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STRENGTH ANALYSIS OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH TITANIUM DIOXIDE

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ABSTRACT

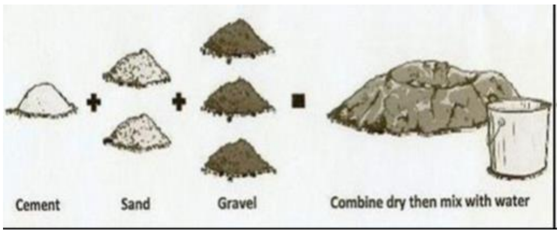
Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete itself is a strong construction material used for almost all type of structural constructions, but some constructions need high strength than that of the conventional concrete. To attain this required strength, the materials in the concrete like cement, fine aggregate and coarse aggregate can be partially replaced with various other materials which will increase the strength and also decrease the overall cost of the construction.

In this project we have partially replaced cement with Titanium Dioxide which will be studied for the increase in strength and selected M25 grade mix design by keeping water-cement ratio as 0.57 and followed IS:10262-2019 and IS:456-2000 for the preparation of concrete mix. We also additionally added a super plasticizer named ‘Conplast SP430’ in our concrete mix which has a property of easy particle dispersion in water which enables the water content to perform more effectively in the concrete mix. Varying percentages of TiO2 is added in different concrete specimens to study the variations of increase in strength. According to the Indian Standards 3 specimens for each sample is used to cast cube, cylinder and beam. Compressive strength, split tensile strength and flexural strength tests on the concrete are carried out after 7 days and 28 days of curing to study the increase in strength of concrete.

Keywords: Strength, Mechanical Parameters, Superplasticizer, Titanium Oxide

1.INTRODUCTION:

Concrete is the most widely used man made construction material in the world, and is second only to water as the most utilised substance in the planet. It is obtained by mixing cementing material, water, aggregates and sometimes admixtures, in required proportions. The mixture when placed in forms and allowed to cure, hardness into a rock – like mass known as concrete. The hardening is caused by chemical reaction between water and cement and it continuous for a long time, and consequently the concrete grows stronger with age. The hardened concrete may also be considered as an artificial stone in which the voids of larger particles are filled by the smaller particles and the voids of fine aggregates are filled with cement. In a concrete mix, the cementing material and water form a paste called cement-water paste which in addition to filling the voids of fine aggregate, coats the surface of fine and coarse aggregates and binds them together as it cures, there by cementing the particles of the aggregates to gather in a compact mass.



The strength, durability and other characteristics of concrete depends upon the properties of its ingredients, on the proportions of mix, the method of Compaction and other controls during placing, compaction and curing. The popularity of the concrete is due to the fact that form the common ingredients, it is possible to tailor the properties of concrete to meet the demands of any particular situation. The key to producing a strong, durable and uniform concrete, i.e., high-performance concrete lies in the careful concrete control of its basic and process components.

1.1 CLASSIFICATION OF CONCRETE:

As mentioned earlier, the main ingredient of concrete are cement, fine aggregates and coarse aggregates. It is usual to specify a particular concrete by the proportions of these constituents are there characteristics, e.g., a 1:1:2 concrete refers to a particular concrete manufactured by mixing cement, fine aggregate and coarse aggregate in a 1:1:2 ratio. This classification specifying the proportions of constituents and their characteristics is termed as prescriptive specifications and is based on the hope that adherence to such prescriptive specifications will result in satisfactory performance. Alternatively, the specifications specifying the requirements of the desirable properties of concrete such as strength, workability etc are stipulated and these are termed as performance oriented specifications. Based on these considerations, concrete can be classified either as nominal mixed concrete or designed in mixed concrete. Sometimes, concrete is classified into controlled concrete and ordinary concrete, depending upon the levels of control exercised in the works and the method of proportioning concrete mixes. Accordingly a concrete ingredient properties fixed by designing the concrete mix with preliminary test are called controlled concrete, where as ordinary concrete is one way or nominal mixes are adopted. In IS 456-2000, there is nothing like uncontrolled concrete; only the degree of control various from very good to cool or no control. In addition to mix proportioning, the quality control includes selection of appropriate concrete materials after proper tests, proper workmanship in Batching, mixing, transportation, placing, compaction and curing coupled with necessary checks and tests for quality acceptance.

1.2 PROPERTIES OF CONCRETE:

Concrete making is not just a matter of mixing ingredients to products a plastic mask, but good concrete has to satisfy performance requirements in the plastic or grill state and also the harden state. In the plastic state, the concrete should be workable and free from segregation and bleeding. Segregation is the separation of coarse aggregates and bleeding is the separation of cement paste from the main mask. The segregation and bleeding result in a poor quality concrete. In its hardened state, concrete should be strong, durable, and impermeable and it should have minimum dimensional changes.

Among the various properties of concrete, it compressive strength is considered to be the most important and is taken as an index of its overall quality. Many other properties of concrete appear to be generally related to its compressive strength.

1.3 GRADES OF CONCRETE:

Concrete is generally graded according to its compulsion strength. The various grades of concrete as stipulated in IS:456-2000 and IS:1343-1980 are given in TABLE 1.1 in the designation of concrete mix, the letter M refer to the mix and the number to be specified characteristic strength of 150mm work cubes at 28days, expressed in MPa (N/mm2). The concrete of grades M5 and M7.5 is suitable for lean concrete basis, simple foundations, foundations for masonry walls and other simple are temporary reinforcement concrete constructions. These need not be designed. The concrete of grades lower than M15 is not suitable for reinforced concrete works and grades of concrete lower than M30 are not to be used in the pre-stressed concrete works.

1.4 CONCRETE ADMIXTURES:

Concrete Admixture is defined as a material other than water, aggregates and hydraulic cement and additives like Pozzolana or slag and fiber reinforcement, used as on ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state. admixtures enhances the properties of concrete for applications in construction with special requirements. Concrete additives are used to achieve desired workability in case of low water cement ratio, and to enhance setting time of concrete for long distance transportation of concrete.

2. LITERATURE REVIEW:

Iman M.Nikbin, Raza Mohebbi, Soudabeh Dezhampanah, Sadegh Mehdipour, Reza Mohammadi, Tahmores Nejat, Gamma ray shielding properties of heavy-weight concrete containing Nano-TiO_2, Radiation Physics and Chemistry Volume 162, Pages 157-167, 2019 Results indicated that increasing the amount of TiO_2 nanoparticles from 0% to 8% leads to increase in UPV and impact resistance and adding 6% of TiO_2 nanoparticles is the most optimum amount of this additive. Whereas, the significant effect on radiation shielding properties occurred within specimen including 8% of TiO_2 nanoparticles.

R. Sakthivel, T. Arun Kitcha, M. Dhanabal , V. Aravindan, S. Aravindh, Experimental Study of Photocatalytic Concrete using Titanium Dioxide, International Journal for Innovative Research in Science & Technology| Volume 4 | Issue 11 | 2018 Titanium dioxide exists in three mineral forms Anatase, Rutile and Brookite, Anatase type TiO2 has a crystalline structure that corresponds to the tetragonal system, Rutile type TiO2 also has a tetragonal crystal structure, Brookite type TiO2 has a crystalline structure that corresponds to theorthorhombic crystalline structure.

Baoguo Han, Zhen Li, Liqing Zhang, Shuzhu Zeng, Xun Yu, Bing Han, Jinping Ou, Reactive powder concrete reinforced with nano SiO_2-coated TiO_2, Construction and Building Materials Volume 148, Pages 104-112, 2017, The mechanical strengths of the Nano SiO_2-coated TiO_2 reinforced reactive powder concrete at different curing ages manifest significant increases, especially flexural behaviors. The flexural and compressive strengths of Nano SiO_2-coated TiO_2 reactive powder at age of 28 d achieve increases of 87%/6.69 MPa and 12.26%/12.2 MPa

Baoguo Ma, Hainan Li, Xiangguo Li, Junpeng Mei, Yang Lv, Influence of nano-TiO_2 on physical and hydration characteristics of fly ash–cement systems, Construction and Building Materials Volume 122, , Pages 242-253, 2016 Introducing NT would lead to a considerable increase in compressive strength at early ages while it had an adverse effect on the later age strength. However, the positive functions of FA in late strength could offset the negative influence of NT and the optimum contents of NT and FA are 3% and 20%, respectively.

Ehsan Mohseni, Farzad Naseri, Ramin Amjadi, Mojdeh Mehrineja, Khotbehsara, Malek Mohammad Ranjbar, Microstructure and durability properties of cement mortars containing nano-TiO2 and rice husk ash, Construction and Building Materials Volume 114, Pages 656-664, 2015 Compressive strength results showed a substantial improvement in samples containing NT and also a slight increase in mortar performance was observed by using up to 10 wt% of RHA as a replacement of cement. However, binary mixtures displayed the best results for strength development and durability. It is also seen that a combination of 15% RHA and 5% NT in mortar led to a positive contribution to durability properties.

Mostafa Jalal, Mojtaba Fathi, Mohammad Farzad, Effects of fly ash and TiO_2 nanoparticles on rheological, mechanical, microstructural and thermal properties of high strength self compacting concrete, Mechanics of Materials Volume 61, Pages 11-27, 2013 partial replacement of cement up to 4 wt% could accelerate C–S–H gel formation as a result of increased crystalline Ca(OH)2 amount at the early age of hydration and hence improve the microstructure of concrete leading to improved durability-related properties and strength enhancement of the concrete.

Mostafa Jalal, Mostafa Tahmasebi, Assessment of nano-TiO2 and class F fly ash effects on flexural fracture and microstructure of binary blended concrete, Science and Engineering of Composite Materials, Volume 22: Issue 3, 2013 They showed that the flexural fatigue performance of concretes containing TiO2 nanoparticles is improved significantly and the sensitivity of their fatigue lives to the change of stress is also increased. In addition, the theoretic fatigue lives of concretes containing TiO2 nanoparticles are enhanced in different extent. With increasing stress level, the enhanced extent of theoretic fatigue number is increased.

3. MATERIALS:

3.1 CEMENT

Ordinary Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and many plasters. British masonry worker Joseph Aspdin patented Portland cement in 1824.

3.2 AGGREGATES

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel, and crushed stone are used mainly for this purpose.

3.3 Fine Aggregate:- The aggregate which pass through 4.75mm IS sieve and entirely retain on 75micron IS sieve is called fine aggregate. It may be natural sand, crushed stone sand or crushed gravel sand. The minimum particle size of fine aggregate is 0.075mm and the maximum partial size is 4.75mm.

3.4 Coarse Aggregate:- The aggregate which pass through 75mm IS sieve and entirely retain on 4.75mm IS sieve is known as coarse aggregate. It may be crushed gravel or stone, un crushed gravel or stone or partially crushed gravel or stone.

3.5 WATER

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

4. EXPERIMENTAL PROGRAMME:

4.1 CEMENT

Ordinary Portland cement is the most common type of cement in general usage. It is a basicingredient of concrete, mortar and many plasters. British masonry worker Joseph Aspdin
patented Portland cement in 1824. It consists of the mixture of calcium, silicates (alite, belite),aluminates and ferrites—compounds which combine calcium, silicon, aluminium and iron in forms which will react with water. Portland cement and similar materials are made by heating limestone (a source of calcium) with clay or shale (a source of silicon, aluminium and iron)and grinding this product (called clinker) with a source of sulphate (most commonly gypsum).

Ordinary Portland Cement (OPC) is the most common cement used in the world mostlybecause of the abundance and low cost to produce it. OPC is produced simply by grinding limestone and secondary materials to a powder. It got its name as it was first produced in Portland.
The grades of Ordinary Portland Cement (OPC) are
(a) Grade 33
(b) Grade 43
(c) Grade 53

Grade 33 means after 28 days, the strength of this type of cement with standard must be 33
N/mm2. The ratio of cement mortar must be 1:3 (standard cement and sand) Cement is used as a binding material in concrete mix. The raw materials used in cementmanufacturing are calcareous materials, such as limestone or chalk and argillaceous material such as shale or clay. In this Project we have used KPC cement of OPC 53 grade at Rs.360/- per bag

Fig 3.1: Ordinary Portland cement (OPC)

4.2 AGGREGATES:

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel, and crushed stone are used mainly for this purpose. Recycled aggregates (from construction, demolition, and excavation waste) are increasingly used as partial replacements for natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted. The size distribution of the aggregate determines how much binder is required. Aggregate with a very even size distribution has the biggest gaps whereas adding aggregate with smaller particles tends to fill these gaps. The binder must fill the gaps between the aggregate as well as paste the surfaces of the aggregate together, and is typically the most

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expensive component. Thus, variation in sizes of the aggregate reduces the cost of concrete. The aggregate is nearly always stronger than the binder, so its use does not negatively affect the strength of the concrete. The aggregate is an inert mineral material used for the manufacture of mortars and concretes. According to Indian standards (IS: 383-1970), a good aggregate for concrete construction should be sufficiently strong chemically inert sufficiently hard and durable.The aggregates may be natural and artificial aggregates. The natural aggregates such as sand, gravel and crushed rock are used for reinforced concrete. The artificial aggregates such as furnace clinker, coke breeze, saw dust and foamed slag are used for the manufacture of concrete of low density. The aggregates according to their size are classified

Fine aggregate

Coarse aggregate

4.3 Fine Aggregate:

Fig 3.2: Fine aggregate

The aggregate which pass through 4.75mm IS sieve and entirely retain on 75micron IS sieve is called fine aggregate. It may be natural sand, crushed stone sand or crushed gravel sand. The minimum particle size of fine aggregate is 0.075mm and the maximum partial size is 4.75mm. The material having particle size varying from 0.002 to 0.06mm is termed as silt and still smaller particles are called clay, it can be said that bulking of sand is simply the looseness of soil without compacting. Usually, water reduces the pores in sand and compacts the sand.Sand is used in concrete for reduction of segregation and fill out the pores between cement and coarse aggregates. The volume of dry sand increases due to absorption of moisture. These volume increase of dry sand is known as bulking of sand. When dry sand comes in contact with moisture, a thin film is formed around the particles, which causes them to get apart from each other. moisture content is increased by adding more water, the sand particles pack near each other and the amount of bulking of sand is decreased. Thus the dry sand and the sand completely flooded with water have practically the same volume.

4.4 Coarse Aggregate:

The aggregate which pass through 75mm IS sieve and entirely retain on 4.75mm IS sieve is known as coarse aggregate. It may be crushed gravel or stone, un crushed gravel or stone or partially crushed gravel or stone.

The minimum particle size of coarse aggregate is 4.75mm and the maximum particle Size is 75mm if the size is more than 75mm then the aggregate is called cyclopean aggregate.

4.5 WATER:

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. As stated by Abrams' law, a lower water-

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to-cement ratio yields a stronger, more durable concrete, whereas more water gives a freer-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure. Hydration involves many different reactions, often occurring at the same time. As the reactions proceed, the products of the cement hydration process gradually bond together the individual sand and gravel particles and other components of the concrete to form a solid mass.

4.6 TITANIUM DIOXIDE:

Titanium dioxide, also known as titanium(IV) oxide or titania is the naturally occurring oxide of titanium, chemical formula TiO_2. When used as a pigment, it is called titanium white, Pigment White 6 (PW6), or CI 77891. Generally, it is sourced from ilmenite, rutile, and anatase. It has a wide range of applications, including paint, sunscreen, and food coloring. TiO_2 is typically thought of as being chemically inert, meaning it doesn't react with other chemicals and is, therefore, a stable substance thatcan be used in many different industries and for a variety of applications. It has two important types which are rutile titanium dioxide and anatase titanium dioxide. The key difference among them is in their appearance. Anatase Titanium Dioxide is colorless, whereas Rutile Titanium Dioxide is usually found in dark red appearance. The cost of Titanium dioxide is Rs.450/- per kg and easily available.

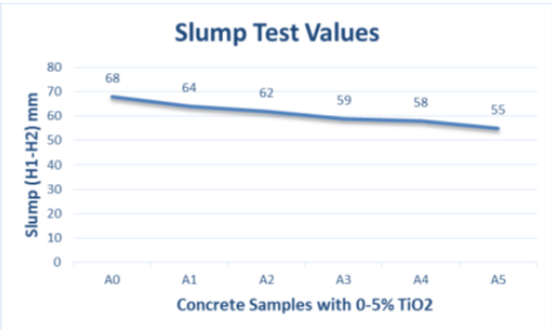
4.7 Rutile Titanium Dioxide

Rutile Titanium Dioxide appears in dark red color and it has high stability. Moreover, it is the most commonly found type of Titanium Dioxide and is usually found in metamorphic and igneous rocks, which are subjected to high-pressure and high-temperature conditions. While talking about the rutile's crystalline structure, it has a tetragonal unit cell having oxygen anions and titanium cations. The coordination number of titanium cations (Ti^{+4}) is 6, while the coordination number of oxygen anion (O^{2-}) is 3. It has a lot of useful applications, the main ones are the manufacturing of metallictitanium and titanium dioxide pigments. Moreover, in fine form, it is used for manufacturing plastics, papers, and paints. The finely pulverized form of titanium dioxide is white in color. Furthermore, the nanoparticles of rutile titanium dioxide have the ability to absorb UV rays and are transparent to visible light.

5. TEST RESULTS & DISCUSSION:

5.1 Slump Test:

Workability is a term associated with freshly prepared concrete. This can be defined as the ease with which concrete can mixed, placed, compacted and finished. Slump test is the most commonly used method of measuring 'workability' of concrete in a laboratory or at site of work. It is used conveniently as a control test and gives an indication of uniformity of concrete from batch to batch. Vertical settlement of a standard cone of freshly prepared concrete is called 'slump'.



5.2 Compressive Strength Test:

Testing hardened concrete plays an important role in controlling and conforming the quality of cement concrete work. The main factor in favour of the use of concrete in structures is its compressive strength. One of the important properties of the hardened concrete is its strength which represents its ability to resist forces. The compressive strength of the concrete is considered to be the most important and is often taken as an index of the overall quality of concrete. The compressive strength of concrete is defined as the load which causes the failure of specimen per unit cross section on compression under given rate of loading.

5.3 Split Tensile Strength Test:

Split tensile strength of concrete is usually found by testing plain concrete cylinders. Cylinders of size150mm x 300 mm were used to determine the split tensile strength. After curing, the specimens were tested for split tensile strength using a calibrated compression testing machine of 2000kN capacity. The resistance of a material to a force tending to tear it apart, measured as the maximum tension the material can withstand without tearing. Tested by keeping the cylindrical specimen in the compressive testing machine and is continued until failure of the specimen occurs.

5.4 Flexural Strength Test:

For this test the beams of dimension 100mmX100mmX500mm were casted. Flexural strength also known as modulus of rupture. The value of the modulus of rupture depends on the dimensions of the beam and manner of loading. In this investigation, to find the flexural strength by using third point loading.

6. CONCLUSION :

The purpose of this research is to finding and comparing out the compressive strength, tensile strength, and flexural strength of M25 grade ceramic tiles and pond ash based concrete with the conventional concrete at the water cement ratio of 0.50 for better replacement. Based on experimental investigations concerning the compressive strength, tensile strength, and flexural strength of concrete. After the completion of all experimental tests, this study is concluded that the ceramic waste tiles and pond ash can be used as a partial replacement of coarse aggregate and fine aggregate in concrete mix.

After completion of all the experimental tests, this study is concluded that the Titanium Dioxide can be used as a partial replacement of Cement in concrete mix. The Compressive, Split tensile and Flexural strengths of M25 grade concrete increases when the cement is replaced with Titanium Dioxide up to 5% out of which 1% gives the maximum increasing values.

By increasing the proportion in the mix leads to the increasing the strength of the concrete up to 4% and after increasing the proportions beyond 4% in the mix leads to the decrease the strength of the concrete. After completion of all the experimental tests we can observe that after 28 days the Compressive strength is increased 26%, Split Tensile is increased 39%, Flexural Strength is increased 15% than the Conventional Concrete.The Workability of the concrete will gradually decrease with increase in the percentage of titanium dioxide in concrete.

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