Experimental Study on Engineering Properties of Recron-3s Polyester Fibre Reinforced Concrete In M50 Grade

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Abstract- *Global warming has emerged today as a life threatening issue for the world. Since concrete has one of the most consumed material after Water on the Earth for Infrastructure and Construction Industries and Day to Day the cost of resources for concrete is going higher and higher which a normal can't able to bear the cost. So in order to reduce the cost and to increase the age of concrete the Secondary materials are replacing the concrete materials for getting better results. In this research program I would like to evaluate the performance of Recron-3s Polyester fiber manufactured by Reliance Industries can increase the Mechanical properties of concrete such as Compressive strength, Flexural, Split Tensile strengths, and the Durability properties when induced with different Acids, Bases and Minerals and also to arrest Shear and Shrinkage cracks. In this research First 15 sets (45 Cubes 150mm x 150mm ,15 sets Cylinders 150mm dia and 300mm height and 15 sets Beams of 500mm x 100mm x 100mm)of normal plain concrete of M50 grade cubes will be casted and in this 15 sets, 7 sets will be normally cured in regular water with Ph maintained between 7.0 to 7.2 in laboratory conditions and next 8 sets will be cured in, HCl, Sea Water (Slat Rich Water) and tested for 3,7,14,28,90,365 days. In the same way Recron-3s Polyester fiber of 12 mm (CT2024,) Length Triangular Polyester fiber will be added in the M40, M50 Grade of Concrete in ratios varying from 90 gms to 125 gms as a Secondary replacement and the required test will be done and both the results will be compared.*

The main aim of the research is to increase the Strength parameters and to reduce the Cost of Concrete construction and also to arrest Cracks so formed by the use of Recron-3S Polyester Fiber in Concrete.

I. INTRODUCTION

Concrete technology has made a tremendous stride in the past decade. Concrete is now no longer a material consisting of cement, aggregates, water and admixtures but it is an engineered material with several new constituents performing satisfactorily under different exposure conditions. Concrete today can be tailor made for specific applications and it contains different materials like micro silica, colloidal silica and many other binders, filler and pozzolanic materials. The development of specifying a concrete according to its performance requirements rather than constituents and ingredients has opened innumerable opportunities for producers and users to design concrete to suit to their specific requirements. The type of concrete that is designed to a specific application is known as high performance concrete. ACI defines high performance concrete [HPC] as “concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and typical curing practices.” HPC should have at least one outstanding property viz. compressive strength, high workability enhance resistance to chemical or mechanical stresses, lower permeability, high durability etc..

II. FIBRE REINFORCED CONCRETE (FRC)

The use of fiber reinforcement is not a particularly recent idea. In fact, the use of dried grass in clay bricks belongs to one of earliest invention of mankind. The first use of reinforcement in concrete is usually credited to Joseph Moneir (1823-1906), who in 1849 made flower pots of rather large tubs for orange trees, by embedding, a mesh of thin iron rods in concrete. Later on, the introduction of reinforcing steel bars, supported by design models for their use, turned concrete into one of the most important building materials. Fiber reinforced concrete [FRC] started to come to its modern industrial use during the 1960's. The first applications were mainly defense related where FRC was utilized in various shelter structures. Further development has led to increased use of FRC as building material that either partially or completely replaces conventional reinforced bars. Some common applications are shot Crete, pavements, industrial floors, bridge decks and precast elements.

While it is technical possible to produce an FRC of very high tensile strength using high fiber content, it is generally not feasible to do so for structural applications, mainly due to practical reasons. The use of high fiber content may lead to severe reduction of the workability of the fresh concrete. Therefore, in low bearing structures, reinforced bars are predominantly used while FRC is limited to applications where cracks distribution and reduction of crack widths are the main purpose.

The positive effects of fiber reinforcement are documented for such a large span of applications that it could be expected to be much more widely used than what is currently the case. It is often argued that the relatively high materials cost of fiber is a reason for a low usage, but since the total production cost may be lowered in many cases, that is not the sole explanation. A more important reason is the current lack of design rules and guidelines which fully utilize the advantage of FRC.

The use of FRC as a building material has been the target of extensive research during the last decade with numerous scientific reports as an output. Still, the resulting impact on existing building codes has been sparse in relation to the effect put into research. A reason for this in general sense may be that conventionally reinforced concrete is treated as an idle elastic-plastic material characterized the only two parameters-strength and stiffness. FRC on the other hand is defined through its toughness, of softening, and in most practical cases has approximately the same strength and stiffness as plain concrete. Therefore fracture mechanic models must be used in order to establish design rules for FRC that takes the softening behavior into account. However, the problem is that fracture mechanics models are still not fully implemented in the design code currently in use. Furthermore, the use of fracture mechanical approaches often leads to models to numerical treatment through e.g. finite element models [FEM], which in turn are not readily expressed in design code formulations.

Another reason for FRC not being used more frequently is due to its still being a new type of building material. This statement may be surprising concerning the large amount of research work that has been done till now, but it is important to realize that FRC is not just one type of material. In fact, that term covers a whole range of type of concrete, the only common denominator being that various types, generally denoted as performance concrete (HPC), develop so does the FRC and the no of possible combinations continue to multiply.

Studies on FRC are usually focused on the influence of the type and amount of the fiber rather than on the properties of the concrete. Hence, the toughness of FRC is usually discussed in terms of fiber content or by comparing one specific fiber type to another. However, often this type of concrete that constitutes the matrix of the FRC can play an equally important role. The influence of the matrix properties may be that in the case of normal strength concrete the toughness normally increases with increased fiber aspect ratio (l/d), but the opposite may be the case of high strength concrete. This is due to either the improved bond or the higher loads at first crack in the matrix, or a combination of both, in concrete of higher strength. This may lead decreased toughness due to sudden fiber rupture rather than continuous functional pullout if the specific surface of the fiber is large enough, i.e. fo
r high aspect ratio.

Generally speaking, it is introduction of a new type of concrete, or concrete made using type of constituents, motivates the study of the effects when used for FRC. Fiber rupture due to a high bond is but one example of the various influencing factors that has an importance of the behavior of FRC. An optimally designed FRC is always the successful combination of the both fiber and concrete with regard to the type of application the material is intended for.

III. DURABILITY OF CONCRETE

The durability of cement concrete is defined as its ability to resist weathering action, chemical attack, abrasion, or any other process of deterioration. Durable concrete will retain its original form, quality and serviceability when exposed to its environment.

Designers of concrete structures have traditionally focused on the strengthcharacteristics of the material. In recent years, the industry has started to adopt a more holistic approach by emphasizing the life-cycle cost of a structure. Hence the durability of concrete is now viewed as equally important as mechanical properties and initial cost. It is estimated that, in developed countries, about 40 percent of total construction resources are applied to repair and maintenance, and only 60 percent to new construction. Water is a primary agent for both creation and destruction of concrete andis deeply involved in nearly every form of concrete deterioration.

Theprincipal causes for deterioration are the corrosion of reinforced steel,exposureto cycles of freezing and thawing, alkali-silica reaction, and chemical attack. With each of these four causes of concrete deterioration, the permeability and the presence of water are implicated in the mechanisms of expansion andcracking.

Apart from the socioeconomic implications of durability, there is also aClear link between durability and the environment. By extending the life cycle of construction materials, we conserve valuable natural resources. The worry on the use of RAC is not limited to structural stability, but also their durability in designing concrete structures.

Significance of durability

When designing a concrete mix or designing of concrete structure, the exposure condition at which the concrete is supposed to withstand is to be assessed in the beginning with good judgment. The environmental pollution is increasing day by day particularly in urban areas and industrial atmospheres. Portland cement permitted a maximum chloride content of 0.05 percent. Maximum permissible chloride content in cement has been increased to 0.1 percent. This high permissible chloride content in cement demands much stricter durability considerations in other aspects of concrete making practices to keep the total chloride content in concrete within the permissible limits. in other words, considerations for durability of modern concrete constructions assume much more importance than hitherto practiced.

III. ENVIRONMENTAL ATTACKS ON CONCRETE

Marine attack on concrete

Large numbers of concrete structures are exposed to sea water either directly or indirectly. The coastal and offshore structures are exposed to simultaneous action of number of physical and chemical deterioration process. The concrete in sea water is subjected to chloride induced corrosion of steel,freezing and thawing, sea weathering, abrasion by sand held in water and other floating bodies.

The process of deterioration of concrete in sea water is the net result of general, physical and chemical factors. It is not easy to improve the performance of concrete in sea water as many of the reactions occur under non-equilibrium conditions. Nitrogen is present in sea water as a dissolved N2 gas, nitrite, ammonia and nitrate as well as in organic forms. The chemical reaction between chlorides, dissolved nitrogen nitrates, ammonia and nitrates of sea water may be preventing to deteriorate the surface as well as the core properties of concrete structures. Thus reduces the strength of the structure.

Hydrochloric acid attack on concrete

Whenever there is chloride in concrete there is an increased risk of corrosion of embedded metal. Chlorides acts on the embedded reinforcing steel causes distress in the concrete structure and leads to deterioration. Calcium chloride and chloride – based add mixtures should never be added in reinforced concrete, pre stressed concrete and concrete containing embedded.

Pozzolon cement are produced by adding pozzolons such as silica fume, rice husk ash and blast furnace slag in 20% replacement for Portland cement. On the 28th day of production, the produced specimens are stored in HCL solution. The strengths are determined after the moulds are stored in solution for 56 days. The highest compressive strength occurs in HCL solution.

The procedure of alumina generation which produces Red Mud waste

- Aluminum or alumina is produced by BAYER process.
- In the Bayer process, bauxite is digested by leaching it with a hot solution of
- Sodium hydroxide,NaOH, at 106-240°C and at 1-6 Atm pressure.
- This converts the aluminium minerals into tetrahydroxidoaluminate Al $(OH)_4$, while dissolving in the hydroxide solution.
- The insoluble compounds (Silica) are separated by settling and the decant solution is further clarified by faltering off remaining solid impurities.
- The waste solid is washed and filter pressed to regenerate caustic soda and
- Red mud presenting a disposal problem.
- The hydroxide solution is then cooled and the dissolved aluminum hydroxide
- Precipitates as a white, fluffy solid.
- When heated to 1050°C (calcined), the aluminium hydroxide decomposes to alumina giving off water vapour in the process.
- A large amount of the alumina so produced is then subsequently smelted in the Hall Heroult process in order to produce aluminium.

IV. OBJECTIVES OF WORK

Basically this paper is based on the dissertation work carried out to overcome the problems created due to shrinkage and air cracks which reduce the life span of concrete structures and to increase the durability of the concrete which was used in marine and industrial constructions with less cost Recron 3s Polyester fibers . Some other objectives are;

- To Reduce cracks during at plastic and hardening stages and Reduce seepage and protects steel in concrete from corroding and walls from damping
- To Protect corners in precast slabs and concrete flooring. Increases abrasion resistance by over 40% thereby increasing. Life of roads, walkways, floors. And Alsoto reduce pitting of the floor.
- To save expensive mortar, cement and sand.And to reduce Time taken for plastering and work is completed faster.
- Marginal increase in flexural, compressive strength based on mix design has been observed. And Considerable reduction in cracks during plastic and hardening stage.
- Conventional building materials such as bricks, cement, lime and their derivatives are becoming increasingly uneconomical because of obsolescence, exhaustion of raw materials, low plant efficiencies and over-whelming costs.

V. EXPERIMENTAL METHODOLOGY

- In order to achieve the above task and to verify the assumptions made general objectives is divided into the following stages. The research studies comprises of following stages:
- **Stage1:** Literature survey of Poleyster fibers, previous research of concrete based on the Polyeter fibers and effects on the important properties of concrete such as workability and strength will be studied.
- **Stage 2:** In this phase concrete samples will be prepared in laboratory. Specimens will be cast for testing the compressive strength of concrete. After 7, 14, 28 and 90 days the compressive strength of these specimens will be computed. Ratio of mix design is constant for M40 & M50 Grades Of characteristic compressive strength 40 $N/mm^{2,}$ 50 N/mm^2These results will be used to find the variation in strength of concrete by using different proportion 90 gms and 125 gms of Recron 3s Polyester fiber with respect to ordinary Conventional Concrete tests will be conducted within estimated time.
- **Stage 3:** Experimental work will be executed, taking into consideration the physical properties of constituent's materials. Laboratory tests and results are reported. Analysis of test results and observations are drawn, all results are completed in the required formats. Based on this comparative study of this experimental work, conclusions and recommendations are presented in order to establish guideline for future.

VI. REVIEW OF LITERATURE

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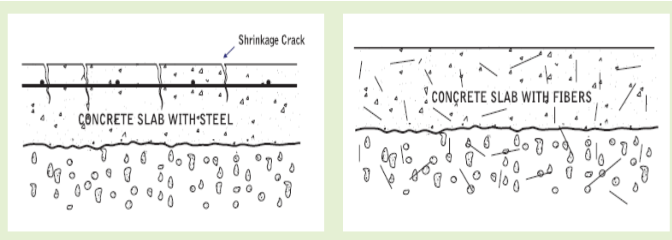
Ramesh *et al*., (2010) According to Ramesh and Rathod reports

TYPICAL PROPERTIES OF RECRON 3S POLYESTER FIBER

Property	Recron 3s CT 2024
Material	100% virgin synthetic fiber
Cross section	Triangular
Fiber length	12 MM
Dispersion	Excellent
Specific gravity	1.36
Color	Brilliant white
Melt point	240 °c
Alkali resistance	Very good
U.V.stability	High

The Polyester fiber was first sun dried, and then it was 2/3rd was mixed with cement water then mix thoroughly in concrete mixer..



Mix Design for M_{25} Graded Concrete

5.4.1 Design – Stipulation

1. Grade Designation :M_{50}
2. Maximum size of aggregate : 20 mm angular
3. Degree of Workability: : 0.8
4. Standard Deviation : 5%
5. Type of Cement :OPC 53 Grade confirming
6. Specific Gravity
   i. Cement :3.12
   ii. Fine Aggregate : 2.62
   iii. Coarse Aggregate : 2.67
7. Bulk Density
   i. Fine Aggregate (gm/cc) : 1.537
   ii. Coarse aggregate (gm/cc) : 1.663
8. Fineness Modulus :2.826

VII. CALCULATION OF MIX DESIGN ANALYSIS (AS PER IS-10262)

Step 1: Calculation of target strength

Characteristics Compressive strength of concrete at 28 days = 50 N/mm^2

f_{ck}= 50 N/mm^2

Target Strength, $f'_{ck} = f_{ck} + 1.65(s)$

Where

f'_{ck} =target average compressive strength at 28 days

f'_{ck} = characteristic compressive strength at 28 days

s = standard deviation

Standard deviation (s) from table (1) IS 10262

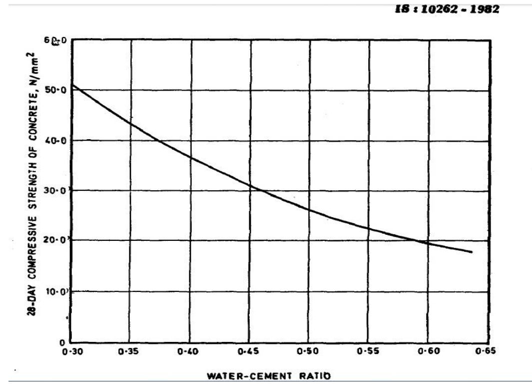
For M_{50}, s = 7.4

f'_{ck}= 50+ (1.65*7.4)

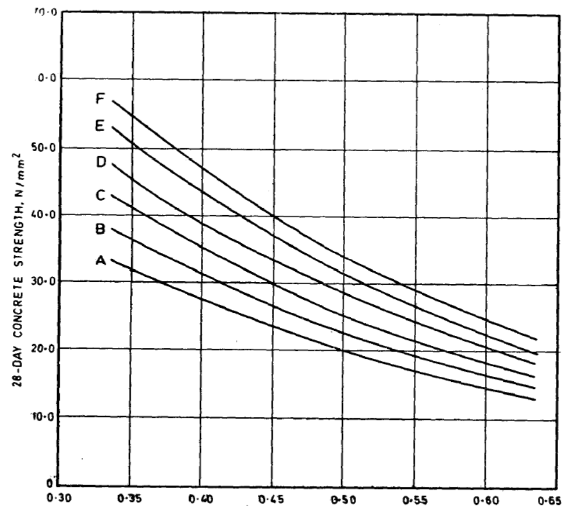
f'_{ck} = 62.21 N/mm^2

Step 2: Selection of w/c Ratio

Selection of w/c ratio from curves



From the above graph the W/c ratio = 0.34



Water Cement Ratio’s

The water cement ratio obtained from curve is 0.43.

A = 31.9-36.8 N/mm^2

B = 36.8-41.7 N/mm^2

C= 41.72-46.6 N/mm^2

D= 46.52-51.5 N/mm^2

E=51.52-56.4 N/mm^2

F=56.42-61.3 N/mm^2

Step 3: Estimation of Air Content

According to IS 10262 – 1982

Nominal maximum size of aggregate i.e. 20 mm – 2%

Step 4; Estimation of Water Content

According to IS code 10262 – 1982

The approximate water content and sand content for concrete grades upto M_{35}

Maximum size of aggregate = 20 mm

Weight of water content = 186 $kg.m^2$

Note: From table maximum water content for MSA 20 mm aggregate is 160 litres up to 50 mm and w/c ratio 0.43

Step 5: Estimation of Cement Content

W/c ratio = 0.34

Water used = 160

Cement content = 186/0.34

= 470.60kg/m^3

Calculation of aggregate content as per IS 10262-1902.

$$V= (W + \frac{C}{SC} + \frac{1}{P} * \frac{fa}{sfa}) * \frac{1}{1000}$$

And

$$V = \left[W + \frac{C}{SC} + \frac{1}{1-P} * \frac{ca}{sca}\right] * \frac{1}{1000}$$

Where,

V = absolute value of fresh concrete – entrapped air content

= 1-0.02

= 0.98m

W = 160 litres = mass of water

C = 470.60 kg/m^3

S_c = specific gravity of cement

= 3.12

P = 0.231

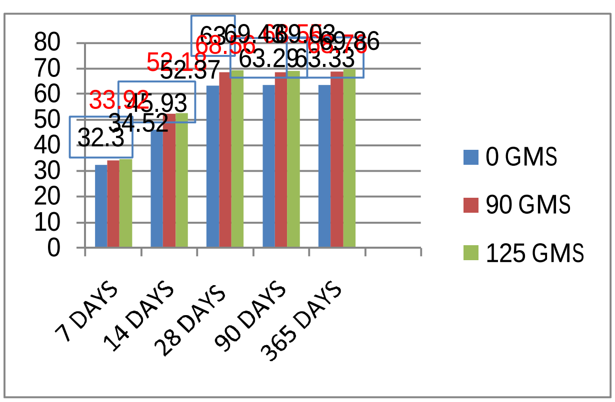
Now, (For Fine Aggregate)

$$0.98 = [\frac{470.6}{3.12} + 160 + \frac{1}{0.28} \times \frac{f_a}{2.62}] \times \frac{1}{1000}$$

F_a = 490.90 kg/ m^3

For Coarse Aggregate

$$0.98 = [\frac{470.6}{3.12} + 160 + \frac{1}{0.28} \times \frac{c_a}{2.62}] \times \frac{1}{1000}$$



TENSILE STRENGTH TEST

C_{ag} = 1280.60 kg/m^3

Now,

Cement = 470.60 kg/m^3

Fine aggregate = 490.90kg/m^3

Coarse aggregate =1281.60 kg/m^3

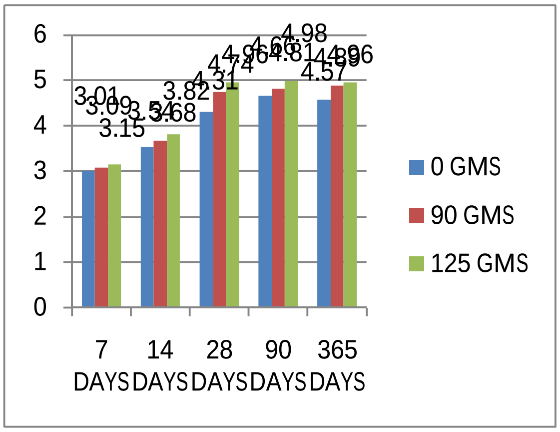
Ratio = 1:1.1:2.76

VIII. RESULTS AND DISCUSSIONS

7,14,28,90,365 Days compressive strength of CVC and 90 gms& 125gms replacement of Polyester fiber.

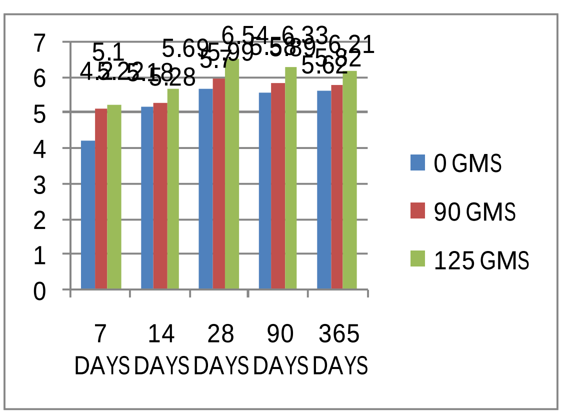
S No.	NO OF DAYS	COMPRESSIVE STRENGTH N/mm²		
		CVC	90 gms	125 gms
1	7 Days 150X150X150(A1)	32.30	33.92	34.52
2	14 Days 150X150X150(A2)	45.93	52.18	52.37
3	28 Days 150X150X150(A3)	63	68.56	69.43
4	90 Days 150X150X150(A4)	63.29	68.55	69.03
5	28 Days 150X150X150(A5)	63.33	68.76	69.86

Si.No	NO OF DAYS	TENSILE STRENGTH N/mm2		
		CVC	90 gms	125 gms
1	7 Days 300 X150(A1)	3.01	3.09	3.15
2	14 Days 300X150(A2)	3.54	3.68	3.82
3	28 Days 300X150(A3)	4.31	4.74	4.96
4	90 Days 300X150(A4)	4.66	4.81	4.98
5	28 Days 300X150(A5)	4.57	4.89	4.96

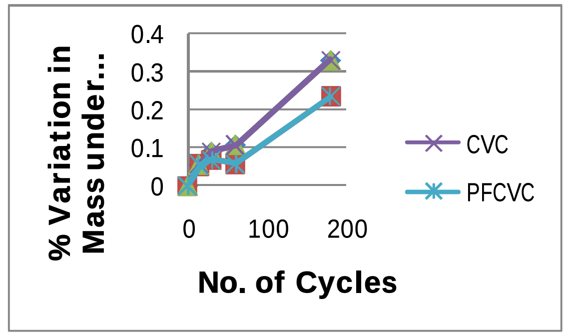


FLEXURAL STRENGTH TEST (ONE POINT LOAD)

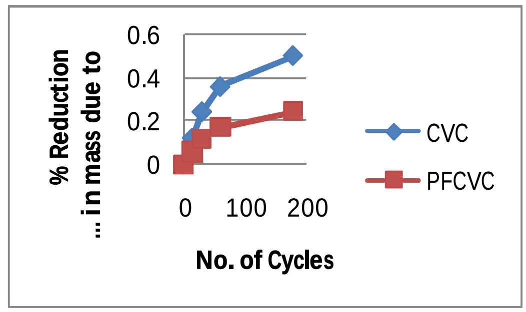
S No.	NO OF DAYS	COMPRESSIVE STRENGTH N/mm²		
		CVC	90 gms	125 gms
1	7 Days 150X150X150(A1)	32.30	33.92	34.52
2	14 Days 150X150X150(A2)	45.93	52.18	52.37
3	28 Days 150X150X150(A3)	63	68.56	69.43
4	90 Days 150X150X150(A4)	63.29	68.55	69.03
5	28 Days 150X150X150(A5)	63.33	68.76	69.86



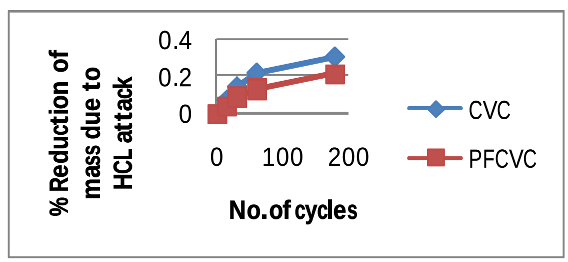
DURABILITY TEST



Comparative Results of % Reduction in Mass for Cube Specimens [150 X 150 X 150] Under Ordinary Water Curing



Comparative Results of % Reduction in Mass for Cube Specimens [150 X 150 X 150] Under Marine Water Attack



Comparative Results of % Reduction in Mass for Cube Specimens [150 X 150 X 150] Under HCL Attack

IX. RESULTS AND DISCUSSIONS

The percentage economy increased with the increase in the grade of concrete but at the same time there is a reduction in the percentage increase in the Flexural strength.

1. When expressing compressive strength versus water cement ratio we can find relatively good linear relationship which indicating that Polyester fiber for contribution to the strength development.

2. Beyond 95 gms replacement of Polyester fiber 125 gms replacement gives effective strength
3. The cost of M_{50} grade of concrete that is 125 gms replacement is around less than the conventional concrete with increase of compressive strength for 28 days.
4. The maximum compressive strength of concrete cube for M50 grade about 125 gmsusage of Recron 3s Polyeter fiber in concrete for 28 days of curing is 69.03 N/mm^2.
5. Considering all above points it is interesting to say that the optimum utilization of 125 gms of Recron 3s Polyester fiber gives good results and surface finishing also appears good which reduces cost of plastering.
6. Considering all above points it is interesting to say that the optimum utilization of red mud in concrete is 15% as partial replacement.

X. CONCLUSIONS

1. From the observations it was found that nearly half of the strength is gained in 7 days and $^2/_3$ to $^3/_4$ of the strength in 14 days and crossed the target mean strength in 28 days,90 days and 365 days duration which satisfies IS 456-2000.
2. The prepared concrete by using Polyester concrete gives good appearance and no plastering required after casting
3. The workability of concrete will get affected due to increase of Poleyster fibers more than 125 gms without proper mixing in cement and causes concrete in lumps.
4. It was observed that this Recron 3s CT2024 polyester fiber of 12 mm size has suddenly increased the flexural strength of PFCVC to +21% in 28 days of curing period while comparing with the flexural strength of CVC mix due to its bonding nature
5. Similarly the compressive strength and split tensile strength of PFCVC has increased to +12% and +15%.
6. The loss in weight of PFCVC and CVC were negligible under marine due to less percentage reduction of loss.
7. Though the results of Flexural strength varies polyster fiber can be used in concrete ass secondary reinforcement.
8. By the above results it canbe stated that usage of Reccron 3s Polyeter fiber Considerable reduction in cracks during plastic and hardening stage and also Reduces seepage and protects steel in concrete from corroding and walls from damping

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