

Mechanical properties of Recycled aggregate concrete with Portland slag cement

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ABSTRACT:

This paper presents the results of experimental research using concrete produced by replacing, part of the natural coarse aggregates with recycled aggregates from concrete demolition. The amount of construction waste increases annually. Also modern technology is given a chance to improve recycling usage in sustainable concrete industry. In modern technology world, recycling plays a vital role to protect the natural resources in our planet. The influence of quality of the recycled aggregate, the percentage of replacement on the targeted quality of the concrete to be produced (strength and workability) has been evaluated. The following properties of recycled concretes were analyzed i.e compressive strength, split tensile strength and flexural strength. Several factors were influenced on strength and workability i.e the type of aggregate, the percentage of replacement, the type of sieve curve. The type of aggregate and the percentage of replacement were the only factors that showed a clear influence on most of the properties. Compressive strength will be clearly affected by the quality of recycled aggregates. If the water–cement ratio is kept constant and the loss of workability due to the effect of using recycled aggregate is more. In present studies W/C ratios were modified based on grade of concrete. The improvement of sustainable concrete, by using recycled coarse aggregates has an important role to ensure the minimization of damages towards environment. This research carries out a thorough investigation of RCA concrete, strength, thermal performance with 30% recycled coarse aggregate content for M20, M25, M30, M35 grades by using slag. It provides a clearer understanding on how it can be applied to improve the usage of 30% RCA content in concrete for sustainable development.

INTRODUCTION

Several studies were made on recycled aggregate concrete with ordinary Portland cement, but present this study mainly focus on usage of Portland slag cement with recycled aggregate concrete with four different grades. Concrete is commonly as a three-phase composite material comprising hardened cement paste, the aggregate structure and the interfacial transition zone (ITZ) between the hardened cement paste and the aggregate surface. The structure of transition zone, especially, voids and micro cracks present, have a greater influence on stiffness on the elastic modulus of concrete. The transition zone serves as bridge between mortar and aggregates. This transition zone influences on durability also. Recycled concrete aggregates contain not only the original aggregates, but also hydrated cement paste. The aims of this study is strengthen mortar by using slag cement it improve the properties of RCA by an economic and environmentally friendly technique. This paste reduces the specific gravity and increases the porosity. The use of recycled aggregate generally increases the drying shrinkage creep and decreases the compression strength of concrete compared to that of natural aggregate concrete. It would have satisfactory results on modulus of elasticity and durability. It enhances the tensile and flexural strength. Generally accepted that when natural sand is used, up to 30 percent of natural crushed coarse aggregate can be replaced with coarse recycled aggregate without significantly affecting any of the mechanical properties of the concrete. The characteristics of recycled aggregate concrete has enhanced with the addition of little amount (1.5%) of Nano-Silica for M30 and M35 grades. The Nano-silica improves the early age compressive strength of concrete than later age. Normally slag has minor early age compressive strength but, it furnish higher compressive strength with age of concrete increases. Recycled aggregate will be possible for construction to replace natural aggregates. The Government is working out on standard specifications for recycling code of practice. The growing environmental concerns; the increasing footprint of landfills coupled with waste landfill costs; the quickly depletion sources of valuable natural aggregate in some developed countries, as well as waste storage limitation, inciting a reduction of the environmental footprint of waste treatments, are the driving forces promoting the recycling of concrete demolition wastes in new concrete. For large construction, concrete is preferred as it has longer life, low maintenance cost & better performance. Conservation of natural resources, saving of energy in production and transportation, and reduction of pollution are also the advantages of recycling. In particular, concrete is a perfect construction material for recycling. Some materials are reused for recycling such as plastic, glass etc. In the same way concrete can also be used continuously as long as the specification is right. Recycling solid waste materials for construction purposes becomes an increasingly important waste management option, as it can lead to environmental and economic benefits. Recycled aggregate reduces the impact of

waste on environment. By using some percentage in construction sector, cost is saved, due to reduction of transportation & manufacturing process. Less emission of carbon due to less crushing by using recycled aggregate concrete⁶. It has been found that workability of concrete with natural and recycled aggregate is almost the same if water saturated surface dry recycled aggregate is used. Also, if dried recycled aggregate is used and additional water quantity is added during mixing, the same workability can be achieved after a prescribed time. Bulk density of fresh concrete is slightly decreased with increase in the quantity of recycled aggregate.

Portland slag cement: The properties of concrete will be greatly affected by changing quantity of cement content. Portland slag cement conforming to IS455-1989 (MAHA SLAG CEMENT)

Table1: properties of slag cement

Specific gravity	2.9	
Initial setting time	55 mins	
Final setting time	600 mins	
Fineness	2%	
Consistency	31%	
Compressive strength	7 days	32.50 N/mm ²
	28 days	45.25 N/mm ²

Fine aggregate: River sand Zone-II as per IS-383 specifications

Table2:Test results of fine aggregate

Specific gravity	2.65
Fineness modulus	3.2
Zone	II

Natural Coarse aggregate (NAC):20 mm nominal size as per IS-383 specifications.

Table3:Test results of coarse aggregate

Specific gravity	2.90
Fineness modulus	5.8
Bulk density	1675.8 KN/m ³
Water absorption	0.5%
Crushing value	18.60%
Impact value	17.50%

- Recycled aggregate concrete (RAC): Nominal size of 20mm aggregate was used. Grading is performed by IS sieve set, grading curve is obtained same as coarse aggregate. Reused aggregate to be created from matured solid that has been obliterated and eliminated from establishments, asphalts, scaffolds or structures, is squashed and handled into different size. Records of the historical backdrop of the destruction concrete – quality, blend plans and so on – would only occasionally be accessible, yet on the off chance that accessible these are valuable in deciding the capability of the recycled concrete.

Table 4: test results of fine aggregate

Specific gravity	2.70
Fineness modulus	5.0
Bulk density	1468.5KN/m
Water absorption	0.5%
Crushing value	35.3%
Impact value	33.2%

Table5: Charesterstics of Nano- silica:

Notation of Nanosilica gel	XLP
Active Nano content (% wt/wt)	14.0-16.0
Ph	9.3-9.6
Specific gravity	1.08-1.11

MIX Proportion:

Table6: Mix proportion of normal aggregate concrete

Grade	SlagCement(kg/m ³)	Fine aggregate (kg/m ³)	Coarse aggregate (kg/m ³)	Water(lt)	Nanosilicamel
M20	316	685	1221	179	----
M25	326	681	1220	179	----
M30	362	652	1220	178	5.46
M35	400	625	1210	178	6

Table7: Mix proportion of recycled aggregate concrete

Grade	SlagCement(kg/m ³)	Fine aggregate (kg/m ³)	Coarse aggregate (kg/m ³)	Recycled aggregate (kg/m ³)	Water(lt)	Nanosilicamel
M20	298	722	775	501	183	----
M25	329	711	764	495	182	----
M30	367	696	750	485	182	5.51
M35	400	687	738	476	181	6.01

Experimental results:

Compressive strength

Table8: It shows compressive strength

GRADE	Compressive strength age N/mm ² (3days,7days,28days)		
	3days	7days	28days
M20(0%)	15.2	18.9	29.9
M20(30%)RAC	13.2	18.1	27.1
M25(0%)	12.8	20.2	32.1
M25(30%)RAC	14.1	20.3	32.9
M30(0%)	21.5	30.5	40.2
M30(30%)RAC	18.5	22.5	39.0
M35(0%)	22.8	28.5	44.2
M35(30%)	21.2	27.2	43.7

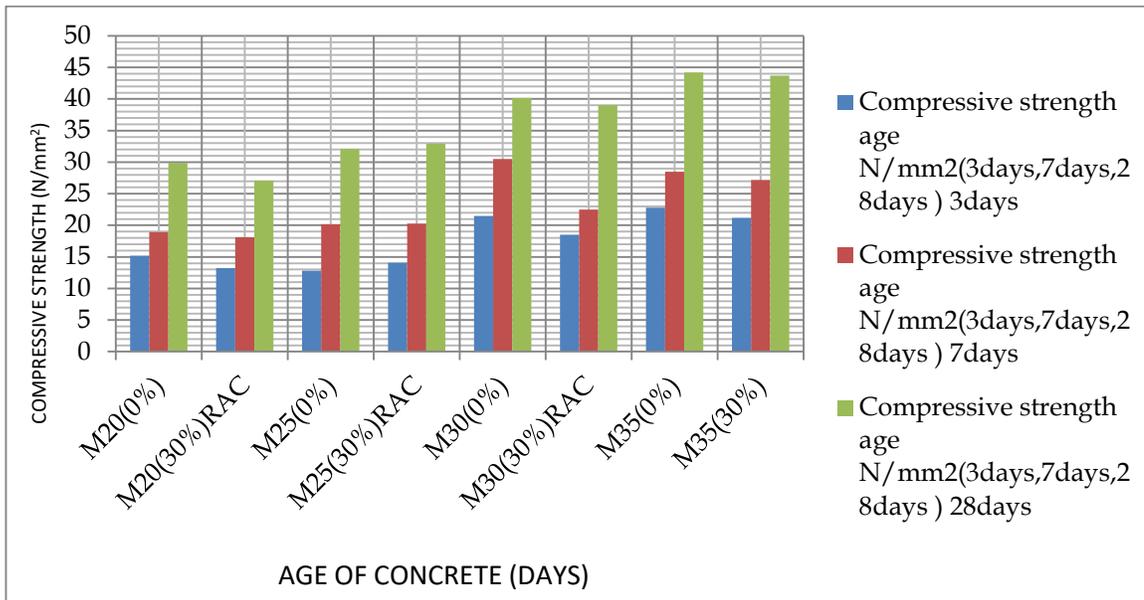


Fig 1.1 Variation of 3, 7 and 28 days compressive strength for M20NAC, M20RAC, M25NAC, M25RAC, M30 NAC, M30 RAC, M35 NAC and M35RAC concrete.

From Table 8 & figure 1.1 shows the Compressive strength of different grades of concrete used in this study i.e.,M20N, M25N, M30N, M35N, M20R, M25R M30R, M35R. It is observed that the compressive strength increase with the replacement of recycled aggregate in concrete.

Split tensile strength:

Table 9: shows split tensile test result

GRADE	Split tensile strength age N/mm ² (3days,7days,28days)		
	3days	7days	28days
M20(0%)	1.1	1.7	2.1
M20(30%)RAC	1.1	1.5	1.9
M25(0%)	1.4	1.9	2.9
M25(30%)RAC	1.2	1.7	2.3
M30(0%)	1.4	2.1	3.8
M30(30%)RAC	1.7	2.02	2.27
M35(0%)	1.7	1.9	4.01
M35(30%)	1.7	2.3	2.4

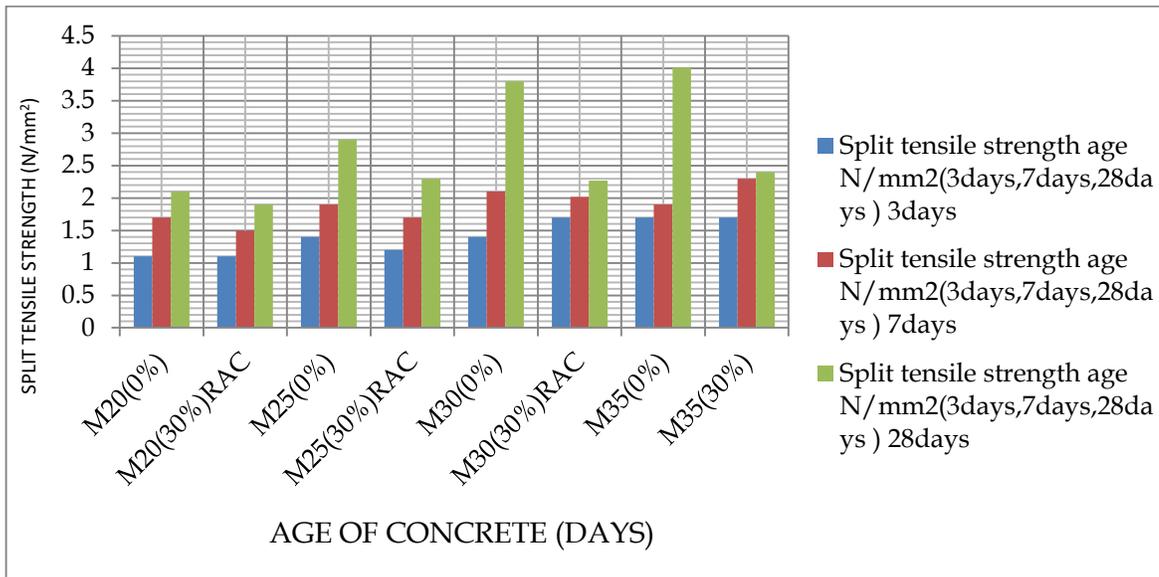


Fig 1.2 Variation of 3, 7 and 28 days split tensile strength for M20NAC, M20RAC, M25NAC, M25RAC, M30 NAC, M30 RAC, M35 NAC and M35RAC concrete.

From Table 9 & Figure 1.2 shows the split tensile strength of different grades of concrete used in this study i.e., M20N, M25N, M20R and M25R . It is observed that the split tensile strength increased with the replacement of recycled aggregate in concrete

Flexural strength

Table 10: It shows flexural strength

GRADE	Flexural strength age N/mm2(3days,7days,28days)		
	3days	7days	28days
M20(0%)	3.1	5.1	5.7
M20(30%)RAC	2.9	4.7	5
M25(0%)	3.7	5.4	6.4
M25(30%)RAC	3.02	5.22	6.12
M30(0%)	4.8	6.01	7.1
M30(30%)RAC	4.4	4.45	6.44
M35(0%)	5.1	5.5	7.4
M35(30%)	4.4	5.5	7.2

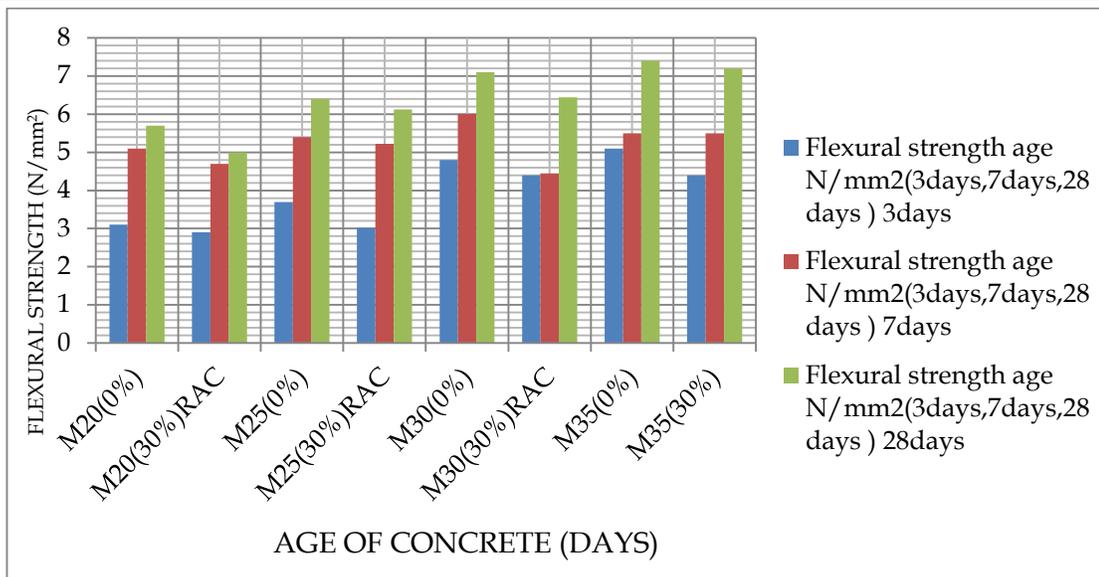


Fig 1.3 Variation of 3, 7 and 28 days flexural strength for M20NAC, M20RAC, M25NAC, M25RAC, M30 NAC, M30 RAC, M35 NAC and M35RAC concrete.

From Table 10 & Figure 1.3 shows the flexural strength of different grades of concrete used in this study i.e., M20N, M25N, M30N, M35N, M20R, M25R, M30R and M35R. It is observed that the split tensile strength increased with the replacement of recycled aggregate in concrete

CONCLUSIONS

1. Recycled aggregate up to 30% does not affect the Mechanical and durability properties.
2. Various tests were made on recycled aggregates and results were compared with natural aggregates are satisfactory as per Indian standards.
3. 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
4. As grade of the concrete increases, Compressive strength, Split tensile strength and Flexural strength increases with the increase of age of the concrete

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