AN EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE USING RECYCLED AGGREGATES AND MANUFACTURED SAND

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Abstract - *This research looks into the feasibility of using manufactured sand(M-sand) or arti:icial sand and recycled coarse aggregate (R C A) to make concrete. In this experimental programme, 44 concrete mixes were prepared in which natural coarser aggregate (NCA) is replaced with RCA in proportions ranging from 10% to 100%. Similarly, M Sand sand is used in place of natural river sand in increments of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%. The binder content and water content were kept consistent for all combinations. M-sand and RCA are evaluated for their effect on the fresh and hardened characteristics of CONCRETE. The study's :indings revealed that the toughened properties of concrete using 50% M-sand are much higher than the control mix. The toughened qualities of the CONCRETE with 100% RCA were discovered to be less than those of Ordinary concrete. As a result, as the amount of RCA substitution grows, so does the strength decreases. The results, however, demonstrated that M-sand may generate CONCRETE with weak and medium compressive strength (20MPa - 45MPa).*

***Key Words*: Fresh Concrete; Recycled Coarser Aggregate; Manufactured sand; Compressing Strength etc.**

1.INTRODUCTION

A lack of land-illing space activities will immediately result from the large volume of garbage produced by construction and demolition (C&D) and industrial by- products. Innovative and unconventional resources can help the construction industry go in the direction of sustainability. RCA has a lower density and a higher water absorption rate than natural coarse aggregate because of the adhering cement mortar on its surface. It is also less expensive. Additionally, it provides extra advantages and lessens the in-luence on the environment. Concrete loses compressive strength when mortar fragments from old concrete are present in RCA.

Since ancient times, construction projects have used river sand as -ine aggregate. However, limitations placed on the usage of river sand from the riverbed as a result of a lack of availability or insuf-iciency or shortage and growing demand have motivated researchers to look for other materials for -ine aggregate. River sand has a smoother surface than M- sand, which is more angular. M-sand is therefore becoming more and more common in the construction sector these days.

1.1 RESEARCH SIGNIFICANCE

Natural river sand is extremely scarce, so substitutes like arti-icial sand, foundry sand, blast furnace slag, pulverised granulated blast furnace slag, and other minerals must be used. Even coarse aggregates are getting more and more dif-icult to -ind, so a replacement material must be used. Most nations have already made the switch to recycling and repurposing old building materials. Utilising demolished concrete is a viable option for doing this; but, before being utilised to make new concrete, the material must be quality-checked. The quality of concrete must be evaluated using a thorough experimental plan. The results of a study that used M-sand to create recycled aggregate concrete are presented in this publication.

Fresh properties such as slump -low test and hardened properties such as compressive strength of concrete are studied.

2. MATERIALS

a). CEMENT: - All mixes are made with Portland pozzolana cement that confirms to IS:1489 Part 1.

The following physical characteristics of Portland Pozzolana Cement, as determined by relevant tests in accordance with IS:4031-1988, are shown:

S.NO.	CHERACTERSTICS	RESULT
1.	Specific gravity	2.92
2.	Fineness modulus	3%
3.	Normal consistency	35%
4.	Initial setting time	37min.

Table 2.1: Portland Pozzolana Cement's Physical Characteristics

b). SAND: - both natural sand and arti-icial sand (M-Sand) were used which con-irm to IS 383:1970.

i. Natural sand: - Natural Sand (River Sand) is a vital ingredient of the concrete mix that ensures the proper adhesion of both cement and aggregate.

In this experiment the sand which passed through an Is sieve of 1.18 mm and retained on _600_µm as according to IS383-1963 de-initions were used.

S.NO.	CHERACTERSTICS	RESULT
1.	Type	Natural
2.	Size	_600_µm
3.	Shape	Rounded
4.	Specific gravity	2.67
5.	Bulk density (Kg/l)	1.725
6.	Grading zone by sieve analysis	Zone 3

Table 2.2 natural sand Physical Characteristics as according to IS:2386-1963

ii. Manufactured sand(M-Sand): - M sand, a sort of arti-icial sand, is created by crushing large, hard stones most often boulders or granite into small pieces that can be then meticulously graded and cleansed. As a river sand alternative, it can be used in a variety of building projects, mostly for making mortar and concrete.

In this experiment the sand which passed through an Is sieve of 1.18 mm and retained on _600_µm as according to IS:383-1963 de-initions were used.

S.NO.	CHERACTERSTICS	RESULT
1.	Type	Artificial
2.	Size	_600_µm
3.	Shape	angular
4.	Specific gravity	2.82
5.	Bulk density (Kg/l)	1.780
6.	Grading zone by sieve analysis	Zone 3

Table 2.3 M-Sand Physical Characteristics as according to IS:2386-1963

c). AGGREGATES: - both normal coarse aggregates (NCA) and recycled coarse aggregates (RCA) were used which con-irm to IS 383:1970.

I. Normal coarse aggregates (NCA): - In this study the normal coarse aggregates of maximum size of 20mm were used which were obtained from a nearby construction site.

II. Recycled coarse aggregates (RCA): - The recycled aggregates of maximum 20 mm in size were used in this experimental study which were derived from the tested destroyed cubes which were tested at laboratory.

The -irst step was to properly wash the newly demolished RCA using water for 30 minutes. RCA was then submerged in water over 24 hours. To get rid of any moisture on the surface, RCA was dried. For batching, RCA, natural coarse aggregate, and -ine aggregates were combined.

PROPERTIES	NATURAL COARSE AGGREGATES	RECYCLED COARSE AGGREGATES
Type	Natural	Recycled
Size(mm)	20	20
Specific gravity(kg/l)	2.70	2.31
Water absorption%	1.35	9.50
Impact value%	19.36	17.55

Table 2.4 NCA and RCA Physical Characteristics as according to IS:2386-1963

d). WATER: - Water, which when merged with cement creates a paste that retains the aggregate together, is the most important component. Through a process called as hydration, water helps concrete to harden. Ordinary For the concrete's mixing and curing, only potable tap water devoid of all impurities—including turbidity, organic content, and alkalinity—was used.

3. EXPERIMENTAL WORK: -

3.1.MIX PROPORTIONING: - A nominal concrete mix of grade M-20 was prepared for this experimental work. The ratio of cement sand and aggregates was kept as C: S: A=1:1.5:3. In each mixture, N-C-A is replaced by R-C-A in proportions of 10%,20%,30%,40%,50%,60%,70%,80%,90% and 100%, and the river sand is substituted by M sand in proportions of 10%,20%,30%,40%,50%,60%,70%,80%,90%, and 100%. Portland cement from Pozzolana was kept constant in all blends. The concrete mixes are made by replacing M sand and recycled coarser aggregates.

Mix type	Cement (kg/m³)	Sand (kg/m³)	M-Sand (kg/m³)	NCA (Kg/m³)	RCA (kg/ m³)	Water (kg/m³)
Control mix	454	681	0	1362	0	205
R10M10	454	612.9	68.1	1225.8	136.2	205
R20M20	454	544.8	136.2	1089.6	272.4	205
R30M30	454	476.7	204.3	953.4	408.6	205
R40M40	454	408.6	272.4	817.4	544.8	205
R50M50	454	340.5	340.5	681	681	205
R60M60	454	272.4	408.6	544.8	817.4	205
R70M70	454	204.3	476.7	408.6	953.4	205
R80M80	454	136.2	544.8	272.4	1089.6	205
R90M90	454	68.1	612.9	136.2	1225.8	205
R100M100	454	0	681	0	1362	205

Table 3.1 Proportions of CONCRETE mix (kg/m3).

3.2. METHODOLOGY: -

I. Batching (by weight) & Mixing: - R C A, natural-coarse-aggregate, -ine-aggregates and cement were mixed in a big steel tray -irst in dry condition by manually weighting meticulously for batching. Water was then added and stirred for a further 6 to 8 minutes.

The complete mixing process was done manually by hands.

II. Casting 0f Cubical moulds: - 44 number of cubes 150 mm x 150 mm x 150 mm in size in total were used to assess the compressive strength of the mixtures after 7 and 28 days.

Recycled coarse aggregate (RCA) with a 20 mm size is used to replace natural coarse aggregate (NCA). The levels of RCA replacement are 10%,20%,30%,40%,50%,60%,70%,80%,90%, and 100%. M-sand is used to replace natural -ine aggregate by 10%,20%,30%,40%,50%,60%,70%,80%,90% and 100%. Slump-low testing and compressive strength testing are two of the procedures used to determine the qualities of concrete mixtures.

III. Pouring & Compacting New or Fresh concrete: - the freshly prepared concrete is then -illed into the moulds of size 150 mm x 150 mm x 150 mm. The concrete is -illed into the moulds in three different layers followed by 25 blows of compaction on each layer with the help of a tamping rod of 60cm in length. The compaction of the concrete was purely done manually by means of hands.

IV. Nomenclature of samples: - The symbol R stands for recycled aggregates, after which comes the proportion of recycled aggregates, and the letter M stands for M-Sand, proceeded by the percentage of M Sand, when manufacturing the test specimens. For instance, R50M50 denotes a blend of 50% M-Sand and 50% RCA.

V. Demoulding of cubes: - After casting the cubes were demoulded after 24hrs carefully by not damaging the edges of the cubes.

VI. Curing of test specimens: - all the test specimens were cured by completely submerging into the water in a curing tank for 7-days and 28-days. The water for curing should be changed after every 7 days. The curing was done con-irming to IS 456-2000 up to the date or day of testing viz 7 and 28 days.

4. Results and discussions

The concrete so manufactured was tested in its fresh and hardened state. First of all the fresh property of concrete I.e workability was determined by means of slump cone test and followed by the test on hardened concrete I,e compressive strength test by a compression testing machine.

4.1. Workability test: - Un-inished or freshly mixed concrete has a trait called workability. Concrete that can be compacted and poured without experiencing any segregation is considered to be workable. Simply said, positioning convenience determines workability. The slump cone test, which measures the workability of freshly prepared concrete, can be used.

The result of slump cone test shows that the Workability was reduced when manufactured sand and RCA were both replaced in greater percentages. The test was performed only on the mixes containing 25%, 50%, 75% and 100%

recycled aggregates and M - Sand because of the very minute readings were recorded for other mixes.

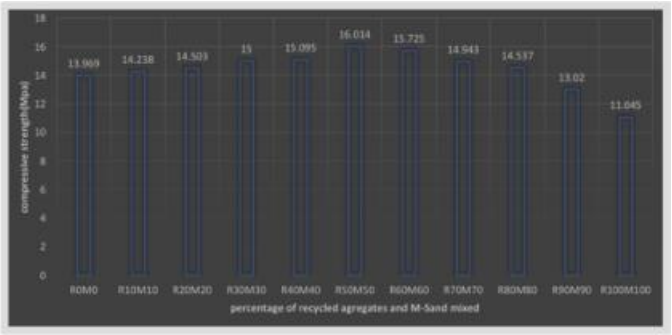
MIX	SLUMP (MM)
Control mix	60
25%RCA and 25%M-Sand	55
50%RCA and 50%M-Sand	40
75%RCA and 75%M-Sand	35
100%RCA and 100%M-Sand	32

Table 4.1 shows the conclusions for workability in terms of slump value

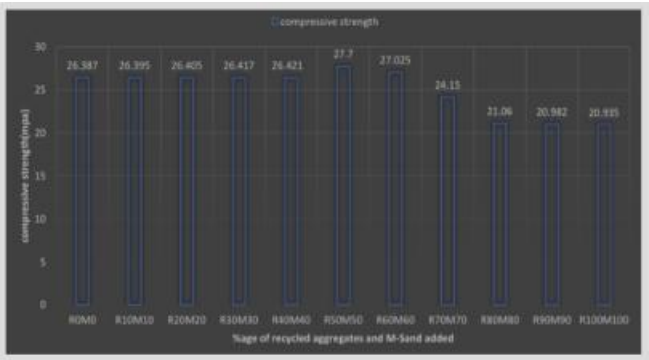
4.2 compressive strength test: - Compressive strength was assessed using a computerised testing machine with a 3000kN capability. A total of 44 cubes were tested in which 22 cubes were tested at 7 days and 22 cubes were tested at 28 days. The average of compressive strength of two cubes were taken into account to measure the compressive strength. The compressive strength of mixes is reduced when NCA is replaced with RCA, as it can be observed from -ig. Compressive strength declines as RCA % rises.

MIX	Average Compressive strength at 7-days (MPa)	Average Compressive strength at 28-days (MPa)
Control mix	13.969	26.421
R10M10	14.238	26.417
R20M20	14.503	26.405
R30M30	13.00	26.395
R40M40	15.095	26.387
R50M50	16.014	27.70
R60M60	15.725	27.025
R70M70	14.943	24.150
R80M80	14.537	21.060
R90M90	13.020	20.926
R100M100	11.045	20.935

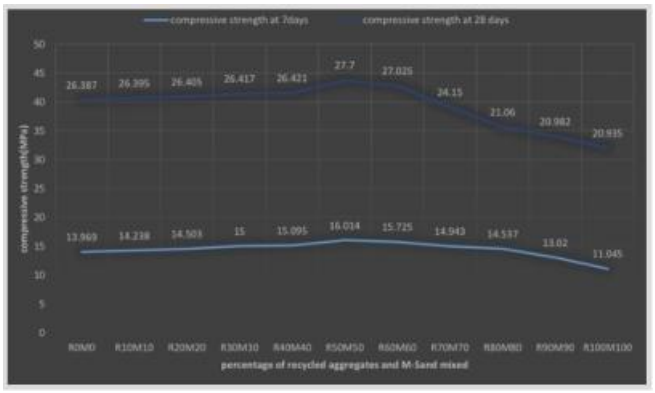
Table 4.2 comparison of compressive strength of concrete mixes of different %ages of RCA and M-Sand



Graph 4.1 Comparison of the concrete mixtures using recycled aggregates and M-sand after 7 days of compressive testing.



Graph 4.2 Comparison of the concrete mixtures using recycled aggregates and M-sand after 28 days of compressive testing.



Graph 4.3 Comparison of the concrete mixtures using recycled aggregates and M-sand after 7 and 28 days of compressive testing.

5. CONCLUSIONS: - The fresh and hardened qualities of the concrete mixes were evaluated through tests. The following conclusions can be drawn as a result of the experimentation.

• The objective of the current experimental work is to assess whether M-sand can completely replace natural -ine aggregate, and as a result, the consequence of M-sand on the mechanical and fresh qualities of concrete employing M-sand is assessed. With an increase in the percentage of both M- sand and RCA, more water is needed to produce a certain level of workability.

• The compressive capacity of concrete mixes is increased by up to 50% when M-sand is used in place of natural -ine aggregate. Its maximum compressive strength was 27.700 N/mm2. The compressive strength of concrete mixes is signi-icantly affected by a further increase in the M-sand replacement %.

• We can see that a 50% replacement mix has more strength than a 20% or 60% replacement mix, hence the optimum value is 50%.

• Nowadays, river sand is in short supply. M-sand meets the sand requirements in concrete.

• Recycled coarse aggregate can be utilised in place of natural coarse aggregate, but only to a limited extent.

• Based on this Ginding, it is stated that reutilising and reusing RCA and M-sand in concrete could aid in the resolution of its handling and disposal issues.

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