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An Experimental Study on Light Emitting Concrete

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Abstract: *The study of light emitting concrete which has the property of transmitting light from concrete by using optical fibers. Since years concrete has a low impression because of its dirty greyish color, opaqueness and sharp edge but this concept has been changed after the development of light emitting concrete, which gives the increased strength, better looks and light transmitting features. Plastic optical fibers are used because of its total internal reflection as its working principle as it gives maximum efficiency in transmitting light. The percentages of optical fiber added in this experimental study are 3%, 4%, 5%. This paper gives the structure a good aesthetic look without loss of strength parameters and serves as aeco-friendly building material and is also a energy efficient which reduces energy consumption by 30% by allowing the natural light by transmitting light through optical fibers and will also have a good scope in future. This experiment will be a series of initiatives to look closely at new and emerging advanced construction in future*

Keywords: Light Emitting Concrete, Optical fiber, Compressive Strength

I. INTRODUCTION

Concrete has been used since roman times for the development of infrastructure and housing, but its basic components have remained the same. Three ingredients make up the dry mix; coarse aggregate, consisting of larger pieces of material like stones or gravels; fine aggregate, made up of smaller particles such as; sand, and cement; a very fine powder material that binds the mix together when water is added.

It is no longer the heavy, cold and grey material of the past; it has become beautiful and lively. By research, lighter, white or coloured, etc. concrete has learned to adapt to almost all new challenges that appeared. In 2001 the concept of light emitting concrete was first put forward by Hungarian architect ‘Aron Losonzi’ at the Technical University of Budapest, and the first light emitting concrete block was successfully produced by mixing large amount of glass fiber in 2003, named as ‘LiTraCon’.The light emitting concrete mainly focuses on transparency and its objective of application pertains to green technology and artistic finish. It is the “combination of optical fibers and fine concrete”. At present, green imperative to develop a new functional material to satisfy the structure in terms of safety monitoring (such as damage detection, fire warning), environmental protection and energy saving and artistic modelling.

Due to globalization and construction of high- rise building, the space between building is reduced, this caused to increasing the use of non- renewable energy sources, so therefore there is a needs of smart construction techniques like green building and indoor thermal system.

II. MATERIALS USED FOR LIGHT EMITTING CONCRETE

Cement

Cement is a binder, a substance that sets and hardens as the cement dries and also reacts with carbon-dioxide in the air dependently, and can bind other materials together. Portland cement is the most common types of cement in general use around the world, used as a basic ingredients of concrete, mortar, stucco, and most non specialty grout. The OPC was classified into three grades namely, 33-grade, 43-grade, 53- grade depending upon the strength of the cement at 28 days when tested as per IS-4030-1988. The cement used in this experimental works is “53 Grade Ordinary Portland Cement”. The specific gravity of cement was 3.14. The initial and final setting were found as 30 minutes and 595 minutes respectively. Standard Consistency of cement was 30%.

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Fine aggregate

Fine aggregate is the inert or chemically inactive material, most of which passes through a 4.75mm IS Sieve and contains not more than 5 percent coarser material.

The fine aggregate sever the purpose of filling all open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength. Usually, natural river sand is used as a fine aggregate. However, at places, where natural sand is available economically, finely crushed stone may be used as a fine aggregate.

Optical Fibers Elements

Optical fibers is a wave guide, made of light emitting dielectric (glass or plastic) in cylindrical form through which light is transmitted by total internal reflection. It guides light waves to travel over long distances without much loss of energy. Optical fibers consists of aninner cylinder made of glass or plastic called Core of very high refractive index. The core is surrounded by a cylindrical shell of glass or plastic of lower refractive index is called cladding.

Water

Water should be free from acids, oils, alkalies vegetables or other organic impurities. Soft water also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the intern aggregate are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.

III. TESTS CONDUCTED ON MATERIALS USED IN LIGHTTRANSMISSION CONCRETE

Preliminary Tests On Cement

In this experiment we have done the preliminary tests on cement, that are

1. Fineness of cement
2. Standard consistency of cement
3. Initial setting time
4. Final setting time
5. Specific gravity
6. Standard consistency of cement

PROPERTIES OF OPTICAL FIBERS USED IN THE EXPERIMENT

Description	
Item type	Optical fiber
Material	PMMA+Plastic
Color	White
Cable length	2m
Diameter	0.75mm
Operating temperature	-58°F-167°F
Life span	20 years

MIX PROPORTIONS

Materials	3% Of Optical Fiber	4% Of Optical Fiber	5% Of Optical Fiber
Cement	117 grams	115 grams	112 grams
Fine aggregate	412 grams	409 grams	406 grams
Optical fiber	18 grams	24 grams	30 grams

IV. EXPERIMENTAL PROCEDURE OF LIGHT EMITTING CONCRETE

Different types of mixes were prepared by changing the percentage of optical fibers. Total 3 types of mixes are prepared. The optical fibers are placed in the cement mortar with percentages of 3%, 4%, 5% by weight of cement. The details of mix designations are as follows: Masonry blocks with desired sizes (70.6mmx70.6mmx70.6mm) were used in this work. Parallel to 70.6mmx70.6mm range, optical fibers were inserted in the path for the preparation of light transmission tubes. The method of transparent concreting is almost identical to the regular concrete. A base plate thermocol is used here for the manufacture of masonry blocks and optical plastic fibers are placed at a uniform spacing and a mortar is poured up to the top stage of the mould and compacted and finished.

EXPERIMENTAL PROGRAMME

- For manufacturing light transmitting concrete block, cement mortar cube size 70.6mmx70.6mmx70.6mm are used.
- The selected proportion is 1:3 (1 part of cement to 3 parts of sand), Cement used is 126gms and 421gms of fineaggregate respectively per one block of size 70.6mmx70.6mmx70.6mm.
- Now the cement mortar is prepared by using w/c as 0.45 for choosing the optimum water content and optimum fiber percentage.
- After that, start filling the cement mortar in layers and by giving hand compaction such that the optical fibers placed in the mould should not get damaged or cut.
- After completely filling the mould with mortar, the mould should be finally placed on a vibrator for final compaction.
- The vibration is done for 3 to 5 seconds to obtain final compaction and smooth finish. The top layer is leveled and finishing is done for aesthetic use.
- Similarly, take 3%, 4%, 5% of fibers which corresponds to 72 strands and were embedded in 3 different configurations i.e., a bundle of 12 strands at six different locations, bundle of 18 strands at four different locations, and bundle of 24 strands at three different locations and the procedure which has been followed above is to be applied for this, the strength parameters has to be calculated. With this, the optimum water cement ratio and the optimum fiber percentage are determined.

CASTING OF 3 NO. OF FINE CONCRETE CUBES WITH 1:3 RATIO BY ADDITION OF 3%, 4% & 5% OF OPTICAL FIBER

Mix the cement of quantity 0.415kgs and fine aggregate of 1.381kgs on a water tight non-absorbent platform until the mixture is thoroughly blended and is of uniform color

Add water of 172.97ml and mix it until the concrete appears to be homogeneous and of the desiredconsistency.

Clean the mould and apply oil.

Fill the concrete in the mould in layers approximately 2cm thick.

Compact each layer with not less than 25 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet-pointed at lower end).

Level the top surface and smoothen it with a trowel.

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked andremoved from the mould and kept submerged in clear freshwater until taken out prior to the test.

Result: 3 no. of fine concrete cubes are prepared.

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Fig. 1 Casting Of Moulds

Compressive Strength Test On Cast OPC

Compressive strength is the ability of a concrete material or a concrete structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. The formula for any material is the load applied at the point of failure to the cross-section area of the face on which the load was applied.

To determine the compressive strength of fine concrete with addition of optical fiberApparatus Required

1. Compression testing machine.
2. Specimen of size 70.6mm x70.6mm x 70.6mm for 3 cubes.

Mixing of Concrete for Cube Test

- Mix the cement of quantity 0.415kgs and fine aggregate of 1.381kgs on a water tight non- absorbent platform until the mixture is thoroughly blended and is of uniform color.
- Add water of 172.7ml and mix it until the concrete appears to be homogeneous and of the desired consistency.

Sampling Of Cube For Test

- Clean the mould and apply oil.
- Fill the concrete in the mould in layers approximately 2 cm thick.
- Compact each layer with not less than 25 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet-pointed at lower end).
- Level the top surface and smoothen it with a trowel.

Curing of Cubes

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the mould and kept submerged in clear freshwater until taken out prior to the test.

PROCEDURE FOR FINE CONCRETE CUBE TEST

- Remove the specimen from the water after specified curing time and wipe out excess water from the surface.
- Take the dimension of the specimen to the nearest 0.2m
- Clean the bearing surface of the testing machine.
- Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides ofthe cube cast.
- Align the specimen centrally on the base plate of the machine.
- Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- Apply the load gradually without shock and continuously at the rate till the specimen fails.
- Record the maximum load and note any unusual features in the type of failure.

Calculations

Size of the cube =70.6mmx70.6mmx70.6mm

Area of the specimen (calculated from the mean size of the specimen) = 351895 mm2

Formula

F = P/A

Where P = load on concrete cube

A = surface area of concrete cube

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V. RESULTS

Fineness test on cement

SI NO	Weight of Sample(W1)	Weight of the cementsample retained on 90μ sieve (W2)	Fineness of cement
01	100	10	10%
02	100	3.3	3.3%
03	100	5.5	5.5%

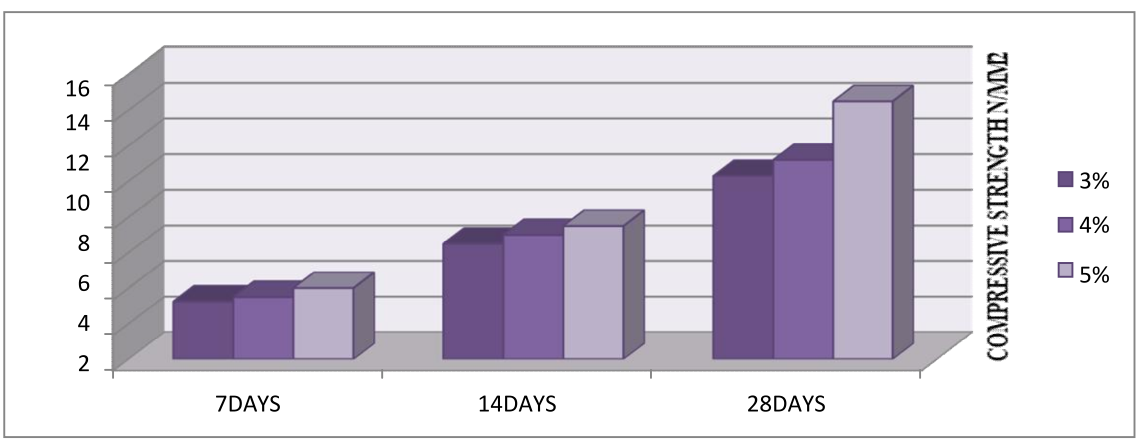
Standard Consistency of Cement

SiNo	Weight of cement (gm)	Percentage of water to beadded (%)	Amount of water added (gm)	Penetration (mm)
01	300	26%	78gm	15mm
02	300	28%	84gm	10mm
03	300	30%	90gm	6mm

S No	Tests conducted	Results
1	Intial setting time of cement	30min
2	Final setting time of cement	595
3	Specific gravity of cement	3.16
4	Fineness modulus of sand	3.54
5	Specific gravity of sand	2.7

COMPRESSIVE STRENGTH OF CUBES

SINO	OPTICAL FIBER PERCENTAGE	COMPRESSIVE STRENGTH		
		7 days(N/MM^2)	14days(N/MM^2)	28 days(N/MM^2)
1	3%	3.25	6.5	10.3
2	4%	3.5	7	11.2
3	5%	4	7.5	14.5



ADVANTAGES OF OPTICAL FIBERS

There are many advantages of using optical fibres over traditional wires. Some of the advantages are listed below:

- Lower cost in the long run
- High electrical resistance. So, safe to use near high-voltage equipment or between areas with different earth potentials
- Low weight
- No cross-talk between cables
- No sparks (e.g. in automobile applications)
- Economical and cost-effective

VI. CONCLUSION

The basic objective of the study is to prepare a concrete with better appearance and increased in strength. Mix designs for light emitting concrete materials has done and a total of 27 specimen are prepared and tested in the aspect of strength calculation and also comparisons has done. The compressive strength of light transmitting concrete is greater than that of conventional concrete up to some certain limit, beyond that limit the compressive strength goes on decreasing with increase in the volume of optical fiber.

- The highest compressive strength occurs at optimum 5% of fibers with 18 strands at 4 positions.
- Light transmitting concrete is an emerging trend in concrete technology.
- Its initial cost is high. But, the routine maintains is required and long run it may be advantageous. In fact it worth the cost

VII. FUTURE SCOPE

Light Emitting Concrete (LEC) is a fascinating innovation that combines traditional construction materials with advanced lighting technology. Its potential applications are diverse and promising, offering both functional and aesthetic benefits. Here are some future scopes for Light Emitting Concrete:

1. Infrastructure and Architectural Design: LEC can be integrated into various infrastructure projects such as bridges, roads, tunnels, and buildings. Its ability to illuminate pathways, enhance visibility, and provide guidance can improve safety and aesthetics in urban environments.
2. Smart Cities: As cities continue to evolve into smart cities, LEC can play a crucial role in enhancing urban landscapes. It can be used for illuminated sidewalks, crosswalks, public spaces, and landmarks, contributing to the overall ambiance and safety of urban areas.
3. Energy Efficiency: Future developments in LEC technology may focus on improving energy efficiency. Research into more sustainable materials and energy-efficient lighting systems could lead to LEC that consumes less power while providing adequate illumination.
4. Customization and Aesthetics: Advancements in LEC could enable greater customization options, allowing architects and designers to create unique lighting patterns, colors, and designs. This could lead to visually stunning structures and landscapes that adapt to different contexts and preferences.
5. Safety and Emergency Response: LEC's ability to illuminate pathways and emergency exits could make it invaluable for safety applications. In the event of power outages or emergencies, LEC could provide reliable illumination, helping people navigate to safety more easily.

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