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High-Strength Structural Concrete with Recycled Aggregates

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Abstract: ***Recycled aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. The aim for this on – going project is to determine the strength characteristic of recycled aggregates for application in high strength structural concrete, which will give a better understanding on the properties of concrete with recycled aggregates, as an alternative material to coarse aggregate in structural concrete. The capacity of this project is to decide and balance the high strength concrete by using special percentage of recycled aggregates. The study was carried out using workability test, compressive test, not direct tensile test and modulus of flexibility test. There were total of eight batches of concrete mixes, consists of each 20% increase of cast-off aggregate substitute from 0% to 100%. In addition, 100% of recycled aggregate mix batches included fly ash, water/cement ratio of 0.45. The workability of concrete significantly reduced as the amount of recycled aggregate increased. This was evaluated during normal slump test and compacting factor test. For power individuality, the results showed that a regularly falling in compressive strength, tensile might and modulus of stretch as the percentage of recycled aggregate used in the specimens increased.***

Keywords: Recycled aggregates, modulus of flexibility test, Compressive strength test

1. Introduction of Recycled Aggregate

Recycling is the act of dispensation the used material for use in creating fresh product. The habit of natural aggregate is getting more and more intense with the advanced maturity in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the substitute materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and devastation debris. These resources are usually from buildings, road and rail network, bridges, and sometimes even from catastrophes, such as wars and earthquakes.

Figure 1: Recycled aggregates

Recycled Aggregate Concrete (RAC) is a concrete that use partly or fully Recycled Aggregate (RA) as coarse or fine aggregate. RAC has been widely used and accepted in world wide. For example in United Kingdom, increasing cost of landfill, anxiety of decreasing in natural resources and increasing in aggregate requirement for construction work has attract the RA application in construction industry. Meanwhile in United States, for encouraging the RA application, special incentives for transportation of waste concrete and processed aggregates from production sites were given. Asia countries also participated in experiencing the RA application in their construction industry. Hong Kong and Japan are two countries which seriously have utilized RA as their construction material. For example, RA has been applied as construction material in Hong Kong Wetland Park project. Meanwhile Japan in May 2000 has published a law on recycling construction materials. These efforts had shown that RA has become an important alternative material in construction industry.

2. Experimental Investigation

2.1. Materials

2.1.1. Cement

Ordinary Portland Cement of Anjani brand of 53 grade confirming to IS: 4031 (Part 4) : 1988 was used in the present study. The properties of cement are shown in Table 1.

Table 1: Properties of Cement

Sl. No	*Property*	*Result*
1.	Normal Consistency	32%
2.	Initial Setting time	45 mins
3.	Specific Gravity	3.15
4.	Fineness of cement	5%

2.1.2. Fine Aggregate

Natural sand as per IS: 383-1987 was used. Locally available River sand having bulk density 1860 kg/m^3 was used The properties of fine aggregate are shown in Table 2.

Table 2: Properties of fine aggregate

Sl. No	Property	Result
1.	Specific Gravity	2.7
2.	Fineness modulus	3.12
3.	Grading zone	IV

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2.1.3. Recycled Aggregate

Recycled aggregate is nothing but the Concrete aggregate collected from demolition sites. Recycled aggregate is produced by crushing concrete, and sometime asphalt, to reclaim the aggregate. Recycled aggregate can be used for many purposes. The primary market is road base.

Table 3: Properties of natural & recycled aggregate

Particulars	*Natural aggregate*	*Recycled aggregate*
Maximum aggregate size	20mm	20mm
Specific gravity	2.848	2.72
Fineness madules	7.083	7.47
density	1805kn\m^3	1650kn\m^3

2.2 Impact Test Value:

Table 4: Properties of impact test value

	2.36 mm passing(gms)	*total wt.(gm)*	*Impact value (%)*
Natural aggregate	26	326	8
Recycled aggregate	36	294	12.8

2.3. Fly Ash

Fly ash is a byproduct of the combustion of pulverized coal in thermal power plants. A dust-collection system removes the fly ash, as a fine particulate residue, from combustion gases before they are discharged into the atmosphere. Fly-ash particles are typically spherical, ranging in diameter from <1 µm up to 150 µm.

2.4. Concrete Mix Proportions

Table 5: Concrete Mix Proportions

praportions	1:1.87:3.06
cement	400
fine aggregates	756
course aggregates	1226
w/c ratio	0.45
water	180

2.5. Details of Mix Batching

Table 6: Details of Mix Batching

Grade	*Mix*	*Recycled Aggregate*	*Fly Ash*
30	MXI	**0%**	5%
	MX2	20%	10%
	MX3	40%	15%
	MX4	60%	20%
	MX5	80%	25%
	MX6	100%	30%

3. Experimental Methodology

3.1. Workability Test

Workability is carried out by conducting the slump test and compaction factor test as per IS 1199-1959 on ordinary concrete and fiber reinforced concrete.

3.2. Compressive Strength Test

Compression test is the most common test conducted on hardened concrete, partly because it is easy test to perform and partly because most of desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compression test is carried out on specimens of cubical shape. The size of specimen is 15×15×15 cms were cast for M40 grade of concrete .after curing, these cubes were tested on compression testing machine AS per I.S. 516-1959. The failure load was noted. In each category two cubes were tested and their average value is reported. The compressive strength was calculated as fallows, compressive strength (Mpa) = failure load/ cross sectional area.

3.3. Experimental Result

3.3.1 Fresh Concrete Test Results

The properties of fresh concrete can be evaluated by slump cone test & compaction factor test with W/C ratio 0.45. The results of properties are given in table 1.

Table 7: Result of slump and compaction factor of fresh concrete

Mixing type	Slump(mm)	Compaction factor
MX1	103	0.980
MX2	94	0.975
MX3	92	0.920
MX4	88	0.915
MX5	84	0.900
MX6	82	0.890

Table 8: Result of slump and compaction of fly ash fresh concrete

Mixing type	Slump(mm)	Compaction factor
MX1	101	0.985
MX2	95	0.972
MX3	91	0.965
MX4	86	0.955
MX5	83	0.942
MX6	80	0.912

3.3.2. Hardened Concrete Strength Results

Result of compressive strength for M30 grade on concrete on cube. The specimens are separated by steel fibers, silica fume & fly ash with varying percentage. The table no.2 shows result of compressive strength at 7& 28 days.

3.4. Effet of Recycled Aggregate on Concrete

The coarse aggregate is replaced with recycled aggregate in different proportion (10%, 20%, 40%, 60%, 80%, and 100%). The specimens casted are cured for 7 and 28 day. The compressive strength test are conducted on cubes and there values are tabulated as show in table 9 and figure 2 shows the comparison of compressive strengths of different proportions of recycled aggregates.

Table 9: Result of compressive strength of concrete

Percentage of recycled coarse aggregate	*Compressive strength for 7 days, Mpa*	*Compressive strength for 28 days, Mpa*
RA 0%	27	37
RA20%	21.5	29
RA40%	18.7	27
RA60%	16.5	24
RA80%	14.5	19
RA100%	12	16

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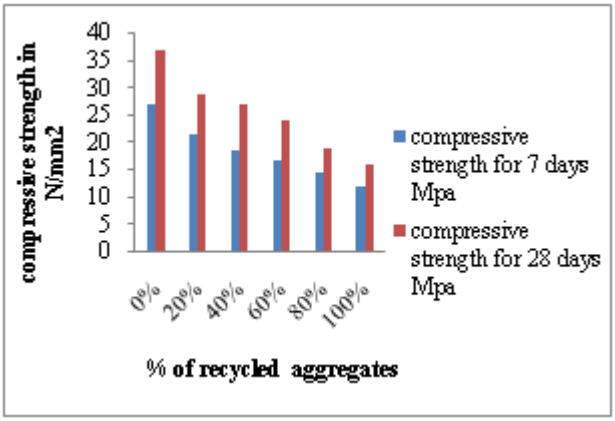

Figure 3: Compressive Strength of Concrete

The below table 10 shows the tabulated values of split tensile strength of recycled aggregate concrete cylinders and figure 3 gives the comparison of the strengths for different curing periods

Table 10: Result of Split Tensile Strength Of Concrete

Percentage of recycled coarse aggregate	*Split tensile strength for 7 days, Mpa*	*Split tensile strength for 28 days, Mpa*
RA 0%	2.3	3.1
RA20%	2.0	2.6
RA40%	1.7	2.4
RA60%	1.5	2.2
RA80%	1.4	2.1
RA100%	1.1	1.8

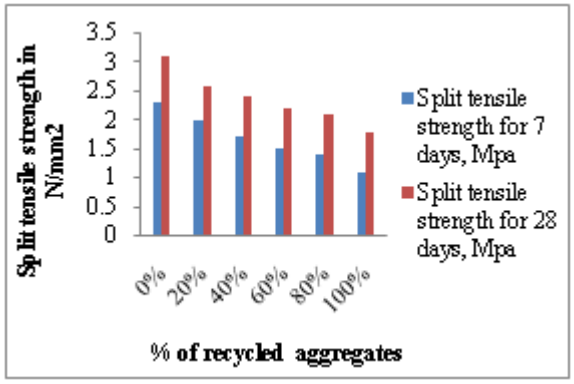

Figure 3: Split Tensile Strength of Concrete

From the above values it can be seen that by increase in percentage of recycled aggregate with natural aggregate in concrete the compressive and split tensile strength of concrete decreases

3.4 Effect Of Fly-Ash On Recycled Aggregate Concrete

Certain percentage of cement is replaced with fly-ash (0%,5%,10%,15%, 20%25and 30%) in mix design for optimum recycled aggregate concrete (0%,20%,40%,60%,80%and100% recycled aggregate replacement; the compressive strength and split tensile strength are tabulated in tables 3 and 4 respectively for values for 7 and 28 days.

Table 11: Result of compressive strength of concrete with fly ash

Percentage of recycled coarse aggregate	*FLY ASH*	*split tensile strength for 7 days, Mpa*	*Split tensile strength for 28 days, Mpa*
RA 0%	5%	2.5	3.3
RA20%	10%	2.1	2.8
RA40%	15%	1.9	2.6
RA60%	20%	1.6	2.4
RA80%	25%	1.4	2.3
RA100%	30%	1.2	1.9

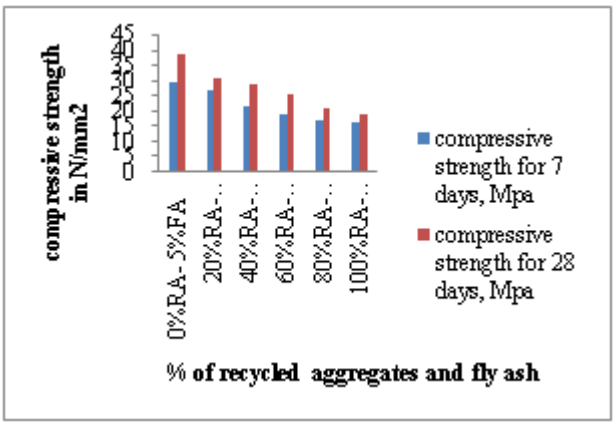

Figure 4: Compressive strength of concrete with fly ash

Table 12: Result of split tensile strength of concrete with fly ash

Percentage of recycled coarse aggregate	FLY ASH	compressive strength for 7 days, Mpa	compressive strength for 28 days, Mpa
RA 0%	5%	30	39
RA20%	10%	27	31
RA40%	15%	21.7	29
RA60%	20%	19.5	26
RA80%	25%	17.5	21
RA100%	30%	16.5	19

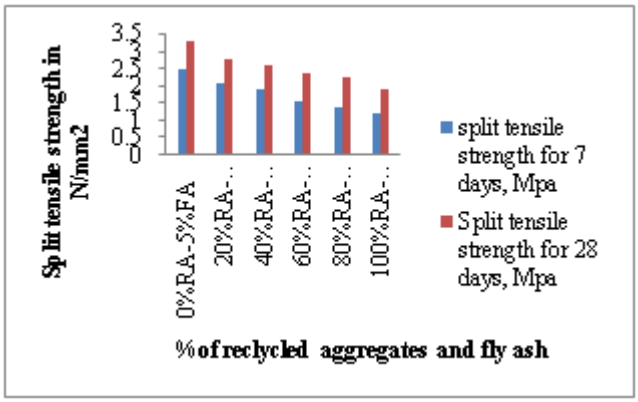

Figure 3: Split Tensile Strength of concrete with fly ash

4. Conclusions

20% of RA and 10% of fly ash is giving approximately same results as that of 100% NA and 0% fly ash. The workability of RAC concrete could be increased by addition of fly ash. It can be found that with increase of recycled aggregate percentage replacement there is a decrease in the strength of concrete.

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