USE OF FLY ASH IN RECYCLED AGGREGATE CONCRETE

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ABSTRACT

Nowadays, environmentally friendly building is becoming a crucial issue in construction industry. The course towards sustainable concrete involves minimizing the environmental impact of concrete production and as well as reducing the global CO2 emissions. Globally, the concrete industry consumes large quantities of natural resources, which are becoming insufficient to meet the increasing demands. At the same time, large number of old buildings and other structures have reached the end of their service life and are being demolished, resulting in generation of demolished concrete. Some of this concrete waste is used as backfill material and much being sent to landfills. Recycling concrete by using it as replacement to new aggregate in concrete could reduce concrete waste and conserve natural resources of aggregate. In the last two decades, varieties of recycling methods for construction and demolition wastes have been explored and are in well-developed stages. Fly ash is known to be a good pozzolanic material and has been used to increase the ultimate compressive strength and workability of fresh concrete. The approach adopted here includes a 30% substitution of natural aggregates by recycled concrete aggregates as well as the use of (0%,5%,10%,15%) by mass of fly ash as a partial substitute of Portland cement. This paper discusses the strength characteristics of natural and recycled aggregate concrete using fly ash. The most important benefit is reduced permeability to water and aggressive chemicals. This increases strength and reduces permeability.

Keywords: Demolished concrete, recycled aggregate, Backfill material, Pozzolanic material

INTRODUCTION

The problems of low tensile strength and poor fracture toughness of cement-based material are serious short coming that not only leads to constraints in structural designs but also effect the long term durability of structures. Concrete is a construction material composed of cement as well as other cementations materials such as fly ash and slag cement, coarse aggregate such as gravel, limestone or granite and fine aggregate such as sand, water and admixtures. Concrete to withstand the action of water without serious deterioration makes it an ideal material for building structures to control, store and transport water. Inspite of all these it has some serious deficiencies which, but for its remarkable qualities of flexibility, resilience and ability to redistribute stress, would have prevented its use as a building material. Efforts to improve the properties of concrete are continuously being made for researchers which led to the development of fibre reinforced concrete, ferro-cement concrete.

The infrastructure needs of our country is increasing day by day and with concrete is a main constituent of construction material in a significant portion of this infra-structural system, it is necessary to enhance its characteristics by means of strength and durability. It is also reasonable to compensate concrete in the form of using waste materials and saves in cost by the use of admixtures such as fly ash, silica fume, etc., as partial replacement of cement.

LITERATURE REVIEW

Siasnndaram (1990) studied the selection of high- volume fly ash concretes in a preliminary investigation of class F fly ash at 58 percent replacement in total cementitious material. They do not perform as well as normal concrete mixes. It was mentioned that the high dosage of super plasticizer adds to the material's workability, but that it would likely slow the setting of certain concrete mixes, especially those with high cementitious material content.

Ravina et al. (1986) investigated ASTM Class F and Class C behaviour with 30 and 50 percent fly ash replacement. The results showed that the rate of volume of bleeding water was either higher or the same as in the original mixes without fly ash. The setting time was typically delayed due to the addition of cementitious material such as fly ash. Class F fly ash use resulted in an increase in the rate and the total amount of bleeding. However, the amount of setting time, an average of two hours, was longer with Class C fly ash than with Class F.

N. BOUZOUBAA, M.H. ZHANG, V.M. MALHOTRA Mechanical properties and durability of concrete made with high volume fly ash cement: This is a study on properties and durability of concrete made with fly ash. The results were compared with normal concrete which included the slump, air content, slump loss, stability of air content, bleeding and setting time; those of hardened concrete investigated included the compressive strength, flexure strength, young's modulus of elasticity, drying shrinkage, resistance to abrasion, chloride ion penetration, freezing and thawing cycle, and to deicing salt scaling. The results show that except for the resistance of the concrete deicing salt scaling, the mechanical properties and the durability of concrete made with fly ash were superior to the normal concrete prepared separately at the mixer.

JAYESHKUMAR PITRODA Harmonizing environment and ecological sustainability by utilization of Fly Ash in concrete: A huge quantity of fly ash is generated daily in 82 major thermal power stations of India. The safe disposal of this fly ash is the major environmental and socio-economic problem. Conventional method of Rigid Pavement construction requires various natural resources like metal stone, sand, murrum, cement, etc. and hence causes ecological degradation and imbalance. The cement is a costly ingredient in such construction. The use of fly ash in rigid pavement construction as cement replacement by 10-30% will save such resources and hence reduces the resultant concrete without any loss in strength. So, use of fly ash in concrete solves the disposal problem and automatically reduces the construction cost. If fly ash is utilized on large scale for rigid pavement construction, harmonized environment and sustainable ecology and economic development of the road infrastructure, can be possible.

METHODOLOGY:

FLY ASH

The two properties of fly ash that are of most concern are the carbon content and the fineness. Both of these properties will affect the air content and water demand of the concrete. The finer the material the higher the water demands due to the increase in surface area. The finer material requires more air-entraining agent to fix the mix with desired air content. The important thing to remember is uniformity. If fly ash is uniform in size, the mix design can be adjusted to give a good uniform mix.

RECYCLED CONCRETE COARSE AGGREGATES (RCA)

RCA used in this research project is crushed using hammer. A part of the building demolished in Khairtabad, Hyderabad and it is crushed using hammer and is sieved with 12.5 mm and 20 mm sieves. The aggregates retained on 12.5 mm sieve and passed through 20 mm sieve is selected and used in this project. The aggregates are surface dried.

3.1 MIX DESIGN OF M20 GRADE CONCRETE

1. Standard deviation taken as 5.0 for good degree of control for M20 grade concrete.

2. Target strength ft = *fck + (t*SD)*
= 20 + (1.65 * 5.0)
= 28.25 N/mm^2

Where t = 1.65 is standard value (tolerance factor) depending upon the accepted proportion of low results and number of tests.

3. From the graph of relation between free water cement ratio and concrete strength of IS 1062-1982, water cement ratio is 0.52

Table 1: Minimum requirement of cement and maximum w/c ratio for different grades of grades of concrete

S.No.	Exposure	Plain Concrete			Reinforced		
		Min. Cement content kg/m^3	Max. water Cement Ratio	Min. Grade.	Min. Cement content kg/m^3	Max. water Cement Ratio	Min. Grade.
1.	Mild	220	0.6		300	0.55	M20
2.	Moderate	240	0.6	M15	300	0.5	M25
3.	Severe	250	0.5	M20	320	0.45	M30
4.	Very Severe	260	0.45	M20	340	0.45	M35
5.	Extreme	280	0.40	M25	360	0.40	M40

APPROXIMATE SAND AND WATER CEMENT PER CUBIC METRE OF CONCRETE FOR GRADES UPTO M 53

Table 2: Water and Sand content approximation

Nominal Maximum Size of Aggregate (mm)	Water Content Per Cubic Meter of Concrete (kg)	Sand As Percent of Total Aggregate by Absolute Volume
10	208	40
20	186	35
40	165	30

From table, for 20mm nominal maximum size of coarse aggregate, sand confirming to zone-II water cement ratio 0.6 and compaction factor 0.8
Water content in cubic meter of concrete is 186 kg/m^3.
Sand is a percentage of total aggregate by absolute volume 35%

Table 3: Adjustments required

Change in condition	Water content	Sand in total aggregate
For increase in water cement ratio by (0.60-0.52) is 0.08	0	-1.5
For increase in compaction factor (0.9-0.8) is 0.1	+3	0
Sand confirming to zone 3	0	-1.5
Total	+3	-3.0

2. Required sand content as a percentage of total aggregate by absolute volume is

35 – 3.0 = 32.0%

3. Required water content

=186 + (186 * 3) / 100 = 191.58 liters.

4. Determination of cement content:

Water ratio is 0.52 and water content as 191.58 liters

Therefore cement = 191.58 / 0.52

= 368.4 kg.

5. Check for minimum cement content as per table: 1, IS 456-2000 for durability criteria. The minimum cement content for severe exposure is 250 kg/m3. Hence, the worked-out cement content satisfies the condition i.e., adopt 368.4 kg of cement content.

6. The entrapped air is 2% so; the absolute volume of concrete is 1 m^3

7. Determination of coarse and fine aggregate content

V = [W + C/Sc + 1/P *(fa/Sfa)] *(1/1000)

0.98 = [191.58 + 368.4/3.05 + (1/0.3)*(fa/2.59)]*(1/1000)

fa = 523.8kg

Similarly for coarse aggregate

V = [W + C/Sc + 1/(1-P) *(Ca /SCa)] *(1/1000)

0.98 = [191.58 + 368.4/3.05 + (1/1-0.3) *(Ca/2.59)] *(1/1000)

Ca = 1205.74kg

Proportion by Weight:

Water (Liters)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)
191.58	368.4	523.8	1205.74

Proportion by ratio:

Water (Liters)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)
0.52	1	1.42	3.27

RESULTS AND GRAPHS
M20 GRADE CONCRETE CUBES

Water cement ratio – 0.52

Mix ratio – 1:1.42:3.27

Aspect Ratio – 40

Cube size – 150 * 150 * 150 mm

4.1 WORKABILITY TESTS

COMPACTION FACTOR TEST

Table 4: Compaction factor values

% Of fly ash	W1=weight of partially compacted concrete (kg)	W2=weight of fully compacted concrete(kg)	Compaction factor
0	4.2	4.9	0.86
5	4.2	4.7	0.89
10	4.3	4.77	0.90
15	4.2	4.6	0.91

4.2 COMPRESSIVE STRENGTHS AT 7, 14, 28 DAYS

COMPRESSIVE STRENGTH AT 7 DAYS:

For Natural Aggregate Concrete

Table 5: Compressive strength at 7, 14, 28 days of natural aggregate concrete

No. of days	Cube	Compressive strength (Mpa)
7	Cube1	20.0
	Cube2	19.6
	Cube3	21.2
14	Cube1	24.9
	Cube2	24.6
	Cube3	25.2
28	Cube1	30.0
	Cube2	29.7
	Cube3	31.4

For 5% replacement of Fly ash and 30% replacement of Recycled coarse aggregate

Table 6: compressive strength at 7, 14, 28 days for 5% replacement of fly ash

No. of days	Cube	Compressive strength (Mpa)
7	Cube1	21.2
	Cube2	20.4
	Cube3	20.9
14	Cube1	26.7
	Cube2	25.8
	Cube3	25.9
28	Cube1	30.1
	Cube2	29.7
	Cube3	31.6

For 10% replacement of Fly ash and 30% replacement of recycled coarse aggregate

Table 7: compressive strength at days 7, 14, 28 days for 10% replacement of fly ash

No. of days	Cube	Compressive strength (Mpa)
7	Cube1	20.2
	Cube2	21.4
	Cube3	21.9
14	Cube1	25.7
	Cube2	26.8
	Cube3	26.9
28	Cube1	31.1
	Cube2	30.7
	Cube3	31.6

For 15% replacement of Fly ash and 30% replacement of Recycled coarse aggregate

Table 8: Compressive strength at 7,14,28 days for 15 % replacement

No.of days	Cube	Compressive strength (Mpa)
7	Cube1	22.23
	Cube2	21.4
	Cube3	20.8
14	Cube1	25.6
	Cube2	26.9
	Cube3	26.7
28	Cube1	31.4
	Cube2	31.6
	Cube3	31.8

CONCLUSION

REVIEW OF USE OF RECYCLED COARSE AGGREGATE & FLY ASH IN CONCRETE

- The applications of recycled coarse aggregate in the construction area are very wide. There are many testings based on the recycled coarse aggregate have been carried out all around the world.
- The main aim of using recycled coarse aggregate is to reduce the use of natural resources. From the literature review shown, the results of different properties are all mainly reducing when the replacement of recycled coarse aggregate used in the concrete increased.
- Another improving method is using the Fly ash in the recycled coarse aggregate mixing. Application of fly ash in the recycled coarse aggregate concrete can improve the durability of the recycled coarse aggregate concrete. The use of fly ash could improve the strength characteristic of recycled coarse aggregate concrete.
- This paper has discussed properties of RCA, the effects of RCA use on concrete material properties...Aggregate properties are most affected by the residual adhered mortar on RCA. Because of this, RCA is less dense, more porous, and has a higher water absorption capacity than NA. While RCA and NA have similar gradation, RCA particles are more rounded in shape and have more fines. Replacing NA in concrete with RCA decreases the compressive strength by 13 %.
- Due to use of recycled aggregate in construction, energy & cost of transportation of natural resources & excavation is significantly saved. This in turn directly reduces the impact of waste material on environment.
- The compressive strength of cubes with replacement is higher than Target mean strength of the M20 concrete mix. So, a replacement up to 15% is acceptable.

RECOMMENDATIONS FOR FURTHER STUDIES

- Further testing and studies on the recycled coarse aggregate concrete is highly recommended to indicate the strength characteristics of recycled coarse aggregate for application in high strength concrete.
- Due to more water absorption of recycled coarse aggregate, it may have less workability.
- Therefore, it is recommended that adding admixtures such as super plasticizer, fly ash, silica fume, etc.., into the mixing so that the workability can be improved.
- More investigations and laboratory tests should be done on the strength characteristics of recycled coarse aggregate. It is recommended that testing can be done on concrete slabs, beams and walls.
- More trials with different particle sizes of recycled coarse aggregate and percentage of replacement of recycled coarse aggregate with fly ash as cementitious material with % replacement of cement is recommended to get different outcomes and higher strength characteristics in the recycled coarse aggregate concrete with fly ash.

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