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Strength and Durability Properties of Nano Concrete by Partial Replacement of Coarse Aggregate with Recycled Aggregate

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ABSTRACT: This paper presents the experimental study of mechanical properties of concrete using recycled aggregate with nano titanium dioxide parameters such as compressive strength, split tensile strength, flexural strength and durability tests like water absorption, acid resistance and chloride resistance of the M30 grade of concrete. The coarse aggregate was replaced with recycled aggregate as proportion of 30%, 60%, 100% and nano titanium dioxide 0.5%, 1%, 1.5%, and 2%. Mix design was prepared with water cement ration 0.46. by replacement of recycled aggregate as coarse aggregate we can reduce the consumption of natural and environmental resources. Test were performed for mechanical properties of concrete using recycled aggregate using variation of nano titanium dioxide. The results indicate that mechanical and durability properties of concrete increases with increases in recycled aggregate and nano titanium dioxide percentage. The results also demonstrated that strength and durability properties gives maximum value at replacement of coarse aggregate by recycled aggregate with using nano titanium dioxide.

KEYWORDS: Nano titanium dioxide, Recycled aggregate, Acid resistance, Chloride resistance

I. INTRODUCTION

Concrete is one of the building materials widely used in civil engineering construction. Many researchers have focused on the improvement of concrete quality regarding its mechanical and durability properties.Nanotechnology is one of the most active research area which has wide applications in almost all the fields.Improving concrete properties by addition of nano particles have shown significant improvement than conventional concrete.Nanomaterial due to its small size possess unique properties such as high specific surface area and high activity.If nanomaterial are combined with traditional building material, this may lead to production of building material with unique properties.The use of nanomaterial cannot only modify properties by potentially enhancing strength and durability but also by introduction new functionality, including photocatalytic activity, self cleaning activity etc.

Construction and demolition waste constitute a major portion of total solid waste production in the world. Construction and demolition waste is generated whenever any constructionand demolition activity takes place, such as buildings, roads, bridges, flyover, subway etc. These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste. Concrete waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to makeconcrete for road construction and building materials. In this project check the properties of concrete with addition of nanomaterials and replacement of coarse aggregate by demolition concrete waste .



(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: <u>www.ijirset.com</u>

Vol. 7, Issue 3, March 2018

II. LITERATURE REVIEW

Worldwide research is in pace on studying the effect of addition of nanomaterials in concrete. Large volume of literature is available in this field and a few of them relevant to the current study are summarized here. Nano particles increases the properties of concrete than conventional concrete.SiO2, Al2O3, Fe2O3, TiO2, ZnO etc. are some examples considered as nanoparticles in nano concrete.Percentages of nanoparticles replacing the cement ranges from 0 to 4% by weight of cement.Replacement of coarse aggregate with demolished concrete waste has also resulted in change properties of concrete which ranges from 0 to 100% of by weight of total coarse aggregate.

III. MATERIALS AND METHODS

III.1 MATERIAL PROPERTIES

Different tests were conducted for each material as specified by relevant IS codes.

III.1.1 Cement

Cement act as a binder material to keep fine aggregate and coarse aggregate together.OPC 53 grade cement are to be used. Laboratory tests were conducted on cement to determine the physical properties such as standard consistency, initial setting time, final setting time, specific gravity and fineness.

Table 1. Physical properties of cement

properties	Test results	Is specification and test procedure
Specific gravity	3.14	3-3.15, IS 4031 part2-1988
Standard consistency	35%	33-35%, IS 4031 part4- 1988
Initial setting time	35 min	>30 min, IS 4031 part5-1988
Final setting time	360 min	<600 min, IS 4031 part5-1988
Fineness	8%	<10%, IS 4031 part1-1996

III.1.2 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement, since it helps to form the strength giving cement gel the quantity and quality of water is required to be looked in to very carefully

III.1.3 Coarse aggregate

The usual range employed is between 9.5mm and 37.5mm in diameter. Typically the most common size of aggregate used in construction is 20mm. A larger size, 40mm, is more common in mass concrete. In this project 20mm aggregate are used.

Properties	Test results	Is specification and test procedure
Specific gravity	2.72	2.5-2.9, IS 2386 part 3-1963
Fineness modulus	6.2	6-6.9, IS 2386 part 1-1963
Moisture content	0.23%	
Water absorption	0.5%	0.5-1%
Impact value	23.8%	For concrete not more than 30%, IS: 2386(Part IV)-1963
Crushing value	17.4%	Should not exceed 45%, IS: 2386(Part IV)-1963

Table 2. Properties of Coarse Aggregate



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

III.1.4 Recycled aggregate

Concrete waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building materials.

Table 3. I Topel lies of Coalse Aggregate	Table 3.	Properties	of Coarse	Aggregate
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Properties	Test results	Is specification and test procedure
Specific gravity	2.76	2.5-2.9, IS 2386 part 3-1963
Fineness modulus	6.3	6-6.9, IS 2386 part 1-1963
Moisture content	0.19%	
Water absorption	0.8%	0.5-1%
Impact value	27%	For cement concrete aggregate impact value
		not more than 30%, IS: 2386(Part IV)-1963
Crushing value	18.8%	Should not exceed 45%, IS: 2386(Part IV)-
		1963

III.1.5 Fine aggregate (M sand)

In this present study, M sand was used as fine aggregate. The sand used for the experimental program was locally procured and conformed to Indian standard specification. The sand was first sieved through 4.75mm sieve to remove any particles greater than 4.75mm and then was washed to remove dust.

Table 4. Properties of Fine Aggregate

Properties	Test results	Is specification and test procedure
Specific gravity	2.76	2.6-2.8, IS 2386 part 3-1963
Fineness modulus	3.11	2.1-3.37, IS 2386 part 1-1963
Moisture content	2.4%	
Water absorption	2%	2-4%

III.2 TESTS PLANNED

Mechanical properties such as strength and durability of different cube, cylinder and beam specimens are to be evaluated. Following tests are planned

1. Workability tests-slump cone test.

- 2. Strength test Compressive strength, Flexural strength and Split tensile strength.
- 3. Durability test Water absorption, Acid resistance and Chloride resistance

IV.RESULTS AND DISCUSSIONS

Different experiments where done to determine properties of nano concrete. For the specimen were tested after 7 and 28 days of curing. The mechanical properties like compressive strength, split tensile strength and flexural strength and also durability properties like water absorption and resistance to different chemical environment was done.



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

IV.I MIXES

Ν	Control mix
T 0.5	Replacing cement with 0.5% nano titanium dioxide
T 1	Replacing cement with 1% nano titanium dioxide
T 1.5	Replacing cement with 1.5% nano titanium dioxide
R 30	Replacing coarse aggregate(CA) with 30% recycled aggregate(RA)
R 60	Replacing coarse aggregate with 60% recycled aggregate
R100	Replacing coarse aggregate with 100% recycled aggregate
T0.5 R30	Replacing cement with 0.5% of nano titanium dioxide & CA with 30% RA
T0.5 R60	Replacing cement with 0.5% of nano titanium dioxide & CA with 60% RA
T0.5 R100	Replacing cement with 0.5% of nano titanium dioxide & CA with 100% RA
T1 R30	Replacing cement with 1% of nano titanium dioxide & CA with 30% RA
T1 R60	Replacing cement with 1% of nano titanium dioxide & CA with 60% RA
T1 R100	Replacing cement with 1% of nano titanium dioxide & CA with 100% RA
T1.5 R30	Replacing cement with 1.5% of nano titanium dioxide & CA with 30% RA
T1.5 R60	Replacing cement with 1.5% of nano titanium dioxide & CA with 60% RA
T1.5 R100	Replacing cement with 1.5% of nano titanium dioxide & CA with 100% RA
T2 R30	Replacing cement with 2% of nano titanium dioxide & CA with 30% RA
T2 R60	Replacing cement with 2% of nano titanium dioxide & CA with 60% RA
T2R100	Replacing cement with 2% of nano titanium dioxide & CA with 100% RA

IV.2 FRESH CONCRETE PROPERTIES

IV.2.1 Workability tests

Slump test is one of the most commonly used tests to find the workability of concrete at the current time. This test involves the use of slump cone and measure the drop in height of the slump of the concrete mix. The test measures consistency of concrete in that specific batch. It is performed to check the consistency of freshly made concrete, and therefore the ease with which concrete flows..

Percentage of nano titanium dioxide	Slump (mm)
0	73
0.5	71
1	68
1.5	65

Table 5.Slump test results for replacing nano titanium dioxide

Slump test results for different percentage of nano titanium dioxide replacement are given in table5. As percentage of nano titanium dioxide increases slump decreases. Decreases in may be due to high surface area of nano titanium dioxide.

Table 6.slump results for replacing recycled aggregate		
Percentage of recycled aggregate	Slump (mm)	
30	72	
60	70.5	
100	67	

Table 6.slump results for replacing recycled aggregat



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

Slump test results for different percentage of recycled aggregate replacement are given in table 6. As percentage of nano titanium dioxide increases slump decreases. Decreases in may be due to high water absorption rate of recycled aggregate compared with normal aggregate

Test results for different percentage of coarse aggregate replaced with recycled aggregate and cement by nano titanium dioxide are given in table 7.

Specimen identification	Slump (mm)
T0.5R30	74
T0.5R60	68
T0.5R100	67
T1R30	73
T1R60	69.8
T1R100	67
T1.5R30	73.8
T1.5R60	71
T1.5R100	70
T2R30	69
T2R60	67.5
T2R100	66

Table 7. Slump test results for replaced concrete



Fig 1 Variation of slump for different percentage of recycled aggregate and nano titanium dioxide replacement



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

IV.3 HARDENED CONCRETE PROPERTIES

IV.3.1 Compressive strength

The following table gives the results of compressive strength for concrete at different percentages of nanotitanium dioxide and recycled aggregate.

Table 8. Compressive strength test results			
	Compressive strength (N/mm ²)		
Specimen			
identification	7 day	28 day	
Ν	22	30.8	
T0.5R30	24	33.6	
T0.5R60	22	30.8	
T0.5R100	21.5	30.1	
T1R30	24.8	34.72	
T1R60	31.5	44.1	
T1R100	23	32.2	
T1.5R30	26	36.2	
T1.5R60	35	49	
T1.5R100	23.2	32.48	
T2R30	22.5	31.5	
T2R60	28	39.2	
T2R100	21	29.4	



Fig 2.Bar chart showing variation of compressive strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nano titanium dioxide at 7day.



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018



Fig 3.Bar chart showing variation of compressive strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nano titanium dioxide at 28 day.

IV.3.2 Split tensile strength

Splitting tensile test is used to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle in nature. The concrete develop cracks subjected to tensile forces. Cylindrical specimen of 150mm diameter and 300mm height is used to find the tensile strength.

	Split tensile strength (N/mm ²)	
Specimen		
identification	7 day	28 day
Ν	1.98	6
T0.5R30	2.02	7.2
T0.5R60	2.01	7
T0.5R100	2	6.8
T1R30	2.03	7.5
T1R60	2.1	8
T1R100	2.02	7.2
T1.5R30	2.04	7.6
T1.5R60	2.2	8.75
T1.5R100	2.01	7.1
T2R30	2.1	7.8
T2R60	2.05	7.3
T2R100	2.03	7.25

Table 9. Split tensile strength result



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018



Fig 4 Bar chart showing variation of split tensile strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nanotitanium dioxide at 7day



Fig 5 Bar chart showing variation of split tensile strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nanotitanium dioxide at 7day

IV.3.3Flexural strength

The flexural strength test was conducted as per IS 516 -1959 on beams using a flexural testing machine. The testing machine shall be of sufficient capacity for the test and capable of applying a load at the rate of 1.8 KN per minute for 100 mm specimens and the rate of 4KN per minute for 150mm specimens. Beams of size 100mm x 100mm x 500mm are used for flexural strength



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Vol. 7, Issue 3, March 2018

Table 10. Flexural strength result

	Flexural strength (N/mm ²)	
Specimen		
identification	7 day	28 day
N	3.7	5.6
T0.5R30	5	8
T0.5R60	4.25	8.1
T0.5R100	4	6
T1R30	4.36	6.2
T1R60	5.1	8
T1R100	4.25	8.2
T1.5R30	5.75	7.75
T1.5R60	6.2	9.2
T1.5R100	5	8
T2R30	4.1	6.1
T2R60	4.25	6.25
T2R100	4.2	6.4



Fig 6.Bar chart showing variation of flexural strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nano titanium dioxide at 7day



Fig 7.Bar chart showing variation of flexural strength of concrete produced by replacing natural coarse aggregate by recycled aggregate and cement by nano titanium dioxide at 28 day



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

IV.3.4 Water absorption

This test inspect water absorption of concrete cubes size 100X100X100 mm. The weights of specimens were measured after casting (W1). After 28 and 56 days of curing in water, the specimen were surface dried and weight is measured (W2).Percentage of water absorption = [(W2-W1)/W1] x100

	Percentage of water absorbed		
Mix	7 day	28 day	
T0.5R30	0.09	0.28	
T0.5R60	0.08	0.27	
T0.5R100	0.086	0.26	
T1R30	0.081	0.24	
T1R60	0.06	0.2	
T1R100	0.07	0.21	
T1.5R30	0.05	0.15	
T1.5R60	0.053	0.16	
T1.5R100	0.056	0.17	
T2R30	0.05	0.15	
T2R60	0.043	0.12	
T2R100	0.04	0.13	

Table11. Water absorption test results



Fig 8. water absorption at 7 day



Fig 9. water absorption at 28 day



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

IV.3.5 Acid resistance

 Table 12. Acid resistance test result

	Loss of weight (%)		Loss of strength (%)	
Mix	7 day	28 day	7 day	28 day
T0.5R30	0.33	1.01	2.7	8.1
T0.5R60	0.39	1.17	3.1	9.32
T0.5R100	0.41	1.25	2.8	8.5
T1R30	0.42	1.28	3	9.05
T1R60	0.38	1.14	2.7	8.3
T1R100	0.44	1.32	3.2	9.8
T1.5R30	0.34	1.02	2.6	7.82
T1.5R60	0.33	1.01	2.5	7.6
T1.5R100	0.37	1.12	2.7	8.12
T2R30	0.34	1.04	2.6	8
T2R60	0.36	1.08	2.72	8.16
T2R100	0.4	1.22	3.1	9.3



Fig 10.Weight loss of replacing concrete after 7 and 28 day (acid resistance)



Fig 11. Strength loss of replacing concrete after 28 day (acid resistance)



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

IV.3.6 Chloride resistance

Table 13. Chloride resistance test result

	Loss of weight (%)		Loss of strength (%)	
Mix	7 day	28 day	7 day	28 day
T0.5R30	0.1	0.3	0.7	2.1
T0.5R60	0.12	0.32	0.71	2.14
T0.5R100	0.13	0.41	0.73	2.2
T1R30	0.13	0.41	0.86	2.6
T1R60	0.1	0.4	0.87	2.63
T1R100	0.14	0.42	0.9	2.7
T1.5R30	0.11	0.35	0.68	2.06
T1.5R60	0.1	0.3	0.67	2.01
T1.5R100	0.12	0.34	0.73	2.2
T2R30	0.14	0.44	1.13	3.4
T2R60	0.17	0.51	1.07	3.21
T2R100	0.16	0.5	1.05	3.15







Fig 13. Strength loss of replacing concrete after 28 day (chloride resistance)



(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

V. CONCLUSION

The enrichment of compressive and tensile strength of concrete was achieved by addition of nano titanium as nano particles of silica act as filler material to fill the void in recycled aggregate and making concrete stronger and denser. The value of compressive strength of different percentage of recycled aggregate replacing coarse aggregate and nano titanium dioxide replacing cement are given in table. The maximum strength is obtained with 1.5% replacing of nano titanium dioxide and 60% replacing recycled aggregate. The values of compressive strength obtained at 7 and 28 day testing are 35N/mm² and 49 N/mm². The value of split tensile strength of different percentage of recycled aggregate replacing coarse aggregate and nano titanium dioxide replacing cement are given in table. The maximum strength is obtained with 1.5% replacing of nano titanium dioxide and 60% replacing recycled aggregate. The values of split tensile strength obtained at 7 and 28 day testing are 2.2N/mm² and 8.75N/mm². The value of flexural strength of different percentage of recycled aggregate replacing coarse aggregate and nano titanium dioxide replacing cement are given in table. The maximum strength is obtained with 1.5% replacing of nano titanium dioxide and 60% replacing recycled aggregate. The values of split tensile strength obtained at 7 and 28 day testing are 6.2N/mm² and 9N/mm².Water absorption test results for different percentage of replaced concrete are given in table. The minimum percentage of water absorption is obtained with 2% replacing of nano titanium dioxide and 60% replacing recycled aggregate. The nano particle filled the minute pores of concrete. So the water absorption is decreases when increases nano titanium content in concrete.Cost comparison between conventional concrete and the concrete mix with 1.5% nano titanium dioxide and replacing cement and 60% recycled aggregate replacing natural coarse aggregate shows that the replaced mix is economical than conventional concrete.

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