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Effect of Plastic and Fibers in No-Fine Concrete on Mechanical and Durability Properties

Agadi Kishan
Assistant professor, School of Civil Engineering,
REVA University, Rukmini Knowledge Park, Kattigenahalli, Yelahanka
Bangalore-560064, Karnataka, India,

Anjana M G
Student, P.G M-Tech-CASE, School of Civil Engineering,
REVA University, Rukmini Knowledge Park, Kattigenahalli, Yelahanka
Bangalore-560064, Karnataka, India,

T G S Vishnu
Student, B.Tech, School of Civil Engineering,
REVA University, Rukmini Knowledge Park, Kattigenahalli, Yelahanka
Bangalore-560064, Karnataka, India,

Veda Susmitha Y
Student, B.Tech, School of Civil Engineering,
REVA University, Rukmini Knowledge Park, Kattigenahalli, Yelahanka
Bangalore-560064, Karnataka, India,

Abstract
In the present days climatic change and global warming are main threat due to human intervention and lots of industrial activities. In the context urbanization and industrialization are major reason for it. Our metropolitan cities and urban areas are covered with buildings, industries, roads which are major barriers for water infiltration. Due to which flooding of water during rainy season taking place, and also decrease in the ground water table due to lack of infiltration activities, lack of water supply to flora and fauna which leading to degradation of environment in the urban areas. In order to overcome all these adverse effects there is requirements of new technologies and methods of building the infrastructures which are eco friendly. In this regards no fine concrete is new technique which allows water to percolate it through. No fine concrete is also known as pervious concrete which allows fluids to pass through it. Which helps in avoiding the flooding of water as well recharges ground water. The advantages of this type of concrete are lower density, lower thermal conductivity, cost effective due to absence of fine aggregate and lower cement content. It also has relatively low drying shrinkage. It is having better insulating property than normal concrete due to presence of larger voids. In the present research, studies were carried on no fine concrete with additive such as ground granulated blast furnace slag (GGBS), waste plastic and polypropylene fiber. And results were compared with no fine concrete without any additive. In the present studies various tests like mechanical tests such as compressive strength, split tensile strength. Durability such as alkali reaction test, acid attack, conducted. From the present study it has been observed that the no fine mix with waste plastic and GGBS as an additive showed better performance in respect to compression, and durability and permeability when compared to no fine mix without any additive and no fine with polypropylene fibers and GGBS.

Keywords: Compressive strength, Split tensile strength, GGBS, Plastic waste, Polypropylene fibers, Acid test, Alkali aggregates reaction, No-fine concrete.

Introduction
Demand for concrete is increasing day by day with increase in infrastructural activities. Alternatives for materials used in concrete are necessary to be found to meet the demand. Disposal of plastic waste has been a challenging issue with environmental aspect due to its very low biodegradability. Annual consumption of plastic around the world has increased from 1950 to 2001 by 5 million tons to 100 million tons respectively. Many researches are carried out in using plastic shredding as partial replacement for both fine aggregates and coarse aggregates in concrete and its strength and mechanical behavior is tested [1]. Properties like chemical resistance, tensile strength, creep and shrinkage of concrete can be increased with the use of plastic waste as constituent of concrete. Here we are using polyethylene for concrete production where the life of concrete is more and hence polyethylene can be used for another few decades without harming the environment [4].

Concrete offers many advantages regarding mechanical characteristics and economic aspects of the construction, the brittle behavior of the material remains a large handicap for the seismic and other application where flexible behavior is essentially required. Recently, however the development of polypropylene fiber-reinforced concrete has provided a technical basis for improving these deficiencies [5].

No fine concrete is used due to high water infiltration

capacity, reduces storm water runoff and water logging problems these days so by use of no fine concrete water gets percolated and ground water can be recharged. They have better insulating property due to presence of larger voids [6].

Research Objective

The main objective of the present study is to investigate the mechanical, durability properties of no-fine concrete, it also to understand the influence of plastic, polypropylene fiber and GGBS in the concrete with no fines and to examine the durability and mechanical properties of the no fine concrete with the addition of plastic and polypropylene fiber. The study is also aimed to comparing the results of no-fine concrete mix with additive (GGBS + Plastic or GGBS + Fibers) with no-fine concrete mix without any additives.

Materials and Methodology

Materials

The materials used in this research are:

1. OPC-53 grade cement (Ordinary Portland Cement)
2. Coarse aggregate (20mm down size)
3. Plastic waste (LDPE)
4. Polypropylene fiber
5. Water
6. Ground Granulated Blast furnace Slag (GGBS)

Tests on Cement and Coarse Aggregate

Table 1 Test on cement

SL. No	Test Conducted	Test Results	Results As Per Is:12269:1987
1	Normal Consistency	28%	-
2	Specific Gravity of cement	3.03	3.15
3	Initial Setting Time	45 minutes	Not less than 30 minutes
4	Final Setting Time	320 minutes	600 minutes (max)

Table 2 Test on Coarse Aggregate

SL. No	Test Conducted	Test Results
1	Specific gravity of coarse aggregate	2.37
2	Water absorption	1.05%

Mix Details

The concrete mix was designed for 1:4 ratio (Cement : Coarse aggregate) by using Ordinary Portland cement, and coarse aggregate (20 mm down size) as per mix design from IS:12727-1989 “Recommended Guidelines for Concrete Mix Design” shown below. The additives such as waste plastic and polypropylene were added as per literature [1], [6].

Table 3 Mix Details

MATERIALS	QUANTITY
Cement	1.552 kg
Coarse aggregate	6.208 kg
Water	698.412 ml
GGBS (5% of cement)	77.6 gm
Plastic waste (5% of cement)	77.6 gm
Polypropylene fibers (1% of cement)	15.52 M

Methodology

Compressive strength test

Compressive strength was controlled by utilizing Compression Testing Machine (CTM) of 3000 KN limit. The compressive strength of concrete was tried utilizing 150x150x150 mm cube specimens. The test was done by setting specimen between the loading surfaces of a CTM and the load was connected until the specimen fails. Three test specimens were thrown and used to quantify the compressive strength for each test conditions and normal esteem was considered. Cubes were tested at the age of 7, 14 and 28 days.

$$\text{Compressive strength} = \frac{\text{ultimate load}}{\text{area of cross section(mm2)}}$$

Figure 1 Compression testing machine

Split tensile test

Split tensile strength was controlled by using Compression Testing Machine (CTM) of 3000 KN restrain. The split elasticity of cement was had a go at using 100x200 mm solid shape examples. The test was finished by setting example between the stacking surfaces of a CTM and the heap was associated until the point when the example parts over the vertical distance across. Three test examples were tossed and used to measure the split rigidity for test conditions and typical regard was considered. Cubes were tried at 28 years old days.

$$\text{Split tensile strength} = \frac{2 \times Load\ at\ failure}{\pi \times length \times Diameter\ of\ specimen}$$

Chloride Penetration Test

Calorimetric chlorination system is one of the tests to discover the chlorine infiltration profundity in the Specimens. For this examination the examples of size 150x150x150 mm examples were taken with mineral admixture like GGBS and following 28 days water curing i.e. from the time of throwing are evacuated and are set in water which contains sodium chloride (NaCl) about1N. Following 28 days chlorine water curing, examples are evacuated and are sliced in to two equivalent pieces each. Quickly, the synthetic called silver nitrate

(AgNO3) of 0.1N is splashed on those examples (broken part). Because of synthetic response between sodium chloride and silver nitrate a white encourage is shaped on the examples and the profundity up to which it demonstrates white precipitate.

Figure 2 Typical Chloride Penetration Depth after 28 Days Exposure

Acid Attack Test

For acid attack test solid block of size 150×150×150 mm are taken with mineral admixture GGBS. The example are taken and cured in form for 24 hours, following 24 hours, all the example are de-molded and kept in curing tank for 28-days. Following 28-days all examples are kept in sulphuric corrosive (H_2SO_4) arrangement. 0.1N solution is considered and added is included in to water. The 1N was kept up all through the season of 28 days. Following 28-days of immersing in corrosive arrangement, the examples are taken out and were washed in running water and kept in the examples were striven for compressive quality. The resistance of cement to corrosive attack was found by the loss of compressive quality on submerging cubes in acid water.

Alkaline Attack Test

For alkali aggregate reaction test, concrete cube of size 150×150×150 mm are taken with mineral admixture GGBS. The example are casted and cured in form for 24 hours, following 24 hours, all the example are de-molded and kept in curing tank for 28-days. Following 28-days all examples are kept in sodium hydroxide arrangement. 0.1N solution is considered and added is included in to water. The 0.1N was kept up all through the season of 28 days. Following 28-days of immersing in corrosive arrangement, the examples are taken out and were washed in running water and kept in the examples were striven for compressive quality. The resistance of concrete to corrosive strike was found by the loss of compressive quality on submerging cubes in salt water.

Results and Discussions

Compressive Strength Test

The compression strength is the measure of compressive stress that a solid material can sustain under gradual loading without getting fracture. In this study the concrete cubes of size 150x150x150 were casted in addition with and without additives like polypropylene fiber, plastic waste and GGBS admixture. The specimen is cured and tested at different ages like 7, 14 and 28 days. The compressive strength results were tabulated and graphs are tabulated below.

Table 4 Compression strength of no-fine concrete cubes with different additives

Materials	7Days (MPa)	14Days(MPa)	28Days(MPa)
Specimen without additives	19.8	21.06	23.6
Specimen with plastic waste	20.1	23.7	24.1
Specimen with fiber	15.37	19.88	21.73

From the table 4 it is observed that concrete with different additives behaves differently at 7, 14 and 28days. It was observed that mix with plastic waste specimen performed better when compared with mix without plastic waste and mix with fiber specimen. The compressive strength of mix without plastic waste has 19.8MPa at 7rd day, with plastic waste has 20.1MPa and with fiber has 10.37 at 7rd day. And similarly the compressive strength of mix without plastic waste has 23.6MPa at 28th day, with plastic waste has 24.1MPa and with fiber has 21.73MPa at 28th day.

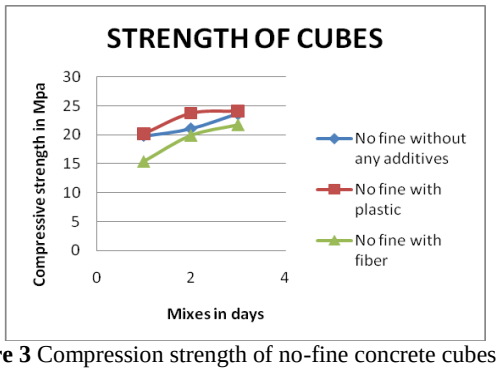

Figure 3 Compression strength of no-fine concrete cubes with different additives

From figure 3 it was observed that at all the ages compressive strength of concrete with plastic mix was more when compared with fiber and without plastic mix. At 28th day with plastic was having compressive strength of 24.1Mpa, with fiber of 20.37MPa and without plastic of 22.5Mpa. As regards to compression strength properties the concrete mix with plastic out-performs than the concrete mix with fiber and without plastic.

Split tensile Strength Test

In the present studies the split tensile test was conducted on cylindrical specimen of size 100x200mm with mixes such as no fine concrete without additive, no fine with GGBS and plastic, no fine with GGBS and fibers. The 28 days water cured were tested. The split tensile strength results and graphs are logged below.

Table 5 Split tensile strength of cylinders

Materials	28Days (Mpa)
Specimen without additives	1.91
Specimen with plastic waste	1.86
Specimen with fiber	1.83

From the table 4 it is observed that concrete with different additives behaves differently at 7, 14 and 28days. It was observed that mix with plastic waste specimen performed better when compared with mix without plastic waste and mix with fiber specimen. The compressive strength of mix without plastic waste has 19.8MPa at 7rd day, with plastic waste has 20.1MPa and with fiber has 10.37 at 7rd day. And similarly the compressive strength of mix without plastic waste has 23.6MPa at 28th day, with plastic waste has 24.1MPa and with fiber has 21.73MPa at 28th day.

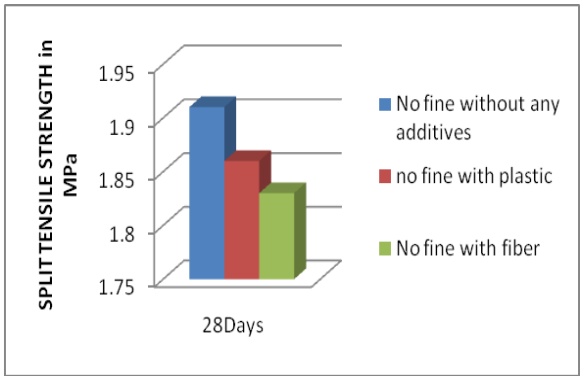

Figure 4 Split tensile strength of no-fine concrete cylinder

From figure it is observed that at the age of 28days the split tensile strength of no-fine concrete mix with plastic and with fiber showed slight less strength when compared to without plastic mix. At 28th day with plastic was having split tensile strength of 1.86Mpa, without plastic of 1.91MPa and with fiber of 1.83Mpa.

Chloride Penetration Test

The calorimetric chlorination test was conducted to no-fine concrete cubes after it was cured for 28days in water and then dipped and cured in 1N sodium chloride solution (NaCl) for 28days. The cubes were casted with and without additives like plastic waste and fiber and are of size 150×150×150mm. The specimens are cured for 56days. The results and graphs are noted below.

Table 6 Chloride Penetration depth of no-fine concrete cubes with additives

Mixes	Chloride penetration depth for 28 days (mm)
Specimen without additives	11.31
Specimen with plastic	13.19
Specimen with fiber	11.06

From the table 6 it is observed that the mixes with without additives and with fiber showed less attack to chloride when compared to mix with waste plastic mix .it is also seen that out of three mixes the mix with fiber showed less chloride attack.

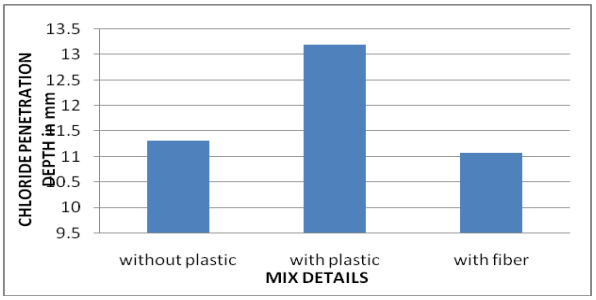

Figure 5 Depth of chloride Penetration in no-fine concrete mix

From the fig.5 chloride penetration in no-fine concrete cubes was observed, which shows the penetration depth of chlorine is less in with fiber mix which is about 11.06mm when compared with without plastic and with plastic mix which is about 11.31mm and 13.19mm respectively.

Acid attack Test

The no-fine concrete cubes with additives like plastic and fibers and without additives were tested for acid attack. The concrete cubes of size 150×150×150 mm were casted and cured for 28 days of water curing, then it was dipped in Sulphuric acid (H_2SO_4) solution for 28 days then it was checked for compressive strength. The average compressive strength of the degraded samples was evaluated at the end of every phase of exposure to the sulphuric acid solutions and compared with the initial 28 days strength of normal water cured specimens of same mixes.

Table 7 Acid attack of no-fine concrete with different additives

Material	Compressive strength in water curing (MPa)	Compressive strength in acid solution (MPa)	% loss in compressive strength(MPa)
Specimen without additives	22.5	19.22	14.57
Specimen with plastic	24.1	22.9	4.98
Specimen with fiber	20.73	18.67	9.94

From the table 7 it was observed that plastic mix were reacted more with the H_2SO_4 solution. Moderate amount of scales were observed on the specimen surface which were dipped in the acid solution. When these specimens were checked for compression strength there was slight reduction in the compression strength. Nearly 5 to 15% losses in the strength with a water cured specimen were observed.

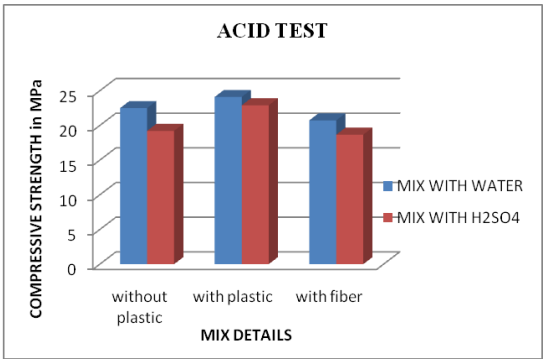

Figure 6 percentage loss in compressive strength due to acidity

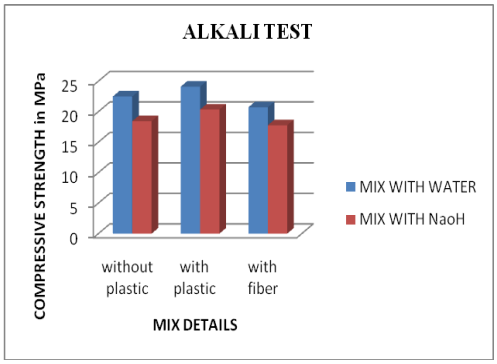

Figure 7 percentage loss in compressive strength due to alkalinity

From the fig.6 it was observed that mix with plastic specimen reacted more with the acid solution when compared with the mix with fiber and without plastic. The normal water cured without plastic concrete cube's 28 days strength was 22.5MPa, where as acid solution cured same mix cube strength was 19.22MPa, there was 14.57% reduction in the strength were observed. Where in The normal water cured with plastic concrete cube's 28 days strength was 24.1MPa, where as acid solution cured same mix cube strength was 22.9MPa, there was 4.98% reduction in the strength were observed, Similarly for fiber it was 9.94% reduction in the strength.

Alkali Attack Test

The no-fine concrete cubes with additives like plastic and fibers and without additives were tested for alkali attack. The cubes are of size 150×150×150 mm were casted and cured for 28days of water curing, then it was dipped in Sodium hydroxide (NaOH) solution for 28days then it was checked for compressive strength. The average compressive strength of the degraded samples was evaluated at the end of every phase of exposure to the Sodium hydroxide solutions and compared with the initial 28 day compressive strength of normal water cured specimens of same mixes.

Table 8 Alkali attack of no-fine concrete cubes

Material	Compressive strength in water curing (MPa)	Compressive strength in acid solution (Mpa)	% loss in compressive strength(MPa)
Specimen without additives	22.5	18.44	18.04
Specimen with plastic	24.1	20.35	15.56
Specimen with fiber	20.73	17.78	14.23

From the table 8 it has been observed that the without additives mix reacted more with the NaOH solution. There was minor amount of scales formed on the surface of cubes, and when these specimens are checked for compression strength there was reduction in the compression strength. Nearly 14 to 18% losses in the compression strength were observed.

From the fig.7 it has been observed that mix with plastic concrete reacted more with the alkaline solution when compared with the mix with fiber and without plastic specimen. The normal water cured without plastic concrete cube's at 28 days strength was 22.5MPa, where as acid solution cured same mix cube strength was 18.44MPa, there was 18.04% reduction in the strength were observed. Where in The normal water cured with plastic concrete cube's 28 days strength was 24.1MPa, where as acid solution cured same mix cube strength was 20.35MPa, there was 15.56% reduction in the strength were observed. Similarly for fiber it was 14.23% reduction in the strength.

Conclusion

No fine concrete is a type of concrete which provides medium for infiltration of water. To enhance the strength and durability of the no-fine concrete additives such as plastic waste, polypropylene fibers and GGB were added to the no-fine, which improved the mechanical and durability properties to some extent. The mechanical and durability test has been carried out on with and without plastic, fibers, GGBS mixes and following conclusion can be drawn.

- From the compressive strength test results it is been concluded that mix with plastic showed comparatively more compression strength than mix with fiber and mix without any additives.
- From split tensile strength test it has been concluded that mix without any additives show higher strength than mix with plastic and with fiber.
- In durability test from chloride penetration test it can be concluded that the depth of chloride penetration was lesser in no-fine with fiber mix than in without additives and with plastic mix.
- From acidic and alkalinity tests it can be concluded that the percentage losses in compressive strength was more in without plastic mix than in with plastic mix and with fiber mix.

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