EXPERIMENTAL STUDIES ON PERFORMANCE OF STEEL FIBER AND POLYMER MODIFIED RECYCLED AGGREGATE CONCRETE

Prathik Kulkarni[1], Kashimalla Ramesh[2], N.M.Kanhe[3], Dhanalakshmi Vasa[4]

[1]*Assistant professor, Civil Engineering, Gurunanak Institute of Technical Campus, Telengana, India*
[2]*Assistant professor, Civil Engineering, Gurunanak Institute of Technical Campus, Telengana, India*
[3]*Professor, Civil Engineering, Principal,Gurunank Engineering College @ Nagpur, Maharastra, India*
[4]*Assistant professor, Civil Engineering, Gurunanak Institute of Technical Campus, Telengana, India*

Abstract

The amount of construction waste has been dramatically increased in the last decade due to increase of population & high rise building in the country. So there is an immediate need of using the aggregate from the old demolished buildings for other construction works such as roads, canals, retaining walls ...etc.

Due to the lack of natural resource and dumping areas in the country, Recycling Aggregate is playing an important role in present situations. In this project a study on M25 Grade of concrete of Natural Aggregate(NA), Recycled Aggregate(RA), 30 Kg /m^3 Steel Fiber Recycled Aggregate(SFRA) (aspect ratio=50), Modified Polymer Recycled Aggregate(PMRA) (Styrene butadiene rubber polymer=5%) has been carried out with water cement ratio =0.50

In this experimental investigation total number of 12 cubes ,12 beams & 12 cylinders of size 150x150mm , 150x150x700mm , 150x300mm specimens respectively were tested for 28 days & 3 cubes of Natural Aggregate, 3 cubes of Recycled Aggregate , 3 cubes of Steel Fibre Recycled Aggregate, 3 cubes of Modified Polymer Recycled Aggregate were tested in compressive testing machine for 7 days. The project is carried out at Gurunanak engineering college, Nagpur

The following tests were carried out for the above specimens for 28 days
1) Compressive test 2) Split tensile test 3) Flexure test

Key words: *na=natural aggregate1, ra=recycled aggregate2, sfra=steel fiber recycled aggregate3, pmra=polymer modified recycled aggregate4, conventional concrete (cc) 5,natural aggregate concrete (nac)6 with that of recycled aggregate concrete (rac7), steel fibre recycled aggregate concrete (sfrac8), polymer modified recycled aggregate concrete (pmrac)9.*

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1. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with a fluid cement which hardens over time. Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on

Natural Aggregates:-
Natural aggregates consist of rock fragments that are used in their natural state, or are used after mechanical processing such as crushing, washing, and sizing. Crushed stone and sand and gravel are the two primary sources of natural aggregate, which are used directly in construction or as a raw material for construction products such as concrete and bituminous road materials

Recycled aggregate:-
When structures made of concrete are demolished or renovated and the aggregate is taken from such buildings is know as recycled aggregate. The extensive research on recycled concrete aggregate and recycled aggregate concrete (RAC) as started from year 1945

Indian Status:-
Central Pollution Control Board(CPCD) has estimated current quantum of solid waste generation in India to the tune of **48 million tons per annum** out of which, waste from construction industry only accounts for more than **25%.** Management of such high quantum of waste puts enormous pressure on solid waste management system

1.1 Benefits Of RA:-

Reduce the amount of virgin rock mined.
Decrease the energy used for processing.
Conserve the energy used for trucking.
They are more cost efficient than most regular aggregates

2. EXPERIMENTAL PROGRAM

The general objectives of theses experimental investigation is to compare the Performance of conventional concrete (CC) or Natural Aggregate Concrete (NAC) with that of Recycled Aggregate Concrete (RAC), Steel Fibre Recycled Aggregate concrete (SFRAC), Polymer Modified Recycled Aggregate Concrete (PMRAC).

The specific objective of the research work is to carry out comparative studies of NAC, RAC, SFRAC, and PMRAC. First of all physical and Mechanical Properties of NAC & RAC were studied. Later on mix design were prepared using NAC & RAC for Water/cement Ratio=0.50. Various tests like compressive test, split tensile test, Flexure test were carried out on these concrete.
The following mentioned physical and mechanical tests were carried out to compare NAC & RAC.

2.1 Physical Properties:-

Properties of aggregates	**(NAC)**	**(RCA)**
Specific gravity	2.70	2.42
Bulk density(kg/l)	1.446	1.286
Flakiness Index (%)	18	21
Elongation Index (%)	0.8	2
Water absorption (%)	0.70	2

2.2 Mechanical Properties For Nac & Rac:-

Properties of aggregates	**(NAC)**	**(RCA)**
Crushing strength (%)	8.205	11.785
Impact strength (%)	5	11.66

2.3 FINE AGGREGATE:-

Fine aggregate used for medium and high strength concrete should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride content. In present work fine aggregate was used locally available sand.

SN.NO	**TEST**	**RESULTS OBTAINED**
1	Specific Gravity	2.6
2	Water absorption	1.01

2.4 Cement:-

Factors which are important in selection of type of cement are compressive strength at various ages, heat of hyderation, alkali content,C_3A content and compatibility with admixtures. Ordinary Portland cement (OPC) of 53 grades was used for preparing concrete throughout the concrete.

Properties of aggregates	NAC	RAC
Specific gravity of cement	3.05	3.05

2.5 Mix Design

Based on the Physical Properties of fine aggregate confirming to M25 grade of NAC using Indian standard recommended method of mix design .The mix was for NAC the same mix design were prepared for RAC, SFRAC, and PMRAC as to compare the various concrete properties of NAC with it. It was decided from past research work to use 40 kg/m3 steel fibre volume and SBR latex dosage in terms of polymer/cement ratio of 10%in RAC.

Mix design for medium strength concrete of grade M25
Mix design for M25 grade of concrete (NAC)

I) Data for mix design:

1) Characteristic strength=25 MPA
2) Maximum size of aggregate=20mm
3) Degree of workability (in terms of slump)=50-100mm
4) Compaction factor=0.85
5) Degree of quality control=Good
6) Type of exposure=Mild

Specific Gravity of:

1) Cement = 3.05
2) Coarse Aggregate = 2.70
3) Fine Aggregate = 2.60

II) Target mean strength of concrete:

Fck = fck + (t * S)
=25 + 1.65*4.0
=31.6 Mpa.

III) Selection of water - cement ratio

For target strength of 31.6 Mpa and water cement ratio=0.50

IV) Selection of water and sand content

For 20mm down grade aggregate and sand confirming to grading zone-II, water content per cubic metre of concrete =186 litres/m3 and sand content as percentage of total aggregate by absolute volume= 35%

For change in value in water ratio, compaction factor, for sand belonging to zone-III the following adjustment is required

Adjustment of sand, compaction factor

Change in condition	Percent Adjustment Required	
	Water content	Sand in total aggregate
For sand confirming to Zone-II of Table 4,IS 383-1970	0	0
For increase in compaction factor (0.85-0.8), this is 0.05	+1.5%	0
For decrease in water cement ratio by (0.60 – 0.50)=0.10	0	-2%
Total	+1.5	-2%

Therefore, required sand content as percentage of total aggregate by

Absolute volume = 35-2 = 33%
Required Water content = 186 +2.79=188.79 lit/m^3

V) Determination of cement content:

Water/cement Ratio	**= 0.50**
Water	= 188.79 lit/m^3
Cement	= 188.79/0.50
Cement	**= 377.58 Kg/m^3**

VI) Determination of coarse and fine aggregate:

For nominal size of 20mm aggregate, the air content is 2% taking into account and applying Following equation
For Fine Aggregate
$V = [W + (C/S_c) + (1/P)*(fa/SFa)] * (1/1000)$
0.98 m3 = [188.79 + (377.58/3.05) + (1/0.33)*(f_a/2.6)] x (1/1000)
f_a= 575.36 Kg/m3
For Coarse Aggregate
$C_a = (1 – P)/P * fa * S_c a/ Sfa$
$C_a = (1 – 0.33)/0.33 * 576.85 * 2.7/ 2.6$
C_a = 1213.08 Kg/m3
The mix proportion then becomes:-Mix proportion

Water	Cement	FA	CA
188.79	**377.58**	**575.36**	**1213.08**
0.50	**1**	**1.523**	**3.21**

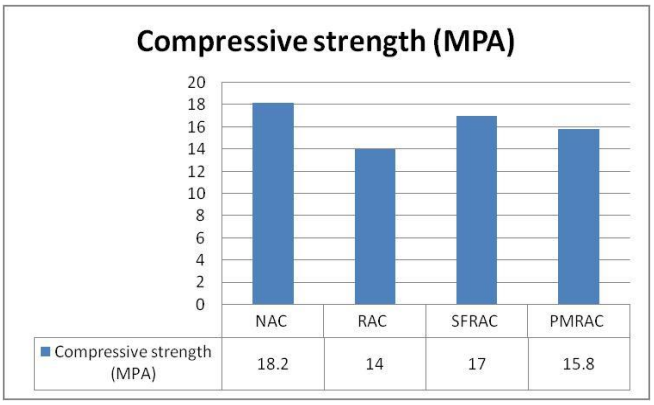
Mix Design	RCA (%)	C (Kg/m3)	FA (Kg/m3)	NCA (Kg/m3)	RCA (Kg/m3)	Free W/C	Fibre content(Kg/m3)	Polymer content (%)
NA	0	377.58	575.36	1213.08	0	0.50	0	0
RA	100	377.58	575.36	0	1213.08	0.50	0	0
SFRA	100	377.58	575.36	0	1213.08	0.5	30	0
SFRA	100	377.58	575.36	0	1213.08	0.5	30	0

3) RESULTS AND DISCUSSIONS

3.1) Compressive strength for 7 days:-

Compressive strength for 28 days is tested in CTM with different nature of concrete as tabulated below. The size of specimen is 150mm x 150mm.
Compressive strength of concrete = load (P)/ Area (A)

Nature of concrete	Compressive strength (MPA)
NAC	18.2
RAC	14
SFRAC	17
PMRAC	15.8



Compressive test was carried out for 7 days on cube of dimensions 150x150x150mm and found that Natural Aggregate Concrete is having more compressive strength when compared with Recycle Aggregate Concrete and there is an increase of 21.4%with addition of Steel Fibres in Recycle Aggregate and a increase of 12.85% in Polymer Modified Recycled Aggregate Concrete

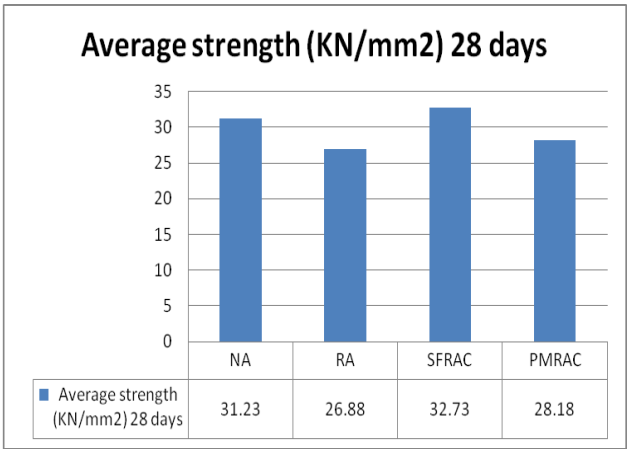
Out of these tests Specific Gravity is one of the important factors that needed to calculate mix design for concrete. The specific Gravity of aggregate is mainly affected by the amount of moister present and the geological properties of aggregate. In this project specific gravity of aggregate was used to determine the volume and weight of aggregate needed for concrete mixes. The determination of specific gravity is according to IS: 383-1970

Cubes after testing Testing of cube In CTM

3.1.1) Compressive Strength of Concrete For 28 Days:-

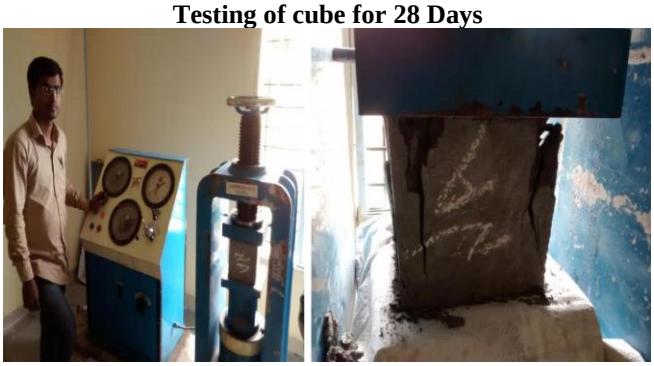
Compressive strength for 28 days is tested in CTM with different nature of concrete as tabulated below. The size of specimen is 150mm x 150m
Compressive strength of concrete = load (P)/ Area (A)

Nature of concrete	Compressive strength (MPA)
NAC	31.23
RAC	26.88
SFRAC	32.73
PMRAC	28.18



The above graphs tells that strength of steel fibre recycled aggregate concrete is more of all the concrete if we compare Natural aggregate concrete (NAC) with Recycled aggregate concrete(RAC) there is a decrease in strength of 16% but when we add fibres and polymer to Recycled aggregate concrete there is increase in strength by 21.76% & 4.83% for Steel Fibre Recycled Aggregate Concrete(SFRAC) & Polymer Modified Recycled aggregate Aggregate Concrete (PMRAC)

Testing of cube for 28 Days

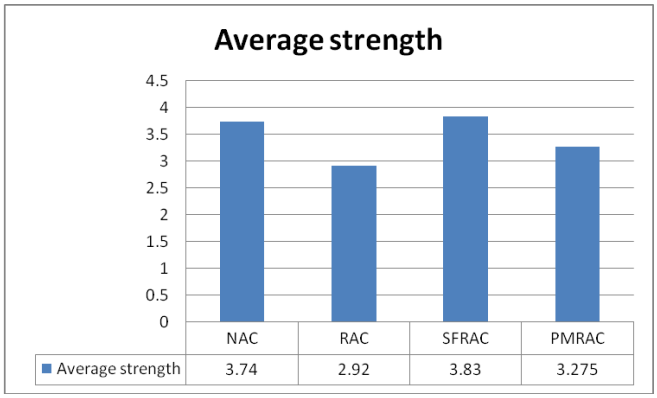


3.2) Split Tensile test

For tensile test the specimen of size 150mmx300mm is tested in CTM . The specimens were demoulded after 24 hrs and was transferred to curing for 28 days.

Split tensile strength of concrete = $2P / \pi DL$

Nature of Aggregate	Average strength
NAC	3.74
RAC	2.92
SFRAC	3.83
PMRAC	3.275



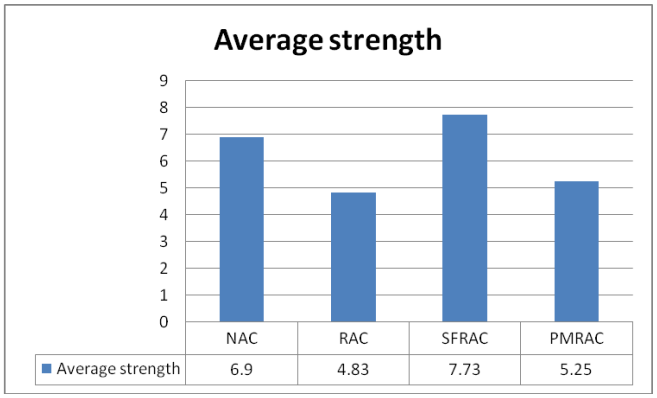
From the graph if we compare Natural Aggregate Concrete (NAC) with Recycled Aggregate Concrete (RAC) the strength of RAC is reduced by 28.0% so to increase the strength of RAC we have added Steel fiber of aspect ratio (a/d=50) and polymer as (ACSBR=apple chemist styrene butadiene rubber) and there was an increase by 31.16% in SFRAC and 12.15% in PMRAC

cylinders Testing of cylinders under CTM

3.3) Flexural test:-

The flexural strength of the specimen is expressed as modulus of rupture which depends on the dimension of the beam and the type of loading . The size of specimen is 150x150x700mm and 3 point loading
The modulus of rupture $fb = PL / bxd^2$

Nature of Aggregate	Average strength
NAC	6.9
RAC	4.83
SFRAC	7.73
PMRAC	5.25



Beams ,cubes, cylinders

Beam after testing

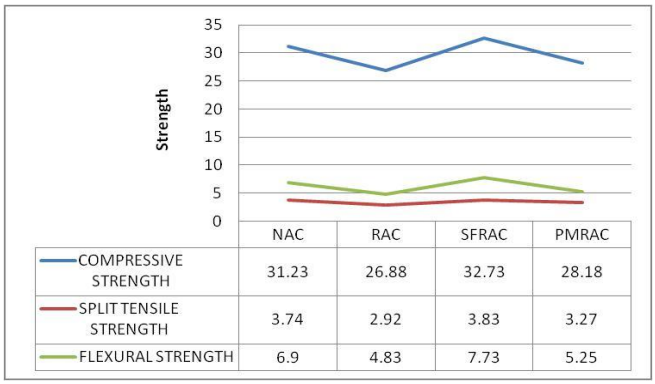
Recycled Aggregate Beam

Steel fiber in beam

Consolidated Report:-

The report consist of all the 3 test i.e, compressive test , split tensile test and flexural test for 28 days and its graphical representation is given below with tabular column.

Nature of concrete	COMPRESSICE STRENGTH	SPLIT TENSILE STRENGTH	FLEXURAL STRENGTH
NAC	31.23	3.74	6.9
RAC	26.88	2.92	4.83
SFRAC	32.73	3.83	7.73
PMRAC	28.18	3.27	5.25



3. CONCLUSIONS

- It has been observed that the specific gravity of Natural Coarse Aggregate is more than the Recycled Coarse Aggregate
- Compressive test was carried out for 7 days on cube of dimensions 150x150x150mm and found that Natural Aggregate Concrete is having more compressive strength when compared with Recycle Aggregate Concrete and there is an increase of 21%with addition of Steel Fibres in Recycle Aggregate and a Decrease of 12% in Polymer Modified Recycled Aggregate Concrete.
- Compressive strength was carried out for 28 days for Natural aggregate concrete (NAC) Recycled aggregate concrete(RAC), Steel Fibre Recycled Aggregate Concrete(SFRAC) & Polymer Modified Recycled aggregate Aggregate Concrete (PMRAC) and the strength of SFRAC is more when compared by NAC by 4.80% and there is a decrease in RAC by 16.18% so to improve the strength of RAC 30 kg/m^{3}of Steel fiber and 5 % of cement as polymer (Styrene Butadiene Rubber)was added and the strength was increased by 21.66% & 4.83%.
- Split tensile test was also carried out for 28 days and the strength of Recycled aggregate was less when compared to Natural aggregate concrete by 28% so to improve the strength we have added Steel fibres and polymer and there was an improvement in concrete by 31.16% for steel fiber and it was observed that SFRAC was having more strength then NAC but polymer modified recycled aggregate concrete has less strength compared to NAC by 14.37% but there is an increase when compared with RAC by 12.15%
- Flexural test was carried out for 28 days under CTM with 3 point loading and it was observed that strength of recycled aggregate is very less when compared with NAC by 42.85% so to improve the strength RAC 30 kg/m^{3}of Steel fiber and 5 % of cement as polymer (Styrene Butadiene Rubber)was added and the strength was improved by 59.84% and 8.69% when compared with RAC.
- Overall view of the project was that the strength of Recycled Aggregate concrete was less when compared with Natural aggregate concrete and to improve the strength we have added 30 kg/m^{3}of Steel fiber and 5 % of cement as polymer (Styrene Butadiene Rubber).

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BIOGRAPHIES

Prathik Kulkarni,
Assistant Professor,
GNITC,
Hyd

Dr. N.M.Kanhe,
Principal,
GNI,
Nagpur.

Kashimalla Ramesh,
Assistant Professor,
GNITC,
Hyd.

Dhanalakshmi Vasa,
Assistant Professor,
GNITC,
Hyd