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A Study on the Shrinkage Control of Concrete Using Synthetic Fibers (Early Age Shrinkage Control Module 2)

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Abstract -- Time dependent strain measured in an unloaded specimen at constant temperature is called as Shrinkage of concrete. Concrete is subjected to volume changes autogenously due to volume change in a concrete which is an undesirable property which affects long term strength and durability of concrete. Cracking is a common problem experienced by concrete structure due to early age shrinkage in case of slabs type structures that shows much longer surface areas such as pavements, bridge decks precast elements, industrial floors and tunnel lining as compared to other structural components such as beams and columns. There are much more solutions to control or reduce early age shrinkage cracking but introduction of synthetic fiber in addition to a simple concrete mix it has been observed that fiber reduces the cracks forming on the concrete surface. In this paper the fibers were introduced in concrete mix by mixture at the time of mixing of concrete which results in reducing the cracking phenomenon.

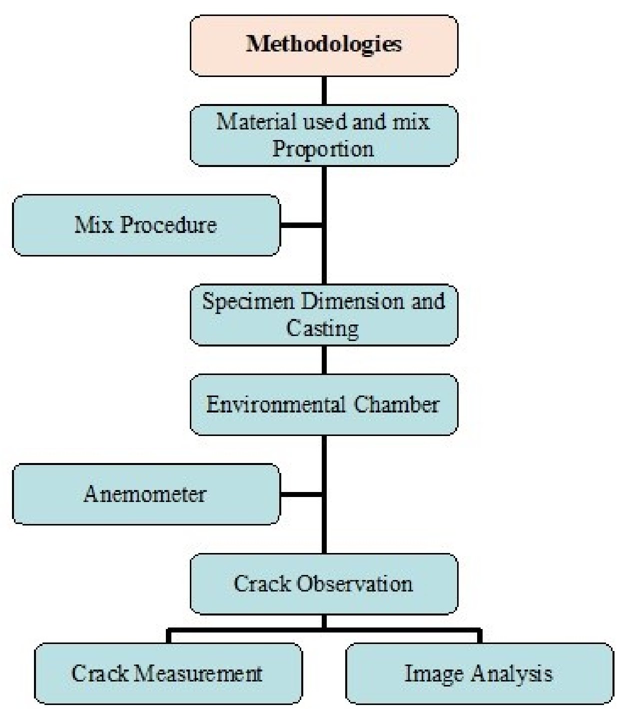
I. INTRODUCTION

Concrete is subjected to volume changes autogenously due to the volume change in concrete which is an undesirable property, affects long term strength and durability concrete. Volume change in concrete causes cracks in concrete there for volume change in concrete is important to the practical engineer. Due to the rapid loss of surface bleed water in evaporation volume change in fresh concrete occurs. Due the cracking phenomenon water and other chemical agents gets access into concrete and get in contact with steel reinforcements which cause reinforcement corrosion upto to breakage.

Fresh concrete during windy, dry and hot weather conditions vulnerable to shrinkage cracking phenomenon. When the rate of evaporation is higher than rate of bleeding can causes high tensile stresses that may be enough to exceed the tensile strength of concrete. If the cracks on surface develop as a result of shrinkage remain unnoticed and become passage for external deteriorating agents and reduce long-term durability.

Recent researches have mentioned that at a very early age concrete can produce large tensile stresses due to the early loss of moisture from fresh concrete. Volumetric changes caused due to reduction in temperature, chemical reaction and moisture loss early-age cracking phenomenon will be occurred. This reduction in volume results in the evolution of tensile stress in concrete and these tensile stresses when gets exceeds the tensile strength of concrete a crack can be expected to occur which is visible.

II. METHODOLOGY



A. Materials Used and Mix Proportions:

- Materials Used:

Design Grade	M 40
Cement Type	Ordinary Portland Cement
Brand of Cement	ACC
Sp. Gravity of Cement	3.15
Sp. Gravity of Fine Aggregate	2.55
Sp. Gravity of course Aggregate	2.65
Assumed type of exposure	Severe

- Mix Proportions:

Water	Cement	Fine Aggregate (Fa)	Coarse Aggregate (Ca)
189	472	583	1136
0.40	1	1.24	2.41

- Fiber Content:

AR-Glass Fiber	Weight (gm)	Polypropylene	Weight (gm)
0 %	0	0 %	0
0.5 %	13.14	0.5 %	13.14
1%	26.29	1%	26.29

Fig. 1: AR Glass Fiber

Fig. 2: Polypropylene

B. Mix Procedure:

The slab mould was casted by the procedure of Hand Mixing. The Cement, Sand, Aggregates were mixed by dry process the water were added for wet mixing. At the time of mixing concrete, the fibers were also mixed in that concrete mixture. After proper hand mixing the slurry will be poured into slab mould.

C. Specimen dimension and casting:

The slab mould of dimension 60x100x200 mm were used which were made of laminated sheet boards. Before placing of concrete to remove the base friction between concrete and surface of laminated board we can use a thin polyethylene sheet. To provide additional restraint and to avoid movement which is longitudinal in nature of the concrete from the edge's nails have been used at the ends.

Fig. 3: Specimen Mould

D. Environmental Chamber:

Test phenomenon has been carried during a less period i.e. 24h in order to check the problems related with cracking in the early age shrinkage. The specimen mould was placed in an environmental chamber having dimensions of 175x350x550 mm as shown in fig. To accelerate the drying of concrete and to control temperature and humidity a high-speed fan with regulator is used which is fixed on the walls of the chamber.

After casting and finishing of moulds the surface was open to environmental conditions such as, high wind speed of 3.9 m/s, a temperature range between 33 ± 1°C and a relative humidity of 50 ± 2 in order to satisfy shrinkage and crack formation phenomena.

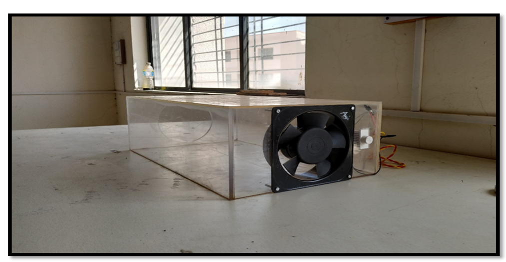


Fig. 4: Environmental Chamber

- Anemometer:

An anemometer is an instrument which measures speed of wind, temperature and wind pressure which is used to measure above mentioned parameters when the samples were in environmental chamber.

Fig. 5: Anemometer

E. Image analysis:

ImageJ analysis software is originated at National Institutes of Health & Laboratory for Optical and Computational Instrumentation (LOCI) which is a application processing on Java based image. ImageJ software process in following ways as display, edit, analyze, process, save, and print 8-bit color and point images. It can read many image having file formats like JPEG,PNG, BMP,GIF, and many more. ImageJ supports image stacks, a series of images that share in a single window, and it is multithreaded so time absorbing operations will be performed parallels on multi CPU hardware.

For the better understanding of the crack development and the cement based systems microstructure Image Analysis software has been used. Using curve tracing tool, length of crack which is developed was determined in the image analysis software to trace the crack then in terms of pixels the length was calculated, after that using the calibration scale it will be converted to length units (mm).

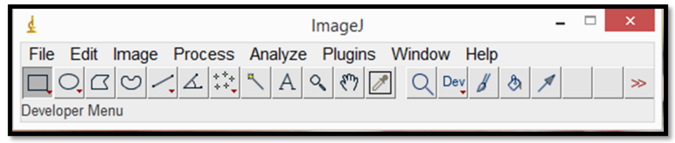


Fig. 6: ImageJ Software

F. Crack observation:

In case of plain cement concrete, after mixing with water around one hundred and sixty min (160 min), a fine hair line crack is visible which is running throughout the width of block above the central stress riser. This fine crack that might have presumably been originated due to settlement was found to widen upon further drying with in the case of fiber reinforced concrete specimens.

In case of plain cement concrete, a fine hairline crack was found. However, for fiber concretes no cracks were found.

Fig. 7: Crack Observation

G. Crack Measurement:

The measurements of cracks include of the length, width of crack (max. & avg.) And area of total cracks. For the measurements of cracks using an optical zoom camera images were captured based on crack visibility, after that image analysis software has been used for processing and editing of captured images to have a clear crack profile using different keys, commands and operations. Below an example is given of an image after the actions taken and operations in Fig. 8.

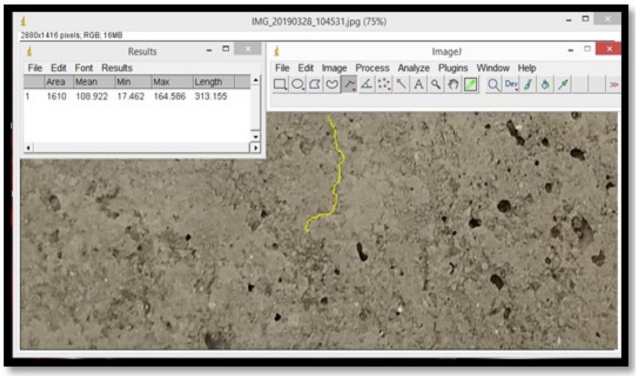


Fig. 8: Crack Observation

III. ANALYSIS AND RESULTS

Experimental results show that the cracks having maximum width were observed on plain cement concrete Specimen and no cracks were observed on the fiber added specimen. The overall cracking phenomenon was reduced with addition of synthetic fibers. The test results of the proposed work are described as follows in two contexts mainly AR-Glass Fiber and Polypropylene.

A. Plain Concrete:

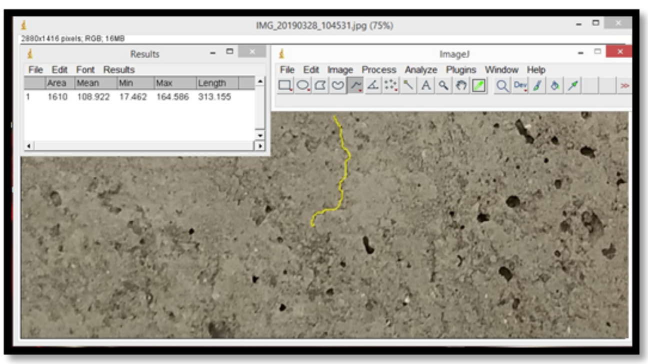


Fig. 9: Plain Concrete Specimen

B. AR- Glass Fiber Reinforced:

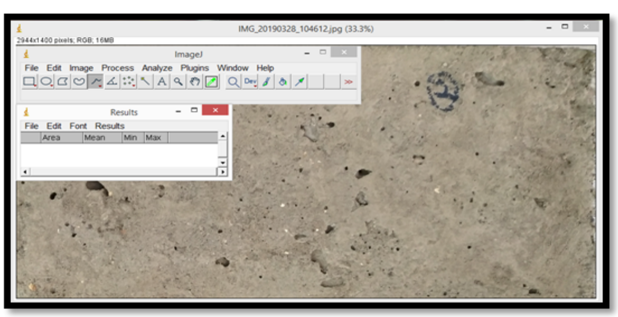


Fig. 10: AR Glass Fiber Concrete Specimen

C. Polypropylene Fiber Reinforced:

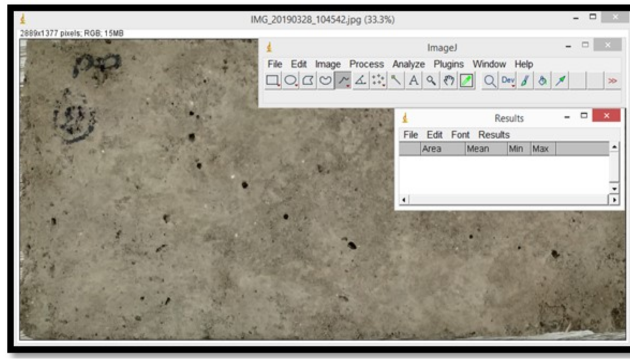


Fig. 11: Polypropylene Fiber Concrete Specimen

IV. OBSERVATIONS

Sr. No.	Type	Crack Width	Crack Length	Crack Area
1	Plain Concrete	17.46-164.59	313.155	1610
2	AR- Glass Fiber Reinforced	-	-	-
3	Polypropylene Fiber Reinforced	-	-	-

V. CONCLUSIONS

The Experimental Results of addition of synthetic fiber namely Polypropylene and AR-Glass to reduce plastic shrinkage conducted on concrete were reported in this paper. The following conclusions were made from the results discussed are as follows:

1. The addition of fiber in cement concrete specimen resulted to reduction in width also in length reduction.
2. The addition of synthetic Fiber (polypropylene and AR-Glass) shows the best performance in a certain delay in crack formation and in decreasing the crack phenomenon.
3. Another most important variable is resulted to be the aspect ratio, if the number of fibers used in same magnitude the results will be same.
4. The image processing software named ImageJ were effective not only in measuring the crack width, but also the length which follows the path

also uses tight curves and right angles for crack measurements.

5. The addition of fiber at the time of mixing of concrete, cubes becomes porous that means the w/c ratio has been decreased due to this type of mixing.

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