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EXPERIMENTAL INVESTIGATION OF CONCRETE USING TITANIUM DIOXIDE

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Abstract *- This study shows the results of a concrete containing titanium dioxide experimental investigation. The main aim of this study is to increase concrete structures' strength and durability. The favourable results are given by a small percentage of titanium dioxide (TiO_2) addition. The concrete is mixed with different percentages of titanium dioxide (0%, 0.5%, 1%, 1.5% and 2%) of powder content. According to IS 10262:2009 and IS 415:2000, the M35-grade concrete mix proportions were obtained. In the laboratory, the concrete was developed and the characteristics of both fresh and hardened concrete were examined using appropriate testing. There have been fresh concrete tests like slump flow testing. The specimens such as cubes, cylinders and beam were casted and cured. After 28 days of curing, hardened concrete tests such as split tensile strength test, compressive strength test and flexural strength tests were experimentally done. At 1.5% replacement of titanium dioxide (TiO2) by weight of cement, the maximum strength was achieved.*

Keywords: Cement, Coarse aggregate, Fine aggregate, TiO_2

1. INTRODUCTION

Most concrete structures were polluted due to environmental factors. The use of titanium dioxide (TiO_2) will make concrete structures free of pollution. When these materials absorb UV radiation from the sun, hydroxyl radicals and superoxide anions are created with the ability to react with polluting molecules like NO_X to convert them into less harmful substances and to increase concrete strength.

1.1 Concrete

Concrete is the world's second most widely used building material. Concrete is a building material composed of cement, fine aggregate, and coarse aggregate mixed with water that is time-hardening. In concrete mixtures, the admixtures or super plasticizers are mainly used to obtain workability. Portland cement is the type of cement most widely used for concrete production.

1.2 Titanium dioxide

Titanium dioxide is titanium's natural oxide. TiO2 is its chemical formula. When adding nano particles (TiO_2) with standard particle size of 15nanometers (nm) to the concrete specimens, physical and mechanical characteristics were measured. These nanoparticles help improve concrete's permeability and strength as a substitute for cement (up to 2% cement weight). Rutile, anatase and brookite are the three common types of titanium dioxide. Titanium dioxide is also said to be concrete self-cleaning or white concrete. It not only gives durability to the structures but also an esthetic appearance.

Rutile is titanium dioxide's most stable form Anatase and brookite are constant, but converted slowly when heated to rutile at normal temperatures. The anatase-based TiO_2 has been used in this project. Nowadays, the applications have been expanding to surfaces with anti-fog properties. Titanium dioxide can be used in different fields ranging from paint, sunscreen to food coloring. Rutile based type titanium dioxide is used in this project.

1.3 Objective of study

This investigation is to bring down air pollution by using concrete with titanium dioxide. Study the compressive and splitting behavior of concrete contains titanium dioxide and to check the flexural strength in concrete. The research is also aimed at finding the optimum percentage of concrete titanium dioxide.

- To improve quality strength.
- To study about the behavior of concrete while the adding titanium dioxide of varying percentages in M35 grade concrete.
- To compare the result with conventional concrete

2. MATERIAL USED

2.1 Cement

Cement is a binder, a material used in construction that strengthens and binds together other materials. The most essential types of cement are used as a component in the manufacture of masonry mortar and concrete. Ordinary Portland cements (53 grades), was used in this project.

The physical properties of cement are listed below in Table 2.1

Table 2.1 Physical properties of cement

No	Properties	Observed value
1	Standard consistency	33%
2	Initial setting time	33min
3	Specific gravity	1.68%

2.2 Fine aggregate

The fine aggregate used in the making of concrete is natural river sand. Several tests were conducted to examine their properties for the required application, including sieve analysis and fineness module, specific gravity and absorption capacity, moisture content and unit weight as per IS:383-1970 specification.

The physical properties of fine aggregate is shown in table 2.2

Table 2.2 physical properties of fine aggregate

No	Properties	Observed value
1	Fineness modulus	3.03
2	Specific gravity	2.60
3	Zone of aggregate	Zone II

2.3 Coarse aggregate

Coarse aggregate is used to make concrete with crushed stone. It's quarried, crushed and graded the commercial stone. A lot of the crushed stone used in granite, calcareous and rock trap. The aggregate is used to refer to basalt, gabbro, diorite and other igneous rocks that are dark-colored, fine-grained. Crushed graded stone is usually just one type of rock and is broken with sharp edges.

The physical properties of coarse aggregate is shown below in table 2.3

Table 2.3 Physical properties of coarse aggregate

No	Properties	Observed value
1	Specific gravity	2.75
2	Nominal size of aggregate	20mm
3	Fineness modulus	6.67%

2.4 Titanium dioxide

The properties of titanium dioxide is shown below in table 2.4

Table 2.4 Properties of TiO_2

No	Properties	Observed value
1	Appearance	White
2	Odour	No
3	Specific gravity	4.26
4	Density	3.82g/cc

2.5 Mix design

The mix proportions for M35 grade concrete was obtained as per IS 10262:2009 is given by table 2.5.

Table 2.5 Mix Proportion for M35 grade

Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water kg/m^3
400	655.11	1133	172.68
1	1.56	2.90	0.43

3. EXPERIMENTAL WORK

In this investigation, test cubes, cylinders and beams were conducted. The step-by-step experimental work is as follows:

1) Material collection such as cement, fine aggregate, coarse aggregate and titanium dioxide were brought.

2) The M35-grade concrete mix design was calculated using standard Indian codes.

3) According to mix design, batching and weighing of materials was done.

4) The fresh concrete test (slump cone test) was performed and the ratio of water cement was found.

5) The sample such as cube and cylinders were prepared and the materials were casted into the respective moulds.

6) The beam mould is prepared and it is also casted using the mix proportions.

7) The moulds are removed and the sample in the water tank was healed.

8) Hardened concrete tests such as compressive strength test, split tensile strength test and flexural strength test have been found after 28days of curing.

4. EXPERIMENTAL PROGRAM AND RESULTS

4.1 Slump cone test

Slump test is the most usual method of measuring concrete consistency that can be used either in the laboratory or in the workplace. Slump is a measure that indicates cement concrete's consistency or workability. Bottom diameter= 200 mm, top diameter= 100 mm and height= 300 mm, however, it is conveniently used as a control test. The slump cone test value was found to be 78 mm for 0.43 water cement ratio. For this investigation, therefore, this ratio is used. Figure 4.1, Figure 4.2 and Figure4.3 show the slump cone test.

Fig 4.1 True slump

Fig 4.2 Shear slump

Fig 4.3 Collapsed slump

4.2 Compressive strength test

Compressive strength test is an important parameter to determine the performance of material during several weather conditions. Here, concrete mix of M35 grade is made with various proportions of titanium dioxide such as 0.5%, 1%, 1.5% and 2%. The size of concrete cube moulds are 15cm×15cm×15cm.Concrete cube specimens are made and cured for 28days. Fig 4.4 shows the graph for the compressive strength test and Fig 4.5 shows the tested cube.

Table 4.1 Compressive strength value

No	Sample ID	Naming of Cubes	At 7days (N/mm²)	At 28days (N/mm²)
1	CC	0% TiO_2	23.5	43.25
2	C1	0.5%TiO_2	32.14	49.46
3	C2	1% TiO_2	34.08	52.32
4	C3	1.5%TiO_2	38.76	59.64
5	C4	2%TiO_2	30.92	47.54

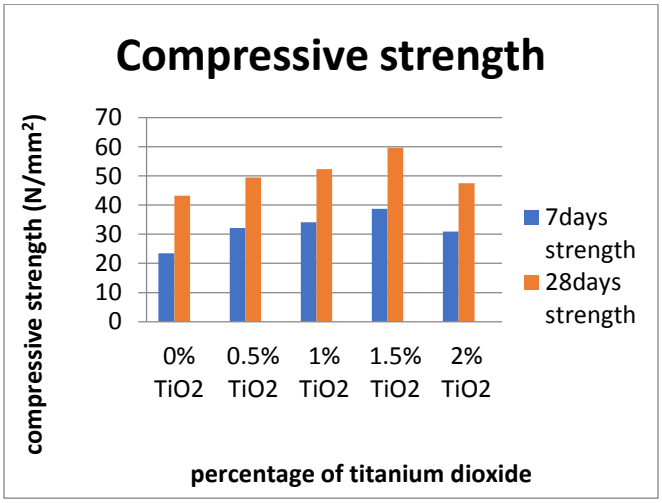

Fig 4.4 Compressive strength values

Fig 4.5 Compressive strength test

4.3 Split tensile strength test

Similar to compressive strength test of cube specimens split tensile strength test is done. Here, concrete mix of M35 grade is made with various proportions of titanium dioxide such as 0.5%, 1%, 1.5% and 2%. Samples of the cylinder are placed horizontally and testing is carried out. Using compressive testing machine, it is also tested. Figure 4.6 shows the divided tensile strength graph and Figure 4.7 shows the tested cylinder.

Table 4.2 Split tensile strength test

No	Sample ID	Naming of concrete Cylinders	At 7days (N/mm²)	At 28days (N/mm²)
1	CY0	0% TiO_2	1.96	3.02
2	CY1	0.5%TiO_2	2.24	3.46
3	CY2	1% TiO_2	2.52	3.85

4	CY4	1.5%TiO_2	2.67	4.12
5	CY5	2% TiO_2	2.35	3.62

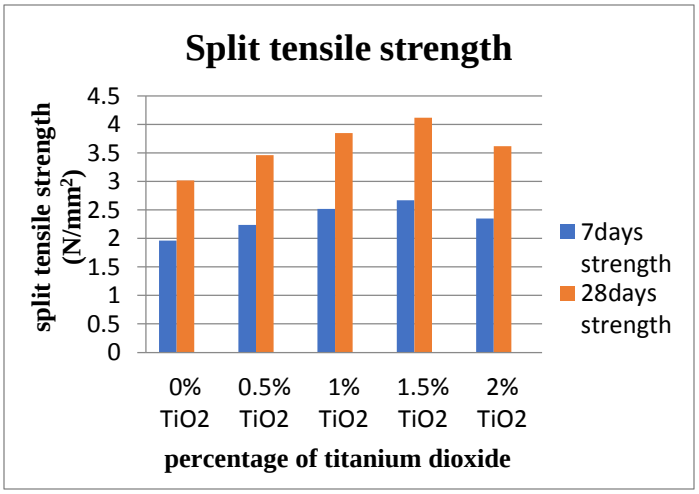

Fig 4.6 Split tensile strength values

Fig 4.7 Split tensile strength test

4.4 Flexural strength test

Flexural strength is the amount of force an object can take without permanently breaking or deforming. The beams are made, one with conventional concrete and other beam with 1.5%replacement of titanium dioxide. The beam is being healed and tested. Fig 4.6 shows the tested beam

Table 4.3 Flexural strength test

No	Mix	At 7days (N/mm^2)	At 28days (N/mm^2)
1	0% TiO_2	4.34	5.49
2	1.5% TiO_2	6.24	7.82

Fig 4.6 Flexural strength of beam

5. CONCLUSIONS

Based on the results and analysis, the following conclusions have been arrived.

- The concrete cube specimen of grade M35 with a 1.5% replacement of TiO_2 provides a higher compressive strength.
- Similarly, concrete cylinder split tensile strength with 1.5% replacement of TiO_2 shows a higher value compared to conventional concrete.
- The values has been gradually increased at 0.5%, 1%, 1.5% replacement of titanium dioxide and at 2% of replacement the value decreases.
- As the value of concrete cubes and cylinder increases by 1.5 % replacement of TiO_2, the flexural strength of the beam was found for 1.5 % replacement of TiO_2.
- Hence the use of smaller percentage of titanium dioxide gives the valuable results.

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