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Research Article

A Comparartive Study On Mechanical Properties Of Steel Fibers Induced Polymer Concrete And Plain Cement Concrete

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***Abstract* –** This article examines the impact of various polymers on the mechanical and structural properties of concrete. The goal of this project is to examine the mechanical and flexural properties of reinforced concrete in polymers as compared to plain cement concrete. Different dosages of polymer are used to alter the structure of cement concrete i.e 2.5% ,5%,7.5%,10%,12.5% and 15% . Additionally, 2% steel fibers are also induced in the each dosage of polymer. The percentages of additives are obtained by total weight of concrete.The first class consists of non-ionic polymers that have either nitrogen or oxygen at their core. In this work, latex polymer with this specific composition is utilized. Synthesis can yield molecular weights of these polymers in the millions . Several tests have been run without bringing about any changes. The 3rd -point loading technique is used to test the flexural strength and properties of concrete modified with polymers and plain cement concrete . Splitting tensile test and compressive strength test are also cinducted as per ASTM standards .It becomes clear how different polymers affect force and flow characteristics as well as the ideal dosage for each. A comparative study was conducted to show how two different kinds of concrete affected the novelty and resistance characteristics of polymer-based concrete., this study combines computational modeling and lab experiments.

Keywords – Concrete-Polymercomposites, Polymer-Modifiedconcrete, Polymerconcrete Workability, Steel Fibers Compressive, Tensile Strength.

I. INTRODUCTION

Concrete is a construction material that is used in a wide range of applications on the ground, underground, and below sea level. It is used to construct foundations, pavements, storage tanks, piles, buildings, dams, and other structures. Concrete's key properties include durability, compressive strength, impermeability, abrasion resistance, and resistance to environmental attacks. Concrete's durability refers to its ability to withstand deterioration caused by heating and cooling, freezing and thawing, and chemical action such as fertilizer. Design, materials, and construction must all work together to create long-lasting concrete.

A tremendous amount of research has been done over the past few decades on the creation of composites based on polymers, composites based on polymers, and composites based on polymers. Nowadays, cement concrete is widely used as a building material due to its many applications, relatively high performances, and durability when compared to the traditional idea of cement. The environmentally friendly cement-polymer composites address the issues of environmental preservation, infrastructure durability, and natural resource conservation.The alteration of the iron's composition can be accomplished by adding polymer-infused water or dispersible polymer particles to the mixture of new cements. Surfactants help to stabilize the polymer emulsion, and each polymer has unique properties for film fabrication depending on the proper conditions for curing and hardeningThe formation of durable and efficient microstructures in PCC is mediated by surfactants and the very low filming capacity of most emulsions.

Even though concrete has a high compressive strength, its porosity and brittleness in terms of adhesion and tension can lead to chemical and physical harm. Conversely, polymers have a higher tensile strength but a lower compression, which enables them to adhere to other materials well and withstand physical and chemical agents such as impact, abrasion, and erosion.Combinations of these two materials have the potential to optimize each of their unique advantages and create composites with exceptional strength and durability.

The cement pieces are more easily dispersed in the mixture and produce a homogenous material. In most cases, there is an increase in the mixture's workability and a decrease in the amount of water needed to prepare it again. The presence of surfactants also affects the hydration of cement particle particles. The higher-intensity surfactants retain the water needed for hydration the same as in mixtures that don't show any modifications. One of the components of surfactant is the hydrogen molecule. Water must be released gradually, which causes the Hydratation to slow down. The use of the fresh mixture is significantly better than that of the regular cement and cement mortar due to the plasticizing and air-entraining effects of the polymers. The water retention of the modified systems surpasses that of the traditional ciment systems. This could increase productivity, prevent drying out, and improve adherence to porous substrates like brick, mortar, and ceramic tiles.

Latex polymer has following characteristics

Property	Range
Solids	68%-69%
Viscosity	1300to 1500 Centipoises
pH	9.00 to 10.00
Weightper gallon	8.8lbs
Condition	MilkyWhite Liquid
Average particle size	Lessthan0.5microns

II. PROBLEM STATEMENT

In Rahim Yar Khan, a city that's growing fast, the people who build things like houses and roads are having a tough time. They usually use a material called Plain Cement Concrete (PCC) for building, but it's not holding up very well. Buildings and roads crack too soon, don't last as long as they should, and fixing them costs a lot of money. Plus, Rahim Yar Khan has really hot summers and cold winters, and sometimes earthquakes, which make these problems even worse. Because of all this, it's getting harder to build things that are strong, last a long time, and don't harm the environment.

This project looks into a new kind of building material called Steel Fibers Induced Polymer Concrete (SFIPC) to see if it's better than the usual PCC. We want to see if SFIPC can make buildings and roads that don't crack as easily, last longer, and are better for the planet. By comparing how strong and durable both materials are, we hope to find a better way to build in Rahim Yar Khan. This could help not just our city, but other places that have the same problems, build in a smarter and more sustainable way.In the bustling city of Rahim Yar Khan, a key urban center experiencing rapid growth and development, the construction industry is at the forefront of building the city's future. However, this growth comes with its own set of challenges, especially concerning the durability and sustainability of the materials used in construction. Traditionally, the industry has relied heavily on Plain Cement Concrete (PCC) for both infrastructure and residential projects. While PCC has been the backbone of construction due to its initial cost-effectiveness and accessibility, it has shown limitations in terms of long-term performance, environmental impact, and resilience to the city's unique climatic and geographical challenges.

III. AIM AND OBJECTIVES

The project seeks to assess the physical and chemical reactions between ingredients pf polymer resin concrete(PRC),andRC.

• Evaluate mechanical properties (strength, durability) of PRC and RC samples subjected to tests .

• Make recommendations for mitigation measures or material modifications based on findings.Analyze the effects of environmental exposure on the bond between reinforcement and concrete in RCC structures. Evaluate changes in tensile strength, corrosion susceptibility, and overall structural integrity.

IV. MATERIALS AND METHODS

4.1 Mix Proportion

The concrete mixture M15 (1:2:4) , which is the subject of this study, is composed of Portland cement with an average grade of 50 and additives that agree with ASTM standards. We made each cheese mixture in batches with the help of a rotating planetarium. The technical mixer involved mixing the arena and hard cement powder for thirty seconds, then adding about half of the water and mixing for an additional minute. The purpose of that the mixer is placed in is to reduce water evaporation and enable water absorption by the combined particles inside the mixer. The polymer and steel fibers are added after five minutes, and they are mixed for an additional minute.

Table 1: Details of batches of specimens

Serial No	Batch	Polymer Dosage %	% age steel fibers
1	B-1	0% polymer added to concrete mix	2% steel fibers added to concrete mix
2	B-2	2.5 % polymer added to concrete mix `	2% steel fibers added to concrete mix
3	B-3	5% polymer added to concrete mix	2% steel fibers added to concrete mix
4	B-4	7.5% polymer added to concrete mix	2% steel fibers added to concrete mix
5	B-5	10% polymer added to concrete mix	2% steel fibers added to concrete mix
6	B-1	12.5% polymer added to concrete mix	2% steel fibers added to concrete mix
7	B-1	15 % polymer added to concrete mix	2% steel fibers added to concrete mix

4.2 Testing of the Specimens

Workability of concrete is determined by Slump Cone test. In this study,compressive strength, and split tensile strength tests, Flexural strengthwere conducted.

4.2.1 Compressive strength:

Each cube has dimensions (150 x 150 x 150) mm, and the compressive tests are conducted on each cube according to ASTM C109. Moulds were deformed and sterilized in water one day after casting until they were tested at seven and twenty-eight days of age. Each mixture's three specimens were examined, and the mean value is obtained.

As seen in Figure 2, the growth of mixtures' compressive strength varies depending on the dosage of polymer content, taking anywhere from 7 to 28 days. It is obvious that when the amount of latex polymer is increased from 5% to 15%, force grows quickly before rapidly decreasing. Based on the experience's results, it is evident that the concrete's compressive force characteristic increases as the polymer dosage increases from 2.5% to 12.5%. Once the dosage reaches its ideal level of about 12.5%, it starts to decrease to 15%.

4.2.2 Splitting tensile strength:

The splitting tensile strength of conventional concrete and polymer-modified concrete is estimated over a period of 7 days and 28 days, respectively, on cylinders measuring 150 mm in diameter and 300 mm in height, in accordance with ASTM C496. Each mixture's three samples were examined, and the average was reported. We see a similar trend to the one previously mentioned, where the tensile force increases as the amount of polymer increases and then decreases. These conclusions are shown in Figure 2.

4.2.3 Flexural strength:

In accordance with ASTM C78 standard, flexural force was measured over a period of seven and twenty-eight days on 100 x 100 x 5000 mm beams that had been submerged in water until the test date. Each mixture's three samples were examined, and the average was reported. Figure 4 show the results of these flexural tests, respectively. When the amount of polymer increases by 2.5% to 12.5%, one observes an improvement in the performance of the polymer-modified concrete in the cases of latex polymer.

V. RESULTS

This study's main goal is to investigate the effects of polymer on concrete. Latex polymer is used in the concrete mixture as 2.5%,5%,7.5%,10%,12.5%,and 15% addition with 2% steel fibers by weight of concrete.

Table 2: Workability of concrete by adding different dosage of polymer .

Sr. No.	% of latex polymer	% of steel fibers	Slump value (mm)	Percentage difference in the Slump value of concrete when different dosages of polymer are added , compared to conventional concrete.
1	0	2	85	-------
2	2.5	2	93.5	9.09
3	5	2	102	16.67
4	7.5	2	106.25	20
5	10	2	112.4	24
6	12.5	2	114	25.4
7	15	2	108	21.3

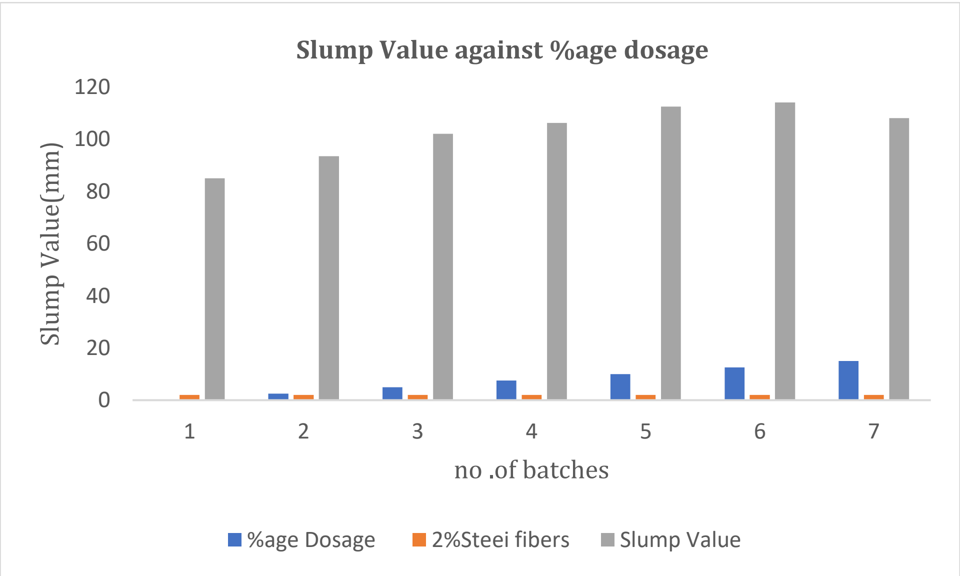

Figure 1: Graph showing workability of concrete with respect to % of Polymer Dosage

The Compressive strength of all mixes is determined concrete with different proportions of waste glass was determined at 28 days. For each set of waste glass content, the development of compressive strength with respect to different waste glass percentages are shown in table 3 and figure 2 shows graphical representation of table.

Table 3: Compressive strength of concrete achieved by adding different dosages of polymer in concrete mix.

Sr. No.	% of polymer dosage	% of steel fibers	7 Avg. compressive strength MPa	28 Days Avg.compressive strength MPa
1	0	2	22.2	26.1
2	2.5	2	23.5	27.4
3	5	2	25.7	29
4	7.5	2	27.6	29.8
5	10	2	29.1	31.3
6	12.5	2	34.4	35.2
7	15	2	27.3	28.8

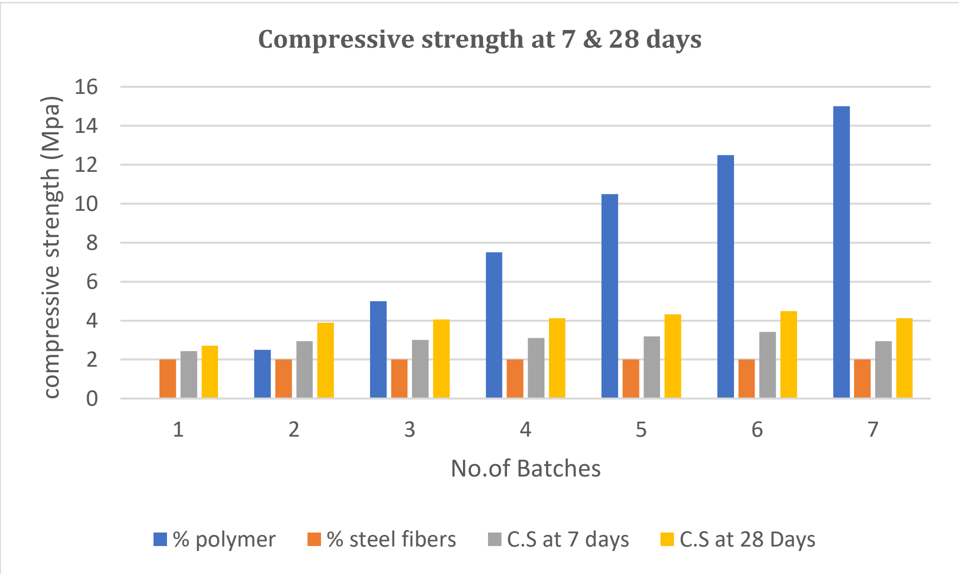

Figure 2: Chart showing compressive strength of concrete with respect to % dosage polymer at 7 and 28 days

The results of splitting tensile strength of concrete with respect to different waste glass percentages are shown in table 4and figure 3 shows the graphical representation of table 4.3. The splitting tensile strength with 0%, 2.5%,5%,7.5%10%,12.5%15%, as addition by weight concerete.

Ultimate load=P= 150.471 KN

Length of Specimen = 12 inch

Diameter of Concrete cylinder = 6 inch

1 KN =101.971 kg

1 kg = 2.2046 lbs.

Split tensile strength = T = 2P/3.14LD

$$T = \frac{2(150..471)(101.971)(2.2046)}{3.14(12)(6)} = 313.156 \text{ psi} = \frac{313.156}{145.04} = 2.136 \text{ MPa} > 1.9 \text{ MPa (Required)}$$

Table 4: Splitting tensile strength of concrete by adding different dosages of polymer.

Sr. No.	% dosage of polymer	% of steel fibers	7 Avg. Splitting tensile strength MPa	28 Days Avg. Splitting tensile strength MPa
1	0	2	2.13	3.11
2	2.5	2	2.40	3.19
3	5	2	2.54	3.28
4	7.5	2	2.76	3.36
5	10	2	2.91	3.43
6	12.5	2	3.33	3.5
7	15	2	2.76	3.19

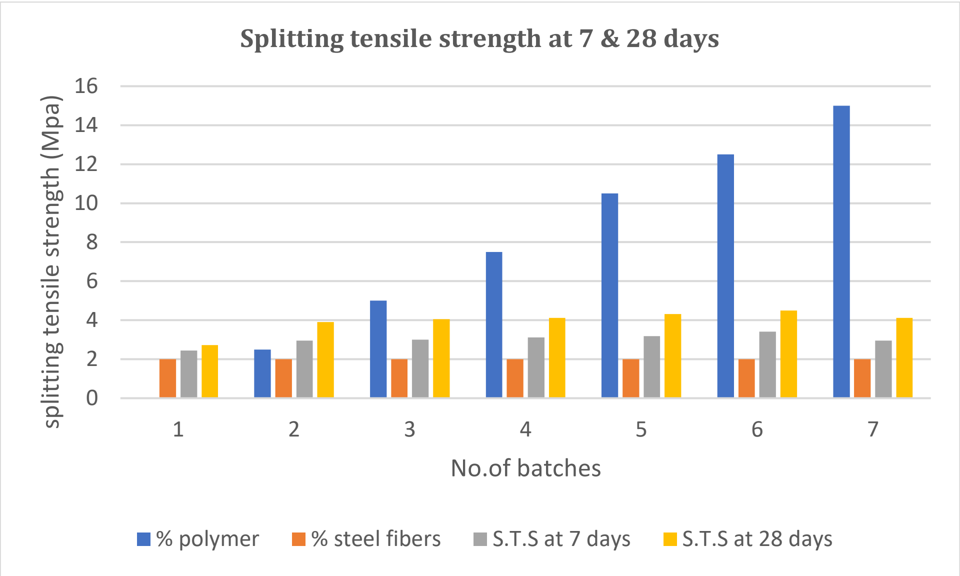

Figure 3: chart showing splitting tensile strength of concrete with respect to different % of polymer dosages.

The results of Flexural strength of concrete with respect to different waste glass percentages are shown in table 5 and figure 4 shows the graphical representation of table 4.4. The Flexural strength with 0%, 2.5%,5%,7.5%,10%,12.5% and 15% dosages of latex polymer along with 2% steel fibers.

Table 5: Flexural strength of concrete by adding different dosages of polymer.

Sr. No.	% dosage of polymer	% of steel fibers	7 Avg. Flexural strength MPa	28 Days Flexural strength Mpa
1	0	2	2.44	2.72
2	2.5	2	2.95	3.9
3	5	2	3.01	4.06
4	7.5	2	3.11	4.12
5	10	2	3.19	4.32
6	12.5	2	3.42	4.49
7	15	2	2.95	4.12

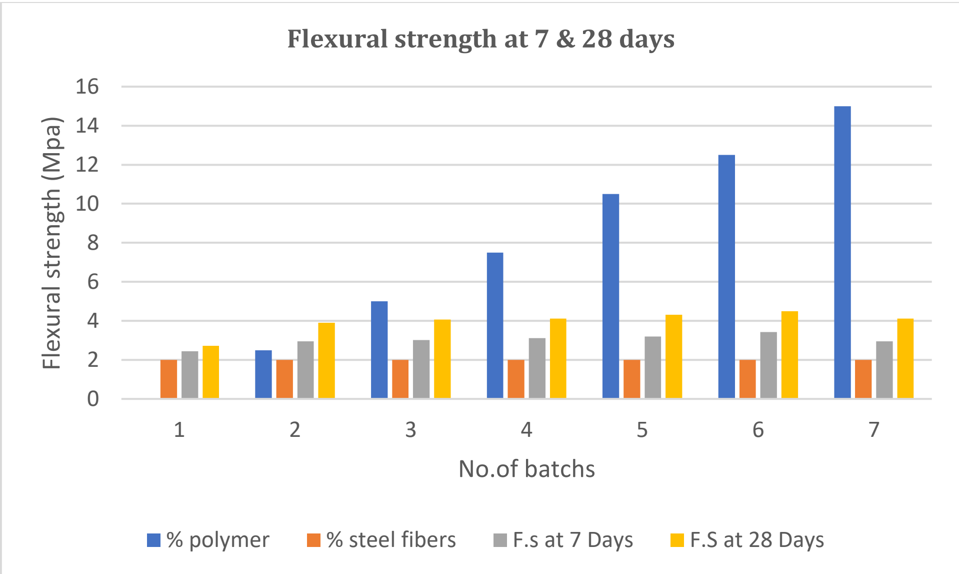

Figure 4: chart showing Flexural strength of concrete with respect to different % of polymer dosages.

VI. CONCLUSION

Based on the findings, it is clear that using polymer-modified concrete is more effective than using conventional concrete in terms of its structural qualities and performance. It has been noted that both in their used and raw states. Adapting to optimal dosages based on compressive strength data is beneficial and produces better results at a young age. In both scenarios, 12.5% of polymer is the ideal dose to achieve full polymerization and improved performance.

One of this material's key characteristics is that a significant portion of its empty space is filled with polymers, resulting in an endless reinforcement network. Depending on the need for greater strength and/or durability, it is possible to impregnate the concrete structure at various depths or just on the surface. Thus, the polymer-enriched Portland cement concrete exhibits a slight increase in its tensile, compressive, and flexural strengths.

The use of latex polymer (colloidal dispersion of latex particles in water) allows for significantly improved performance at reasonable dosages and costs. As a result, a wide variety of latexes are now available for use in polymer cement concrete products. For the surface of soils, latex-containing polymer cement concrete is mostly used because it is relatively inexpensive and non-dumping. In the construction industry, polymer-modified concrete can be used, particularly to create high-performance structural structures. structures used for food production. canalization pipes. Seawater storage tanks, desalination plants, and water distillation plants. Marine structures and mural panels. tunnel liners, prefabricated tunnel segments, and swimming pools. On the other hand, this material.

This paper presents the findings of an experimental study conducted to investigate the properties and mechanism of polymer-based concrete. Additionally, the ideal polymer quantity that affects mechanical and structural characteristics is mentioned.

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