Study of Recycled Aggregate Concrete Containing Silica Fume as Partial Replacement for Cement

Narendra Gupta[1], Pankaj Agrawal[2], Anudeep Nema[3]

[1]*M.Tech Scholar, Eklavya University Damoh M.P.*
[2]*Assistant Professor Eklavya University Damoh M.P.*
[3] Assistant Professor Eklavya University Damoh M.P.

Abstract - *Recycled Aggregate Concrete (RCA) is a concrete product made from recycled aggregate in whole or in part from natural aggregates. The purpose of this study is to characterize ACR and compare it to concrete based on natural aggregates2. Recycled concrete aggregate has also been described as "the most innovative development in concrete structures in decades". Not only does it conserve non-renewable resources, it has been proven to be economically and environmentally beneficial. rice paddy. In this study, conventional grade 43 Portland cement was used, and the weight percent of recycled aggregate partially replacing natural aggregate was 0%, 10%, 20%, 30%, 40%, and 50%. Concrete blocks and columns are molded and laboratory tested. In order to determine the optimal replacement rate, mechanical property tests such as compression tests and tensile tests were conducted. The results show that the optimal rate of replacing recycled aggregate with natural aggregate is 30%. Replacing up to 30% can achieve the same strength as conventional concrete. Above 30%, the resulting strength tends to decrease.*

Key Words: Workability, Compressive Strength, Tensile Strength, Silica Fume.

1. INTRODUCTION

Today the concrete industry consumes a lot of natural resources. This causes great damage to the environment and homeland. The less cement and natural aggregates used to make concrete, the less impact it has on the environment. Rising landfill costs and scarcity of natural resources for aggregate are driving the use of construction waste as an aggregate source. Sustainable building has become a major concern with building practices harming the future of our planet. This is because the construction industry consumes a large amount of natural resources and produces a large amount of waste. High raw material consumption in the construction industry has become one of the main causes of environmental destruction, pollution of the motherland and depletion of mineral resources. Over 165 million tons of natural aggregates are used in civil and industrial construction each year. The UK currently generates around 109 million tonnes of construction and demolition waste. About 60 million tons of this comes from concrete. Sources of raw materials such as coarse aggregate, sand and cement are disadvantageous as these resources cannot cover the high demand in the construction industry. The use of recycled aggregates can therefore be one of the key initiatives to achieve sustainable construction.

As recycled aggregate (RA) is increasingly recognized and accepted as a viable alternative to natural aggregate (NA), it is important to understand recycled concrete aggregate. How does RAC compare to conventional concrete? Through proper mix design and the introduction of different forms of aggregate and different super plasticizers, it is possible to influence the performance of structural concrete and obtain the same strength as concrete. I can. Corresponding natural aggregates (NAC), or sometimes improved, where coarse aggregates generally have superior strength, durability, and weather ability, and are free of surface impurities such as sludge, manure, and organic matter. It is important that the particles are not chemically absorbed in an acceptable amount and will not affect the hydration of cement and water and the adhesion of cement powder. Aggregates can be classified by weight, rock type and shape

2. MATERIALS USED

2.1 Cement

All materials used in the concrete mix are essential, but cement is often the most important as it is usually the delicate link in the chain. The function of cement is firstly to bind sand and rock together and secondly to fill the voids between the sand and rock particles into a compact mass. Although it accounts for only about 20% of the concrete mix volume, it is the active ingredient in binders and the only scientifically controlled concrete component. Variation in that amount affects the compressive strength of the concrete mix. Grade 43 ordinary Portland cement (OPC) was used for all concrete mixes in this study.

2.2 Aggregate

Aggregate is a matrix or primary structure consisting of relatively inert coarse particles. Coarse aggregates are mainly used to add bulk to concrete. The primary function of fine aggregates is to help create a uniform, workable concrete mix. The fine aggregate also helps the cement paste to keep the coarse aggregate particles in suspension. This effect promotes the ductility of the concrete mix and prevents the separation of coarse and coarse aggregates during transportation. Aggregates make up about 75% of the concrete body, so its impact is very significant. The properties of these particles greatly affect the performance of concrete.

2.2.1 Fine Aggregate

IS: 383-1970 determines fine aggregate when passing 4.75mm IS sieve. Fine aggregates are often referred to as sand-sized aggregates. In this study, locally available riverbed sand was used. The percentage passing the 600 micron sieve is 62.35. Sand corresponds to classification zone - III according to standard IS 383 - 1970.

2.2.2 Course Aggregate

Coarse aggregate is defined as retained by a 4.75 mm IS sieve. Coarse aggregate is often used in two or more sizes to increase the density of the resulting concrete mix. Two types of aggregates with different sizes were used in this study. Details of the contents are as follows.

- Aggregate passing 20 mm sieve
- Aggregate passing 10 mm sieve.

Coarse aggregate is defined as retained by a 4.75 mm IS sieve. Coarse aggregate is often used in two or more sizes to increase the density of the resulting concrete mix. Two aggregates of different sizes were used in this study. The details of the contents are as follows.

2.2.3 Natural Course Aggregate

Crushed granite with nominal sizes of 10 mm and 20 mm were used as natural coarse aggregate.

2.2.4 Recycled Course Aggregate

Concrete wastes of the material testing laboratory were used as coarse aggregates. Both natural and recycled aggregates followed the same grading and the same is shown in Table 1 & Table 2

Table-1: Cube Compressive Strength at 28 days for 20 mm Size of Aggregate

20mm size % retained per 100kg		
sieve size	% retained on the sieve	Cumulative % retained
20 mm	5%	5%
16+12.5+10mm	60%	65%
4.75 mm	25%	90%
2.36 mm	10%	100%

Table-2: Cube Compressive Strength at 28 days for 10mm Size of Aggregate

10mm size % retained per 100kg		
sieve size	% retained on sieve	Cumulative % retained
12.5 mm	8%	8%
10mm	32%	40%
4.75 mm	55%	95%
2.36 mm	5%	100%

2.2.5 Silica Fume

The terms microsilica, condensed silica fume, and silica fume are commonly used to describe ferrosilicon, a by-product extracted from silicon off-gases. Other metal alloy melting furnaces. However, the terms fumed silica and microsilicic acid are used for high quality concentrated silica fumes suitable for use in the cement and concrete industries. The term silica fume was used in European standards. Silica fumes were first detected in Norway in 1947 when the Environmental Protection Agency began filtering blast furnace exhaust gases. Most of these fumes consisted of fine compositions with a high proportion of silica. The pozzolanic reactivity of silica has been well known and has been extensively studied. Over 3000 publications on fumed silica and fumed silica concrete. AASHTO M 307 Per ASTM C 1240, silica fume can be used as an additional cementation material to improve strength and durability. Silica fume consists of fine particles with a specific surface area approximately six times that of cement, as the particles are much finer than cement particles. Therefore, it was found that the pore space decreased when silica fume was mixed into concrete. Silica fume is a pozzolana because it is reactive, like volcanic ash. Its effects include strength modulus, ductility, sound absorption, vibration damping capacity, wear resistance, porosity, strength of bonding with rebar, shrinkage, permeability, resistance to chemical attack, reduction of alkali-silica reactivity, and creep rate. , which is related to corrosion resistance. Embedded rebar, freeze-thaw resistance, coefficient of thermal expansion (CTE), specific heat, defect dynamics, thermal conductivity, dielectrics.

2.2.6 Water

Drinking water is generally sufficient for use on concrete. Water from lakes and streams, which are usually inhabited by marine life, is also suitable. Sampling is not required when water is obtained from the above sources. If the water is suspected of containing sewage, mine water, waste from factories or canning factories, it should be used for concrete unless tests give satisfactory results. Water from such sources should be avoided as low water levels and intermittent hazardous waste discharges into rivers can alter the water quality and fiber dispersity of blends containing short microfibers. there is. Drinking water was used as it was delivered to the building laboratory of our research institute. The water used for mixing and curing must be clean and free of hazardous levels of oils, acids, alkalis, salts, sugars, organics, or substances that could harm concrete. . According to IS: 456-2000, drinking water is generally considered sufficient for mixing and hardening concrete. Therefore, drinking water was used for the preparation of all concrete samples.

2.2.6 Admixtures

Water-reducing and set-retarding admixtures are permitted in order to increase the workability of the concrete and to extend the time of discharge from 60 to 90 minutes. These admixtures are permitted and often required for superstructure concrete. Chemical admixtures and mineral admixtures as defined by ASTM C 494 are as follows:

Super plasticizer CONPLAST SP 430 is a chloride free workability retention admixture based on selected organic polymers. Designed to provide workability retention where rapid workability loss is caused by high ambient temperatures or to compensate for delays in transportation. It is particularly suited to concrete mixes containing micro silica. Silica fume was used as a mineral admixture. It acts as a filler material, and gives the early strength to the concrete could change due to low water or by intermittent discharge of harmful wastes into stream. The water used was the potable water as supplied in the structures laboratory of our institute. Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic materials or other substances that may be deleterious to concrete. As per IS: 456-2000 potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for preparation of all concrete specimens

3. MIX PROPORTIONS

Different quantities of materials and the mix proportions of the materials for each mix is shown in Table 3

Table 3. Quantities of Materials for Mix of Concrete

Mix	Opc	S.F	Cag 20mm	Cag 10mm	RCA 20mm	RCA 10mm
M1	90%	10%	50%	50%	0%	0%
M2	90%	10%	45%	45%	5%	5%
M3	90%	10%	40%	40%	10%	10%
M4	90%	10%	35%	35%	15%	15%
M5	90%	10%	30%	30%	20%	20%
M6	90%	10%	25%	25%	25%	25%

4. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

4.1 Slump Test

Slump test is the most commonly used method of measuring the consistency of concrete Slump test was carried out on all the concrete mixes in the concrete laboratory. This test was very useful in detecting variation in the uniformity of a mix of given proportions. It also gives an idea of Water cement ratio to be used for different mixes. Fresh unsupported concrete flows to and sinking in the height takes place. This vertical settlement is known as Slump. Concrete is said to be workable if it can be easily mixed, compacted and easily finished. The results of all slump values of all mixes are shown in Table 4 The internal surface of mould was cleaned thoroughly and free from moisture and any concrete before commencing the test. The mould was placed on rigid, horizontal and non- absorbent surface. The mould filled in 4 layers, each approximately one quarter of the height of the mould. Each layer shall tamper with 25 strokes. After leveling the top, the mould was removed from concrete immediately by raising it slowly in a vertical direction. This allows the concrete to subside and slump shall be measured by measuring the difference between the heights of mould and highest point of the specimen being tested.

Table-4: Slump Values for Different Concrete Mixes

Mix	description	Slump (mm)
M1	0%RA +100%NA + 10% SF	113
M2	10%RA +90%NA + 10%SF	108
M3	20%RA +80%NA + 10%SF	100
M4	30%RA +70%NA + 10%SF	98
M5	40%RA +60%NA + 10%SF	95
M6	50%RA +50%NA + 10%SF	90

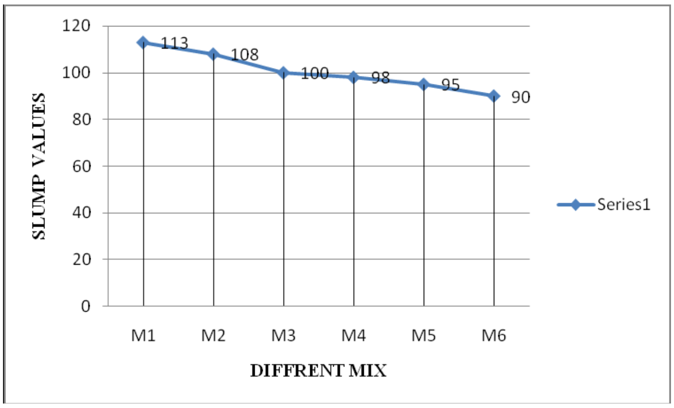

Fig-1: Workability of Different Mix

From Table 4, it can be seen that the slump value is decreasing with increase in the recycled concrete percentage in the mix. This is because the recycled aggregates absorb more water than the normal aggregates because of the presence of dust and the mortar on the surface of recycled aggregates. All slump values were maintained in between 90-110mm by varying the dosage of super plasticizer.

4.2 Compressive Strength

Cubes of sizes 150 x 150 x 150 mm were cast for strength testing. These cubes were cured for 7, 14, 28, 56 and 90 days and tested in Compression testing machine having a capacity of 200 T. The specimens were allowed to dry in sunlight for 1 day and are placed centrally in the testing machine and the load was applied continuously, uniformly and without any shock. Mixes cured at different ages are presented and discussed in this section. The compressive strength test results of all the mixes at different curing ages are shown in Table – 5. Variation of compressive strength of all the mixes with curing age is shown in Fig. – 2

Table-5: Compressive Strength (MPa) Values of all Mixes at Different Curing Ages

MIX	Mix Description	Compressive Strength (MPa)				
		7-Day	14-Day	28-Day	56-Day	90-Day
M1	0%RA+100%NA	31.1	32	34.6	37.6	40.5
M2	10%RA+90%NA	30	31.6	34.4	37.5	40
M3	20%RA+80%NA	29.3	30.7	34	37	39.7
M4	30%RA+70%NA	30.8	31.8	34.2	36.9	39.3
M5	40%RA+60%NA	26.3	28.7	31.3	33.2	36.8
M6	50%RA+50%NA	25.9	29.8	31.8	32.6	35.7

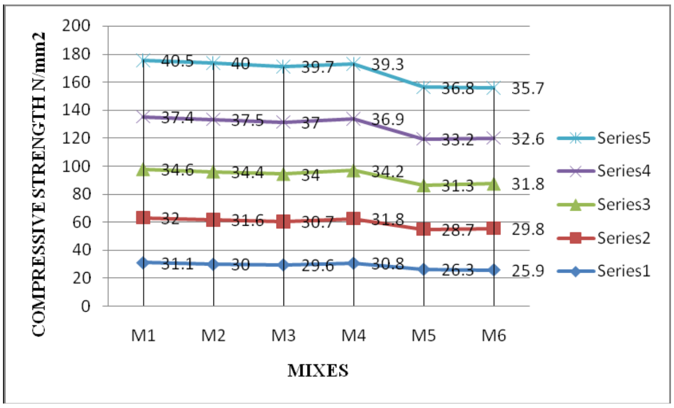

Fig-3: Split Tensile Strength at 28 days

From the above test results and the graphical changes shown in Table 4.4 and Figure 4.2, it was observed that the split tensile strength results for M2, M3 and M4 were comparable to mixture M1. This shows that the split tensile strength results of recycled aggregate concrete with 30% replacement of natural aggregate with recycled aggregate show the same value compared to normal aggregate concrete or conventional concrete. After 30% exchange i. H. With 40% and 50% substitution of NA for RA, there is an irregular behavior in the values of the cleavage tensile strength. The percent strength loss from the 0% RA blend to the 30% RA blend was 5.01%. From the above test results and the changes in the graphs shown in Table 4.4 and Figure 4.2, it was observed that the cleavage tensile strength results of M2, M3 and M4 were comparable to blend M1. This shows that the split tensile strength results of recycled aggregate concrete with 30% replacement of natural aggregate with recycled aggregate show the same value compared to normal aggregate concrete or conventional concrete. After 30% exchange, i.e.

5. CONCLUSIONS

- The greater water absorption capacity of recycled aggregate has a large effect on the water added to the mix, which can affect the workability of the concrete.
- Up to 30% same compressive and tensile strength as conventional concrete can be achieved replacing natural aggregate with recycled aggregate. But according to the overall study, the values of compressive strength and fractional tensile strength decrease with increasing substitution of recycled aggregate
- Increasing the recycled aggregate content beyond 30% has an effect negatively on the compressive strength of recycled aggregate concrete. The reduction in compressive strength after 28 days is about 10% when using 50% recycled aggregate.

- Separation tensile results also show a tendency to decrease compressive strength beyond 30% replacing recycled aggregate.

- The pore filling capacity of silica fume improves the mechanical properties and durability of recycled aggregate concrete. The use of silica fume to partially replace cement reduces the water absorption capacity of recycled aggregate concrete.

6. REFERENCES

[1] AASHTO M 307 ASTM C 1240. “Standard Specification for Silica Fume Used in Cementitious Mixtures”, American Society for Testing and Materials, Annual Book of ASTM Standards, Volume04.02, West Conshohocken, Pennsylviania.

[2] Ajdukiewicz, A., and Kliszczewicz, A. (2002). Influence of recycled aggregates on mechanical properties of HS /HPC, 24, 269–279.

[3] Asamoah, M., and Afrifa, R. O. (2010). A study of concrete properties using phyllite as coarse aggregates. Materials and Design, 31(9), 4561–4566.

[4] ASTM standards C 1585-04 "Standard test method for measurement of the rate of adsorption of water by hydraulic cement concrete", American Society for Testing and Materials, Annual Book of ASTM Standards, Volume04.02, West Conshohocken, Pennsylviania.

[5] British Standard, BS 1881-208:1996 “Recommendations for the determination of the initial surface absorption of concrete”, BSI 389 Chiswick High Road London W4 4AL

[6] British Standard, BS 812 series, “Describes methods for determining the flakiness index of coarse aggregate”, BSI 389 Chiswick High Road London W4 4AL