EXPERIMENTAL INVESTIGATION OF SMART CONCRETE BY USING THERMOMORPH POLYPLASTICS

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Abstract: This study has been undertaken to investigate the strength improvement in concrete under tension and compression by making the comparative results between conventional and smart concrete. To test the strength of concrete different equipments, materials are utilised in the laboratory. Some of the tests include slump cone test, compressive strength test, and split-tensile strength test. All these test shows the strength improvement ranging between conventional and smart concrete and the graphical representation of the test data is submitted in this framework. The aim of this project is to achieve higher grade strength from the lower grade mix design and to implement the application of tough materials like stones during concrete casting.

Index Terms-Polyplastics PCL, smart concrete, stannous octoate.,

1. INTRODUCTION

Smart concrete is a material prepared with improved strength than the conventional concrete. The strength improvement in smart concrete is achieved by the addition of Polycaprolactone **PCL** substance during concrete casting whereas the conventional concrete does not mixed with the Polycaprolactone **PCL** pellets. Polycaprolactone **PCL** is a thermo morph Polyplastic material which can be moulded to the desired shape and improved strength.

The process happened in the smart concrete is that the concrete is developed to higher grade strength from the lower grade mix of concrete casting. Thermomorph Polyplastics has made it possible in developing the higher grade strength from the lower grade mix of concrete casting. Concrete with different grades has so many benefits and applications in the field of construction.

In economics, there is proportion generally exist between demand, supply and price. If the demand is high the supply will be also high and if the demand is low, the supply becomes less but the price becomes high. Thermomorph Polyplastics are not adopted as a construction material so far and they have been used in small-scale modelling, repair of plastic objects and rapid prototyping. Using of Thermomorph Polyplastic can increase the demand and supply and the price value will be reduced automatically and can also bring a tremendous development in the speed construction process. Durability and strength of the huge mass structures can be tremendously increased in the smart way and it may result in structural reliability to the people demanding Thermomorph polyplastics.

2. THERMOMORPH POLYPLASTICS

Thermomorph polyplastics is obtained artificially from polycaprolactone **PCL** which is a prepared by a ring opening polymerization using a catalyst such as stannous octoate. This polymerization catalyst is produced due to the reaction between tin (II) oxide and 2-ethylhexanoic acid and is a colourless liquid at room temperature. The chemical formula of stannous octoate is $\mathbf{C_{16}H_{30}O_4Sn}$. The density of the catalyst at 25^0C is 1.251 g /cm^3.

The polycaprolactone **PCL** is classified as a polyester plastic. It has the lowest density among other polyester plastics. But it has the highest ductility and the melting point of polycaprolactone **PCL** is 60^0C. The young's modulus of polycaprolactone **PCL** is 1200 N/mm^2 whereas the young's modulus of conventional concrete is already ranging between 50000 N/mm^2. But, the concrete has less ductility. By replacing the conventional concrete with polycaprolactone **PCL** has additionally improved the young's modulus and with improved ductility. Finally, the conventional concrete is transformed to smart concrete by the addition of polycaprolactone **PCL** pellets.

4. COLLECTION OF MATERIALS

The materials are collected from different sources and they are tested in the laboratory for its quality check, concrete mix design for casting following recommended IS guidelines. From the IS269:1989, the Ordinary Portland Cement **OPC** 43 grade is selected. From the IS383:1970, the river sand is taken as fine aggregate for concrete casting and blue metal of 20 mm grade is taken as coarse aggregates. These are the materials are used in casting conventional concrete. Drinking water is used in concrete casting. For smart concrete, the polycaprolactone **PCL** pellets are melted at a temperature below 60^0C to avoid the effect of scalding.

Polyplastics is a very tough, nylon-like plastic and is softened to a putty-like consistency at below 60^0C using hot water and the substance is then molded to the desired shape. In this project, the molded polyplastics is coated to the outer surface of the coarse aggregates and is then finally immersed in cold water. Finally, the strength of the individual coarse aggregate is developed and is then mixed during casting. In general, about 60% volume of coarse aggregates occupies the volume of concrete. In such volume about 5% coarse aggregates are modified aggregates coated in its outer surface using polyplastics.

Comparative test results are taken between conventional and smart concrete and the observation is made on fresh and hardened period in both conventional and smart concrete in the range of strength improvement based on the observation made after curing in 7,14 and 28 days.

5. TEST ON CONCRETE

STEP 1- MATERIAL TEST

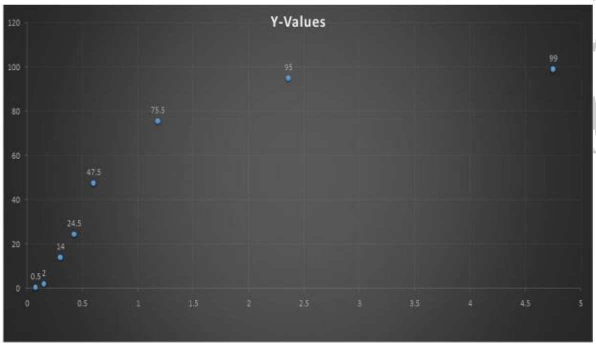
The material test is made on cement, sand, coarse aggregates and water which helps to determine the mix design proportion and concrete casting in the mold of cube and cylinder for taking the test on compression and split-tensile strength.

(a) SPECIFIC GRAVITY TEST:

S.NO	TYPE OF MATERIAL	SPECIFIC GRAVITY VALUES
1.	Cement	**3.478**
2.	River sand	**2.636**
3.	Blue metal	**2.645**

(b) SIEVE ANALYSIS TEST:

ON FINE AGGREGATE



RESULT:

From graph,

D10=0.26

D30=0.45

D60=0.81

Co-efficient of uniformity (C_u) = (D60/D10)

= 0.81/0.26

=3.24

Co-efficient of curvature (C_c) = ($D30^2$/ D10 X D60)

= 0.45^2/ 0.26 X 0.81

=0.96

(c) ON COARSE AGGREGATE

S.NO	SIEVE SIZE (mm)	WEIGHT RETAINED (gm)	TOTAL WEIGHT RETAINED (gm)	TOTAL% RETAINED (gm)
1.	**80**	0	0	0
2.	**40**	250	250	5
3.	**20**	1750	2000	40
4.	**10**	1600	3600	72
5.	**4.75**	1400	5000	100
6.	**2.36**	0	5000	100
7.	**1.18**	0	5000	100
8.	**0.6**	0	5000	100
9.	**0.3**	0	5000	100
10.	**0.15**	0	5000	100

RESULT:

The fineness modulus of coarse aggregate is 6.17. If the limit of fineness modulus lies between 6-6.9, the maximum size of coarse aggregate is 20mm. From this test value, the fineness modulus of coarse aggregates is found to be 20mm.

STEP 2- MIX DESIGN

In this project, the concrete casting is carried out in a design grade mix **M20** where the proportion of cement, fine aggregate and coarse aggregate is **1:1.5:3.**

(a) DESIGN STIPULATION

From IS 10262:1982

Characteristic compressive strength required in field at 28 days = 20 N/mm^2

Maximum size of coarse aggregate = 20mm

Test data:

From the material test, the following data is observed,

Specific gravity of cement = 3.478

Specific gravity of fine aggregates = 2.636

Specific gravity of coarse aggregates = 2.645

From the sieve analysis, the fine aggregate confirming to grading zone 2 of table 4 from IS 383:1970 and the coarse aggregate is confirming to grade 20mm and adopting water-cement ratio as 0.5.

From these test data the 1m^3 of design grade mix **M20** becomes **1:1.61:3.05**

(b) CONCRETE MIX SPECIMEN CASTING:

The concrete is casted in cube and cylinder mould and the test is carried out in compressive strength and split-tensile strength.

FOR CUBE MOULD

Dimension of cube mould = 150 x 150 x 150 mm

From the test data, the mix proportion becomes **1:1.61:3.05** for the concrete grade mix **M20.**

To know the total volume, the obtained grade proportion is to be added and is given as = 1+1.61+3.05 = 5.66

To counter the effect of shrinkage, the value of factor of safety considered between the ranges **1.54 to 1.57.**

Volume of dry concrete = 1.57 x Volume of wet concrete

Total volume of concrete required = 1.57 m^3.

Volume of cement = [(Cement x 1.57) / (Cement + Sand + Aggregate)]

= [(1 x 1.57)/ (1 + 1.61 + 3.05)] = 0.277m^3 = 0.277 x 10^{-9} mm^3

$1m^3$ of cement = 1440 kg

= 0.277×10^{-9} x volume of cube x 1440 = 1.346 kg.

Assuming 50% 0f cement in Water-cement ratio = 1.346 x 0.50 = 0.673 liters = 673 ml.

Finally, the cube mould mix proportion becomes,

1.346 kg: (1.61 x 1.346 kg): (3.05 x 1.346 kg)

1.346 kg: 2.167 kg: 4.1053 kg

FOR CYLINDER MOULD

Dimension of cylinder mould = 150 x 150 x 300 mm

From the test data, the mix proportion becomes **1:1.61:3.05** for the concrete grade mix **M20.**

To know the total volume, the obtained grade proportion is to be added and is given as = 1+1.61+3.05 = 5.66

To counter the effect of shrinkage, the value of factor of safety considered between the ranges **1.54 to 1.57.**

Volume of dry concrete = 1.57 x Volume of wet concrete

Total volume of concrete required = 1.57 m^3.

Volume of cement = [(Cement x 1.57) / (Cement + Sand + Aggregate)]

= [(1 x 1.57)/ (1 + 1.61 + 3.05)] = $0.277m^3$ = 0.277×10^{-9} mm^3

$1m^3$ of cement = 1440 kg

= 0.277×10^{-9} x volume of cylinder x 1440 = 2.115 kg.

Assuming 50% of cement in Water-cement ratio = 2.115 x 0.5 = 1.058 liters = 1058 ml

2.115 kg: (1.61 x 2.115 kg): (3.05 x 2.115 kg)

2.115 kg: 3.4051 kg: 6.4507 kg

STEP 3- TEST ON SPECIMEN

For the prepared cube and cylinder mould following the mix proportion, the specimen test is conducted.

SLUMP CONE TEST:

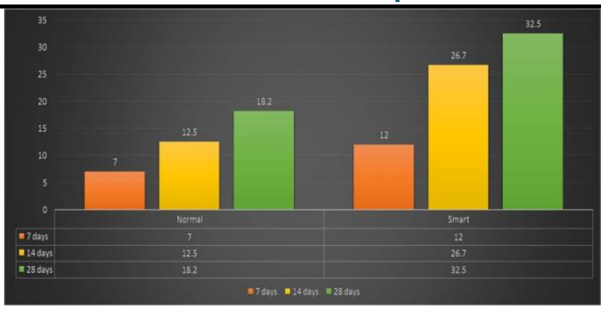
S.NO	TYPE OF CONCRETE	SLUMP (mm)
1.	Conventional concrete	66
2.	Smart concrete	76

RESULT:

From the slump values, the nature of concrete mix is observed to be noble mix and the degree of workability is medium. Such concrete based on slump can be widely used in canal linings, road, curbs, parapets, piers, slabs and walls.

(b) COMPRESSIVE STRENGTH TEST:

S.NO	TYPE OF CONCRETE	DAY	LOAD (KN)	AREA (mm^2)	COMPRESSIVE STRENGTH (Load/Area) N/mm^2
1.	Conventional concrete	7 14 28	157.50 281.25 409.50	150 x 150	7 12.5 18.2
2.	Smart concrete	7 14 28	270 600.75 731.25	150 x 150	12 26.7 32.5

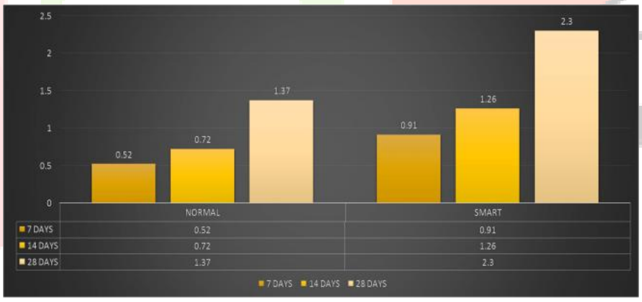


RESULT:

From the test values, it is clearly observed that the compressive strength of smart concrete is higher than the conventional concrete by 5% volume addition of molten polycaprolactone **PCL** pellets in coated with coarse aggregates.

(c) SPLIT-TENSILE STRENGTH TEST:

S.NO	TYPE OF CONCRETE	DAYS	LOAD (KN)	AREA (mm^2)	SPLIT-TENSILE STRENGTH (Load/Area) N/mm^2
1.	Conventional concrete	7 14 28	9.2 12.7 24.2	(π/4) x (150^2)	0.52 0.72 1.37
2.	Smart concrete	7 14 28	16.1 22.3 40.6	(π/4) x (150^2)	0.91 1.26 2.30



RESULT:

From the test values, it is clearly observed that the split-tensile strength of smart concrete is higher than the conventional concrete by 5% volume addition of molten polycaprolactone **PCL** pellets in coated with coarse aggregates.

Finally, it is analysed that the **M20** grade mix followed in smart concrete casting has resulted nearly to a grade mix **M30.**

CONCLUSION:

Experimental studies were carried out on concrete by adding thermomorph polyplastics by coating the molten form of pellets in 5% volume of coarse aggregates to the concrete casting in order to get higher strength in normal grade in smart ways. Physical properties such as compressive strength and split-tensile strength were evaluated. Based on the experimental result, the following conclusions are drawn.

The agent of polyplastics pellets is used in design grade mix **M20** and analyzed the result. It reveals that the compressive strength and Split-tensile strength is increased in higher variations in a smart way when compared with **M20** grade mix of same water-cement ratio in cube and cylinder moulds.

Finally, it is concluded from the test observation and result analysis that the use of polyplastics pellets as a construction material for concrete casting would bring a definite improvement to high range strength for the same grade mix and bring a remarkable change in the world of Civil Engineering.

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