SYNERGISTIC EFFECTS OF BIO-ENZYMES AND GLASS FIBER REINFORCED POLYMER ON CONCRETE PROPERTIE

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Abstract - *Concrete technology is rapidly advancing with the use of innovative materials and chemical admixtures to improve the strength, durability, and sustainability of concrete. This study investigates the effect of bio-enzyme and Glass Fiber Reinforced Polymer (GFRP) on the properties of concrete. Bio-enzyme, an eco-friendly additive, is added to concrete mixes in different dosages of 500 ml/m^3, 600 ml/m^3, and 650 ml/m^3 to determine the optimum quantity for enhancing concrete performance. Concrete grades M30, M35, and M40 are prepared with the addition of GFRP fibers of thickness ranging from 0.3 mm to 0.4 mm. The experimental program includes workability, compressive strength, and split tensile strength tests to evaluate the behavior of modified concrete compared to conventional concrete. In the present era of global warming, reducing CO_2 emissions from cement production has become essential. Therefore, partial replacement of cement with materials such as GFRP helps in minimizing environmental pollution and improving sustainable construction practices. The study aims to develop high-performance, durable, and eco-friendly concrete by utilizing bio-enzyme and GFRP as alternative materials while maintaining the required strength characteristics of concrete.*

Key Words: Fresh Concrete test, Hardened Concrete test, Durability test, Workability Split Tensile Test

1 INTRODUCTION

Bio-enzyme and Glass Fiber Reinforced Polymer (GFRP) are emerging materials widely used in modern concrete technology to improve the strength, durability, and sustainability of construction materials. Bio-enzyme is an eco-friendly organic additive produced through the fermentation of natural materials, which enhances the bonding properties and workability of concrete while reducing water demand. It also contributes to sustainable construction by minimizing the use of harmful chemical admixtures. GFRP sheets are lightweight, corrosion-resistant, and high-strength composite materials made from glass fibers and polymer resin.

1.1 BIO ENZYME

Bio-enzyme is a natural and eco-friendly liquid produced by the fermentation of organic materials such as fruit peels, jaggery, and water. In concrete technology, it is used as a chemical admixture to improve the workability, bonding, and strength of concrete while reducing water consumption. Bio-enzyme helps in enhancing the durability and performance of concrete by improving the hydration process of cement. It is considered a sustainable material because it reduces the use of harmful chemicals and supports environmentally friendly construction practices.

1.2 GFRP (GLASS FIBER REINFORCED POLYMER)

Glass Fiber Reinforced Polymer (GFRP) sheet is a lightweight, high-strength composite material made of glass fibers embedded in a polymer resin. It is widely used in the construction industry for strengthening, repairing, and retrofitting concrete structures due to its excellent tensile strength, corrosion resistance, and durability. GFRP sheets are easy to install and improve the load-carrying capacity and crack resistance of reinforced concrete members. Because of their low weight and high performance, GFRP sheets are considered an effective and economical solution for modern structural applications.

1.3 HCL

In durability studies of concrete, HCl (Hydrochloric Acid) is used to check the acid resistance and durability of concrete. Concrete specimens are immersed in HCl solution to study the effect of acidic conditions on strength, weight loss, and surface damage. This test helps to evaluate how well concrete can resist chemical attacks in aggressive environments such as industrial areas, sewage plants, and chemical industries.

2 MATERIAL AND METHODOLOGY

2.1 Fine Aggerate (IS 2386 Part-1)

Table 1 Properties of Fine Aggerate

Properties	Sand
Sieve analysis	Zone II
Fineness modulus	2.871
Specific Gravity	2.64
Water Absorption	1.77
Bulk Density	1.62 (Loose) 1.76 (Compacted)

2.2 Coarse Aggerate (383-1987)

Table 2 Properties of Fine Aggerate

Properties	20mm	10mm
Specific Gravity	2.88	2.99
Water Absorption	1.46%	0.29%
Aggregate Impact Value	9.81%	9.33%
Aggregate Crushing Value	11.75%	9.98%
Flakiness Index	10.89%	25.26%
Elongation Index	6.84%	7.66%
Bulk Density	1.62 (Loose) 1.75(Compact)	1.53 (Loose) 1.79(Compact)

2.3 Properties of Fly ash

Table 3 Properties of fly ash

Properties	value
Hazardous component	None
PH Value	3-5
Specific Gravity	1-1.09
Flammability	Inflammable
Color	Dark Brown

2.4 Mix Design (10262-2019)

- For M 30 Grade Concrete mix

Table 4 mix proportion (per cubic meter)

water	Cement	FA	CA	Total
197.16	448.09	771.3	1082.5	2553.4
0.44	1.00	1.72	2.41	5.57

- For M 35 Grade Concrete mix

Table 5 mix proportion (per cubic meter)

water	Cement	FA	CA	Total
157.6	405	791.4	1181.5	2535.5
0.39	1.00	1.95	2.92	6.3

- For M 40 Grade Concrete mix

Table 6 mix proportion (per cubic meter)

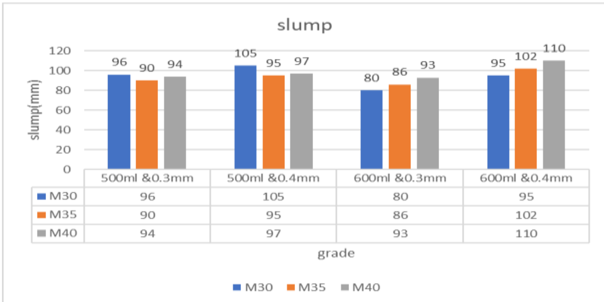
water	Cement	FA	CA	Total
153.57	437	816.3	1125.3	2532.4
0.35	1.00	1.87	2.58	5.8

3. RESULT

3.1 Workability

- The concrete slump test assesses the workability of newly mixed concrete prior to setting.
- It is conducted to evaluate the flowability of freshly prepared concrete, thereby measuring its workability.
- The workability of concrete is tested according to IS 1199.

Chart-1 slump value comparison



3.2 Compressive test result

- The compressive strength test was conducted to determine the load-carrying capacity of concrete specimens.
- Concrete cubes were tested after the specified curing period (7, 14, and/or 28 days).
- Compressive strength increased with curing age due to continuous cement hydration.
- The specimens achieved the required strength for the designed concrete grade.
- The failure pattern observed was typical concrete crushing under compression loading.
- The test results indicated good quality concrete with adequate compaction and curing.

Where, fc=P/A
Fc= Compressive strength (N/mm^2)
P= Maximum load applied (N)
A= Area of cube specimen (mm^2)

Chart-2 Compressive test result of 7 day

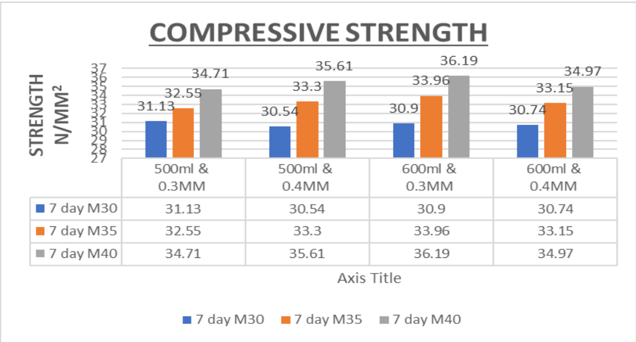


Chart-3 Compressive test result of 14 day

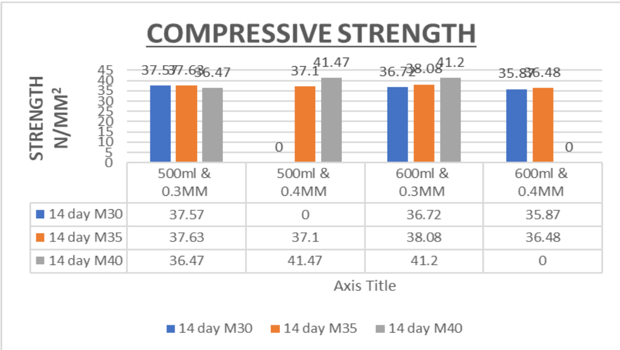
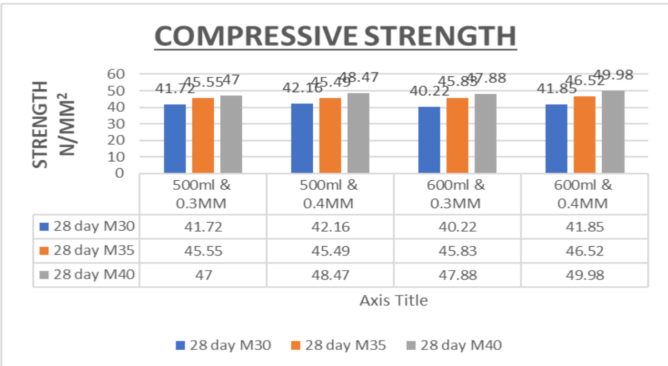


Chart-4 Compressive test result of 28 day



3.3 Split Tensile test result

- The split tensile test was conducted to determine the tensile strength of concrete specimens.
- The test measures the concrete's resistance to cracking under indirect tensile loading.
- Tensile strength increased with the age of concrete due to continued hydration and strength development.
- The specimens exhibited a typical vertical crack along the loaded diameter at failure.
- Higher split tensile strength indicates better crack resistance and structural performance.

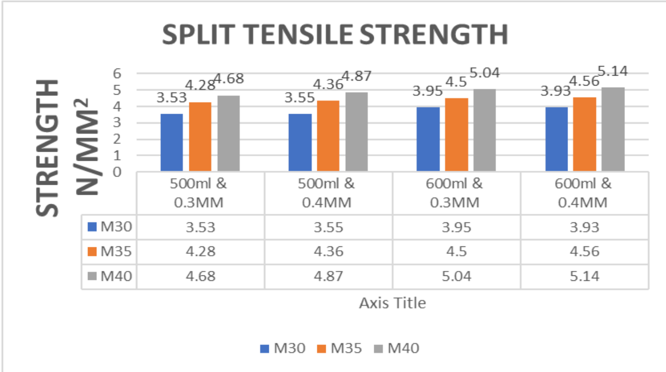
ft=2P/3.14DL

P= Maximum load applied (N)

D= Diameter of cylinder (mm)

L= Length of cylinder (mm)

Chart-5 Split Tensile test result



3.4 Durability test result

- Durability tests evaluate the ability of concrete to resist environmental deterioration and maintain its strength over time.
- The specimens were subjected to aggressive conditions such as acid attack, water absorption, sulphate exposure, or chloride penetration.
- The test results indicated changes in weight, compressive strength, and surface condition of the concrete.
- Lower weight loss and lower strength loss indicate better durability performance.
- Concrete containing supplementary materials or additives generally showed improved resistance to chemical attack.
- Reduced water absorption suggests a denser concrete matrix and enhanced durability.
- No significant cracking, spalling, or surface deterioration was observed in durable specimens.

Chart-6 Durability test result for M 30

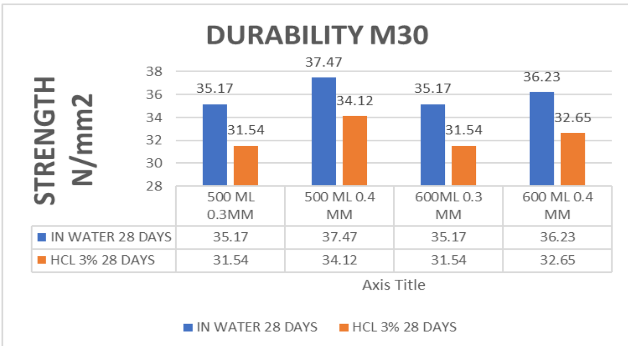


Chart-7 Durability test result for M 35

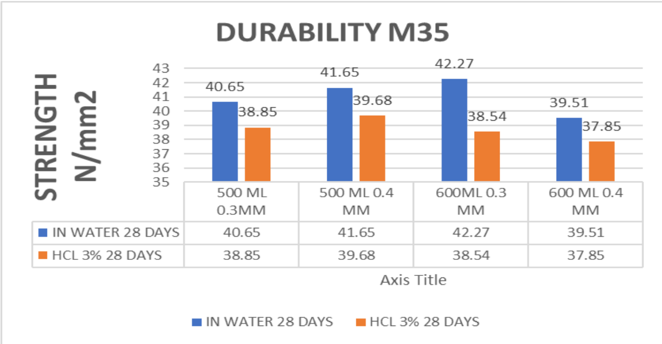
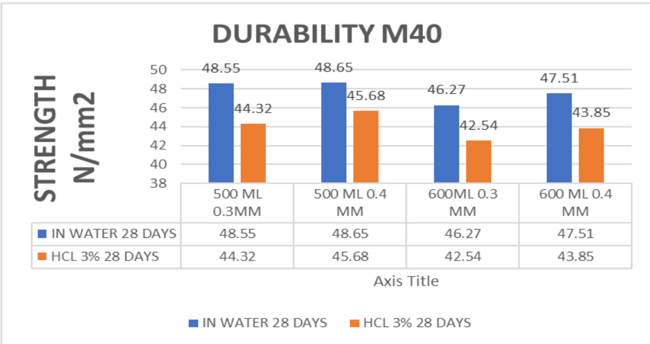


Chart-8 Durability test result for M 40



3.5 Flexural Strength test Beam Result of M30, M35, M40 Grade of Concrete

- In this study, 24 beams and 24 cubes were used, totaling 48 specimens for control.
- Cement was substituted with fly ash at varying percentages of 6%, 12%, 18%, and 24%, while sand was replaced with stone dust at percentages of 8%, 18%, 28%, and 38%.
- Molds for flexural strength testing of 150x150x600mm beams were prepared, with 3 specimens tested at each age using different mix design ratios (beams tested at 7 days and 28 days).
- All freshly cast specimens were left in molds for 24 hours before being removed and then submerged in water for curing until strength testing was carried out.

Chart-9 Comparison of flexural strength values at 7days

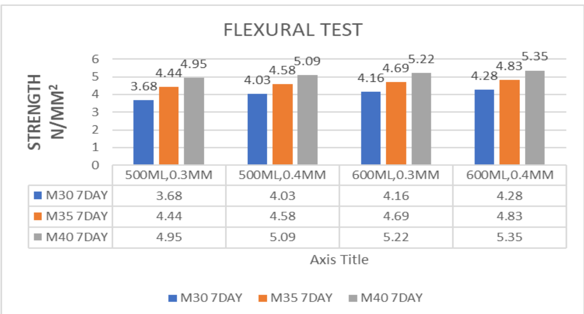
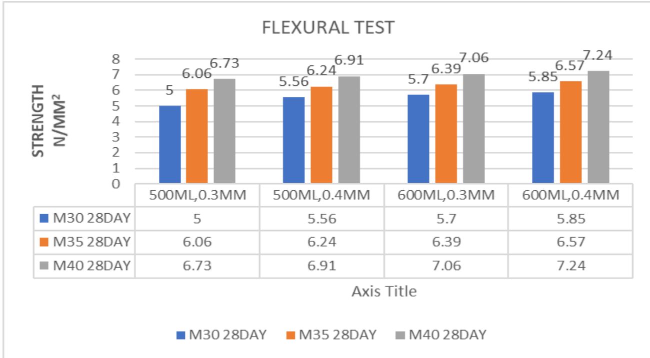


Chart-10 Comparison of flexural strength values at 28 days



4. CONLUSION

- It is observed that there is increase in workability (Slump test) for the M30, M35 and M40 grade of Concrete treated with 600 ml/m³ with 0.4MM dosage of Bio-Enzyme & GFRP respectively when compared to untreated concrete.
- It is observed that there is increase in strength by 7.39 % & 7.56 % & 3.52 % for the M30 & M35 & M40 grade of concrete treated with optimum dosage of Bio-Enzyme & GFRP with ageing when compared to untreated concrete.
- The split tensile strength of concrete continues to rise, reaching increments of 2. 61%, 10. 14%, and 16. 28% for the M30, M35, and M40 concrete grades, respectively, with the substitution of cement with Bio Enzyme and GFRP.
- It is observed that there is increase in strength rapidly at early stage treated with Bio-Enzyme & GFRP.
- In Durability test using HCL solution in concrete, Results shows that in normal M30, M35 and M40 grade of concrete maximum loss in strength is by 12.87%, 8.83%, 9.82%
- Optimum dosage of Bio-Enzyme is 600ml/m3 with 0.4mm GFRP.

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