Experimental Investigation of Recycled Coarse Aggregate in Concrete with Mineral Admixtures

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Abstract

Concrete is a composite material composed of aggregates bounded together with a fluid cement which hardens over time. Concrete is the most common and useful material in the construction industry and its demand get increasing day to day. Coarse aggregate is a compressive member plays an important roll in concrete. Extraction of natural coarse aggregate to produce concrete has considerable environmental consequences. So in order to reduce the usage of natural coarse aggregate recycled aggregate can be used as the replacement material, which is generally collected from demolished buildings, roads, bridges etc. To enhance the strength of recycled aggregate concrete two different admixtures are added along with the concrete Silica Fume, Fly Ash by using this admixtures we can reduce the percentage of usage of cement in concrete. So that emission of CO2 gas during production of cement get reduces. The aim of the project is to increase the strength of concrete by adding more percentage of recycled coarse aggregate by replacing natural coarse aggregate.

Key Words: NCA, RCA, Silica fume, Fly ash

1. Introduction

All countries are focusing on sustainable technology that can be adopted for the use of concrete in a better way. So it is felt that the use of cementitious materials improve packing density of concrete which can be a solution to many problems. The cementitious materials including recycled coarse aggregates are mixed in different proportions 25%, 50%, 75% and the mixed concrete is casted into cubes of size 150x150x150mm, cylinders of size 150x300mm and prisms of size 100x100x500mm. These specimens are casted and tested for 14 and 28 days of curing.

1.1 Advantages of using recycled coarse aggregate with admixtures

Using recycled concrete aggregate reduces the impact on landfills, decreases energy consumption & cost saving. Using recycled aggregate material as gravel reduces the need for gravel mining. Silica Fume increases the strength and durability of concrete. Silica fume improves resistance to corrosion and protect the structure from aggressive salt.Fly ash improves workability. Fly ash prevents the concrete from acids and alkali silica reaction.Dry shrinkage of high volume fly ash concrete is generally less than conventional concrete.

1.2 Objectives of the Project

To study the recycled coarse aggregate concrete and its effect as waste minimize in construction. To reduce the quantity of cement in manufacture of concrete.To determine the strength characteristics of concrete by adding recycled coarse aggregate (25%,50%,75%) along with silica fume(5%) and fly ash(30%).To carry out different testes on recycled aggregate concrete and natural aggregate concrete and compare their results. To reduce the impact of waste materials on environment. To reduce the cost of concrete.

2. Methodology

Literature review, Collection of materials, Testing of materials, Concrete mix design, Testing on fresh concrete, Casting of specimens, curing of specimens, Testing on hardened concrete, Conclusion, References.

2.1Collection of Materials

Fine Aggregate, Coarse Aggregate (20mm), Water, Cement (OPC 53 grade), Silica fume, Fly ash, Recycled coarse aggregate (20mm), Super Plastizer.

Fig 1 Collection of Materials

2.1.1 Recycled Coarse Aggregate

In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement material. These recycled coarse aggregate is generally collected from demolished buildings, roads, bridges etc. Recycled aggregate is comprised of crushed, graded inorganic particles processed from the materials that have been used in the construction &demolition debris.

Fig 2 Recycled Coarse Aggregate

2.1.2Silica Fume or Micro Silica

Silica fume is a byproduct of producing silicon metal or Ferro Silicon alloys. One of the most beneficial use of silica fume is in concrete because of its chemical and physical properties. Silica fume is 100 to 150 times smaller than a cement particle it can fill voids created by free water in the matrix. Silica fume is added to fresh concrete it chemically react with calcium hydrates (CH) to produce additional calcium silicate hydrates (CSH).

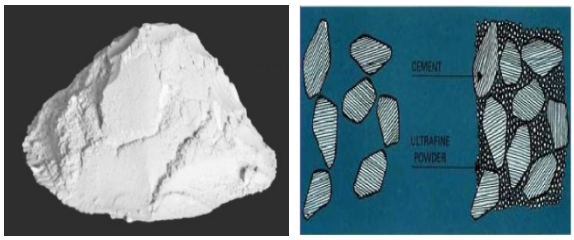


Fig 3 Silica Fume

2.1.3 Fly ash

The ash produced at thermal power stations by burning of coal and lignite is known as fly ash. Fly ash is a pozzolonic material which behaves like cement in presence of lime/cement and water. It improves workability.Prevent the concrete from acids and alkali silica reaction.Resistance to freezing & thawing.

Fig 4 Fly Ash

3. Testing of Materials

Table 1 Material testing values

Coarse Aggregate		Recycled Coarse Aggregate	
properties	**Values**	**Properties**	**Values**
Specific Gravity	2.6	Specific Gravity	2.7
Fineness Modulus	5.6	Fineness Modulus	6.2
Water Absorption	0.5%	Water Absorption	1.2%

Fine Aggregate		Cement, Silica Fume, Fly Ash	
properties	**Values**	**Properties**	**Values**
Specific Gravity	2.7	Specific Gravity(C)	3.15
Fineness Modulus	3.62	Specific Gravity(SF)	2.2
Water Absorption	1.2%	Specific Gravity(FA)	2.5

4. Concrete mix design

Type of cement - OPC 53 grade

Water cement ratio - 0.45

Weight of cement – 438kg/m³

Weight of fine aggregate –717.12kg/m³

Weight of coarse aggregate – 1035.88kg/m³

Table 2 Mix Proportion

Cement	Fine aggregate	Coarse aggregate	Water
438	717.12	1035.8	197
1	1.6	2.3	0.44

4.1Description of Mix Proportion

Table 3 Description of Mix Proportion

Design ID	Material	Proportion (%)
M1	Conventional Concrete	-
M2	RCA	25
	Silica Fume	5
	Fly Ash	30
	Super plastizer	1
M3	RCA	50
	Silica Fume	5
	Fly Ash	30
	Super plastizer	1
M4	RCA	75
	Silica Fume	5
	Fly Ash	30
	Super plastizer	1

5. Testing on Fresh Concrete

5.1Slump Cone Test

Fig 5 Slump Cone Test

The slump value of the concrete is 80mm

5.2Flow Table Test

Fig 6 Flow Table Test

The flow % of the concrete is 58%

6. Casting of Specimens

The concrete after workability was used for casting the casting of concrete is by using steel moulds. Cube, Cylinder, Prism moulds are used for casting concrete. Cube moulds of size 150x150x150mm. Cylinder moulds of size 150x300mm. Prism moulds

100x100x500mm were used. The concrete was filled in three layers. Each layer was compacted with standard tamping rod.

Fig 7 Casting of Specimens

7. Curing Of Specimens

After 24 hrs the specimens are immersed in to water for initial curing. The specimens are removed from the mould after 24 hrs and cured in water for 14& 28 days.

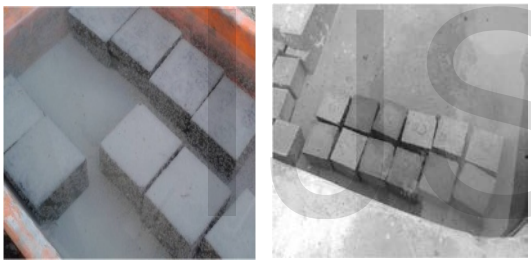


Fig 8 Curing Of Specimens

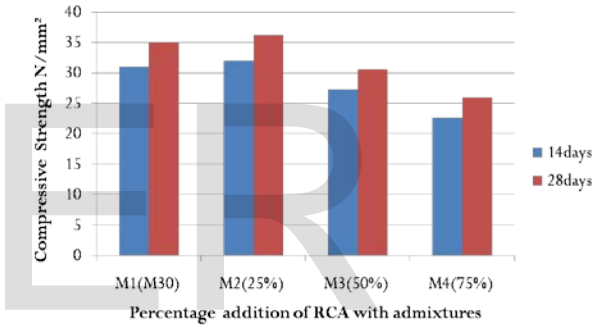
8. Testing of Hardened Concrete

8.1Compressive strength of cubes

Fig 9 Compression Test on Concrete Cubes(UTM)

Table 4 Compressive strength values

Types of mix	compressive strength in(N/mm²) 14days	compressive strength in(N/mm²) 28days
M1(M30)	31.02	35.07
M2(25%)	32.03	36.2
M3(50%)	27.34	29.62
M4(75%)	22.65	24



8.2 Split tensile strength

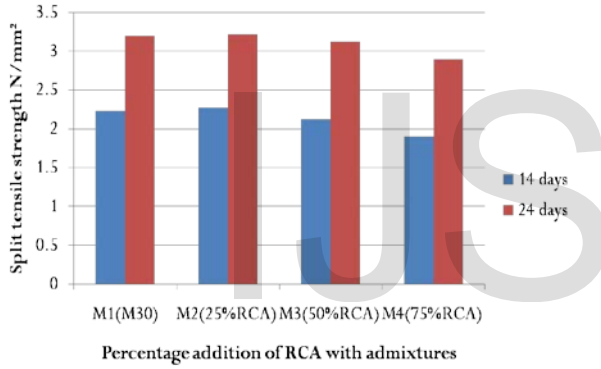
Fig 10 Split tensile Strength Test on Concrete Cylinders(UTM)

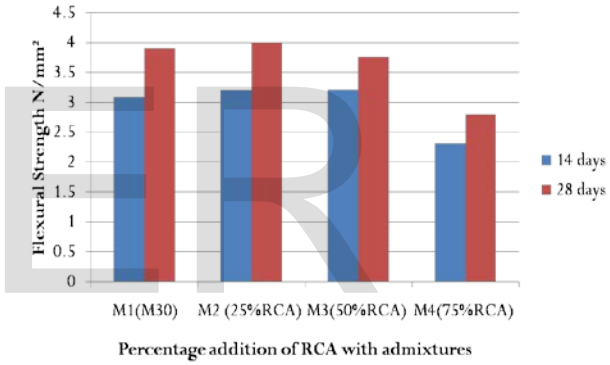
Table 5 Split tensile strength values

Types of mix	flexural strength in(N/mm²) 14days	flexural strength in(N/mm²) 28days
M1(M30)	3.08	3.90
M2(25%)	3.20	4
M3(50%)	3.21	3.76
M4(75%)	2.31	2.80

Table 6 Flexural strength values

Types of mix	split tensile strength in(N/mm²) 14days	split tensile strength in(N/mm²) 28days
M1(M30)	2.23	3.20
M2(25%)	2.27	3.22
M3(50%)	2.12	3.13
M4(75%)	1.9	2.9





8.3 Flexural strength of prism

Fig 11 Flexural Strength Test on Concrete Prism

9. Conclusion

The performance of concrete with different proportion of recycled aggregate was studied in depth. The compressive strength test, Split tensile strength test, Flexural strength test were carried out and following conclusion are drawn.

Using recycled aggregate up to 50% along with admixtures the strength (compressive strength, split tensile strength, flexural strength) get increases and the value is nearer to conventional concrete. Above 50% there is a reduction in the strength of concrete. The strength is more at 25% replacement. By using recycled coarse aggregate the cost of construction get reduced and by adding silica fume there is an increase in the fresh as well as hardened properties of concrete at the same time durability will get

increases, reinforcement corrosion is reduced. Fly ash also helps to reduce percentage of usage of cement and gives good workability during the production of recycled aggregate concrete.

References

[1] Mukesh Limbachiya, Mohammed Seddik Meddah, Youssef Ouchagour, "Use of recycled concrete aggregate in fly-ash concrete", Construction and Building Materials 27 (2012) 439–449

[2] S.C.Kou, C.S.Poon, "Enhancing the durability properties of concrete prepared with coarse recycled aggregate", Construction and Building Materials 35 (2012) 69–76

[3] O.Cakır, "Experimental analysis of properties of recycled coarse aggregate (RCA) concrete with mineral additives", Construction and Building Materials 68 (2014) 17–25

[4] Wai Hoe Kwan, Mahyuddin Ramli, Kenn Jhun Kam, Mohd Zailan Sulieman, "Influence of the amount of recycled coarse aggregate in concrete design and durability properties", Construction and Building Materials 26 (2012) 565–573

[5] Mohamed Heba.A, "Effect of fly ash and silica fume on compressive strength of self-compacting concrete under different curing conditions" Ain Shams Engineering Journal (2011) 2, 79–86

[6] Miren Etxeberria Shi-Cong Kou, Chi-Sun Poon, " Influence of recycled aggregates on long term mechanical properties and pore size distribution of concrete" Cement & Concrete Composites 33 (2011) 286–291

[7] M. Despotovic, Nenad S. Ristic Zoran Jure Grdic , Gordana A. Toplicic-Curcic,Iva, "Properties of self-compacting concrete prepared with coarse recycled concrete aggregate" Construction and Building

[8] Ebid, Samir H.Okba Ashraf M. Wagih, Hossam Z. El-Karmoty Magda, "Recycled construction and demolition concrete waste as aggregate for structural concrete" Housing and Building National Research Center(HBRC)Journal (2013)9,193-200

[9] Huai-shuai Shang,Tie-jun Zhao,Wei-qun Cao, "Bond behavior between steel bars and recycled aggregate concrete after freez-thaw cycles" Cold Regions Science and Technology 118 (2015) 38–44

[10] W.Y. Tam Duangthidar Kotrayothar, Jianzhuang Xiao Vivian, "Long-term deformation behavior of recycled aggregate concrete" Construction and Building Materials 100 (2015) 262–272

Books-Advanced concrete technology (MS Sheety)
Concrete Mix Design (M.C.Nataraja) – IS 10262-2009 (Concrete Mix Proportioning)