EXPERIMENTAL STUDY ON MECHANICAL STRENGTH AND DURABILITY OF GLOW-IN-DARK CONCRETE

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Abstract: *The use of products with a glow effect provides increased safety at night and is an additional means in signaling on dangerous and worst-lit sections of road, parking lots, bicycle paths. A concrete observe light in day time and produces glow at night-time proves to be efficient in manages daily energy consumption in an efficient manner especially when the demand is peak at the night time, this concrete applies the basic principle of phosphorescence in which the phosphorescent materials absorb solar radiation in the daytime and emits the light energy in the dark. It is also ecofriendly, cost efficient and appealing to the eye due to its luminescent property. Luminescent concrete composition consists of cement, fine aggregate, such as sand and phosphorescent materials such as strontium aluminate, sulfide powder, titanium di oxide and resins such as epoxy, polyester resin for better bondage.*

Keywords: **Compression strength, Durability, Intensity, Photoluminescent, Split tensile strength, strontium aluminate**

1. INTRODUCTION

Concrete is by far the most used produced and consumed construction material on earth. Its global consumption amounted for 4.4 billion metric tons in 2021. As it has a wide range of uses in construction field. Innovation of concrete is being brought up to enhance the luminescence and maintain mechanical strength of the concrete.

The product here is generally related to glow-in-dark materials and particularly to glow-in-dark concrete. This invention deals with developing a glow-in-dark or luminescent concrete store system, which can absorb light energy and emit the stored light energy with different colors, when the source of light is completely removed.

The glow-in-dark concrete comprises photoluminescent pigments mixture. The glow-in-dark concrete includes titanium di oxide, sulfide powder, strontium aluminate, epoxy resin, cement, sand, gravel, and water.

2. LITERATURE SURVEY

[1] MONALISA BOTH, PAULO REIS JUNIOR, TATIANE ISABEL HENTGES, MARI AURORA FAVERO REIS [2021] "PHOTOELECTRIC EFFECT ON CONCRETE ARTIFACTS PRODUCED WITH THE ADDITION OF LUMINESCENT SUBSTANCES AND POLYMER RESIDUES", 89711-330-The tests carried out in this experiment showed that there was emission of photons in the newly formed concrete minutes after exposure to solar radiation. Concrete with addition of polymer showed a more intense and uniform glow when compared to conventional concrete.
When comparing the mixtures with the addition of polymers (mixture A and B), it is possible to identify that concrete with extrusion polymer (mixture B) presents a better performance in the binding of components. This result reduces the need for a large number of additives, reducing production costs. Both polymers are recycled waste. contributing to the sustainability of the product.

As for the strength in concrete artifacts, the results of the tensile strength tests on the blocks showed that the experiments with the extruded-type polymeric aggregate presented similar values to the reference concrete.

[2] MOHAMMAD SALEEM, AKIRA HOSODA (2021) "DEVELOPMENT AND TESTING OF GLOW-IN-THE-DARK CONCRETE BASED RAISED PAVEMENT MARKER FOR IMPROVED TRAFFIC SAFETY", ISSN 1392-3730, VOLUME 27 ISSUE 5-The value and, contribution of the presented experimental pioneering proof-of-concept research work to the body of knowledge is as summarized:

1) A glow-in-dark concrete based raised pavement marker is presented which has the ability to provide visible light thus eradicating the need of retroreflection and electroluminescence.
2) GiD based RPM specimens depicted good durability performance under mechanical and thermal loading.
3) Glow-in-dark testing has revealed that the glow intensity increases with increase in percentage of nano powder. Furthermore, the glow duration is not affected after the material has been charged for 5 mins.
4) The demo video detailing the application of the GiD based RPM depicted increased visibility of the markers and road edge which added to the safety of road users.

3. OBJECTIVES

The following are the objectives of the present project:

- To determine the intensity of luminescence when the source of light energy is removed.
- To determine the compressive strength and split tensile strength of the Glow-in-concrete.
- To evaluate the durability of glow-in-dark concrete.

4. MATERIALS AND PROPERTIES

4.1 TITANIUM DIOXIDE

Titanium dioxide has two main forms, where primary form, is 98 percent of total production, is pigment grade titanium dioxide. The pigmentary form makes use of titanium dioxide's excellent light-scattering properties in applications that require whit opacity and brightness. The secondary form in which titanium dioxide is produced is as an ultrafine product. This form is selected when different properties, such as transparency and maximum ultraviolet light absorption.

4.2 STROTIUM ALUMINATE:

Strontium aluminate act has the strongest and powerful phosphorescent agent that can produce glow up to 14hours after absorption of solar radiation or artificial light. Strontium aluminate produce green and aqua glow, where green glow gives the highest brightness and aqua glow gives the longest glow time.

4.3 SULFIDE POWDER:

Calcium sulfide, strontium sulfide and zinc sulfide used as colored pigment.

4.4 EPOXY RESIN:

A solvent is required to mix strontium aluminate, titanium dioxide, sulfide powder, to form paste or solution for equal proportion of mixing and even distribution of materials. Mostly resins especially epoxy resins and polystyrene resins are used as solvents.

4.5 CEMENT:

For the experiments conducted, Ordinary Portland cement (53 grade) is used. The properties of cement are tested according to the codal provisions.

Table 1. Property of Cement

SL NO	Property of cement	Result
1	Normal consistency	34%
2	Initial setting time	35min
3	Specific gravity	3.12

4.6 FINE AGGREGATE:
For the experiment, locally available M sand is used. The fine aggregate conforming to zone 2 (IS 383-2016 grading requirements).

Table 2. Property of fine aggregate

SL No	Property of fine aggregate	Result
1	Specific gravity	2.65
2	Fineness modulus	2.63

4.7 Coarse Aggregate:
The coarse aggregate of maximum size 20mm were used and tested as per the IS 2386-1963. The specific gravity of coarse used is 2.8

5. MIX DESIGN AND METHODOLOGY

5.1 MIX DESIGN:

- Ordinary Portland cement (53 grade) is used. The target mean strength for specified cube strength is 20 + (1.65) x 4 = 26.6 MPa
- The water-cement ratio required for the target mean strength of 26.6 MPa is 0.50. This is lower than the maximum value of 0.55 prescribed for "Mild" exposure. Adopt W/C ratio of 0.50.
- For 20 mm maximum size aggregate, and sand conforming to grading Zone 2.

Table 3. Mix proportion

Water	Cement (53 grade)	Fine aggregate	Coarse aggregate
197.16 lt/m^3	394.32 Kg/m^3	639.09 Kg/m^3	1209.6 Kg/m^3
0.5	1	1.62	2.94

5.2 METHODOLOGY:

- Collection of materials required
- Conduction of basic tests on materials
- Preparing mix design for M20 grade concrete
- Preparation of light emitting fresh to cast specimens
- Demolding and curing the concrete specimens for 3, 7, 14, and 28 days.

- ➢ Determination of intensity of light, mechanical strength and durability of concrete
- ➢ Discussion and conclusion

The mixing of glow in dark concrete involves two steps:

- The first step consists of mixing the cement, coarse aggregate and fine aggregate with their respective water cement ratios (i.e., 0.5:1:1.62:2.94).
- The second step is the preparation of paste of glow in dark pigments (i.e., titanium dioxide (3%), sulfide powder (3%), and epoxy resin (6%) are mixed). Then the luminescent slurry is mixed with the first step elements. The whole mix is now regarded as the mixture of glow in dark concrete mixture.

6. LABORATORY TESTS ON MECHANICAL STRENGTH, DURABILITY AND LUMINESCENCE

6.1 COMPRESSION STRENGTH:

The compressive strength was obtained by testing 150x150x150mm cubes. The curing is maintained for 3, 7, 14 and 28 days.

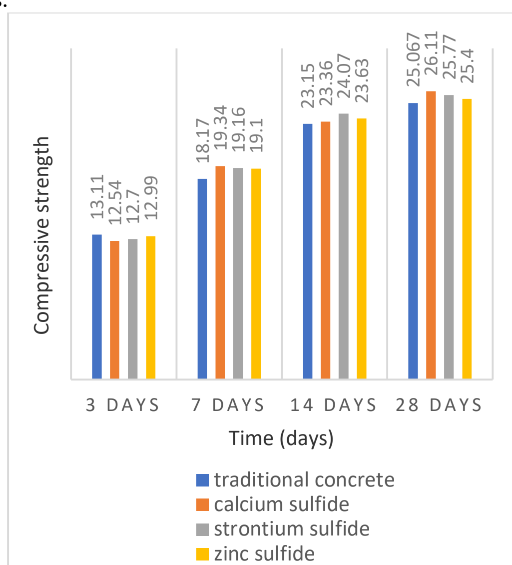

Figure.1 Compressive Strength Test Results

When compared to traditional concrete, concrete mixed with calcium sulfide, strontium sulfide, zinc sulfide shows the following percentage increase in the compression strength.

Table 4. Percentage increase in compression Strength

Days	Sulfide mixed with concrete	Percentage increase
7 days	Calcium sulfide	8.8%
	Strontium sulfide	7.48%
	Zinc sulfide	7.02%
14 days	Calcium sulfide	1.1%
	Strontium sulfide	5.05%
	Zinc sulfide	2.63%

28 days	Calcium sulfide	0.45%
	Strontium sulfide	3.7%
	Zinc sulfide	1.9%

6.2 SPLIT TENSILE STRENGTH

The split tensile strength was obtained by testing cylinder of height 300mm and diameter150mm. the curing is maintained for 3, 7, 14 and 28 days.

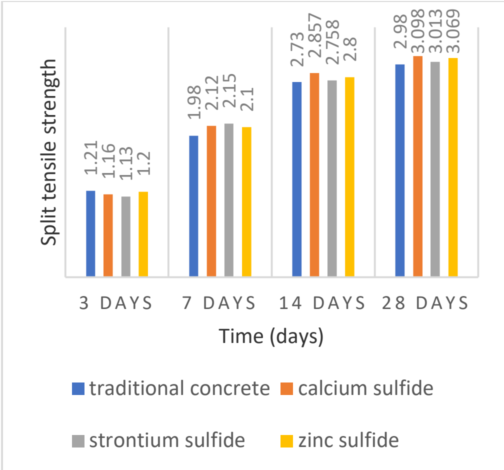

Figure. 2 Split Tensile Strength Results

When traditional concrete is compared with the concrete mixed with calcium sulfide, strontium sulfide, zinc sulfide shows the following percentage increase in the split tensile strength.

Table 5 Percentage Increase in Split Tensile Strength

Days	Sulfide mixed with concrete	Percentage increase
7 days	Calcium sulfide	7.0%
	Strontium sulfide	8.5%
	Zinc sulfide	6.06%
14 days	Calcium sulfide	4.6%
	Strontium sulfide	1.02%
	Zinc sulfide	2.56%
28 days	Calcium sulfide	3.96%
	Strontium sulfide	1.1%
	Zinc sulfide	2.98%

6.3 CARBONATION TEST

Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the oxide film is no longer stable.

Figure.3 Carbonation Test on Concrete Cube

In the test conducted there was no carbonation reaction in the concrete cube, hence the glow in dark concrete is resistant to carbonation.

6.4 SORPTIVITY TEST:
Sorptivity test results are obtained by testing 75x75x75mm. The curing in maintained for 7 days and oven dried (at 50^0C) to remove excess of moisture.

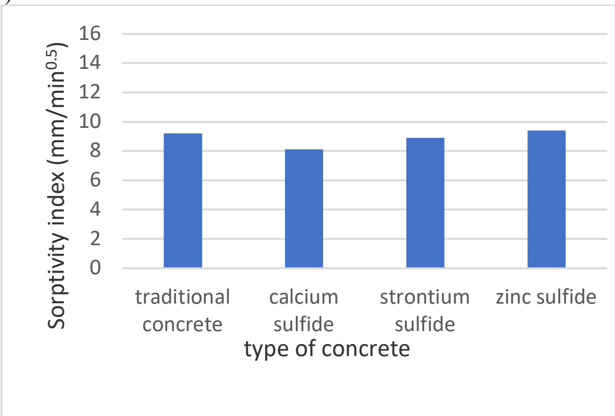

Figure.4 Sorptivity Index Chart

From the above sorptivity index chart the obtained results show's that sulfide mix concrete is equivalently durable as traditional concrete.

6.5 LUMINESCENCE TEST:
A light measuring lux meter was used to analyze the intensity and duration of light emitted in candelas per square meter (cd/m^2).

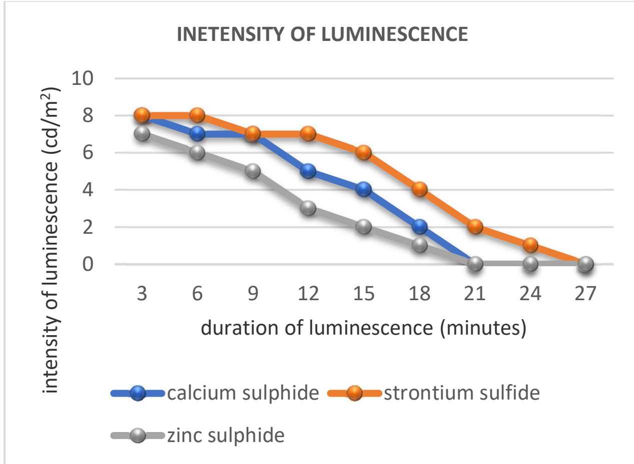

Figure.5 Intensity of Luminescence

Concrete mixed with calcium sulphide can glow about 21minutes with more intensity, whereas strontium sulphide mixed concrete can glow up to 27minutes with low intensity and zinc sulphide can glow up to 19 minutes with low intensity.

7. CONCLUSION:

The following are the conclusions made from the experimental study's

- The compression strength, split tensile strength, durability and luminescence tests were conducted on glow in dark concrete.
- As for strength of concrete compression strength and split tensile strength is slightly higher than the traditional concrete.
- Durability results on the glow in dark concrete is also virtuous.
- Concrete with addition of strontium aluminate showed more intense and uniform glow when compared to traditional concrete.

8. ACKNOWLEDGEMENTS

We are thankful to Mr. Shashikumar A, Associate professor, Department of civil Engineering for his guidance. We also thank department of civil engineering S J C Institute of technology, Chickaballapur.

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