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Polyester Resin and Waste PVC pipe based Light Transmitting Concrete

Concrete-material-Technique

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Abstract - *As a part of dissertation light transmitting concrete is prepared by waste PVC pipes and polyester resin which is capable of transmitting light through the concrete. Waste glasses is laminated with polyester resin liquid on to the surface facing sun and then this complete assembly is utilized to prepare light transmitting concrete that works very effectively for electrical energy saving construction material inside the structures by utilizing light of sun for lightening in interiors and also reduces the total dead weight of concrete buildings very effectively which is further being applied on the base of building in very less cost using relatively cheaper resources. The quantity and volume of cement, sand and aggregate in ordinary concrete of M25 grade, with that in mind dissertation was conducted. This dissertation included the manufacturing of concrete mix which is 1 cement: 1 sand: 2 Aggregate as per specification thoroughly with waste PVC pipes filled with chlorinated water and polyester resin and then light transmitting concrete cubes were casted. The light transmitting concrete cubes was prepared of volume 150mm×150mm×150mm as we have this mould available in the laboratory. After manufacturing of the cubes the different laboratory experiments as per IS Code provision are carried out to determine the workability, compressive strength, transmissibility of exterior light and flexural strength test in accordance as specified in IS-456 as well as IS-3370.*

***Keywords* -** *Cement, Sand, Aggregate, Resin Hardener, Polyester resin, Waste glasses.*

I. INTRODUCTION

Concrete is the very extensively used and most widely adopted construction material worldwide. Due to fast globalization sustainable construction is emerging as a main concern in the construction industry. Discovering sustainable construction optimizes the depletion of raw materials like cement sand and solar energy is significantly utilised for protecting the environmental pollutions. This research also promotes the practice and design of concrete structures which is less energy consuming moreover eco friendly too. Concrete ingredients are opaque in nature and highly dense too which hinders the light transmission and consequently concrete becomes opaque. However, It is possible to transform concrete from opaque to transparent by integrating Polyester resin and waste pvc pipes with a concrete matrix. Along with light transmittance, transparent concrete is capable to show the presence of any proximal persons, things etc. situated on the brighter side of the wall; therefore, it can also be used very effectively for application in the construction of lockups, offices, banks, and museum to enhance safety, supervision, and security. Commercial and residential buildings are the most electricity consuming sectors. The building sector electricity demand accounts for about 33% of energy demand worldwide. Artificial lighting consumes about 18% of the total available electricity in the world. Moreover the electric lighting requirement has continuously been increasing with the increase in the global population, urbanization, and construction of multi-storey buildings. When multi-storeyed buildings are built very near to each other, natural solar light is hindered to transmit through due to the present obstruction from neighbourhood structures. The brightness of the interior in structure is entirely managed by artificial lighting and bulbs which consume a heavier amount of electricity. Utilising natural solar light in an interior reduces the requirement for artificial light and cost of energy and promotes better comfortable condition for humans. Indoor conditions of structure with sufficient natural solar light illumination have been proved to decrease the stress of humans and improve visual quality. Discovering a new type of construction material that can minimize the demand for artificial electric energy for lighting is vital. This dissertation attempts to raise such issues through the manufacturing of transparent concrete using locally available cheaper materials that can work as energy-saving constructional material in a variety of architectural slabs of structures, without any kind of compromising the fundamental engineering properties of the concrete material. Transparent concrete is a very aesthetical concrete that provides daylight in structures and promotes development of green buildings as well as sustainable construction. Cement-based transparent concrete is a combined mixture of conventional concrete components such as Cement, Sand, Aggregate and water and about 15%-20% of polyester resin by percentage of the total concrete volume. Transparent concrete panels should comply with the strength, serviceability, and durability criteria to successfully hold the expected deflection. Moreover the transmittance of light should be enough to fulfil the illuminance level for the routine work of occupants in interiors of structures and also comply with fundamental standards. There is no recent work on the design, manufacturing, and application of resin based transparent concrete in INDIA. This work wishes to add cognizance of translucent concrete in the construction industry of INDIA and to gain insight into the development of transparent concrete panels using locally available materials which have achieved a lot of success in recent past years in the sustainable and effective construction and building efficiency issues throughout the world. Moreover, the effect of polyester resin on the structural performance of transparent concrete panels has not been studied precisely. This research has also discovered the flexural strength of concrete panels. The laboratory results revealed that the compressive and tensile strengths in transparent concrete decreased as the percentage volume of polyester resin was increased.

II. SIGNIFICANCE OF RESEARCH

1- Develop another way to acquire permanent energy during daytime by solar radiation for lightning in interiors.
2- Utilize sunlight for illumination inside the interiors of concrete buildings. So it desires to save electricity in day time.
3- Prepare Light transmitting concrete for aesthetically pleasing by transmittance of light through the concrete surface.
4- Make Light transmitting concrete by waste glasses and polyester resin for transparency which is relatively cheaper than light translucent concrete prepared by optical fiber cables.
5- Reduce the total dead weight of concrete that is further applied on the base of concrete building.

III. MATERIALS

3.1 Cement

Portland pozzolana cement (as per Indian Standard code of practice 4031-1988 and 1489-1991(Part 1 and 2)) is used for our dissertation purpose and the following properties are calculated as per table 1.

Table 1. Physical properties of cement

<table>
<tr><th>S. No.</th><th colspan="2">Property</th><th>Observed value</th><th>Expected value</th></tr>
<tr><td>1</td><td colspan="2">Specific gravity</td><td>3.153</td><td>≅ 3.15</td></tr>
<tr><td>2</td><td colspan="2">Fineness modulus test</td><td>2.8%</td><td>≤5%</td></tr>
<tr><td>3</td><td colspan="2">Normal consistency</td><td>28.0%</td><td>25 to 30 %</td></tr>
<tr><td>4</td><td colspan="2">Soundness</td><td>2.0 mm</td><td>$\leq 10\ mm$</td></tr>
<tr><td>5</td><td colspan="2">Initial setting time</td><td>33 min</td><td>$\geq 30\ min$</td></tr>
<tr><td>6</td><td colspan="2">Final setting time</td><td>568 min</td><td>$\leq 600\ min$</td></tr>
<tr><td rowspan="4">7</td><td rowspan="4">Compressive strength (in N/mm^2)</td><td>3rd day</td><td>13.50</td><td rowspan="4">≥ 33 N/mm^2</td></tr>
<tr><td>7th day</td><td>23.40</td></tr>
<tr><td>14th day</td><td>34.80</td></tr>
<tr><td>28th day</td><td>53.20</td></tr>
</table>

3.2 Aggregate

3.2.1 Fine aggregate:-

sand is used as a fine aggregate in our work. Fine aggregate which is used in tests for this specific concrete possess following properties according to table-2 and the sand belongs to zone III as per the specifications of IS 383:1970.

Table 2. Properties of fine aggregate

S. No.	Property	Observed value	Expected value
1	Specific gravity	2.645	≅ 2.70
2	Silt content	1.3 %	≤ 6%
3	Bulking of sand	1.83	---

3.2.2 Coarse aggregate:-

Nominal maximum size of coarse aggregate of 20mm is used for the preparation of this light transmitting concrete and the sieve analysis is done as per the specifications of IS 383: 1970 for graded aggregates. Coarse aggregate have following properties according to table-3.

Table 3. Properties of coarse aggregate

S. No.	Property	Observed value	Expected value
1	Specific gravity	2.68	$\cong 2.70$
2	Water absorption	2.67 %	$\leq 6\%$
3	Flakiness index (F.I.)	0.86%	$\leq 10\ to\ 15\%$
4	Elongation index (E.I.)	2.15%	4 to 5 times of F.I.

3.3 Water:-Properties of water have also greater impact on the concrete, thus the water which is utilized in the dissertation for the preparation of the concrete proper qualities. That water has the following properties according to table-4.

Table 4. Water quality parameters

S. No.	Property	Observed value	Expected value
1	pH value	7.1	6.5 to 7.5
2	Organic content	0.05 ppm	$\leq 200\ ppm$
3	Inorganic content	110.25 ppm	$\leq 3000\ ppm$
4	Sulphate content	2.36 ppm	$\leq 400\ ppm$
5	Total suspended matter	187 ppm	$\leq 2000\ ppm$
6	Chloride content	13.20 ppm	$\leq\ 500\ ppm$

3.4 Polyester resin:-

- For transmittance of light through concrete and reduction of deadweight of concrete clear casting polyester resin is used.
- Resin has higher resistance against abrasion and hardness (on Barcol scale 38 – 42) thus coated on waste glasses.
- The properties of CCPR are shown in table 5 and 6 respectively.

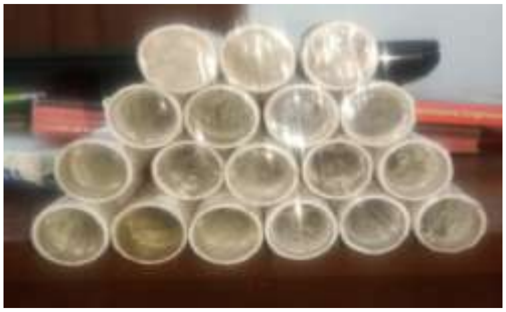


Fig.1 Resin in PVC mould

Table -5 Polyester resin properties

S. No.	Property	ASTM Test method	Results in M-Pa
1	FLEXURAL STRENGTH	D-790	91
3	TENSILE STRENGTH	D-638	44
4	TENSILE MODULUS	D-638	4945
5	TENSILE ELONGATION%	D-638	1.5
6	Heat Distortion Temperature	D-648	115 °F / 46.1 °C
7	Hardness, Barcol 934-1	D-2583	38 – 42
8	Refractive Index	1.52	

Table- 6. Polyester Resin properties related to production

S. No.	TYPICAL RESIN PROPERTIES @ 77°F RESULTS	
1	Catalyst %	1.0
2	Gel Time, (min)	15 – 25
3	Gel to Solid state Time, (min)	35– 55

3.5 Design for M-25 Grade Concrete

- Target Minimum Compression Strength after 28 days: 25 MPa
- Type of Exposure: Moderate

3.6 Waste CPVC pipes

Waste CPVC pipes are utilized to minimize plastic waste and clear waste glasses have a good refractive index nearly equal to the polyester resin, therefore more light can be achieved through light transmission via light transmitting concrete. Waste CPVC pipes were found out of following properties according to table no. 7.

Table 7. Specification of waste CPVC pipes

Material	S. No.	Description	Property
Properties of PVC pipes	1	Bottle color	White
	2	Bottle water sealing	Good quality
	3	Water	colorless
	4	Residual Chlorine	1.0 ppm

IV. MANUFACTURING PROCESS

Light transmitting concrete is made of cement, sand, aggregate, waste PVC pipes and polyester resin. The manufacturing process of Light transmitting concrete is just the same as the manufacturing of regular concrete. As per advancement of this research, in this manufacturing process waste PVC pipes and polyester resin medium are inserted. Due to waste PVC pipes and clear polyester resin, strength and consistency of light transmitting concrete are greater than the ordinary concrete as calculated during tests results. Almost free energy loss by light transmission through waste PVC pipes and polyester resin make the possibility to see light array and even different colors through Light transmitting concrete even by very thicker walls. In this way, the outcome product is like solid glass in this concrete as new building material, which provides uniformness in its interior structure as well as on its outer surfaces. The waste PVC pipes and polyester resin lead the light to be passed between the two sides of the Light transmitting concrete cubes. Due to their proper arrangement inside the concrete, the solar light on the exterior wall appears unchanged on the interiors as well and there is appreciable similarity in exterior light and interior of the structure. Use Polyester resin and waste PVC pipes enhances the strength of concrete as it has a relatively high strength of 91 N/mm^2. Moreover, the color of the light also remains similar as it does not get dispersed in resin and glass medium. Polyester resin is in liquid state until it is mixed with the resin hardener .Once the resin hardener is mixed in a waste PVC pipe,it will take time in 2-4 hours to be settled like solid filled it is fixed in the concrete-mould and then this concrete is placed by fixing the clear casting polyester resin in concrete mold. Water to Cement ratio (w/c) is kept 0.45 in this light transmitting concrete preparation.

4.1 Test conducted on concrete:-

There are three types of tests possible in concrete-

1- Workability test
2- Compressive strength test
3- Flexural strength test

4.1.1 Workability Test

The workability of light transmitting concrete is calculated by conducting slump test and compaction factor test.

Table 8 Workability test results

S. No.	Experiment	Test result	
		Slump	**Compaction factor**
1	Workability test	90mm	0.93

4.1.2 Compressive Strength Test

- The strength after 28 days of concrete cubes of cubes at which concrete sample fails under uniaxial compression test is the ultimate characteristic compressive strength.
- The compressive strength is calculated by compressive strength test (CST) which is carried on the compressive strength testing machine.
- Concrete cubes of 150mm×150mm×150mm size are tested for the strength calculation.

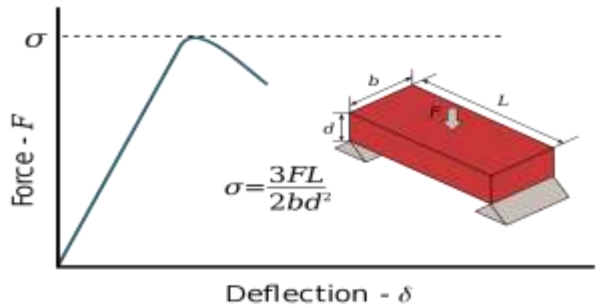
Table 9. Test Result

Test day	Observed Compressive strength (in N/mm^2)		
	Ordinary concrete	**Light Transmitting concrete**	**Clear Casting resin**
3^{rd} day	12.6	15.95	91
7^{th} day	16.82	18.91	91
14^{th} day	22.82	25.57	91
28^{th} day	25.35	28.15	91

Fig.3. Compressive strength comparison curve

4.1.3 Flexure strength Test

Flexural strength of light transmitting concrete is calculated by conducting tests on Universal Testing Machine (UTM). The stress generated in a concrete beam just before yielding is Modulus of rupture or flexural strength.



Where, F=Applied load,b=width, d=depth, L=length

Test Result:- Average Flexural strength of light transmitting concrete cubes = 9.10N/mm^2

V. WEIGHT COMPARISON

Light transmitting concrete cube prepared by this experiment is having relatively lesser weight than the regular concrete as it is explained in the table below.

Table 10. Concrete weight comparison

S.No.	Ordinary Concrete (in Kg)	Light Transmitting Concrete (in Kg)
1	8.22	7.50
2	8.36	7.54
3	8.31	7.63
4	8.18	7.43
5	8.23	7.54

Fig. 3 Light Transmitting concrete

VI. CONCLUSION

1. Light transmittance and mechanical properties through this concrete was demonstrated and the hypothesis of light transmission is verified. Waste pipes and polyester resin based concrete allow the use of solar light for illumination in interiors.
2. Waste PVC pipes utilized in the making of light transmitting concrete. It optimizes the environment pollution as waste pvc pipes get wasted in large quantities and pollutes the environment.
3. Light transmitting concrete was manufactured using extraordinary advantageous material polyester resin to achieve transparency.
4. It is concluded that utilization of waste pvc pipes and polyester resin, the compressive strength is enhanced as waste glasses and polyester resin possess higher strength than regular concrete.
5. Resin based light transmitting concrete would be very efficient in daytime for buildings.
6. Conclusion of this dissertation is that transparency of light in concrete is available without any compromise with strength criteria of concrete.

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