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Experimental Study of Mechanical Properties of Concrete using Recycled Aggregate with Nano Silica

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Abstract - *This paper presents the experimental study of mechanical properties of concrete using recycled aggregate with nano silica parameters such as compressive strength, flexural strength and split tensile strength of the M20 and M30 grade of concrete. The fine aggregate was replaced with recycled aggregate as proportions of 0%, 20%, 30%, 40%, 50% and nano silica 0%,1%,2%,3% and 4%. Mix design was prepared (1:2.71:3.64) with water cement ratio 0.53 for M20 and (1:2.04:2.94) with water cement ratio 0.45 for M30 grade of concrete. By replacement of recycled aggregate as fine aggregate we can reduce the consumption of natural and environmental resources. Test were performed for mechanical properties concrete using recycled aggregate using variation of nano silica. The results indicate that mechanical properties of concrete increases with increase in recycled aggregate and nano silica percentage. The results also demonstrated that the compressive strength, flexural strength and split tensile strength gives maximum strength at replacement of fine aggregate by recycled aggregate with using nano silica.*

Key Words: *Compressive Strength, Flexural Strength, Recycled Aggregate, Nano silica, Splitting Tensile Strength.*

1. INTRODUCTION

The use of recycled aggregates in concrete opens a whole new range of possibilities in the reuse of materials in the building industry. The utilisation of recycled aggregates is a good solution to the problem of an excess of waste material, provided that the desired final product quality is reached. This reduces the consumption of the natural resources as well as the consumption of the landfills required for waste concrete. Recycling is the act of processing the used material for use in creating new product. The usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. Technology today has advanced so far that it is forcing us to think of new concept called sustainability. To employ recycled aggregate derived from concrete waste in a reinforced concrete structure, properties as compression resistance, recycled aggregate water absorption ratio, recycled aggregate crushing resistance and concrete modulus of elasticity can give away important information on understanding the mechanical behaviour and provide indications of the new product's reliability. The reduction of mechanical strengths can be improved with use of nano - technology applied to concrete includes the use of nano materials. Nano-materials refer to materials that at least, one of its dimensions is less than 100 nm. With regard to issues such as strength, resistance, durability, and high performance, the construction industry is one of the important users of nano-materials. By adding the nano materials, concrete composites with superior properties can be produced. Nano silica is one of the most applied nano-particles in concrete. It is a new pozzolanic material which is in water in a solid or liquid form. In the concrete industry. Addition of nano silica (NS) in concretes and mortars results in more efficient hydration of cement. Due to the pozzolonic activity, additional calcium silicate hydrates are formed to generate more strength and to reduce free calcium hydroxide. This also helps in reducing the cement requirement, NS improves the microstructure and reduces the water permeability of concrete thus making it more durable.

2. OBJECTIVE

The main objective of this research work is to study the characteristic properties of concrete produced by replacing the natural aggregate by recycled aggregate in different percentages along with colloidal nano silica and to improve the properties of recycled aggregate concrete. Also the objective of this study is to investigate the mechanical properties like split tensile strength, compressive strength and flexural strength.

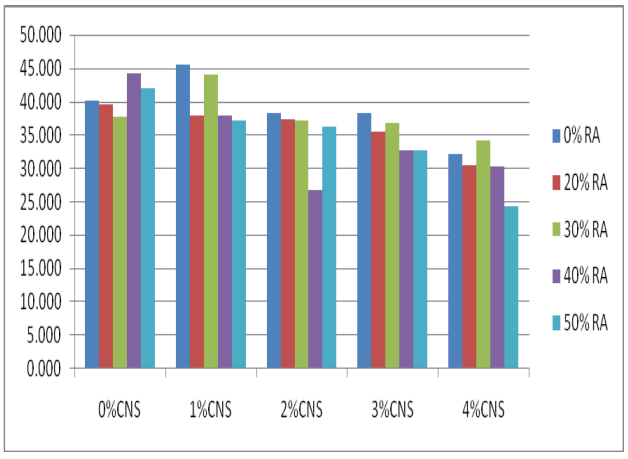
3. RESEARCH METHODOLOGY

The concrete ingredients were weighed according to their mix proportion and they were dry mixed. All the aggregates were maintained in saturated surface dry (SSD) state. The recycled aggregates were subjected to pre-wetting. The natural coarse aggregates were replaced by recycled aggregates in the proportion of 0%, 10%, 20%, 30%, 40% and 50% along with 0%, 1%, 2%, 3% and 4% colloidal nano silica as replacement to cement. To determine the strength characteristics, three specimens for each variation for the various tests were cast and cured for 28 days. Concrete cubes of size 150x150x150 mm were tested for compressive strength as per IS: 516-1959. To get the tensile strength, cylindrical specimens of size 150mm diameter and 300 mm length were tested as per IS:5816-1999. For flexural strength, beam specimens of size 150x150x700mm were tested. Two point loading was adopted on an effective span of 600 mm to get pure bending, while testing the beam specimens as per IS:516-1959. The results are analyzed.

4. RESULTS AND DISCUSSION

Compressive Strength of M-30 Grade of Concrete

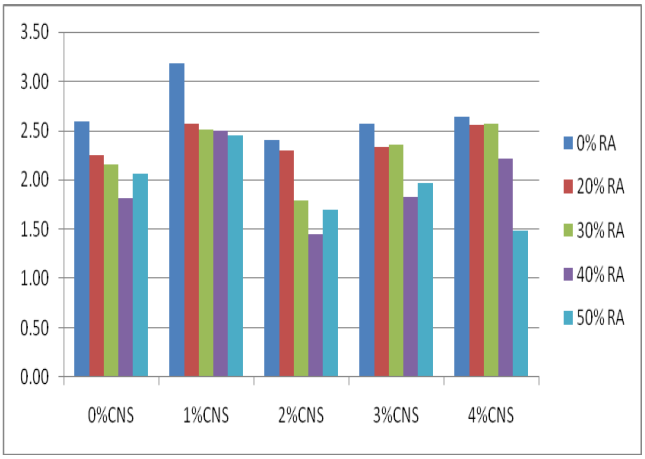
Sr. No.	Mix Identity	Avg. Compressive Strength (N/mm²)
1	0	33.96
2	0.2	33.16
3	0.3	30.31
4	0.4	31.63
5	0.5	33.64
6	1	31.53
7	1.2	34.28
8	1.3	30.97
9	1.4	32.73
10	1.5	31.62
11	2	28.82
12	2.2	3080
13	2.3	30.13
14	2.4	31.59
15	2.5	29.71
16	3	32.47
17	3.2	33.67
18	3.3	27.94
19	3.4	32.06
20	3.5	32.16
21	4	28.02
22	4.2	33.32
23	4.3	32.16
24	4.4	29.65
25	4.5	30.6



Bar Chart Showing Variation Of Compressive Strength Of Concrete Produced By Replacing Natural Coarse Aggregate By Recycled Aggregates And Cement By Nano Silica

Tensile Strength of M-30 Grade of Concrete

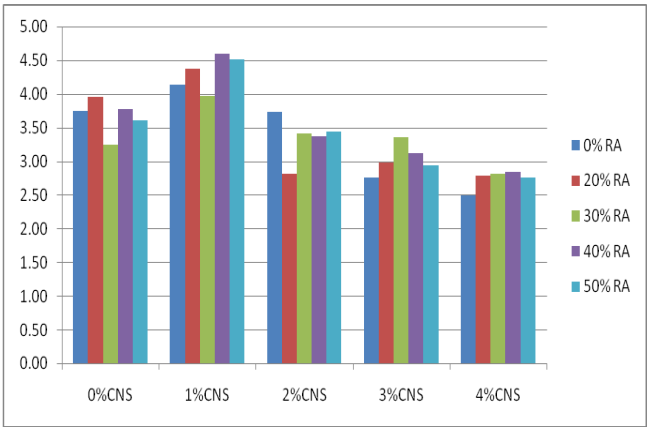
Sr. No.	Mix Identity	Avg. Tensile Strength (N/mm²)
1	0	2.59
2	0.2	2.25
3	0.3	2.15
4	0.4	1.81
5	0.5	2.06
6	1	3.18
7	1.2	2.57
8	1.3	2.51
9	1.4	2.50
10	1.5	2.45
11	2	2.40
12	2.2	2.30
13	2.3	1.79
14	2.4	1.45
15	2.5	1.69
16	3	2.57
17	3.2	2.33
18	3.3	2.35
19	3.4	1.83
20	3.5	1.96
21	4	2.63
22	4.2	2.55
23	4.3	2.57
24	4.4	2.22
25	4.5	1.49



Bar Chart Showing Variation Of Tensile Strength Of Concrete Produced By Replacing Natural Coarse Aggregate By Recycled Aggregates And Cement By Nano Silica

Flexural Strength of M-30 Grade of Concrete

Sr. No.	Mix Identity	Avg. Flexural Strength (N/mm^2)
1	0	3.75
2	0.2	3.96
3	0.3	3.24
4	0.4	3.78
5	0.5	3.61
6	1	4.13
7	1.2	4.38
8	1.3	3.98
9	1.4	4.60
10	1.5	4.52
11	2	3.73
12	2.2	2.82
13	2.3	3.41
14	2.4	3.37
15	2.5	3.43
16	3	2.76
17	3.2	2.99
18	3.3	3.36
19	3.4	3.11
20	3.5	2.94
21	4	2.50
22	4.2	2.79
23	4.3	2.82
24	4.4	2.84
25	4.5	2.76



Bar Chart Showing Variation Of Flexural Strength Of Concrete Produced By Replacing Natural Coarse Aggregate By Recycled Aggregates And Cement By Nano Silica

5. CONCLUSIONS

1. Workability of concrete reduces as the percentage replacement of natural coarse aggregates by recycled aggregates increases.
2. There is a reduction in compressive strength of concrete with increase in the percentage replacement of natural coarse aggregates by recycled aggregates and cement by nano silica. With 50% replacement of natural coarse aggregates by recycled aggregates and cement by 4% nano silica shows 15.52% decrease of compressive strength.
3. The optimum combination is for 40% replacement of natural aggregate by recycled aggregates and 3% of replacement of cement by nano silica.
4. There is a reduction in tensile strength of concrete with increase in the percentage replacement of natural coarse aggregates by recycled aggregates and cement by nano silica. With 50% replacement of natural coarse aggregates by recycled aggregates and cement by 3% nano silica shows 23.71% decrease of Tensile strength.
5. There is a reduction in flexural strength of concrete with increase in the percentage replacement of natural coarse aggregates by recycled aggregates and cement by nano silica. With 50% replacement of natural coarse aggregates by recycled aggregates and cement by 4% nano silica shows 33.66% decrease of Flexural strength.
6. For replacement of natural aggregates by recycled aggregates upto 20%, the effects are marginal; the reduction in workability in terms of slump is about 14.71%
7. From compressive strength consideration the optimum mix proportion is for mix with 40% replacement of natural coarse aggregates by recycled aggregates and 3% cement by nano silica. It is observed that for 50% replacement of natural coarse aggregates by recycled aggregates there is sudden reduction in compressive strength for all doses of nano silica.
8. From tensile strength consideration the optimum mix proportion is for mix with 20% replacement of natural coarse aggregates by recycled aggregates and 1% cement by nano silica. It is observed that for 50% replacement of natural coarse aggregates by recycled aggregates there is extreme reduction in compressive strength for all doses of nano silica.
9. From flexural strength consideration the optimum mix proportion is for mix with 20% replacement of natural coarse aggregates by recycled aggregates and 2% cement by nano silica. It is observed that for 40% replacement of natural coarse aggregates by recycled aggregates there is intense reduction in compressive strength for all doses of nano silica.

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