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Comparative Study of High Performance Concrete by Replacing Silica Fumes and Addition of Recron 3S Fiber Material

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ABSTRACT:

The project deals with the high performance of concrete by replacing and addition of chemical admixtures for obtaining the characteristic target mean strength by replacing the silica fumes in cement and addition of polyester fiber material for getting maximum compressive strength, Split tensile strength, Flexural strength. High Performance Concrete (HPC) now a day's used widely in the construction industry worldwide. To produce HPC with normal ingredients we use mineral admixtures like Silica fume, fly ash and metakoline and workable agents Super plasticizers are also used. The usage of mineral admixtures in the concrete not only enhances its strength properties But also durability. The compressive strength, split tensile strength, flexural strength are investigating finding the optimum use of mineral admixture (Silica fume of levels 0, 5, 10, 15 and 20% at 7 days and 28 days of curing). The present investigation aims to give design mix for HPC by using silica fume and super plasticizers.

INTRODUCTION

In construction industry, strength is a primary criterion in selecting a concrete for a particular application. The concrete used for gaining strength over a long period of time after casting. The characteristic strength of concrete is defined as the compressive strength of a sample that has been aged for 28 days.

Neither waiting 28 days from such a test would not serve the rapidity of construction nor would neglecting it serve the quality control process on concrete in large construction sites [1]. Therefore, rapid and reliable prediction of the strength of concrete would be of great significance. For example, it provides a chance to do the necessary adjustment on the mix proportion used to avoid the situation where concrete does not reach the required design strength or by avoiding concrete that is unnecessarily strong and also for more economic use of raw materials and fewer construction failures, hence reducing construction cost.

Prediction of the compressive strength of concrete, therefore, has been an active area of research and a considerable number of studies have been carried out. Many attempts have been made to obtain a suitable mathematical model [2] which is capable of predicting strength of concrete at various ages with acceptable (high) accuracy.

The concrete is a versatile construction material owing to the benefits it provides in terms of strength, durability, availability, adoptability and economy. It is aassorted mix of cement, water and aggregates. Excessive efforts have been made to improve the quality of concrete by various means in order to raise and maximize its level of performance. Using same ingredients with little adjustments in the micro- structure (and probably adding specific materials), it is possible to obtain some of the special types of concrete such as high strength concrete (HSC) [3], self-compacting concrete (SCC) [4] and roller compacted concrete, high volume fly ash concrete (HVFAC) [5], etc. The development of these concretes has brought forth the need for admixtures, both- mineral and chemical, to improve the strength of concrete.

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High-strength concrete has a compressive strength greater than 40 MPa. defines High strength concrete as concrete with a compressive strength greater than 40 MPa and below 60 MPa. High-strength concrete is made by lowering the water-cement (W/C) ratio [6] to 0.38 or lower. Often silica fume is added to prevent the formation of free calcium hydroxide crystals in the cement matrix, which might reduce the strength at the cement-aggregate bond. Low W/C ratios and the use of silica fume make concrete mixes significantly less workable, which is particularly likely to be a problem in high-strength concrete applications where dense rebar cages are likely to be used. To compensate for the reduced workability, super plasticizers are commonly added to high-strength mixtures. Aggregate must be selected carefully for high-strength mixes, as weaker aggregates may not be strong enough to resist the loads imposed on the concrete and cause failure to start in the aggregate rather than in the matrix or at a void, as normally occurs in regular concrete [7].

In some applications of high-strength concrete the design criterion is the elastic rather than the ultimate compressive strength.

The admixtures may be added in concrete in order to enhance some of its properties desired specially. Very fine materials such as fly ash, a product of coal-burning power plant, render the fresh concrete more plastic.

Other admixtures including various fats, sugars and minerals are used to increase or decrease the rate of hardening of concrete. It gives the increase of durability and resistance to weathering. Contrary to the ordinary concrete, the concrete containing different admixtures has extra- ordinary rheological properties, especially its super workability and flow ability that make it superior as compared to other concrete mixes. There have been many studies which reported the effect of different types of admixtures and in few cases, that of the inclusion of fibers on rheological behavior as well as strength properties of the various types of the concrete.

MATERIALS USED:

The following materials were used in the investigations
Cement:
Ordinary Portland cement available in the local market of standard brand was used in the investigation. Care has been taken to see that the procurement made from a single batch is stored in airtight containers to prevent it from being affected by the atmospheric and monsoon moisture and humidity.

Fine aggregate

The locally available river sand is used as fine aggregate in the present investigation. The sand is free from clay, silt and organic impurities [8]. The fine aggregate used should conform to the standard specifications as per IS 2386-1963. The fine aggregate used is river sand confirming to zone –II. It is clean, free from organic matter, silt & clay. The specific gravity of fine aggregate is 2.67 and fineness modulus is 2.674.

Coarse aggregate

Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc.. The coarse aggregate [9] is also tested for its various properties. The coarse aggregate should also conform to the standard specifications. it is well graded and its specific gravity is 2.704 and fineness modulus is 7.55. the material is of uniform colour and has good angularity.

Water

The locally available potable water accepted for local construction is used in the experimental investigation after testing. The pH value should not be less than6. Water cement ratio of 0.4 is adopted for M40 grade of concrete in the experimental investigation.

Admixture:

High range water the reducing admixtures known as super plasticizers are used for improving or workability for decreased water-cement ratio without decreasing the compressive strength. These admixtures when they

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disperse in cement agglomerates significantly decrease a viscosity of the paste by forming a thin film around the cement particles. In the present work water-reducing admixture Conplast SP430 is differentiated from conventional super plasticizers in that it is based on a unique carboxylic ether polymer with long lateral chains. This greatly improves cement dispersion. At the start of the mixing process an electrostatic dispersion occurs but the cement particle's capacity to separate and disperse. This mechanism considerably reduces the water demand in flowable concrete. Conplast SP430 combines the properties of water reduction and workability retention. It allows the production of high performance concrete and/or concrete with high workability. As the water cement ratio is very less, to achieve the repaired workability CONPLAST SP430 was used as a water reduce dosages of the chemical is 58.8 kg per cubic meter.

Micro Silica (Silica Fumed Densified)

1. It is a very reactive and effective pozzoloanic material due to its fine particle size and high purity of sio2 (99.5 %) content.
2. It enhances the mechanical properties, durability and constructability in concrete.
3. It is used in the production of high strength & high performance concrete.
4. It is used in the production of high performance concrete structures like bridges where the strength and durability properties of the concrete is required.
5. It can be used to build marine structures as it reduces the damage caused due to the reaction of chloride and various chemicals, it helps in protection of steel from rust and corrosion and increases the life of structure.
6. The recommended dosage is 7-10% of the cement weight added to the concrete.

Micro silica or silica fumed is the most commonly used mineral admixture in high strength concrete. It has become the chosen favorites for high strength concrete and is a good pozzoloan [10 & can be used in a big way , adding to the concrete mix will dramatically enhance the workability , strength & impermeability of concrete mixes while making the concrete durable to chemical attacks, abrasion & reinforcement corrosion, increasing the comprehensive strength . There is a growing demand in the production of concrete mixes, high performance concrete, and high strength, low permeability concrete for use in bridges, marine environment, and nuclear plants etc..

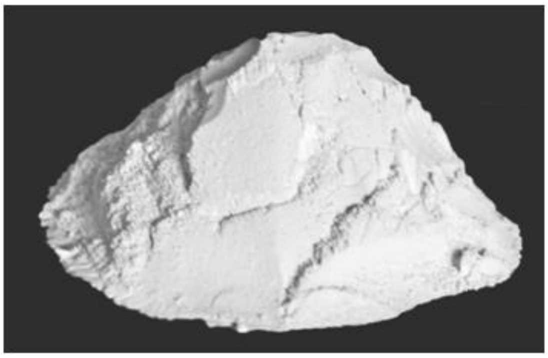

Figure 1: Silica fumes

Silicon metal and alloys are produced in electric furnaces. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than using as landfill. The most important use of this material is as a mineral admixture in concrete. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fineness in fine particle sizes, large surface area, and the high Silicon dioxide (SiO_2) content, silica fume is a very reactive pozzolan when used in concrete [11].

Recron 3s (Polypropylene Fibre Material)

Recron-3s is a discrete, discontinuous short fiber that can be used in concrete to control and arrest cracks. It arrests shrinkage cracks in concrete and increases resistance to water penetration, abrasion and impact. It makes concrete homogenous and also improves the compressive strength, ductility and flexural strength together with im proving the ability to absorb more energy. Use of uniformly dispersed Recron 3s fibers reduces segregation and bleeding and also results in a more homogeneous mix of concrete. Recron3s is meant for secondary reinforcement only.

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Figure 2: Recron 3s Polypropylene Fiber

Role of Recron 3s:

Cracks play an vital role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. Therefore, it is important to reduce the crack width and this can be achieved by adding polypropylene fibers [12] to concrete. The bridging of cracks by the addition of polypropylene fibers. Thus addition of fibers in cement concrete matrix bridges these cracks and restrains them from further opening. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibers. This process, apart from preserving the integrity of concrete, improves the load-carrying capacity of structural member beyond cracking. The major reasons for crack formation are Plastic shrinkage, Plastic settlement, Freeze thaw damage, Fire damage etc.

Fiber mechanism

Fibers work with concrete utilizing two mechanisms, the spacing mechanism and the crack bridging mechanism. The spacing mechanism requires a large number of fibers well distributed within the concrete matrix to arrest any existing micro-crack that could potentially expand and create a sound crack. For typical volume fractions of fibers, utilizing small diameter fibers or micro fibers can ensure the required number of fibers for micro crack arrest.

The second mechanism termed crack bridging requires large straight fibers with adequate bond to the concrete. Steel fibers are considered to be a prime example of this fiber type which is commonly referred to as large diameter fibers or macro fibers. Benefits of using larger fibers include impact resistance, flexural and tensile strengths, ductility, and fracture toughness.

Mixing of recron 3s material in concrete

Recron 3s material is added to the nominal mix concrete to obtain the target mean strength. It is added to the concrete mix in 900grms/m3 (maximum). Weigh recron and mix it with the required water for the concrete mix and stir very well and add some amount of mixed cement & sand material. Then it is poured in to the sample and mixed very well. 10% of extra recron material is taken. When recron material is not mixed well, the strength of the concrete mix is decreased. When we add the recron to the concrete mix it absorbs the water in the concrete mix. After the completion of casting it releases the water slowly. After mixing recron to the concrete mix take sample for the slump cone test, pour the sample in to the slump cone, damp well, remove the cone. Note down the slump cone value and check if the value is satisfied with our mix design. If it is not satisfied leave the sample and go for a new mix unless the sample value is satisfied.

Figure 3: Mixing of recron in water

Figure 4: Adding some amount of cement, silica fumes mix

Figure 5: Adding the mixed precipitate to the sample

CASTING OF SPECIMENS

The iron moulds are cleaned and any dust particles are their remove then. The mineral oil is applied on all the sides of the mould. The moulds are placed on a level platform. The well mixed concrete is filled into the moulds by vibration with needle vibrator.

Figure 6: Placing the concrete filled moulds on vibrating machine

Figure 7: Casted specimens left for setting

Excess concrete was removed with towel and top surface is finished level and smooth as per IS 516-1969. If the slump value satisfied cast the sample in to cubes and damp well for not obtaining the voids in the cubes. After casting the cubes leave them for 24 hours of an initial setting time and after 24 hours remove the mould and keep the cubes in curing tank for 7 days (or) 28 days as per our trails.

CURING OF SPECIMENS

The specimens are left in the moulds undisturbed at room temperature for about 24 hours of casting. The specimens are then removed from the moulds and immediately transferred to the curing pond containing clean and fresh water and cured for required period as per IS: 516-1969.

Figure 8: Curing of specimens in tank

TESTING OF SPECIMENS

After completion of curing take the batch of cubes, let them dry and leave them in the atmosphere until the absorbed water is exhausted. The cast specimens are tested as per standard procedures, immediately after they are removed from curing period and wiped off the surface water as per IS 516-1969. The test results are tabulated carefully. Take the cubes for testing in the U.T.M and take the load values of three cubes. Find out the average of load for three cubes. Also calculate the stress value for 7 days & 28 days.

Description of compression testing machine

The compression testing machine used for testing the cube specimens is of standard make. The capacity of the testing machine is 2000KN. The machine has a facility to control the rate of loading with a control valve. The plates are cleaned and oil level is checked, and kept ready in all respects for testing. After the required period of curing, the cube specimens are removed from the curing tank and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally. The smooth surfaces of the specimen are placed on the bearing surfaces [13]. The top plate is brought in contact with the specimen by rotating the handle. The oil pressure valve is closed and the machine is switched on. A uniform rate of loading 140kg/sq.cm is maintained.

Figure 9: Compressive testing machine

TESTS CONDUCTED:

For the trial and error method we are doing here we have to specify the test results for the various materials we are using like cement sand coarse aggregate water , and the remaining chemicals which we are using will have the tests results with the company which we are buying with that chemicals only

Compressive strength of concrete specimen

Concrete specimen cubes were used to determine the compressive strength of silica fume replaced concrete with addition of Conplast SP430 and recron 3s as per IS 516-1969. The results are properly tabulated

Split tensile strength of concrete specimens

Concrete specimen cylinders were used to determine the split tensile strength of silica fumes and recron 3s fiber with different variations of replacement as per IS 516-1969. The results are properly tabulated.

Flexural strength of concrete specimens

The stresses induced in concrete pavements are mainly flexural.

Therefore flexural strength is more often specified than compressive strength in the design of mixes of pavement construction. The flexural strength is mainly calculated for the permeability test of concrete specimens and mix designs. Flexural strength carries out a study case and reference in differentiating the property of designed concrete [14]. While calculating the strength it is having a specific procedure to follow. By the procedure only the exact value of gaining strength by trail and error method is obtained.

As per IS 516 the procedure is followed and specimens are tested.

Figure 10: Flexural strength testing machine

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RESULTS

Compressive strength Graphs and discussions

The graphical representation and discussions of obtained results are shown below

The compressive strength of concrete at 7 days age are graphically represented in Figure 11.

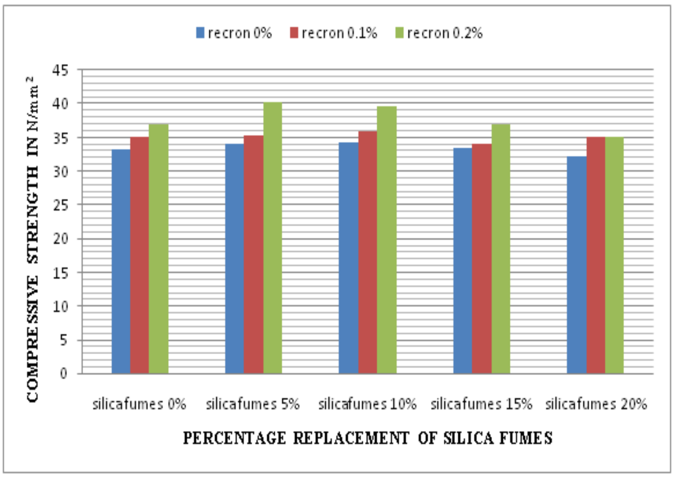

Figure 11: Compressive strength values at age of 7 days
Here the compressive strength values at age of 7 days are plotted in graph.

The compressive strength values at age of 7 days are satisfied up to 15% replacement of silica fumes in cement content. Addition of polypropylene fibers also giving satisfactory strengths in 0, 0.1 and 0.2 % addition of recron fibers.

The compressive strength of concrete at age of 28 days with different replacement percentages are shown in figure 12

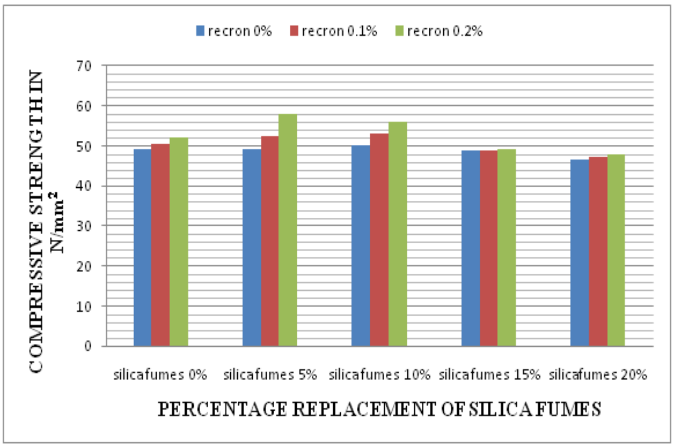

Figure 12: compressive strength values at age of 28 days

Here also the compressive strength values are satisfied up to the replacement of silica fumes at 15% in cement content and addition of polypropylene fibers up to 0.2%. The compressive strength values are satisfying with respect to target mean strength at simultaneous replacement of silica fumes at 15% and addition of polypropylene fibers up to 0.2 %. There after the compressive strength is decreasing at 20 % replacement of silica fumes. The strength decreased is 4% with respect to target mean strength.

Split tensile strength graphs and discussions

The split tensile strength values at age of 7 days are graphically represented below in Figure 13.

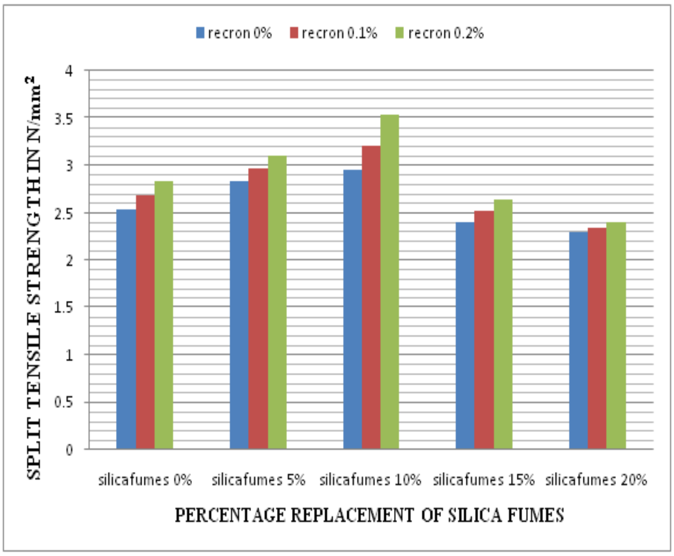

Figure 13: Split tensile strength at age of 7 days

In case of split tensile strength are satisfying upto 10% replacement of silica fumes comparative to control concrete. With addition of polypropylene fibers the tensile strength is increased. With respect to addition of fibers content the strength is increasing.

After 10% replacement of silica fumes the strength is decreased with respect to increase of silica fumes at 15 and 20% the percentage of strength decreased is 5% and 10% with respect to control concrete.

The split tensile strength at age of 28 days is graphically represented below in Figure:14.

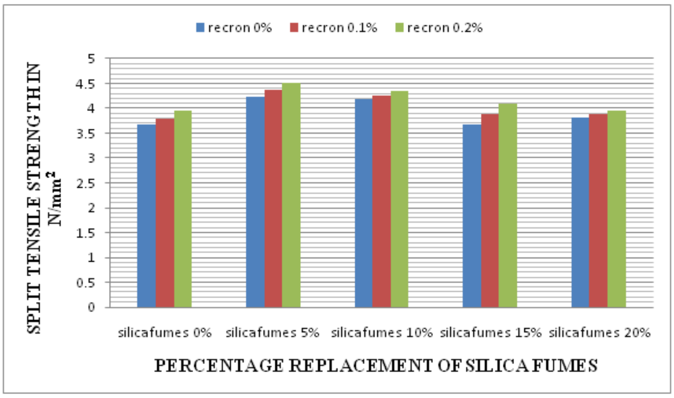

Figure 14: split tensile strength at age of 28 days

The split tensile strengths control concrete value for 28 days strength is 3.68N/mm2.

With respect to silica fumes upto 15% replacement is satisfying the control concrete mix. By increasing the fibers content the strength is increasing simultaneously. At 0.2% usage of polypropylene fibers for 20% replacement of silica fumes the split tensile strength value is satisfactory. But in overall split tensile strength investigation the replacement of silica fumes is considered upto 15% and usage of fibers is recommended upto 0.2%.

Flexural strength graphs and discussions

The flexural strength at age of 7 days are graphically represented below in figure 15

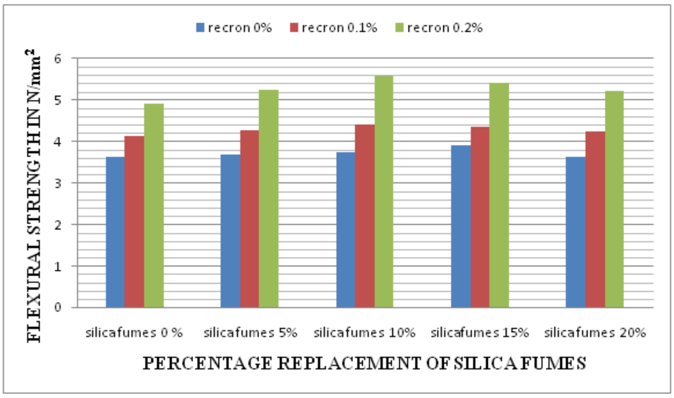

Figure 15: Flexural Strength at age of 7 days

The flexural strength at age of 7 days for control concrete is 3.63N/mm2.

At age of 7 days the flexural strength values are satisfying upto 15% replacement of silica fumes in case of 0% fibers. Here the impact of fibers is clearly observed. By the increase of polypropylene fibers the flexural strength is gained.

In case of silica fumes 0,5,10,15 and 20% replacement and 0.1 and 0.2% addition of polypropylene fibers are giving satisfactory results with respect to control concrete.

The flexural strength values at age of 28 days are graphically represented below in Figure: 16

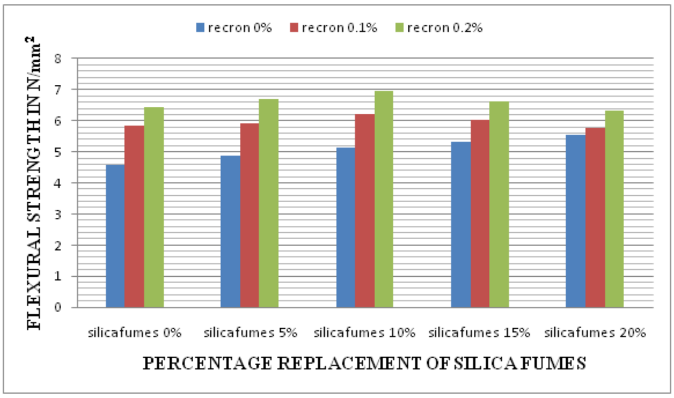

Figure 16: Flexural Strength at age of 28 days

The flexural strength value at age of 28 days for control concrete is 4.56N/mm2.

Here in case of flexural strength for 28 days strength the flexural strength is rapidly increased by the usage of polypropylene fibers. Fibers are acting as secondary reinforcement material in the case of flexural strength. All the replacements and all the additions of silica fumes and polypropylene fibers are satisfying the control concrete mix values.

CONCLUSION

An experimental study was conducted on cubes, cylinders for compressive, split tensile strength, respectively by mixing of recron 3s fiber. Based on the investigation the following conclusions were drawn they are

1. From the result, it is found that the optimal replacement percentage of cement with silica fume is found to 10%. When recron 3s fibers are not added.
2. Usage of 0.2% Recron fiber and 5 to 10 % of silica fumes is the optimum combination to achieve the desired

need.

3. Usage of recron 3s will reduce the cost of maintenance by reducing the micro cracks and permeability and hence the durability will increase. It is found that use of recron 3s fiber reduce the segregation.

4. The compressive strength of recron fiber with silica fumes was 17.5% greater than conventional concrete compressive strength

5. The split tensile strength of recron fiber with silica fume was increased at 5% silica fume and 0.2% recron 3s fiber.

6. The split tensile strength also shows an increment of 10.5 % to the conventional concrete of split tensile strength.

7. The flexural strength of recron fiber with silica fumes was increased at 10% replacement and 0.2 % recron 3s fiber.

8. The increased percentage in flexural strength is 50% with respect to the control concrete.

9. The research work on pozzolanic materials and fiber along with pozzolanas is still limited. But it promises a great scope for future studies. Following aspects are considered for future study and investigation;

10. Percentage and actual fineness of silica fumes require as partial cement replacement for good strength development.

11. While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which leaded into splitting of beam in two piece geometry. But due to addition of steel fibers in concrete cracks gets ceased which results into the ductile behavior of fibered concrete.

Future scope study:

Usage of recron is satisfying the flexural values and replacement of silica fumes with respect to cement is giving good strength properties. By these materials the strength properties are increasing. Effectively flexural strength behavior is giving good strength properties. In construction of tanks and pavements gives best results in construction industry. Further the chemical reactions and elevated temparatures are studied.

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