

# Effect on Mechanical Properties of No-Fine Concrete by Partial Replacement of Fly Ash in Cement with Polypropylene Fiber and Hydrogen Peroxide

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**ABSTRACT:** No-fine concrete (also called porous concrete, permeable concrete, pervious concrete and porous pavement) is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. No-fine concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. In this thesis, studied the strength & permeability characteristics of a No-fine concrete with mix (1:4) made with 50% partial replacement of fly ash, mineral & chemical admixtures like polypropylene fiber (0.9 kg/m<sup>3</sup>) and hydrogen peroxide as a air entraining admixture ( 5% by weight of cement) were used. The properties such as compressive strength, indirect tensile strength, permeability, flexural strength & bond strength with initial tests were performed and the principal advantages, major disadvantages, principal applications in Indian construction industry were discussed. Specimens were tested with multiple trial mixes, observed that compressive strength ranging between 11 MPa to 19.6MPa, indirect tensile strength ranges from 2.1 MPa to 3.2 MPa, permeability values ranges from 0.4 cm/sec to 1.2 cm/sec, bond strength ranges from 1.8 MPa to 2.2 MPa and flexural strength ranges from 0.8 MPa to 2.05 MPa.

**KEYWORDS:** No fine concrete, permeability, bond strength.

## I. INTRODUCTION

No-Fines Concrete is a method of producing light concrete by omitting the fines from conventional concrete. No-fines concrete as the term implies, is a kind of concrete from which the fine aggregate fraction has been omitted. This concrete is made up of only coarse aggregate, cement and water. Very often only single sized coarse aggregate, of size passing through 20 mm retained on 10 mm is used. No-fines concrete is becoming popular because of some of the advantages it possesses over the conventional concrete. The single sized aggregates make a good no-fines concrete, which in addition to having large voids and hence light in weight, also offers architecturally attractive look.

The advantages of this type of concrete are lower density (1600- 2000 kg/m<sup>3</sup>), lower cost due to lower cement content, lower thermal conductivity, relatively low drying shrinkage, no segregation and capillary movement of water, better insulating characteristics than conventional concrete because of the presence of large voids.

The bond strength of no-fines concrete is very low and, therefore, reinforcement is not used in conjunction with no-fines concrete. However, if reinforcement is required to be used in no-fines concrete, it is advisable to smear the reinforcement with cement paste to improve the bond and also to protect it from rusting.

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## II. METHODOLOGY

In order to develop the No-fine concrete technology, therefore, trial-and-error process was used. The focus of the study was to identify the salient parameters that influence the mixture proportions and the properties of No-fine concrete.

The test procedure included the initial steps of deciding on the tests to be conducted and choosing a number of aggregate ratios for the No-fine concrete. This was followed by conducting the preliminary mix design and compressive strength tests on these samples to determine the mix that performed most successfully.

With the mix ratio known, the remaining tests began. This included the determining the properties of aggregates, cement, Fly ash, Polypropylene fiber and Hydrogen Peroxide. The samples were tested using standard hardened concrete tests like compressive strength and indirect tensile strength.

Trail Mix:

The Trial mix in this case was the determination of the ratio of aggregate. Cement and water that possessed the most favourable properties. For this particular situation three trail mixes were designed. The mixes were determined from previous literature. There are only three constituents of No-fine concrete that can be considered and varied: aggregate, cement and water content.

The mix designs for No-fine concrete were obtained from printed articles. There were a large number of different mixes that are currently being used for a whole range of applications. For this reason three different mixes were trailed. The aggregate-cement-water ratios were:

TABLE I: MIX PROPORTIONS USED FOR NO-FINE CONCRETE TRIAL MIXES

Aggregate	Cement	Water
8	1	0.4
6	1	0.4
4	1	0.4

The trial mixes were used to determine the most suitable mixture for the analysis. The three different samples were mixed and tested for compressive strength and indirect tensile strength at 7 days, 14 days and 28 days. From these results, the most appropriate mix was determined and used for the remainder of the analysis.

The specimens were tested for compressive strength and indirect tensile strength at 7 days, 14 days and 28 days. The results of those tests can be found in the table below.

TABLE II: COMPRESSIVE AND TENSILE STRENGTH FOR MIX PROPORTION (1:4)

Curing Period (days)	Compressive Strength (MPa)	Indirect Tensile Strength (MPa)
7	7.5	1.2
14	9.0	2.5
28	13.7	3.8

TABLE IV: COMPRESSIVE AND TENSILE STRENGTH FOR MIX PROPORTION (1:8)

Curing Period (days)	Compressive Strength (MPa)	Indirect Tensile Strength (MPa)
7	1.8	0.6
14	3.5	1.2
28	4.33	2.0

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From the tables II, III and IV, the no-fine concrete mix design found that an aggregate-cement-water mix of **4:1:0.4** produced the highest compressive strength out of the different mix proportions trialled. Since the highest compressive strength was found in the 4:1:0.4 mix, it was used for the remainder of the testing in this project.

## III. EXPERIMENTAL STUDIES

### A. PRELIMINARY WORK

The remainder of this chapter is involved with the properties of materials and procedures of all the hardened concrete tests that were conducted.

### B. PROPERTIES OF MATERIALS USED IN THE EXPERIMENTAL WORK

The materials used in experimental work are:

- Cement
- Coarse aggregate
- Water
- Polypropylene fiber
- Fly ash
- Hydrogen Peroxide

TABLE V: PHYSICAL PROPERTIES OF CEMENT

S.No	Property	Experimental Values
1	Fineness of cement	6.50%
2	Specific gravity	3.10
3	Normal Consistency	29%
4	Initial Setting Time	50 min
5	Final Setting Time	320 min

TABLE VI: SIEVE ANALYSIS OF COARSE AGGREGATE

S.No	Sieve Size (mm)	Weight Retained (gram)	% Weight Retained	Cumulative % Weight Retained	Cumulative % Weight Passing
1	20	0	0	0	100
2	12.5	2000	40	40	60
3	10	1000	20	60	40
4	4.75	2000	40	100	0
5	2.36	0	0	100	0
6	1.18	0	0	100	0
7	0.6	0	0	100	0
8	0.3	0	0	100	0
9	0.15	0	0	100	0

TABLE VII: PHYSICAL PROPERTIES OF COARSE AGGREGATE

S.No	Property	Value
1	Specific gravity	2.77
2	Bulk density loose	14.90kN/m <sup>3</sup>
	compactd	16.7kN/m <sup>3</sup>
3	Water absorption	0.5%
4	Fineness modulus	7.00%

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TABLE VIII: PHYSICAL PROPERTIES OF WATER

S.No	Parameter	Value
1	pH	7.10
2	Taste	Agreeable
3	Appearance	Clear
4	Turbidity (NT Units)	1.75
5	Hardness (mg/l)	250

TABLE IX: PHYSICAL PROPERTIES OF FLY ASH

S.No	Properties	Result
1	Specific Gravity	1.975
2	Fineness Modulus	1.195%

TABLE X: PHYSICAL PROPERTIES OF POLYPROPYLENE FIBRE

Form	100% Virgin Polypropylene Fibre
Specific gravity	0.91 g/cm <sup>3</sup>
Alkali content	Nil
Sulphate content	Nil
Chloride content	Nil
Elasticity modulus	3500-4800mpa
Tensile strength	350N/mm <sup>2</sup>
Melting point	160-170c
Ignition point	590c
Cement compatibility	Excellent

TABLE XI: PHYSICAL PROPERTIES OF HYDROGEN PEROXIDE

Molecular Formula	H <sub>2</sub> O <sub>2</sub>
Appearance	Very light blue colour; colourless
Odour	Slightly sharp
Acidity	11.75
Density	1.135 g/cm <sup>3</sup>

TABLE XII: TYPICAL RANGES OF MATERIALS PROPORTIONS IN NO-FINE CONCRETE

	Proportions (kg/m <sup>3</sup> )
Cementitious materials	270 to 415
Aggregate	1190 to 1480
Water : cement ratio ( by mass )	0.27 to 0.4
Aggregate: cement ratio( by mass )	4 to 4.5:1
Fine : coarse aggregate ratio ( by mass )	0 to 1:1

## IV. RESULTS AND DISCUSSIONS

The experimental results were presented and discussed. Each of the compressive strength, indirect tensile strength, permeability, flexural strength and Bond strength test data plotted in figures corresponds to the mean value of the three test concrete cubes and cylinders in series.

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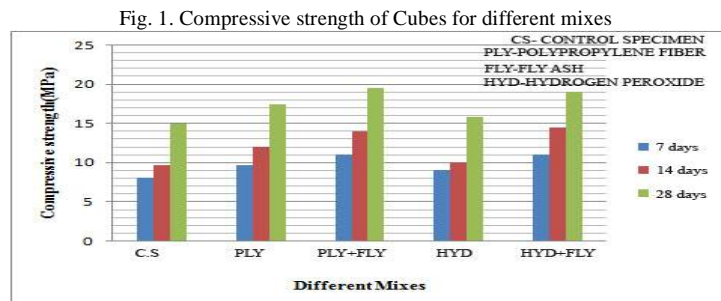
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TABLE XIII: COMPRESSIVE STRENGTH OF CUBES FOR DIFFERENT MIXES

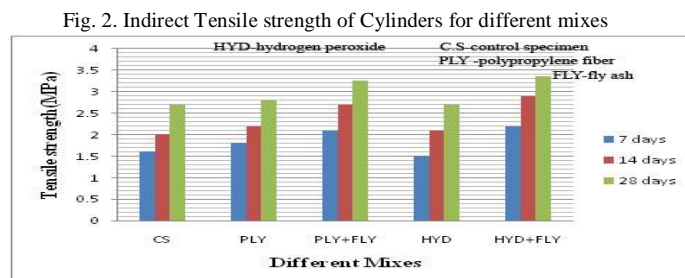
Curing Period (Days)	Control specimens (MPa)	Control specimen + polypropylene (MPa)	Control specimen+ polypropylene +Fly ash (MPa)	Control specimen+ H <sub>2</sub> O <sub>2</sub> (MPa)	Control specimen +Flyash+H <sub>2</sub> O <sub>2</sub> (MPa)
7	8	9.6	11	9	11
14	9.7	12	14	10	14.5
28	15	17.5	19.6	15.8	19



From table XIII when compared to control specimen, it was observed that compressive strength increased by 16.67%,27.27%,11.11% & 27.27% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 7 days curing period. Similarly, it was observed that compressive strength increased by 19.16%,30.71%,3% & 34.28% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 14 days curing period. & It was observed that compressive strength increased by 14.28%,23.46%,5.06% & 21.05% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 28 days curing period.

TABLE XIV: INDIRECT TENSILE STRENGTH OF CYLINDERS FOR DIFFERENT MIXES

Curing Period (Days)	Control specimens (MPa)	Control specimen + polypropylene (MPa)	Control specimen+ polypropylene +Fly ash (MPa)	Control specimen+ H <sub>2</sub> O <sub>2</sub> (MPa)	Control specimen +Flyash+H <sub>2</sub> O <sub>2</sub> (MPa)
7	1.6	1.8	2.1	1.7	2.2
14	2.0	2.2	2.7	2.1	2.9
28	2.7	2.8	3.26	2.7	3.35



From table XIV when compared to control specimen, it was observed that tensile strength increased by 11.11%,23.80%,6.25% & 27.27% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 7 days curing period. Similarly, it was observed that tensile strength increased by 9.09%,25.92%,5.88% & 31.03% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 14 days curing period. & It was observed that tensile strength increased by 3.57%,17.17%,0% & 19.40% in polypropylene fiber mix, polypropylene

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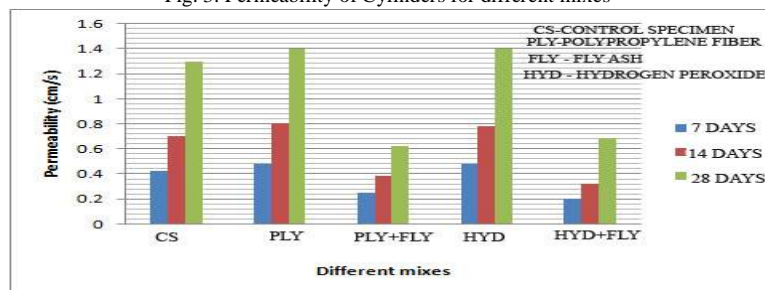
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fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 28 days curing period.

TABLE XV: PERMEABILITY OF CYLINDERS FOR DIFFERENT MIXES

Curing Period (Days)	Control specimens (MPa)	Control specimen + polypropylene (MPa)	Control specimen+ polypropylene +Fly ash (MPa)	Control specimen+ H <sub>2</sub> O <sub>2</sub> (MPa)	Control specimen +Flyash+H <sub>2</sub> O <sub>2</sub> (MPa)
7	0.42	0.48	0.25	0.48	0.2
14	0.7	0.8	0.38	0.78	0.32
28	1.3	1.4	0.62	1.4	0.685

Fig. 3. Permeability of Cylinders for different mixes

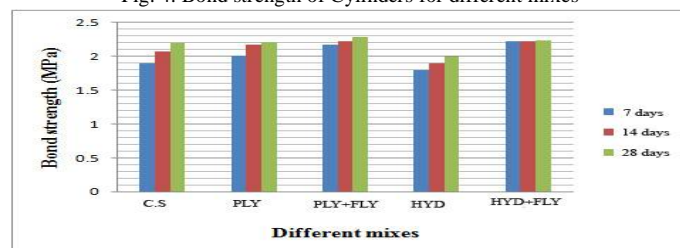


From table XV Compared to control specimen, it was observed that permeability increased by 12.5% in both polypropylene fiber mix & hydrogen peroxide mix and decreased by 40% & 52.38% in polypropylene fiber mix + fly ash mix & fly ash + hydrogen peroxide respectively at 7 days curing period. Similarly, observed that permeability increased by 12.5% ,10.256% in polypropylene fiber mix & hydrogen peroxide mix and decreased by 45% ,54.28% in polypropylene fiber mix + fly ash mix & fly ash + hydrogen peroxide respectively at 14 days curing period & It was observed that permeability increased by 7.14% in both polypropylene fiber mix & hydrogen peroxide mix and decreased by 47.30%,52.30% in polypropylene fiber mix + fly ash mix & fly ash + hydrogen peroxide respectively at 28 days curing period.

TABLE XVI: BOND STRENGTH OF CYLINDERS FOR DIFFERENT MIXES

Curing Period (Days)	Control specimens (MPa)	Control specimen + polypropylene (MPa)	Control specimen+ polypropylene +Fly ash (MPa)	Control specimen+ H <sub>2</sub> O <sub>2</sub> (MPa)	Control specimen +Flyash+H <sub>2</sub> O <sub>2</sub> (MPa)
7	1.9	2.01	2.17	1.8	2.22
14	2.069	2.175	2.228	1.9	2.228
28	2.196	2.21	2.286	2.0	2.236

Fig. 4. Bond strength of Cylinders for different mixes



From table XVI when compared to control specimen, it was observed that bond strength increased by 5.47%,12.44% & 14.41% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, & fly ash + hydrogen peroxide mix and decreased by 5.55% in hydrogen peroxide mix respectively at 7 days curing period. Similarly, it was observed that

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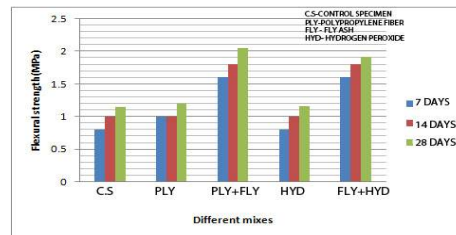
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bond strength increased by 4.17 %, 7.13% & 7.135% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, & fly ash + hydrogen peroxide mix and decreased by 8.89% in hydrogen peroxide mix respectively at 14 days curing period & it was observed that bond strength increased by 0.63%, 3.93% & 1.788% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, & fly ash + hydrogen peroxide mix and decreased by 9.8% in hydrogen peroxide mix respectively at 28 days curing period.

TABLE XVII: FLEXURAL STRENGTH OF PRISMS FOR DIFFERENT MIXES

Curing Period (Days)	Control specimens (MPa)	Control specimen + polypropylene (MPa)	Control specimen+ polypropylene +Fly ash (MPa)	Control specimen+ H <sub>2</sub> O <sub>2</sub> (MPa)	Control specimen +Flyash+H <sub>2</sub> O <sub>2</sub> (MPa)
7	0.8	1.0	1.6	0.8	1.6
14	1.0	1.0	1.8	1.0	1.8
28	1.15	1.2	2.05	1.16	1.92

Fig. 5. Bond strength of Cylinders for different mixes



From table XVII when compared to control specimen, it was observed that flexural strength increased by 20% in polypropylene fiber, 50% in both polypropylene fiber mix + fly ash mix & fly ash + hydrogen peroxide mix & no change in hydrogen peroxide mix respectively at 7 days curing period. Similarly, it was observed that flexural strength increased by 44.44% in both polypropylene fiber mix + fly ash mix & fly ash + hydrogen peroxide mix & no change in polypropylene fiber and hydrogen peroxide mix respectively at 14 days curing period. & It was observed that flexural strength increased by 4.16%, 43.90%, 0.86% & 40.10% in polypropylene fiber mix, polypropylene fiber mix + fly ash mix, hydrogen peroxide mix & fly ash + hydrogen peroxide mix respectively at 28 days curing period.

## V. CONCLUSION

From the experimental study following conclusions were obtained:

1. Compressive strength, tensile strength, flexural strength and bond strength of specimens with partial replacement of fly ash in cement and polypropylene fiber increased by 23.46%, 17.17%, 43.90% and 3.93% respectively, when compared with control specimens.
2. Compressive strength, tensile strength, flexural strength and bond strength of specimens with polypropylene fiber increased by 14.28%, 3.57%, 4.16% and 0.63% respectively, when compared with control specimens.
3. Compressive strength, flexural strength of specimens with hydrogen peroxide increased by 5.06% & 0.86% respectively, no change was observed in tensile strength and bond strength decreases by 0.98%, when compared with control specimens.
4. Compressive strength, tensile strength, flexural strength and bond strength of specimens with partial replacement of fly ash in cement and Hydrogen peroxide increased by 21.05%, 19.40%, 40.10% and 1.78% respectively, when compared with control specimens.
5. Permeability increased by 7.14% in both polypropylene fiber mix and Hydrogen peroxide mix and it was observed that there was a decrease in permeability of 47.30% and 52.30% in the case of mix with partial replacement of fly ash in cement and polypropylene fiber and partial replacement of fly ash in cement + Hydrogen peroxide mix.

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