IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 17, Issue 2 Ser. V (Mar - Apr 2020), PP 20-30
www.iosrjournals.org

Study on different mixed proportions of recycled concrete and effect of WRA on the strength of concrete

Abdirahman Ahmed Gedi*[1], Gui-hua Xie[2], Yang Liu[1], Peng Yan[1]
[1]*(Postgraduate student, Department of Civil Engineering, Jiangsu University, Zhenjiang 212013, China)*
[2]*(Associative Professor, Department of Civil Engineering, Jiangsu University, Zhenjiang 212013, China)*

Abstract: *With the continuous progress of our society and the rising of urban infrastructure and the construction industry, the problems of construction waste caused by it are becoming more and more dangerous. Construction waste comes from the demolition and reconstruction of urban waste buildings and the collapse of houses due to earthquakes and other natural disasters, including muck, waste concrete blocks, waste bricks, and steel bars. The treatment of these construction wastes is usually only transported to the suburbs for storage and landfilling. A large amount of dust generated during the transportation process pollutes the air. At the same time, the storage process will occupy a large amount of land, and the harmful substances contained in the garbage will also affect nearby the impact of water resources. In contrast, World's gravel resources are facing a serious shortage, and high-quality native aggregates have tended to be depleted in some areas. In this grim situation, how to turn waste construction waste into a treasure to realise reuse is an important way to save land resources, an important measure to develop a green city and a green economy, and also has a good development prospect.Therefore, research on recycled concrete is essential for saving resources, protecting the environment, and achieving sustainable development of the construction industry. The purpose of this paper is to study the mix design of recycled concrete and its physical and mechanical properties, and the effect of the water reducing agent on the properties of recycled concrete will be studied experimentally, followed by the main conclusions on the determination of the optimal compositing materials for recycle concrete based on the mechanical behaviors and to provide some references for the study of high-strength and high-performance recycled concrete. The compressive strength test of coagulated cubes is used to study the change law of concrete compressive strength under different substitution rates. The test results show that when a replacement ratio concrete is less than 30% of recycled aggregate, it does not affect the mechanical compressive properties of the concrete mixture and the concrete after hardening. The 28-d compressive strength of recycled concrete reached its maximum at a replacement rate of 60%. It is concluded that the reasonable incorporation of fly ash and recycled aggregate can not only effectively improve the performance of concrete mix but also significantly improve the compressive strength of concrete after condensation hardening.*

Key Word: *Recycled aggregate concrete, recycled aggregate, Fly ash, Compressive strength, water reducing agent.*

Date of Submission: 02-04-2020 Date of Acceptance: 18-04-2020

I. Introduction

In recent decades, energy and environmental issues have been put on the agenda of the world. With the rapid development of the construction industry in the world, concrete, as the essential human-made building materials, but the occupation of natural resources and the negative impact on the environment also led to the discussion of sustainable development.

On the one hand, according to the statistical results of authoritative departments, concrete, as the largest consumer of natural resources such as water, sand, pebble, and gravel, is now consuming natural aggregate at a rate of about 80 × 108t per year. On the other hand, the amount of waste concrete removed every year in the world, waste concrete produced by new buildings, and waste concrete discharged by concrete factories and prefabricated component factories are enormous. For example, the emissions of waste concrete in the European community increased from 5500 × 104t in 1980 to 16200 × 104t in 2002, while the emissions of waste brick will be stable at 5200 × 104t per year; about 6000 × 104t of waste concrete in the United States every year; about 1600 × 104t of waste concrete in Japan every year; about 0.3T of waste concrete in Germany every year; and about 0.3T of waste concrete in China every year According to the calculation of 4000 × 104t waste, 34% of which are concrete blocks, the resulting waste concrete is 1360 × 104t. Also, the waste concrete generated by 4000 × 104t construction waste generated by new buildings is expected to increase in the future.

Some developed countries in the world have researched recycled concrete as early as after World War II and made some significant research results, which are still in the ascendant. In recent years, some experts and scholars in China have also carried out some preliminary exploration in this field, but the research is still in the experimental stage, and the research is not in-depth.

Recycled coarse aggregate refers to the mixing of waste concrete blocks with gradation according to a certain proportion after crushing, cleaning, and grading, which is used to partly or completely replace natural aggregate. The application of recycled aggregate in concrete can effectively protect the environment, save resources, and effectively recycle resources. Many scholars have done much research on the compressive strength of recycled concrete. Hou et al. [1] studied the compressive strength of concrete by changing the replacement rate of recycled coarse aggregate. It was found that Recycled concrete has higher strength and better environmental and economic benefits compared with that of ordinary concrete. According to kartam et al. [2], four factors affect the recycling of C & D waste. The first is the purity of the recycled material.

The choice between recycling and other appropriate treatment methods depends on the concentration of hazardous substances in recycled C & D materials. Second, collection and transportation cost. The third is the cost of classification and conversion to reusable materials, as well as the cost of landfill or incineration of any remaining materials. Finally, recycled materials must meet the relevant specifications and standards. Recycled aggregate usually has high water absorption and low specific gravity[3]. The density of recycled aggregate is lower than that of ordinary aggregate. The porosity of recycled aggregate is also much higher than that of natural aggregate[4]. At a high water-cement ratio (between 0.6 and 0.75), the strength of recycled aggregate is comparable to that of reference concrete, even at a 75% replacement level [5]. According to the research of Nixon [6] and Hansen [7], and other scholars [8, 9], the research found that the compressive strength of recycled aggregate concrete decreases with the increase of recycled aggregate content, and the decrease range is 0% to 30%. Wang [10] test shows that there is no obvious regularity between the compressive strength of concrete and the content of recycled aggregate. Yoda et al. [11], ridzuan et al. [12], Ke et al. [13] and other scholars found that the compressive strength of recycled aggregate concrete decreases with the increase of the content of recycled aggregate concrete, while the strength of concrete increases with the increase of the content of recycled aggregate concrete.

Fly ash is a kind of pozzolanic material, which can improve the compressive strength and durability of concrete. In the past, some researchers used different theories to study the effect of mineral and chemical admixtures on the performance of concrete. Some of the main research work are listed below. Fly ash is a kind of pozzolan with particle size is similar to Portland cement[14]. Replacing cement with fly ash can reduce the amount of Portland cement. Replacing raw materials with industrial by-products is an inevitable trend of its established interests [15]. In general, the demand for Portland cement in developing countries is increasing. Cement factories produce more carbon dioxide (CO2) to the atmosphere [15, 16]. Rohman (2009) studied the application of recycled coarse aggregate in the manufacture of new concrete. He found out that the compressive strength target was 17.5MPa. The compressive strength of the specimens with 50% recycled coarse aggregate decreased 14.62%, and 100% recycled coarse aggregate decreased 23.5% compared with control specimens [14]. Rohman (2013), et al. studied the influence of fly ash content on the compressive strength of recycled concrete aggregate concrete. Their research is mainly to understand the influence of fly ash on recycled coarse aggregate. Fly ash is used as a partial substitute of Portland cement in the proportion of 0%, 10%, 20%, 30%, and 40%. After replacing cement, the compressive strength increased by 16.4% and decreased to 20% [17]. A dabhade et al. (2014) studied "the influence of fly ash on recycled coarse aggregate concrete." The strength of concrete specimens is improved by using fly ash instead of Portland cement. The water-cement ratio of all mixtures is 0.38. Using recycled coarse aggregate instead of natural aggregate, the proportion is 0%, 20%, 30%, 40%, 50% and 100% respectively. The empirical formulas are obtained with concrete strength as the dependent variable, recycled aggregate content, fly ash content, and concrete age as an independent variable. The results show that the proportion of recycled coarse aggregate up to 40% will lead to a decrease of compressive strength [18].

The variation of recycled coarse aggregate concrete with the replacement rate of recycled aggregate with fly ash is quite discrete. The reason may be that the influence of recycled aggregate replacement on aggregate gradation has been neglected in the previous studies. The variation of the replacement rate of recycled coarse aggregate has a large span, and the variation range is about 30%. In this study, 8 groups of recycled concrete with different replacement ratio of recycled aggregate concrete were designed to conduct compressive strength test, control aggregate gradation, change the amount of recycled aggregate in recycled concrete, and explore the influence of recycled coarse aggregate on compressive strength.

II. Part one:comparisons of different mixed proportions of recycled aggregate

1 Test Materials

Concrete is made by mixing, stirring, vibrating, and other processes such as coarse aggregate, fine aggregate, cementitious materials, and water. The concrete design strength grade is C30. The cement is made of ordinary Portland cement PO 42.5, Fly ash: Class II fly ash, the coarse aggregate is made of crushed stone with a particle size of 5.0~31.5mm and recycled coarse aggregate, the fine aggregate is made of medium sand with fineness modulus of 2.7, and the water is tap water.

2 Coarse aggregate Performance

Recycled coarse aggregate (RC) is the abandoned concrete taken from Jiangsu university experiment laboratory. After hand crushing, the coarse aggregates were taken to conduct a sieve analysis test according to the Chinese code *Recycled coarse aggregate for concrete (GB/T 25177-2010)*. Natural coarse aggregate (NC) was made of artificial gravel produced by a local shop, Zhenjiang city, with a particle size of 5.0~31.5mm. The gradation was analyzed by the standard method provided in Chinese code *Pebble and crushed stone for construction (GB/T 14685-2011)*. The two kinds of coarse aggregates were shown in Fig 1. Their gradation was shown in Table 1. It is obvious that the gradation of the coarse aggregates are continuous which is of beneficial for the compactness of the concrete.

(a) Recycled coarse aggregates (b) Natural coarse aggregates

Fig.1 Coarse aggregates

Table 1 Recycled coarse (RC) aggregate and natural coarse (NC) aggregate grain composition

Particle size range / mm	Recycled coarse aggregate (RC)		Natural coarse aggregate (NC)	
	Percentage of total weight retained /g	Cumulative % age of total retained	Percentage of total weight retained /g	Cumulative % age of total retained
31.5	1.4	1.4	0	0
25	13.2	14.6	1.03	1.03
20	38.3	52.9	27.2	28.23
16	17.7	70.6	20.9	49.13
10	25.4	94	46.9	96.03
5	2.5	96.5	2.8	98.83
2.5	0.2	98.5	0.0111	98.84
Panel	1.3	100	1.2	100

3. test concrete mix design

Recycled concrete should have excellent workability and strength for use in civil buildings. The expected design strength grade of concrete is C30 in this study and 8 test groups were designed. The water-to-binder ratio, sand ratio, fine aggregate, and water consumption in each group were unchanged. On this basis, the replacement ratio of recycled coarse aggregate was 0, 20%, 40%, 60%, and the fly ash replacement rate was 0% or 10%. The water-cement ratio is 0.6, and the fine aggregate in each cubic meter of concrete is set to 634 Kg; Replace the natural coarse aggregate with recycled concrete with a replacement ratio of 0 to 60% and prepare the test pieces.

Table 2 Mix proportions of thee concrete.

Specimen No.	W/B	WATER (kg/m^3)	FA (kg/m^3)	PC (kg/m^3)	SAND (kg/m^3)	STONES (kg/m^3)	RCA (kg/m^3)
A1	0.6	180	0	300	634	1286	0
A2	0.6	180	30	270	634	1286	0
B1	0.6	180	0	300	634	1028.8	257.2
B2	0.6	180	30	270	634	1028.8	257.2
C1	0.6	180	0	300	634	771.6	514.4

C2	0.6	180	30	270	634	771.6	514.4
D1	0.6	180	0	300	634	514.4	771.6
D2	0.6	180	30	270	634	514.4	771.6

4 Test procedure

The dimensions of the test pieces are 150 mm×150 mm×150 mm. Vibration operation was applied on all specimens to compact their structures. After the curing of 24 h under room temperature, the molds were removed. After 28 days under the standard curing conditions, the tests of compressive strength were carried out according to *Standards for testing methods of mechanical properties of ordinary concrete (GB/T50081 2010)*. The loading speed was controlled within 11.3-18KN/s until the tested cube lost its bearing capacity.

Fig.2 set up for compressive strength test.

Fig.3 samples of specimens after 28 days.

5 test results and analysis

5. 1 Effect of recycled coarse aggregate on compressive strength of concrete

5. 1. 1 Failure mode

During the compressive test of concrete specimens, the surface of the surface initially formed cracks and continued to extend, and the load continued to increase. The surface of the specimen began to crack and peel off, especially in the middle. After the surface layer is peeled off, the middle and the upper and lower coarser fracture state are finally formed, and the hoop effect is more obvious, as shown in Fig.5. From the perspective of damage, recycled concrete is the same as ordinary concrete.

Fig. 4 Compression failure samples

5. 1. 2 Compressive strength test results

The test data of the 28-d compressive strength of recycled concrete is shown in Fig.6. In order to ensure the accuracy of the data, each test piece produces 3 test pieces. When the difference between the maximum value or the minimum value of the three values measured and the average value is less than 20%, the arithmetic mean of 3 values is taken. Otherwise, the average of the three test pieces in the middle was taken as the compressive strength of the test pieces of the set. The test results show that the difference between all the data and the average value is less than 20%, indicating that the measured data has a small degree of deviation, no abnormality, and meets the requirements.

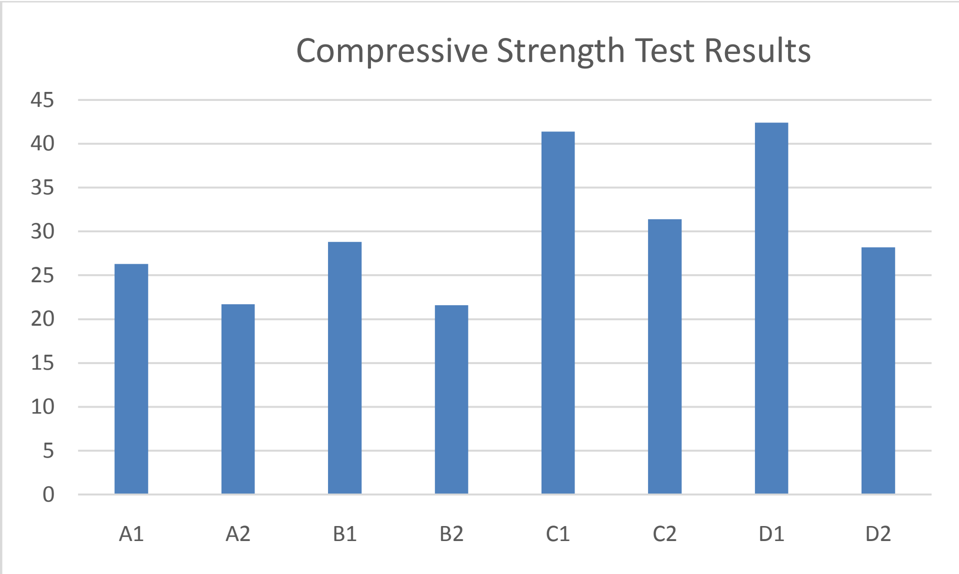

Fig.5. Compression failure samples

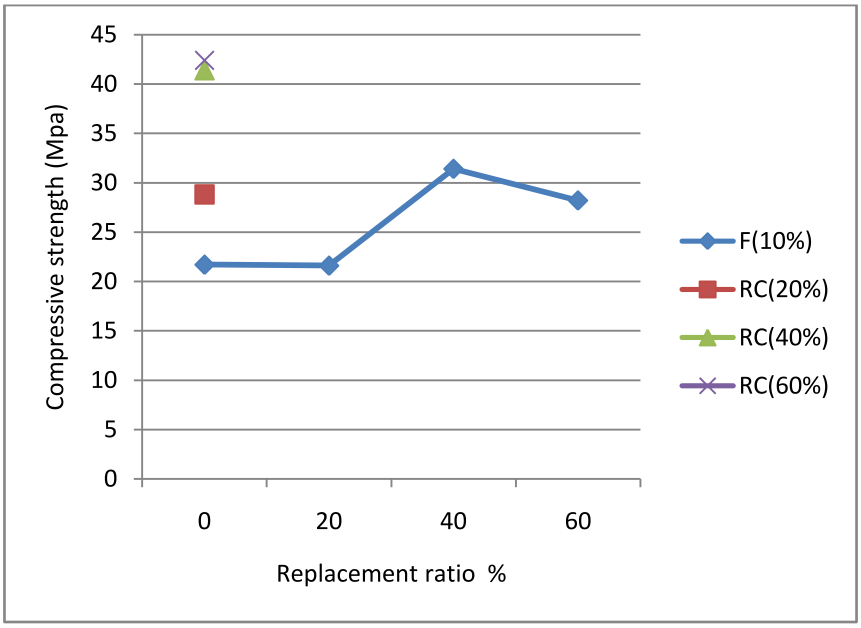

Figure.6. Relationship between (recycled coarse aggregate and Fly ash) replacement rate and compressive strength.

As the replacement rate of recycled aggregates gradually increases, the fracture surface of the concrete shows cracks at the interface between the old mortar and the new mortar and at the interface between the old mortar and the natural aggregate.

The reason why the compressive strength is the largest when the recycled coarse aggregate content is 60% is as follows. First, the cement slurry combined on the surface of the recycled coarse aggregate is relatively dense, and the surface roughness after crushing has a good biting force with the fresh concrete; Second, due to the tremendous water absorption rate of the recycled coarse aggregate, the water-cement ratio is decreased, and the water storage capacity is ample. When the concrete is hydrated, it is gradually released under the action of external pressure so that the concrete is fully hydrated, and its strength is increased. However, when the content of the regenerated coarse aggregate is more significant than that of the natural coarse aggregate, the strength of the recycled coarse aggregate is gradually reduced when the replacement ratio of the recycled coarse aggregate exceeds 60%.

Part two: Effect of high dosage of water reducing agent on concrete properties

1 Introduction

Most of the concrete used contains at least one admixture. In 1975, the proportion of concrete admixtures used in Australia, Germany and Japan was 80%, 60% and 80% respectively [19]. Water reducing agent is a special chemical product added before concrete mixture pouring. They come from the same product line as the reducers... Increase concrete strength by 25% (because less water is required to keep the concrete mixture in working condition).

The function of water reducing agent is obvious, that is, to produce concrete with high workability or concrete with high strength. The mechanism of water reducing agent is to give cement particles a high negative charge, which makes them repel each other under the same static charge. By removing the flocculation of cement particles, more water is provided for concrete mixing[20].

Table 3 Mix proportion of the concrete test

Mix No.	W/B	Water (kg)	PC (kg)	SAND (kg)	STONES (kg)	RCA (kg)	WRA
I	0.6	180	300	634	514.4	771.6	0
II	0.6	180	300	634	514.4	771.6	3%

Compressive strength of concrete with different mix proportion is shown in the below Table 2. This test is performed on 14, 21, and 28 days. Concrete with water reducing of 3% replacement of cement and concrete without watering reducing agent.

Table 4 the strength of different duration of the concrete cubes

Strength	I (MPa)	II (MPa)	Decrease (%)
on the14th day	30.37	9.10	70.0
on the 21th day	32.15	9.24	71.2
on the 28th day	34.0	11.0	67.6

We can observe from the table that the strength of concrete with mix II added water reducing agent of 3% was very low on the 14th day, and the development of the strength of concrete was very slow until the 28th day. We can also see that the strength of mix II concrete is below 50% of desired strength of concrete. On the contrary, we got the desired strength within 14 days from mix II. Moreover, the decrease caused by the high dosage of water reducing agent was lowered as the development of the concrete strength`. This may be attributed to the decrease in reaction rate of cement with water, resulting from the participating of water reducing agent. It can be expected consequently that the gap in the strength between the both will be narrowed as the extension of the curing period.

2: Analysis of scanned images

The formation and distribution of two different mix proportions are pictured below. The microstructure of the two mixes were examined and compared to each other. The microstructure and strength properties of all the two mixes were formed after 28 days. The reason behind the strength of the concrete was analyzed and explained based on the differences in the microstructure of concrete mixes.

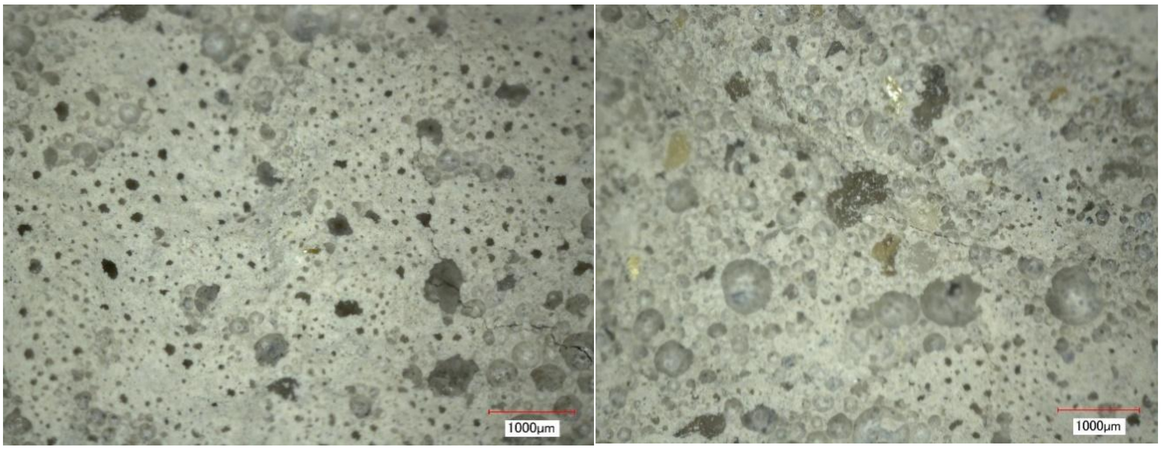

Fig 7 Samples concrete with water reducing agent

1) different: in the structure varying with scanning position that indicates the quality of concrete is uneven.
2) they are similar in the porosity: we have found out from the surface of inner structure of concrete many pores and voids and it indicates high porosity which indicates that the cement was not developed fully.
ComparativeOn contrast (mix 2)
Without water reducing agent

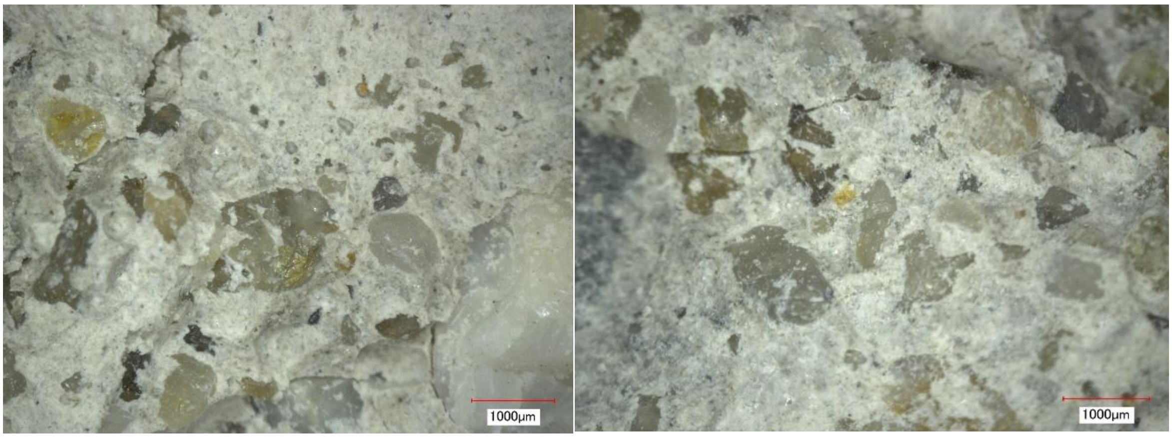

Fig8: samples concrete without water reducing agent

1. the inner structure of the concrete is similar; it indicates more even.
2. we can see from the picture that the concrete has much less pores and compacted well, resulting from the more sufficient reaction of the cement particles with water molecular.

Table 5. comparison between the density of the two mixed proprtions

No	Details	Mix II (with WRA)	Mix I (without WRA)
1	Average Mass of cubes (kg)	6.56	7.56
2	Average volume of Cubes (m^3)	0.15*0.15*0.15	0.15*0.15*0.15
3	Apparent Density of cubes (kg/m^3)	1943	2240
4	Density decrease (5%)	15.24	

We can observe from Table 3 that the density of concrete with mix II was smaller than that of mix I with a decrease of 15.24%. Also, from Table 3, we estimated the porosity difference ΔP between the concrete with Mix II and Mix I, as the following:

$$\Delta P = (\rho_{0I} - \rho_{0II})\rho$$

Where and ρ_{0I} and ρ_{0II} are the apparent densities of concrete with Mix I and with Mix II, respectively; and ρ =2630 kg/m^3 which is the absolute density of the concrete with the same proportion for cement, water and aggregates as shown in Table5.

Table 6 Compressive strength of superplastic concrete

Mix No.	WRA (%)	Compressive strength in (MPa)	Increase (%)
M1	0	44	—
M2	0.6	52	18.18%
M3	0.8	54	22.73%
M4	1.0	55	25.%
M5	1.2	43	-2.27%

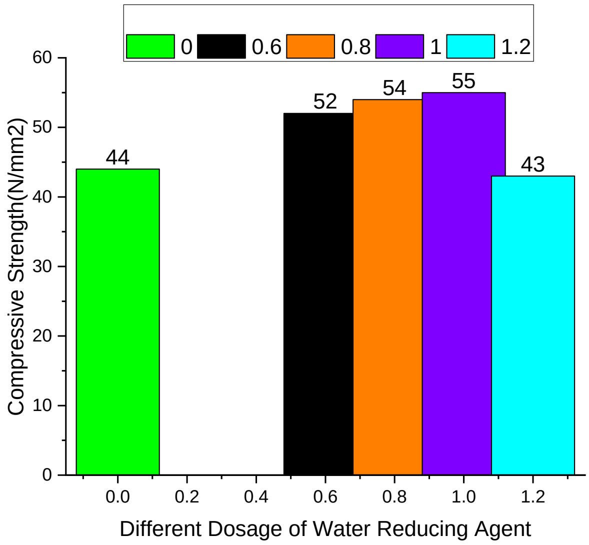

Fig9: Compressive strength of concrete with different content of Superplasticizer

When observe the effect of dosage of the WRA, WRA presents different behaviors on the compressive strength of concrete. When the dosage varies in the scope of 0 to 1%, the increase in dosage will increase the compressive strength for all ages. Since addition of WRA will provide more water for concrete mixing, not only the hydration process will not be disturbed, but it is accelerated by the additional water from deflocculation of cement particles. Hence, increase in dosage will increase the entrapped water and promote hydration of cement. However, from the experimental results in this study and from Table 6, it seems that there is an optimum limit for the dosage of admixture. When the dosage goes beyond this limit, the increase in dosage will reduce the compressive strength reversely. This phenomenon occurs since WRA overdosage will cause bleeding and segregation, which will affect the cohesiveness and uniformity of the concrete. As a result, compressive strength will reduce[21].

Table 7 Porosity of superplasticizer concrete.,

Concrete mix	Porosity of Superplasticizer Concrete (%)	
Control (Plain Concrete) M	11.54	
Control (Plain Concrete) M1	13.23	
400ml/100 kg of cement MS1	11.11	19.08%
600ml/100 kg of cement MS2	10.65	24.22%
800ml/100 kg of cement MS3	10.33	28.07%
1000ml/100 kg of cementMS4	10.7	23.64%
1200ml/100 kg of cementMS5	10.85	21.93%

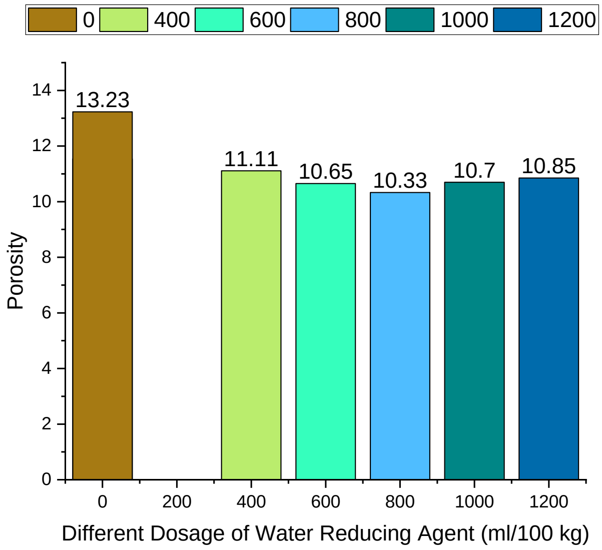

Fig10: Porosity of concrete with different content of SP

it is clear that porosity reduce with time. The reason for this phenomenon is that pore structure and size decreases when the pores are filled by the hydration product- calcium silicate hydrate. Since hydration process continues as long as there is reaction within the raw materials, further reduction in porosity is expected for age of longer than 28 days. Coming to the effect of dosage, the higher the dosage of superplasticizer, the lower the porosity is. The reason for this observation is that increase of dosage will increase water provided for concrete lubrication. As a result, effectiveness of compaction increases due to increase of workability. However, there should be an optimum dosage that produces lowest water absorption and porosity. Further increase of dosage that higher than the optimum dosage not only will give no effect on the porosity due to higher porosity for the occurrence of bleeding and segregation.

III. Conclusion

There were two different tests were conducted in this paper. The first experiment a 28-d compressive strength test of Green concrete formed by replacing different coarse aggregates and Fly ash, and analysis of different replacement ratios of both recycled coarse aggregates and Fly ash. And the second test was conducted to study the effect of water reducing agent on properties of concrete with characteristic strength of 30 N/mm2. The properties of concrete containing with and without WRA had been successfully studied. From the results of the study presented earlier, the following conclusions are offered:

1) According to the compressive strength test of concrete 28 d, the compressive strength of concrete 28 d was not deteriorated by the incorporation of fly ash and recycled aggregate. When the amount of fly ash and the amount of recycled aggregate are less than 30%, the effect on the concrete strength is not apparent, reaching the same level of compressive strength of the control group (ordinary concrete), and it is concluded that the concrete is less than 30% of fly ash and recycled aggregate does not affect the mechanical compressive properties of the concrete mixture and the concrete after hardening. This will be used to incorporate fly ash and recycled aggregate into the concrete in the future to achieve full utilization of waste. The purpose of reducing concrete costs and other purposes provides a sufficient scientific basis.

2) 28 d compressive strength gradually decreases with the increase of the replacement rate of recycled coarse aggregate, then gradually increases and then decreases the wave shape, and then gradually decreases after the maximum compressive strength of 60%. The 28-d compressive strength of recycled concrete reached its maximum at a replacement rate of 60%. The research results can provide reference and reference for the application of recycled coarse aggregate in engineering.

3) At the same time, through the compressive strength test of concrete 28 d, it is concluded that when the amount of fly ash is between 10% and 30% and the amount of recycled aggregate is distributed in the range of 30% to 60%, the double-mixed coal The compressive strength of ash-recycled aggregate concrete is significantly higher than that of ordinary concrete, which exceeds the strength of concrete design. It is concluded that the reasonable incorporation of fly ash and recycled aggregate can not only effectively improve the performance of concrete mix but also significantly improve the compressive strength of concrete after condensation hardening. This provides reliable experimental data for future scientific research on increasing the

application of fly ash and recycled aggregate in concrete and the performance of fly ash recycled aggregate concrete.

4) Compressive strength can be improved by WRA to get high strength than the desired characteristic strength. however, very high dosage of WRA have reduced the strength of concrete.

5) after using high dosage of water reducing agent in the concrete, the porosity of concrete increased and pore structure and size increased due to less cohesiveness resulted from segregation and bleeding.

6) Density of the concrete decreased after added high amount of water reducing agent and it produced less dense concrete.

References

[1]. González-Taboada, I., et al., Study of recycled concrete aggregate quality and its relationship with recycled concrete compressive strength using database analysis. Materiales de Construcción, 2016. **66**(323): p. 089.

[2]. Kartam, N., et al., Environmental management of construction and demolition waste in Kuwait. Waste management, 2004. **24**(10): p. 1049-1059.

[3]. Pavlů, T., V. Kočí, and P. Hájek, Environmental Assessment of Two Use Cycles of Recycled Aggregate Concrete. Sustainability, 2019. **11**(21): p. 6185.

[4]. Karim, Y., et al., A review on recycled aggregates for the construction industry. American Journal of Civil Engineering and Architecture, 2016. **4**(1): p. 32-38.

[5]. Katz, A., Properties of concrete made with recycled aggregate from partially hydrated old concrete. Cement and concrete research, 2003. **33**(5): p. 703-711.

[6]. Padmini, A., K. Ramamurthy, and M. Mathews, Influence of parent concrete on the properties of recycled aggregate concrete. Construction and Building Materials, 2009. **23**(2): p. 829-836.

[7]. Yadav, S. and S. Pathak, Durability Aspects of Recycled Aggregate Concrete: An Experimental Study. International Journal of Civil and Environmental Engineering, 2018. **12**(3): p. 313-323.

[8]. Silva, R., et al., Statistical modeling of carbonation in concrete incorporating recycled aggregates. Journal of Materials in Civil Engineering, 2016. **28**(1): p. 04015082.

[9]. Ozbakkaloglu, T., A. Gholampour, and T. Xie, Mechanical and durability properties of recycled aggregate concrete: effect of recycled aggregate properties and content. Journal of Materials in Civil Engineering, 2018. **30**(2): p. 04017275.

[10]. Ye, T., et al., Flexural behavior of corroded reinforced recycled aggregate concrete beams. Advances in Materials Science and Engineering, 2018. **2018**.

[11]. Shylaja, N., et al., Effect of Strength Properties of Recycled Aggregate Concrete. International Journal of Applied Engineering Research, 2018. **13**(7): p. 100-102.

[12]. Paul, S.C. and G. Van Zijl, Mechanical properties of concrete containing recycled concrete aggregate. Proceeding of Concrete for a Sustained Environment, Johannesburg, South Africa, 2010.

[13]. Ke, G., et al., Practical research on recycled concrete. Concrete, 2002. **4**: p. 47-48.

[14]. Rohman, R.K. and S. Aji. Effect of fly ash on compressive strength of concrete containing recycled coarse aggregate. in AIP Conference Proceedings. 2018. AIP Publishing LLC.

[15]. Vidivelli, B. and T. Subbulakshmi, Prediction of the Mechanical Behaviour of High Performance Concrete with Industrial By-Products through Regression Analysis. 2016.

[16]. Markewitz, P., et al., Carbon capture for CO2 emission reduction in the cement industry in Germany. Energies, 2019. **12**(12): p. 2432.

[17]. Deepa, C., K. SathiyaKumari, and V.P. Sudha, Prediction of the compressive strength of high performance concrete mix using tree based modeling. International Journal of Computer Applications, 2010. **6**(5): p. 18-24.

[18]. Vinay, K., STUDY OF STRENGTH CHARACTERISTICS OF CONCRETE USING RECYCLED AGGREGATES.

[19]. González-Taboada, I., et al., Study of recycled concrete aggregate quality and its relationship with recycled concrete compressive strength using database analysis. Materiales de Construcción, 2016. **66**(323): p. 089.

[20]. Kartam, N., et al., Environmental management of construction and demolition waste in Kuwait. Waste management, 2004. **24**(10): p. 1049-1059.

[21]. Pavlů, T., V. Kočí, and P. Hájek, Environmental Assessment of Two Use Cycles of Recycled Aggregate Concrete. Sustainability, 2019. **11**(21): p. 6185.

[22]. Karim, Y., et al., A review on recycled aggregates for the construction industry. American Journal of Civil Engineering and Architecture, 2016. **4**(1): p. 32-38.

[23]. Katz, A., Properties of concrete made with recycled aggregate from partially hydrated old concrete. Cement and concrete research, 2003. **33**(5): p. 703-711.

[24]. Padmini, A., K. Ramamurthy, and M. Mathews, Influence of parent concrete on the properties of recycled aggregate concrete. Construction and Building Materials, 2009. **23**(2): p. 829-836.

[25]. Yadav, S. and S. Pathak, Durability Aspects of Recycled Aggregate Concrete: An Experimental Study. International Journal of Civil and Environmental Engineering, 2018. **12**(3): p. 313-323.

[26]. Silva, R., et al., Statistical modeling of carbonation in concrete incorporating recycled aggregates. Journal of Materials in Civil Engineering, 2016. **28**(1): p. 04015082.

[27]. Ozbakkaloglu, T., A. Gholampour, and T. Xie, Mechanical and durability properties of recycled aggregate concrete: effect of recycled aggregate properties and content. Journal of Materials in Civil Engineering, 2018. **30**(2): p. 04017275.

[28]. Ye, T., et al., Flexural behavior of corroded reinforced recycled aggregate concrete beams. Advances in Materials Science and Engineering, 2018. **2018**.

[29]. Shylaja, N., et al., Effect of Strength Properties of Recycled Aggregate Concrete. International Journal of Applied Engineering Research, 2018. **13**(7): p. 100-102.

[30]. Paul, S.C. and G. Van Zijl, Mechanical properties of concrete containing recycled concrete aggregate. Proceeding of Concrete for a Sustained Environment, Johannesburg, South Africa, 2010.

[31]. Ke, G., et al., Practical research on recycled concrete. Concrete, 2002. **4**: p. 47-48.

[32]. Rohman, R.K. and S. Aji. Effect of fly ash on compressive strength of concrete containing recycled coarse aggregate. in AIP Conference Proceedings. 2018. AIP Publishing LLC.

[33]. Vidivelli, B. and T. Subbulakshmi, Prediction of the Mechanical Behaviour of High Performance Concrete with Industrial By-Products through Regression Analysis. 2016.
[34]. Markewitz, P., et al., Carbon capture for CO2 emission reduction in the cement industry in Germany. Energies, 2019. **12**(12): p. 2432.
[35]. Deepa, C., K. SathiyaKumari, and V.P. Sudha, Prediction of the compressive strength of high performance concrete mix using tree based modeling. International Journal of Computer Applications, 2010. **6**(5): p. 18-24.
[36]. Vinay, K., STUDY OF STRENGTH CHARACTERISTICS OF CONCRETE USING RECYCLED AGGREGATES.
[37]. Salem, M., S. Alsadey, and M. Johari, Effect of Superplasticizer Dosage on Workability and Strength Characteristics of Concrete.
[38]. Falah, M.W. and R.J. Ghayyib, Evaluating The Effects of Using Superplasticizer RHEOBUILD® 600 on The Workability and Compressive Strength of Normal Concrete. Journal of University of Babylon for Engineering Sciences, 2018. **26**(5): p. 95-104.
[39]. Alsadey, S., Influence of superplasticizer on strength of concrete. International Journal of Research in Engineering and Technology, 2012. **1**(3): p. 164-166.

Abdirahman Ahmed Gedi,etal. “Study on different mixed proportions of recycled concrete and effect of WRA on the strength of concrete.” *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 17(2), 2020, pp. 20-30.