iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IX **Month of publication:** September 2018

DOI:

Performance of Recycled Aggregate in Concrete with Microsilica

Akhil S Kumar[1], Tincy Anna Yohannan[2]
[1]PG Scholar, [2]Asst.Professor, Department of Civil Engineering, Sri Vellappally Natesan College of Engineering

***Abstract:** Demand for infrastructure due to the continuous population growth, and increased urbanization, have led to greater consumption of concrete. Addition or replacement of some of the materials may change the properties of the concrete.. Utilization of recycled aggregate in concrete has been employed due to awareness of society in natural resources protection by efficient disposal of demolished wastes. However the concrete using recycled aggregate has obtained lower performance when compared to concrete using natural aggregate. In this research, microsilica has been used for improving the performance of recycled aggregate concrete. Concrete specimens containing various percentages of recycled aggregate (0%, 25%, 50% and 75%) and (0%, 6%, 8%, 10% and 12%) has been prepared. Various tests were done on fresh concrete and compressive strength test, split tensile strength test, flexural strength test on cured hardened concrete. From the work it was found that after 28 days, the mix exhibited more compressive strength, split tensile strength and flexural strength than normal aggregate concrete. Compressive strength of mix containing 25% recycled aggregate and 8% microsilica were increased by 7.25%, split tensile strength increased by 16.04%, flexural strength increased by 9.09%. More properties were analysed by conducting durability tests. Load deflection test on 28 days cured beam specimen with optimum mix exhibited better performance. The optimum mix showed 9.14% higher strength than ordinary concrete..*

***Keywords:** Recycle aggregate, Microsilica, Compressive strength test, Split tensile strength test, Flexural strength test, Load deflection test*

I. INTRODUCTION

Concrete is the premier construction material across the world and the most widely used in all types of civil engineering works, including infrastructure, low and high-rise buildings, defence installations, environment protection and local or domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixtures. Among these, aggregates are inert granular materials such as sand; crushed stone forms the major part. Traditionally aggregates have been readily available at economic price. However, in recent years the extraction and use of aggregates from natural resources has been questioned. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection, the availability of natural resources to future generations has also been realized. The recycling of waste concrete is seen as one of the best ways to combat the rapid increase in the generation of construction and demolition waste concrete. Waste concrete is crushed and processed into aggregates that are then used as a constituent of coarse aggregates in newly cast concrete. This is referred to as recycled aggregate concrete (RAC). The process of recycling waste concrete is relatively simple, and it includes breaking, removing, and crushing of concrete. There are a variety of benefits in recycling waste concrete rather than treating it as ordinary rubbish. For instance, reusing crushed waste concrete as aggregate in concrete can reduce the landfill space and the need of gravel mining as well as the pollution involved in burying or transporting them. In addition, in many places where the quality aggregates are in a short supply, using RAC in construction is viable and economic.

Works have shown that aggregates from different sources, exhibit different engineering properties. Aggregates are the key ingredients in concrete making up 70-80 % of volume in concrete and dictating the strength and density relationship. Hence using recycled concrete as aggregate will require checking the quality of the aggregates, since they are collected from different sources, grades of concrete and age. Works on recycled concrete have emphasized that the basic material properties, such as shape, texture, specific gravity, absorption, moisture content, permeability, strength 3 characteristics, deleterious substance, resistance to freeze–thaw, etc., need to be thoroughly evaluated before it is used to produce concrete. Technology of RAC production is different from the production procedure for concrete with natural aggregate. Because of the attached mortar, recycled aggregate has significantly higher water absorption than natural aggregate. Therefore, to obtain the desired workability of RAC it is necessary to add a certain amount of water to saturate recycled aggregate before or during mixing, if no water-reducing admixture is applied. One option is to first saturate recycled aggregate to the condition of water saturated surface dry, and the other is to use dried recycled aggregate and to add the additional water quantity during mixing.

Microsilica, also known as Silica fume is fine amorphous silica. Microsilica is a filter powder generated from the reduction of high purity quartz – ferrosilicon metals or silicon metals. Microsilica consists primarily of very fine smooth spherical silicon oxide particles with an extremely high surface area. Microsilica improves concrete through two mechanisms by pozzolanic effect and filler effect. Pozzolanic effect is that when water is added to OPC, hydration occurs resulting in the formation of calcium silicate hydrate (CSH) and calcium hydroxide. In the presence of microsilica, the silicon dioxide from the microsilica will react with the calcium hydroxide to produce more aggregate binding CSH thereby increasing the binding property.

Microsilica is an extremely fine material, with an average diameter 100 times finer than cement. At a typical dosage of 8% by weight of cement, approximately 100,000 particles for each grain of cement will fill the water spaces in fresh concrete. This eliminates bleed and the weak transition zone between aggregate and paste found in normal concrete. This micro filler effect will greatly reduced permeability and improves the paste-to-aggregate bond of silica fume concrete compared to conventional concrete.

Due to its very fine nature and thus greater surface area, microsilica will increase the water demand. The use of a super plasticizer to compensate for the higher water demand is universally recommended. Super plasticizers have a greater effect in microsilica concrete than in normal concretes because of the larger total surface area. It is possible now to dose high dosage of super plasticizers for very low water cement ratios concrete without bleeding and segregation problems encountered with normal OPC concrete. It enables us to produce very flow able concrete without segregation and very high strength concrete.

II. NEED FOR THE STUDY

The increasing demand for infrastructure due to the continuous population growth, and the high rate of urbanisation, has led to increased consumption of concrete. The continuous use of natural aggregates in conventional concrete has serious environmental and economic consequences as it can lead to the depletion of natural resources (aggregate), increasing disposal problems and significant energy consumption in quarrying activities. The partial or full substitution of natural aggregate by recycled coarse aggregate retrieved from demolition debris is a favourable alternative to mitigate the environmental and economic effects of using natural aggregates. This project aims in effective utilization of recycled aggregates by percentages and the mechanical properties of concrete are improved by microsilica

III. SCOPE AND OBJECTIVES

The project aims at conducting feasibility study of producing recycled aggregate concrete (RCA) with microsilica.
The specific objectives of the present work are,

A. To find out the mechanical properties of recycled aggregate incorporated with microsilica.
B. To estimate the durability of the microsilica incorporated recycled aggregate concrete.
C. To study the flexural behaviour of recycled aggregate beam with microsilica.

IV. METHODOLOGY

The experimental study consists of testing the mechanical and durability properties of recycled aggregate concrete containing the various materials selected for the study. The additional materials used were microsilica and recycled aggregate in beam specimens. Steps involved are,

A. Material Testing
B. Mix Design
C. Casting of specimens with different percentages of microsilica (6%, 8%, 10% and 12%) and recycled aggregate (0%, 25%, 50% and 75%)
1) Slump Test
2) Compacting Factor Test

D. Curing
1) Compressive Strength Test
2) Split Tensile Strength Test
3) Flexural Strength Test

E. Casting of beam specimens with optimum percentage of recycled aggregate and microsilica

F. Curing and Testing of beam specimens

1) Load Deflection Test

G. Durability Test

1) Carbonation Test

2) Sulphate resistant Test

3) Bulk Diffusion Test

H. Comparison of Results

Table 1 Mix design

Material	Quantity (kg/m^3)	Mix Proportion
Cement	425.733	1
Fine Aggregate	645.5	1.52
Coarse Aggregate	1158.28	2.72
Super Plasticizer	1.09	1.09
Water Cement Ratio	0.45	0.45

The mix proportion for the M30 grade of concrete was arrived through a number of trial mixes. The mix was designed in accordance with IS 10262-2009. The mix proportion for M30 grade of concrete is shown in Table 1.

Table 2 Mix designation

Mixes	Microsilica (%)	Recycled aggregate (%)
RCA0MS0	0	0
RCA0MS6	6	0
RCA0MS8	8	0
RCA0MS10	10	0
RCA0MS12	12	0
RCA25MS6	6	25
RCA25MS8	8	25
RCA25MS10	10	25
RCA25MS12	12	25
RCA50MS6	6	50
RCA50MS8	8	50
RCA50MS10	10	50
RCA50MS12	12	50
RCA75MS6	6	75
RCA75MS8	8	75
RCA75MS10	10	75
RCA75MS12	12	75

RCA0MS0 is our control mix which has 0% recycled aggregate and 0% microsilica. On considering mix RCA0MS6, 6% of microsilica is added to 0% recycled aggregate. While considering RCA25MS6 denotes that the mix contains 25% recycled

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

aggregate and 6% microsilica in it similarly in other mixes. Total 17 different mixes were used in the study to find out which mix shows better performance in recycled aggregate concrete with microsilica.

V. RESULTS AND DISCUSSION

The results obtained from the experimental investigations are discussed below. Initially the workability properties such as slump value and compaction factor are discussed. Then the results from mechanical strength tests such as compressive strength, split tensile strength, flexural strength of 7th day and 28th day cured normal concrete are also discussed.

A. *Compressive Strength*

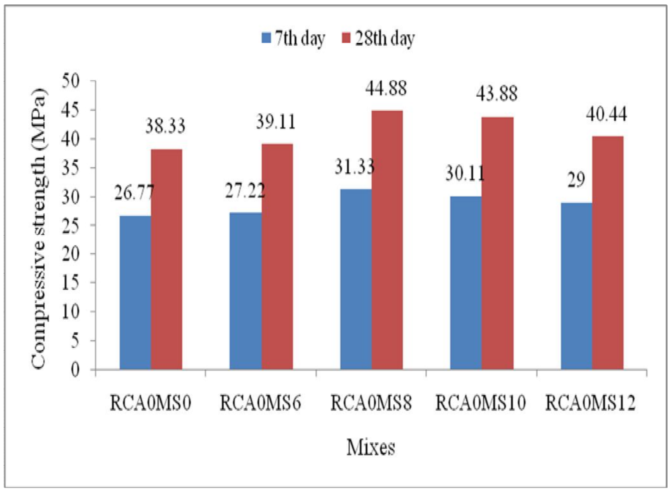


Fig. 1 Compressive strength of normal aggregate concrete mixes

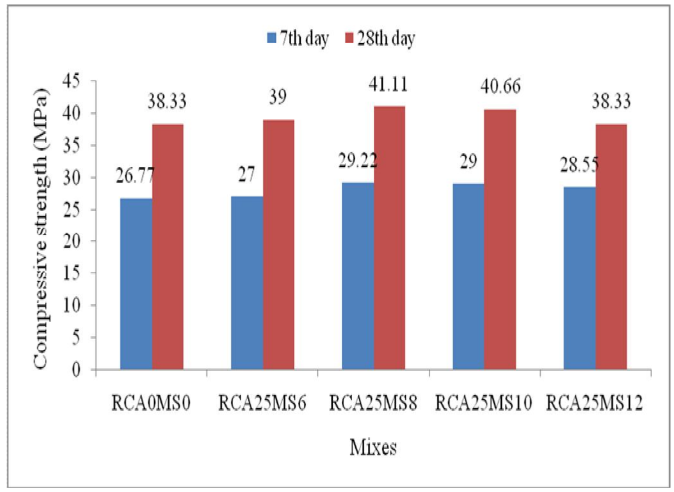


Fig. 2 Comparison of compressive strength of normal aggregate concrete and 25% recycled aggregate mixes with varying percentages of microsilica

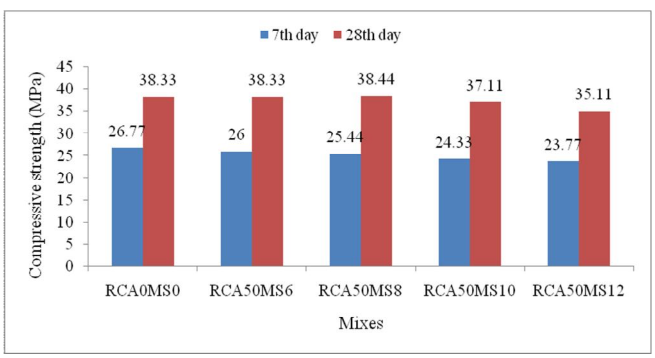


Fig. 3 Comparison of compressive strength of normal aggregate concrete and 50% recycled aggregate mixes with varying percentages of microsilica

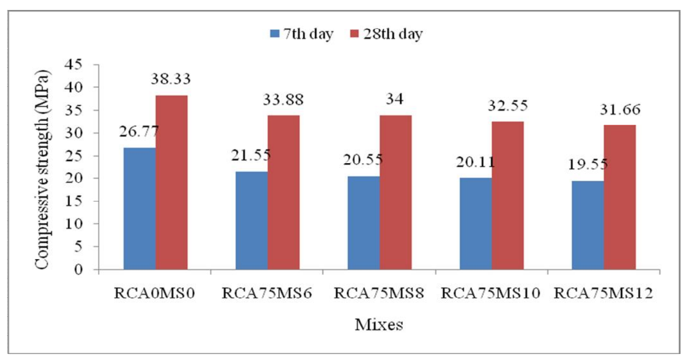


Fig. 4 Comparison of compressive strength of normal aggregate concrete and 75% recycled aggregate mixes with varying percentages of microsilica

Fig. 1 shows the optimum of microsilica in normal aggregate concrete mixes. It is obtained that 8% microsilica as optimum.
Fig. 2 shows the mixes with 25% recycled aggregate with 6%, 8%, 10% and 12% of microsilica. Fig. 3 shows the mixes with 50% recycled aggregate with 6%, 8%, 10% and 12% of microsilica and Fig. 4 shows the mixes with 50% recycled aggregate with 6%, 8%, 10% and 12% of microsilica. From all the mixes the optimum of microsilica obtained is 8% indicated that microsilica is independent of aggregate used. From compressive strength test recycled aggregate concrete mix with 25% RCA with 8% showed greater strength than characteristic mean strength fck' hence it is taken as optimum mix.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

B. Split Tensile Strength

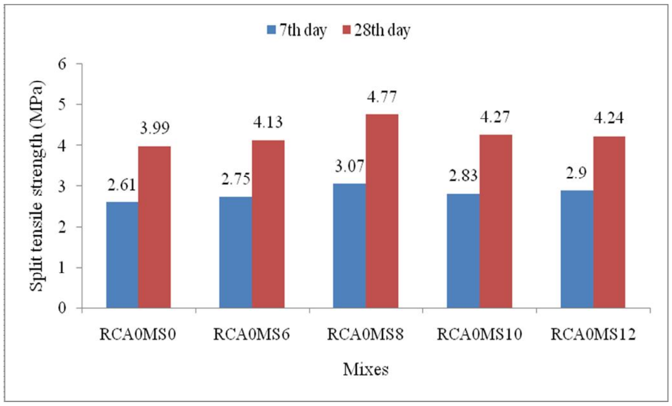


Fig. 5 Split tensile strength of normal aggregate concrete mixes

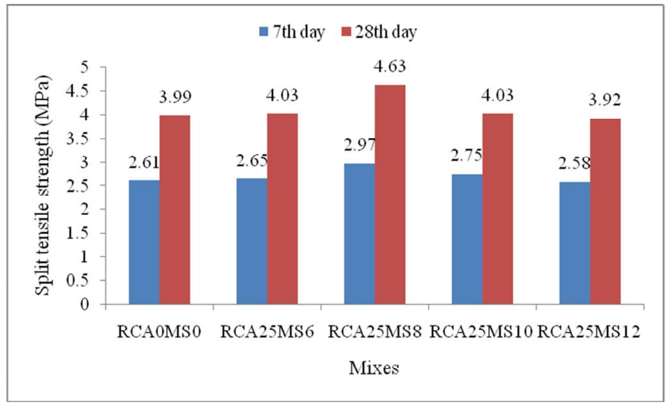


Fig. 6 Comparison of split tensile strength of normal aggregate concrete and 25% recycled aggregate mixes with varying percentages of microsilica

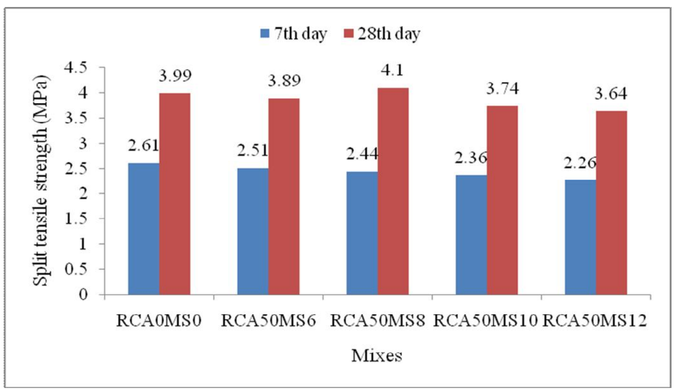


Fig. 7 Comparison of split tensile strength of normal aggregate concrete and 50% recycled aggregate mixes with varying percentages of microsilica

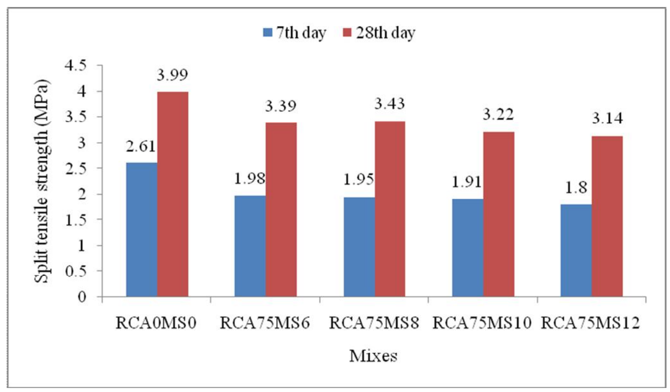


Fig. 8 Comparison of split tensile strength of normal aggregate concrete and 75% recycled aggregate mixes with varying percentages of microsilica

C. Flexural Strength Test

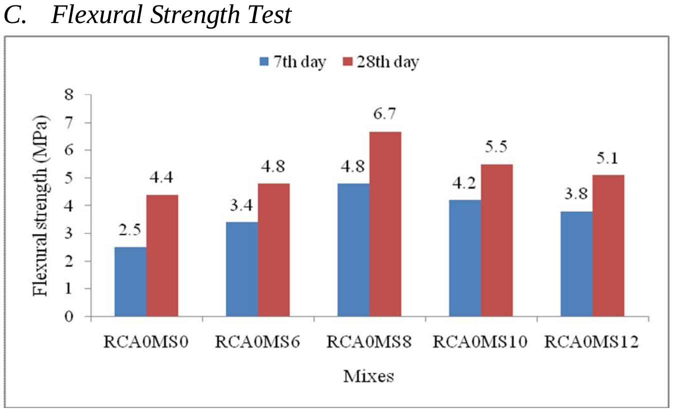


Fig. 9 Comparison of flexural strength of normal aggregate concrete mixes

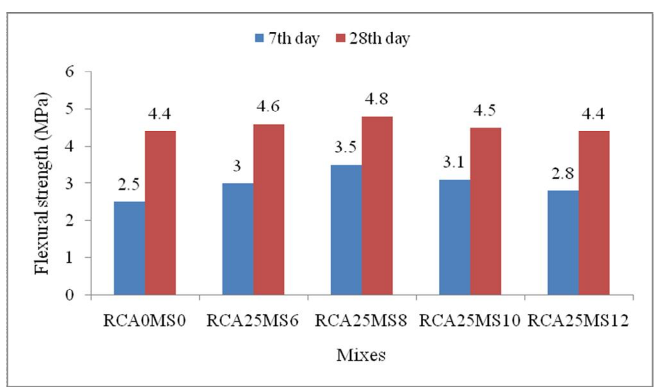


Fig. 10 Comparison of split tensile strength of normal aggregate concrete and 25% recycled aggregate mixes with varying percentages of microsilica

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

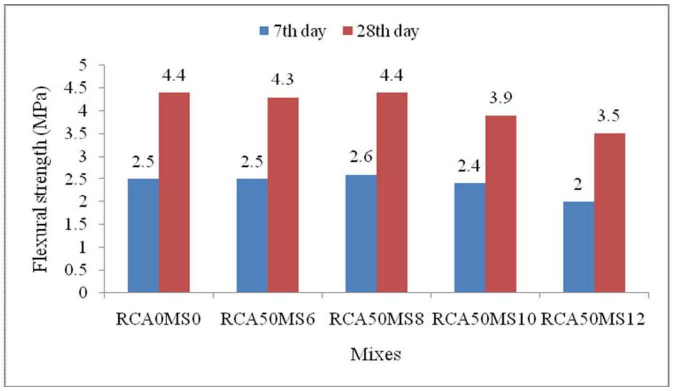


Fig. 11 Comparison of split tensile strength of normal aggregate concrete and 50% recycled aggregate mixes with varying percentages of microsilica

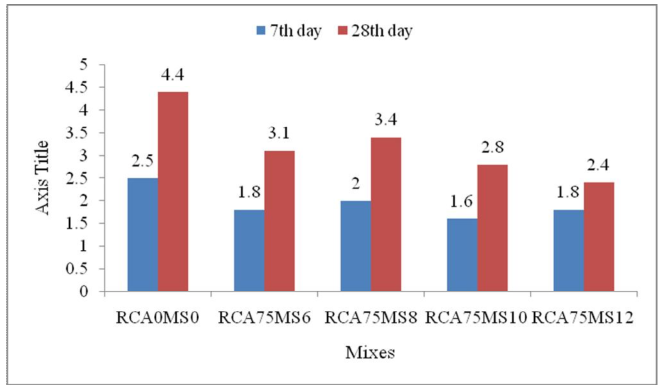


Fig. 12 Comparison of split tensile strength of normal aggregate concrete and 75% recycled aggregate mixes with varying percentages of microsilica

D. *Durability Test*

1) *Carbonation Test*

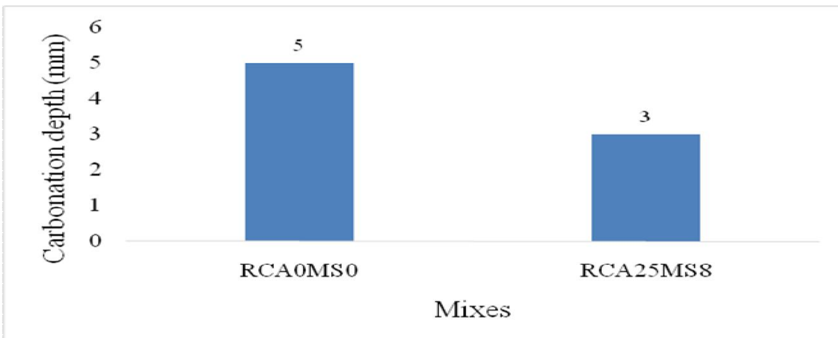


Fig. 13 Variation of carbonation depth after 56 days

From Fig. 13, it is observed that the carbonation effect gets reduced in the mix with optimum percentage of microsilica in 25% recycled aggregate concrete than the control mix. It is because of the pore filling capability of microsilica.

2) *Sulphate Resistance Test*

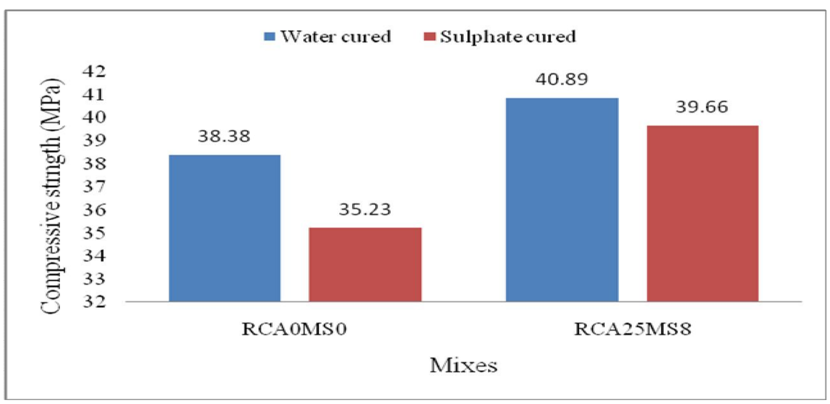


Fig. 14 Strength variation of mixes after 56 days

Fig. 14 shows the percentage loss of strength after 56 days of each specimen was compared. The strength loss were found to be less than that of control mix for specimen containing 25% recycled aggregate with 8% microsilica.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

3) Bulk Diffusion Test

Table 3 Depth of penetration and diffusion coefficient for mixes

Mix	Depth of penetration (mm)	Diffusion coefficient (10^{-12}) m^2/s
RCA0MS0	18	4.18
RCA25MS8	10	1.29

Based on the result shown in Table 3, it was analyzed that both the mixes are in the range of average permeability based on concrete society recommendations, that is in the range of (1 to 5) x 10^{-12} m^2/s. but on comparing mix with 25% recycled with 8% microsilica showed less permeability than control mix.

4) Load deflection characteristics: The beam specimens of 1500 x 200 x 300 mm were subjected for load deflection testing. 28 days cured specimen was given load to study its behaviour. The ultimate load and deflection of control beams and microsilica admixed recycled aggregate beams were shown in Table 4 and results obtained from load deflection test were shown in Table 5.

Table 4 Ultimate load and deflection of control and optimum specimen

Specimen	Ultimate load (kN)	Maximum deflection (mm)
Control beam (RCA0MS0)	212.1	12.28
Final mix (RCA25MS8)	231.5	13.37

Table 5 Deflection of comparison

Load (kN)	Deflection (mm)	
	RCA0MS0	RCA25MS8
0	0	0
25	0.99	1
50	1.62	1.4
75	2.53	2.1
100	3.34	2.93
125	4.3	3.86
150	5.1	4.62
175	6.18	5.79
200	8.64	7.79
225		10.23

The ultimate load obtained for the concrete containing 25% recycled aggregate and 8% microsilica (RCA25MS8) shows 9.14% higher strength than ordinary concrete mix (RCA0MS0). Ordinary recycled aggregate concrete performs lower strength than normal mix, this enhance in strength is due to the pozzolanic activity of optimum percentage of microsilica in recycled aggregate concrete. Fig. 15 shows the load deflection curve.

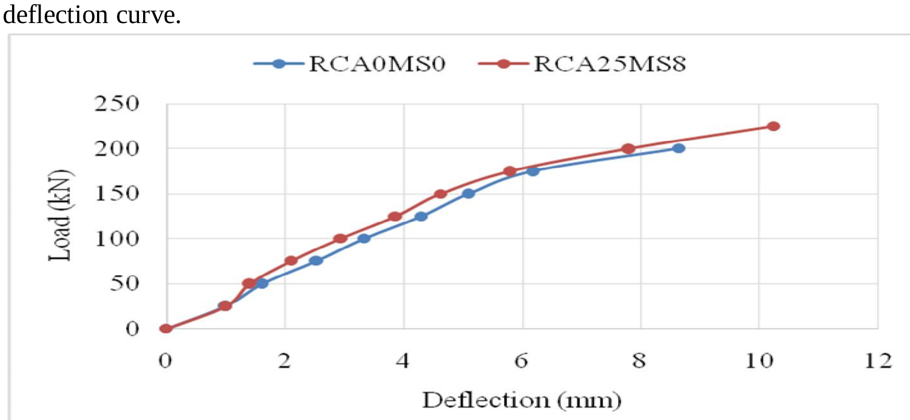


Fig. 15 Load deflection curve

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IX, Sep 2018- Available at www.ijraset.com

5) *Crack pattern:* For crack pattern study the specimen of RCA25MS8 mix were compared with RCA0MS0 mix specimens. The crack developed on specimens after two point loading is described in this section. In all specimens the first crack developed is due to the flexural failure and the complete failure of specimen is due to shear. Fig. 16 shows the cracks developed in the control specimen. The crack developed in the middle of the beam is due to flexure. These are the first cracks developed. By the increase of load the shear crack at the support will be produced and get widens. The failure of control beam occurred at lower loads and greater cracks were developed.

Fig. 16 Development of cracks in control specimen

The cracks developed in RCA25MS8 specimen were also by flexure and shear failure. There were only small flexural cracks as compared with control specimen. The width of the flexural cracks was less than control specimen. Deflection of RCA25MS8 was also found to be lesser when compared with control specimen under same loads. Even though recycled aggregate reduces the mechanical performance of specimen, microsilica under optimum percentage can enhance up to a certain limit. At the ultimate load shear failure and shear cracks are developed. The ultimate load carrying capacity of RCA25MS8 was higher than control specimen. Fig. 17 shows the cracks developed in RCA25MS8 specimen.

Fig. 17 Development of cracks in RCA25MS8 specimen

VI. CONCLUSION

Experimental investigations were carried out to study the properties of admixed recycled aggregate with microsilica, properties includes compressive strength, flexural strength, split tensile strength and durability properties such as carbonation, bulk diffusion and sulphate resistance were studied. Strength enhanced optimum mix were subjected to load deflection test. Based on the observations the following conclusions can be arrived.

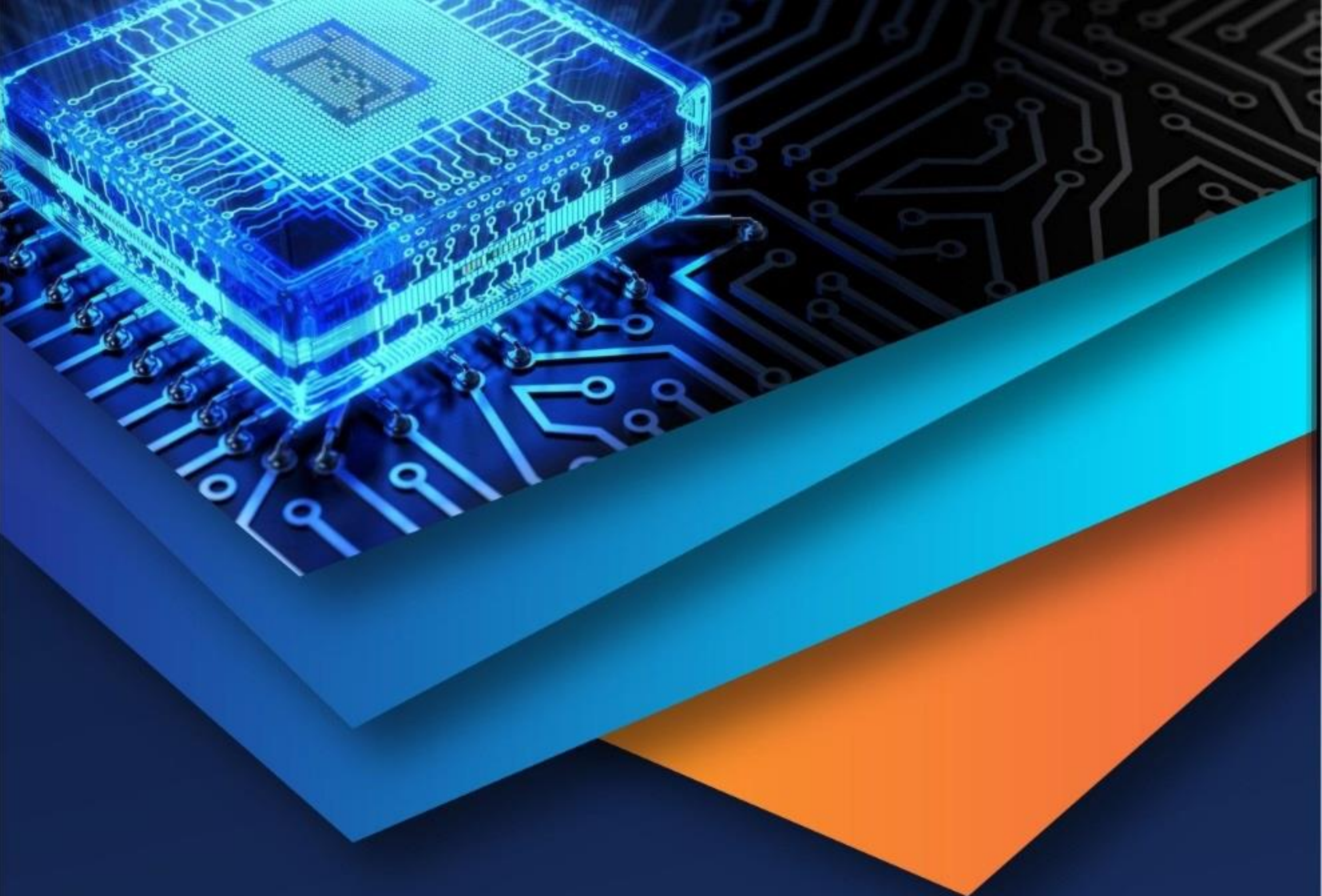
A. Microsilica contributes strength to both conventional and recycled concrete. But In recycled aggregate admixed with microsilica, recycled aggregate reduces the strength when compared with microsilica admixed normal aggregate mix.
B. 25% recycled aggregate admixed with 8% microsilica showed greater strength than mixes containing 50% and 75% recycled aggregate admixed with microsilica. 50% recycled aggregate with 8% microsilica has slight comparable strength with normal aggregate concrete.
C. Increase in microsilica and recycled aggregate reduces the workability of concrete, compressive strength increased by 7.25%, split tensile strength increased by 16.04%, flexural strength increased by 9.09%.
D. By the durability tests such as bulk diffusion, carbonation and sulphate resistance test, mix containing 25% RCA with 8% showed good characteristics.
E. By the load deflection test, the ultimate load carrying capacities of RCA25MS8 specimens were found to be 9.14% higher strength than ordinary concrete mix.

VII. SCOPE FOR FUTURE WORK

A. The present study was based on M30 grade. The work can be extended by considering other grades of concrete.
B. Work can be done using other cement replacing materials such as metakaolin, GGBS, fly ash etc.
C. Studies can be planned for concrete reinforced with different fibres.

REFERENCES

[1] Ahmed S F U, “Properties of Concrete Containing Construction and Demolition Wastes and Fly Ash”, Journal of Materials in Civil Engineering, Vol. 25, 2013.
[2] Ajibola I T, Jian Y and Samir D, “Enhancing the Performance of Recycled Aggregate Concrete with Microsilica”, International Journal of Structural and Civil Engineering Research, Vol. 4, 2015.
[3] Akshaykumar H, Brijesh R, Kaushal K and Jatinkumar B P, “Use of Micro Silica in Concrete”, International Journal for Innovative Research in Science & Technology, Vol. 2, 2016.
[4] Alok K, Monendra S, Dheeraj K S, Krishan J and Dinesh, “Addition of silica fume and fly ash to enhance the compressive and flexural strength of concrete”, SSRG International Journal of Civil Engineering, Vol. 3, 2016.
[5] Amudhavalli N K and Jeena M, “Effect Of Silica Fume On Strength And Durability Parameters Of Concrete”, International Journal of Engineering Sciences & Emerging Technologies, Vol. 3, 2012.
[6] Giner V T, Ivorra S , Baeza F J, Zornoza E and Ferrer B, “Silica fume admixture effect on the dynamic properties of concrete”, Construction and Building Materials, Vol. 25, 2011.
[7] Hanumesh B M, Varun B K and Harish B A, “The Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement”, International Journal of Emerging Technology and Advanced Engineering, Vol. 5, 2015.
[8] Mudasir H P and Renuka P D, “High Density Concrete Using Fly Ash, Micro Silica and Recycled Aggregate – An Experimental Study”, International Journal of Engineering Trends and Technology, Vol. 10, 2014.
[9] Revathi P, Ramesh R A and Lavanya K, “Influence of Treatment Methods on the Strength and Performance Characteristics of Recycled Aggregate Concrete”, Journal of Materials in Civil Engineering, Vol. 27, 2015.
[10] Sabale V, Borgave M and Shinde S, “Study the Effect of Addition of Silica Fume on Properties of High Strength Concrete”, International Journal of Engineering Research & Technology, Vol. 3, 2014.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY