

# Performance Evaluation of Sustainable Concrete with Fly Ash and Waterproof Chemical

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**Abstract-**This study investigates the permeability and compressive strength characteristics of concrete using different mix compositions, with a focus on improving durability. Four M40 mix concrete mixes (conventional, fly ash based, waterproofing admixture, and combination of fly ash and admixture) yielding comparable compressive strength; the combined mix (fly ash+ admixture), which most reduce water penetration. The combined effect improved impermeability and durability in water exposed conditions without compromising strength.

**Keyword-** compressive strength, permeability, cement, fly ash, waterproof chemical.

## I. INTRODUCTION

The concrete durability largely depends on its permeability, as high water ingress can cause corrosion and deterioration. This study evaluated M40 concrete with various modifications: conventional, fly ash, waterproofing admixture, and combination of fly ash and waterproofing admixture. Compressive strength tests showed all mixes met design requirements, with the combined mix performing comparably to conventional concrete. Permeability measured via Darcy's apparatus revealed that the waterproofing admixture significantly reduced penetration, while fly ash alone had little effect under the test condition. The combined mix achieved the lowest permeability, demonstrating a combined effect that improved impermeability without

sacrificing strength. Integrating fly ash promotes sustainability by recycling industrial waste and waterproofing admixture extends service life.

### A. Objective of the study

The objective of project is as follows:

- To analyse the influence of fly ash and waterproofing admixture as a partial replacement of cement.
- To compare the compressive strength and permeability of different concrete mixes.
- To determine the most effective concrete mix.

## II. METHODOLOGY

### A. Material used

1. Cement: Ordinary Portland Cement OPC 53 grade.
2. Fine aggregate: Sand that passes through a 4.75mm sieve.
3. Coarse aggregate: Standard crushed stones with sizes ranging from 10mm to 20mm.
4. Water: Normal tap water
5. Admixture: Superplasticizer
6. Fly ash: by-product of thermal power plants
7. Waterproofing admixture: Dr Fixit Pidiproof LW+ 101

### B. Mix design

The mix was prepared for M40 grade concrete as per relevant IS code guidelines.

The quantity required for conventional M40 grade concrete. The concrete mix will be referred as “Mix I”.

TABLE 1: Quantity for Mix I (Per m3)

Name	Quantity kg
Cement	412
water	148
Fine aggregate	648
Coarse aggregate	1234
Admixture	4.12

The quantity required for fly ash concrete (25% replacement of cement). The concrete mix will be referred as “Mix II”.

TABLE 2: Quantity for Mix II (Per m3)

Name	Quantity kg
Cement	309
Fly ash	103
water	148
Fine aggregate	648
Coarse aggregate	1234
Admixture	4.12

The quantity required for waterproofing admixture Concrete (0.4% of cement). The concrete mix will be referred as “Mix III”.

TABLE 3: Quantity for Mix III (Per m3)

Name	Quantity kg
Cement	412
water	148
Fine aggregate	648
Coarse aggregate	1234
Waterproofing Admixture	1.65

The quantity required for Combination of Fly Ash + Water Proofing admixture. The concrete mix will be referred as “Mix IV”.

TABLE 4: Quantity for Mix IV (Per m3)

Name	Quantity kg
Cement	309
Fly ash	103
water	148
Fine aggregate	648
Coarse aggregate	1234
Waterproofing Admixture	1.24

### C. Casting procedure of specimens

1. We prepared four total mixes (Mix I, Mix II, Mix III, Mix IV) With three cubes(150mm×150mm×150mm) and three half cylinders(150mm×150mm) fabricated for each.
2. In this all moulds were cleaned thoroughly and lightly oiled to prevent adhesion of concrete to the mould surface.
3. Batching of materials or mix all dry material (cement, aggregate, fly ash) thoroughly.
4. Concrete was filled into the mould in three equal layers and each layer was compacted using a tamping rod and by vibration.
5. After 24 hours of casting, remove specimens from moulds and cure the specimens in clean water for 28 days.



Fig. 1. Batching of materials



Fig. 2. Concrete was filled into mould



Fig. 3. Curing of concrete

D) Tests

(A) Compressive strength:

The compression strength test using a compression testing machine. In this test, a standard specimen such as a cube is placed between two steel plates of the compression testing machine. A gradually increasing load is applied axially until the specimen fails. All the cube casted for all mix were tested in this machine.



Fig. 4. compression testing machine



Fig. 5. Compressive test

(B) Permeability:

Permeability of concrete mixes using Darcy's apparatus under controlled laboratory conditions. It is based on darcy's law for steady state flow.

The concrete permeability apparatus meets the requirement of IS: 3085-1965 and is used for determining the permeability of concrete specimens cast in the laboratory.



Fig. 6. Permeability apparatus

(C) Permeability test procedure

1. Surface preparation of specimen: after curing, remove the specimen and allow surface drying.
2. Apply hot wax coating on the curved surface side of the measuring cylinder. Ensure no gaps or cracks in wax coating, only top and bottom faces remain open.
3. Fixing the specimen in Darcy's apparatus and tighten the apparatus to avoid leakage.
4. Connecting water supply: connect the inlet pipe.
5. Setting a constant hydraulic head (height of water)
6. Applying air pressure by air compressor system. Controlled air pressure was applied above the water reservoir to force water through the concrete specimen and maintaining constant pressure.
7. The water emerging from the outlet was collected in a measuring cylinder.
8. Permeability of specimen can be calculated by following formula

$$K = QL/ATH$$

Where, K = Coefficient of Permeability

Q = Flow Rate

A = cross-sectional area of specimen

H = Pressure head

L = Length of the concrete specimen

T = Time in seconds



Fig. 7 Sealing with wax



Fig. 8. Fixing Specimen in Apparatus

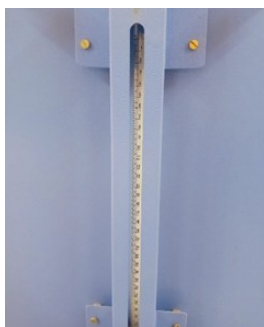


Fig. 9. Setting Head



Fig. 10. Pressure Gauge



Fig. 11. Collected water

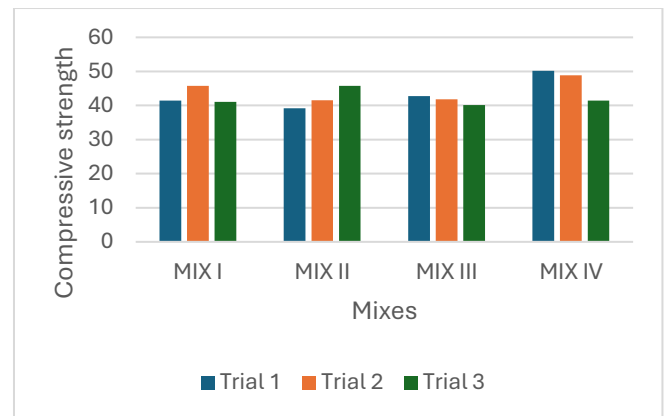
### III. RESULT

#### A. Compression Test Result

TABLE 5: Compressive strength

Mix	Compressive strength (N/mm <sup>2</sup> )			
	Trial 1	Trial 2	Trial 3	Average
Mix I	41.42	45.78	41.11	42.77
Mix II	39.24	41.54	45.78	42.18
Mix III	42.72	41.85	40.11	41.56
Mix IV	50.14	48.83	41.42	46.79

Graph 1: Comparison of Compressive Strength for all mix



#### B. Permeability Test Result

The permeability of all mix is as follows:

TABLE 6: Permeability of Mix I

No. of Trial	H mm	Q mm <sup>3</sup>	K (m/s)
Trial 1	247	0.47	$1.08 \times 10^{-8}$
Trial 2	252	0.51	$0.96 \times 10^{-8}$
Trial 3	259	0.54	$1.12 \times 10^{-8}$

TABLE 7: Permeability of Mix II

No. of Trial	H mm	Q mm <sup>3</sup>	K (m/s)
Trial 1	249	4.95	$0.92 \times 10^{-7}$
Trial 2	257	5.28	$1.06 \times 10^{-7}$
Trial 3	263	5.62	$0.98 \times 10^{-7}$

**TABLE 8:** Permeability of Mix III

No. of Trial	H mm	Q mm <sup>3</sup>	K (m/s)
Trial 1	254	0.049	$1.04 \times 10^{-9}$
Trial 2	261	0.052	$0.95 \times 10^{-9}$
Trial 3	268	0.056	$1.10 \times 10^{-9}$

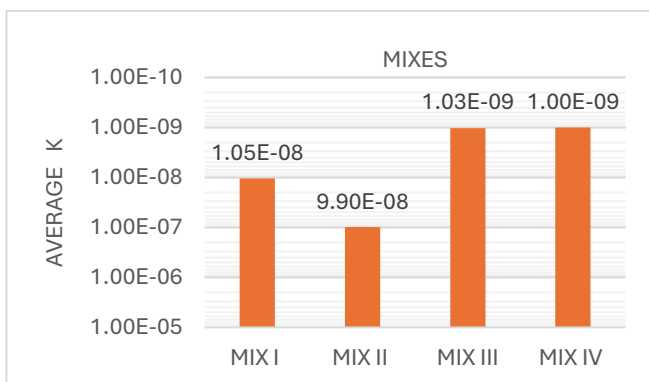
**TABLE 9:** Permeability of Mix IV

No. of Trial	H mm	Q mm <sup>3</sup>	K (m/s)
Trial 1	251	0.051	$0.097 \times 10^{-9}$
Trial 2	258	0.053	$1.06 \times 10^{-9}$
Trial 3	264	0.055	$0.99 \times 10^{-9}$

**TABLE 10:** Average Permeability

Concrete Type	Average K (m/s)
1. Conventional	$1.05 \times 10^{-8}$
2. Fly Ash	$0.99 \times 10^{-7}$
3. Water Proofing Chemical	$1.03 \times 10^{-9}$
4. Fly Ash + Water Proofing Chemical	$1.00 \times 10^{-9}$

Graph 2: Comparison of Permeability of for all mix



### C Analysis of Result

The combined mix achieves a balance between these effects, resulting in optimum performance and none of the all mix

negatively affected compressive strength significantly, which is crucial for structural application.

Permeability results showed major differences conventional concrete has moderate permeability, and fly ash concrete showed relatively higher permeability, the waterproofing admixture more reduction in permeability. Where as the combined mix of fly ash and waterproofing admixture performed best showing the lowest permeability.

### IV. CONCLUSIONS

In this study, it was observed that all four mixes achieved satisfactory compressive strength suitable for structural applications. The most significant findings of this study were observed in the permeability results. The combined mix of fly ash and waterproofing admixture demonstrated the best performance among all mixes. It showed the lowest permeability values, indicating maximum resistance to water penetration. Therefore, the study confirms that the use of fly ash along with waterproofing admixture is highly beneficial for producing durable concrete, especially in structures exposed to water or aggressive environmental conditions. This combination not only improves impermeability but also contributes to sustainable construction by utilizing industrial by-products like fly ash.

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