland cement was used throughout this work. It was conforming to the Iraqi Standard No. 5/1984[9]. The cement is made in Iraq and is in the form of 50 kg bags.

Table 1. Ordinary Portland cement test results

Test description	Test result
Initial setting time	114 minutes
Final setting time	292 minutes

4.1.2 Fine Aggregate (Sand)

Natural sand from Al-Ukhaider region was used in this work. The test results were conforming to Iraqi specification (IQS 45/1984) [10].

4.1.3 Recycled Coarse Aggregate

Concrete mass from demolition buildings sites collected in different sizes, crushed to produce several smaller sizes and grades, sieve analysis has been made as shown in Fig. (1), and the maximum size of recycled coarse aggregate is (25) mm.

4.1.4 Natural Coarse Aggregate (Gravel)

Natural coarse aggregate with a maximum size of (25) mm from Al-Nibaae region was used as coarse aggregate. The grading test results is shown in Fig. (1).

4.1.5 Mineral Admixtures (Silicafume)

Silicafume, with 10 percent replacement by weight of cement, has been used in order to improve the performance of concrete with recycled aggregate.

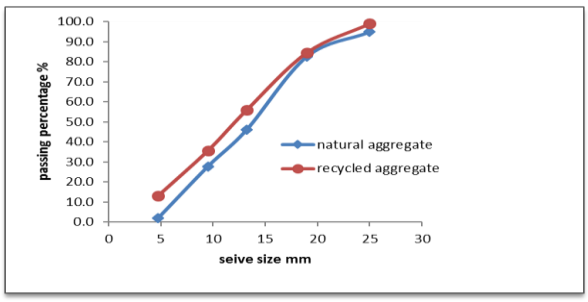

Fig. 1. Gradation curves for natural and recycled aggregate

4.2 Specimen preparation

In this work, several concrete cubes with (150) mm have been made with concrete mix ratio 1:2:4. These cubes have been divided into five groups according to recycled aggregate and admixtures percentage, the replacement percentage of recycled aggregate studied in this work are 0%, 50% and 100%, while admixtures percentage added are 0% and 10%. The five groups can be described as follows:

i) Group A: Concrete cubes made with 0% replacement percentage of recycled aggregate (100% natural aggregate), 0% added admixtures and slump value about 10mm.

ii) Group B: Concrete cubes made with 50% replacement percentage of recycled aggregate and 50% of natural aggregate, 0% added admixtures and slump value about 7mm.

iii) Group C: Concrete cubes made with 100% replacement percentage of recycled aggregate (0% natural aggregate), 0% added admixtures and slump value about 5mm.

iv) Group D: Concrete cubes made with 50% replacement percentage of recycled aggregate and 50% of natural aggregate, 10% added admixtures and slump value about 12mm.

v) Group E: Concrete cubes made with 100% replacement percentage of recycled aggregate (0% natural aggregate), 10% added admixtures and slump value about (12) mm.

4.3 Tests of Concrete Specimens

All concrete cubes specimens have been tested for compressive strength at 28 days. Hydraulic test machine (ELE International ADR 3000) as shown in Figure (2) is used in these tests. Figures (3) and (4) show concrete cubes during test procedure.

Table (2) summarizes the concrete compressive strength test results with corresponding replacement percentages of recycled aggregate and Silica Fume admixture.

The effects of replacement percentage of recycled aggregate and the use of silica fume admixture on concrete compressive strength have been illustrated in Figure (5) and Figure (6).

Fig. 2. Compressive strength test machine

Fig. 3. Group A concrete cube during the test

Fig. 4. Group B concrete cube during the test

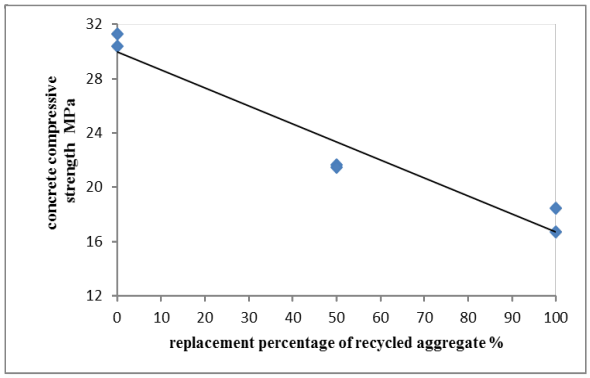

Fig. 5. Concrete compressive strength VS. Replacement percentage of Recycled aggregate (without silicafume)

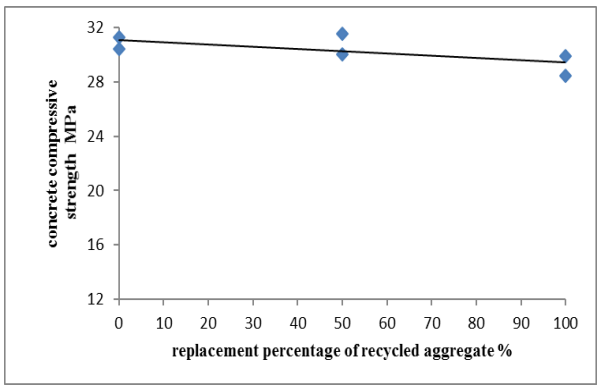

Fig. 6. Concrete compressive strength VS. Replacement percentage of Recycled aggregate (with silica fume)

5 Results and discussion

The main objective of this work is to determine the compressive strength of concrete. Concrete mixes with compressive strength of 30MPa are made using recycled aggregate with percentage (0, 50, and 100) % of the total coarse aggregate with and without adding silica fume. The use recycled aggregate as an aggregate cause a reduction in the compressive strength of concrete in comparison with concrete made with natural aggregate only, these percentages of reduction are (30, and 43) % for (50, and 100)% replacement of natural aggregate. This might be due to weakness of the recycled aggregate that the failure being in it.

Addition of silica fume to the recycled concrete aggregate cause an increase in the concrete compressive strength. This increase in the concrete compressive strength is due to its pozzolanic action which coming from its reaction with calcium hydroxide in the matured cement leading to production of cementitious material.

6 Conclusions

The main conclusions obtained from this work are summarized as follow:

1) The use of recycled aggregate in construction reduces the impact of waste material on environment, also reduces the excavation and transportation of natural aggregate from natural resources.

2) The compressive strength of natural aggregate concrete was higher than the compressive strength of recycled aggregate concrete.

3) The decrease in compressive strength with 50% replacement of aggregate concrete is 30%, while this percentage of decrease is 43% for 100% replacement of aggregate concrete.

4) The increase in compressive strength is observed to be about 42.5% with 50% replacement of aggregate concrete due to addition of 10% silica fume, while this increase in compressive strength is 65% for 100% replacement of aggregate concrete.

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Table 2. Concrete compressive strength test results

No.	Group	Replacement percentage of recycled aggregate %	Silicafume admixture %	Average concrete compressive strength (MPa)
1	A	0	0	30.9
2	B	50	0	21.6
3	C	100	0	17.6
4	D	50	10	30.8
5	E	100	10	29.2