

# International Journal of Innovative Research in Science, Engineering and Technology

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## A Study on Properties of Concrete with Bottom Ash, Quarry Dust and Polypropylene Fibre as Partial Replacements

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**ABSTRACT:** Concrete is the most vital material for the construction of high rise buildings and various infrastructures. Infrastructure development in such areas particularly in developing countries like India is more. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water and river sand is the main raw material used as fine aggregate in the production of concrete.

The main objective of this investigation is to determine the Compressive strength, Split Tensile Strength, Flexural strength, Modulus of Elasticity and Acid Attack of M30 grade concrete with use of 10%, 20% & 30% of Quarry Dust, 10%, 20% & 30% of Bottom Ash as replacement of Fine Aggregate and Polypropylene Fibre (0.5% & 1.0%) of Total Weight of Cube as Admixture. The Results will be tabulated and compared with Conventional Concrete. With Polypropylene Fibre as admixture exhibits more strength than the control mix. Combined application of Bottom Ash (20%), Quarry Dust (30%) & Polypropylene Fibre (1.5%) shows 20.27% improved Compressive Strength compared to Controlled Concrete. Similar trend is observed in other mechanical properties. 10.35% improvement in Split Tensile Strength, 10.01% improvement in Flexural Strength and 6.75% rise in Modulus of Elasticity. Loss of Weight in Acid Attack is minimum for 20% Bottom Ash.

**KEYWORDS:** Bottom Ash, Quarry Dust, Polypropylene fibre, Partial Replacement, Split Tensile Strength, Flexural strength, Modulus of Elasticity.

### I. INTRODUCTION

Concrete is the utmost important material for the erection of high rise buildings and several infrastructures. Infrastructure development in such areas predominantly in developing countries like India is more. Concrete is a blend of cement, fine aggregate, coarse aggregate and water and river sand is the key raw material used as fine aggregate in the manufacture of concrete. The natural sources of river sand are getting exhausted steadily. The need for the safeguarding of the natural environment and the ban on excavating in some areas is further provoking the problem of accessibility of river sand.

### II. OBJECTIVE

The objectives of present research work is to obtain the, Effect of Bottom Ash on Compressive Strength, Tensile Strength, Modulus of Elasticity and Flexural Strength of concrete. Effect of Quarry Dust on Compressive Strength, Tensile Strength, Modulus of Elasticity and Flexural Strength of concrete. Effect of combined application of Bottom

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Ash, Quarry Dust and Polypropylene on Compressive Strength, Tensile Strength, Modulus of Elasticity and Flexural Strength of concrete. Comparison of the test results of Conventional Concrete and Bottom Ash concrete. Comparison of the test results of Conventional Concrete and Quarry Dust concrete. Comparison of the test results of Conventional Concrete with combined use of Bottom Ash, Quarry Dust and Polypropylene concrete preparation.

### III. EXPERIMENTAL INVESTIGATION

#### 3.10 PROPERTIES OF MATERIALS

#### 3.11 CEMENT

In the present investigation Ordinary Portland Cement (OPC) of 53 Grade confirming to IS specifications was used. The properties of cement are shown in Table.1.

Table 1. Properties of Cement

S. No	Characteristics	Test results	Requirements as per IS 12269 – 1987
1	Fineness (retained on 90-µm sieve)	6%	<10%
2	Normal Consistency	32%	--
3	Initial setting time of cement	50 min's	30 minutes (minimum)
4	Final setting time of cement	480 min's	600 minutes (maximum)
5	Expansion in Le-chatelier's method	4 mm	10 mm (maximum)
6	Specific gravity	3.15	3.10 – 3.25

#### 3.12 FINE AGGREGATE

Locally available river sand confirming to IS specifications was used as the fine aggregate in the concrete preparation. The properties of fine aggregate are shown in Table.2.

Table 2. Properties of Fine Aggregate

S.No	Property	Value
1	Specific Gravity	2.52
2	Fineness Modulus	3.19
3	Bulk Density (Loose)	14.50 kN/m <sup>3</sup>
4	Grading of Sand	Zone – II

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### 3.13 COARSE AGGREGATE

Crushed granite metal of nominal size 20 mm and 10 mm obtained from the local quarry and confirming to IS specifications were used. The properties of coarse aggregate are shown in Table.3. The coarse aggregate used for the preparation of concrete is a combination of 20 mm and 10 mm size aggregates in ratio 1.5: 1.0.

Table3. Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.7
2	Bulk Density (Loose )	14.80 kN/m <sup>3</sup>
3	Water Absorption	1.2 %
4	Fineness Modulus	7.36

### 3.14 BOTTOM ASH

Bottom ash is part of the non-combustible residue of combustion in a furnace or incinerator. In an industrial context, it usually refers to coal combustion and comprises traces of combustibles embedded in forming clinkers and sticking to hot side walls of a coal-burning furnace during its operation. The portion of the ash that escapes up the chimney or stack is, however, referred to as fly ash. The clinkers fall by themselves into the bottom hopper of a coal-burning furnace and are cooled. The above portion of the ash is referred to as bottom ash. Coal Bottom Ash was procured from Astrra Chemicals, Mumbai. Coal Bottom Ash. The properties of Coal Bottom Ash are shown in Table 4

Table 4. Physical Properties of Bottom ash

S.No	Physical Properties	Results
1	Specific gravity	2.19
2	Water absorption	28.9
3	Fineness modulus	1.83
4	Colour	Black

### 3.15 QUARRY DUST:

The crushed rock particles having size below 4.75 mm is defined as fine aggregate. It is further classified into coarse, medium and fine. The size of grains from 4.75mm to 2mm is known as coarse, 2mm to 0.425mm as medium and 0.425 mm to 0.075 mm defined as fine. The properties of Quarry Dust are shown in Table 5.

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Table 5. Physical Properties of Quarry dust

S.No.	Physical Properties	Results
1	Specific Gravity	2.57
2	Fineness Modulus	2.41
3	Density	1.85 gm/cc
4	Void Ratio	0.42

### 3.16 QUARRY DUST:

Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging and labeling, textiles, stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. Table 6 specifies properties of polypropylene fibre

Table 6. Physical Properties of Polypropylene fibre

S No	Properties	Value ( As per MTC)
1	Specific gravity of fibre	0.9-0.91
2	Length	6mm to 12mm
3	Water absorption	0.3% after 24 hours (The water absorption of polypropylene fibre is about 0.3% after 24 hours immersion in water, and thus its regain – the amount of water absorbed in a humid atmosphere – is virtually nil)

### 3.17 WATER

Water used for casting and curing of concrete test specimens is free from impurities which when present can adversely influence the various properties of concrete.

### 3.17 CONCRETE MIX PROPORTION

The concrete mix design was proposed by using Indian Standard for control concrete. The grade was M30. The mixture will be prepared with the cement content of 340 kg/m<sup>3</sup> and water to cement ratio of 0.45. The mix proportion of materials is 1:2.13:3.57 as per IS 10262-2009.

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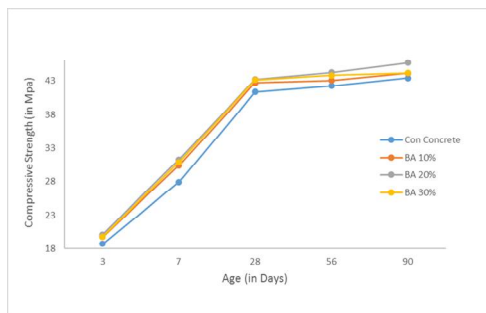
## 3.20 TEST SPECIMENS

Concrete test specimens consist of 150 mm × 150 mm × 150 mm cubes, cylinders of 150 mm diameter and 300 mm height and 100 mm × 100 mm × 500 mm prisms. Concrete cube specimens were tested at 3, 7, 28, 56 & 90 days of curing to obtain the compressive strength of concrete. Cylindrical specimens were tested at the age of 28 days to obtain the compressive strength, split tensile strength and Modulus of Elasticity of concrete. The prisms were tested at the age of 28 days to obtain the flexural strength of concrete. The rate of loading is as per the Indian Standard specifications. Sulphate resistance is also performed for durability.

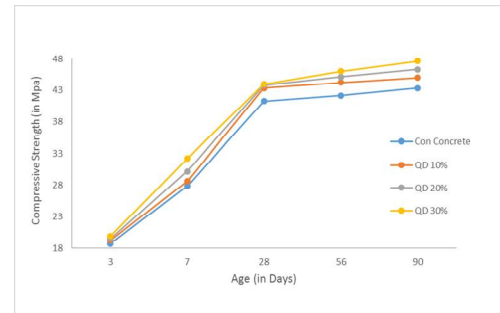
## IV. RESULTS AND DISCUSSIONS

### 4.10 COMPRESSIVE STRENGTH

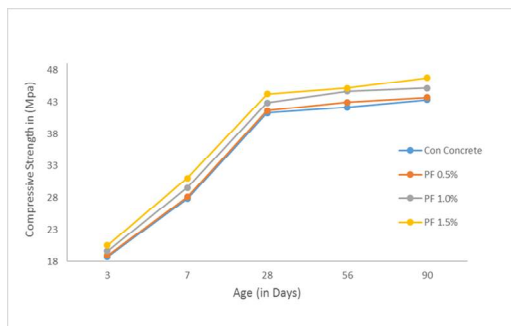
The variation of the cube compressive strength with the age of M30 grade concrete prepared using the various proportions of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF) is shown in Fig.1. It can be observed that the compressive strength of concrete prepared by replacing Bottom Ash, Quarry Dust as replacement of Fine Aggregate exhibits improved Compressive Strength individually. With Polypropylene Fibre as admixture exhibits more strength than the control mix. Combined application of Bottom Ash (20%), Quarry Dust (30%) & Polypropylene Fibre (1.5%) shows 20.27% improved Compressive Strength compared to Controlled Concrete.



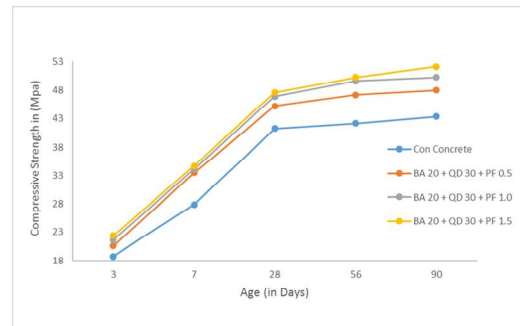
(i) Bottom Ash



(ii) Quarry Dust



(iii) Polypropylene Fibre



(iv) Combined Application

Fig. 1. Variation of the cube compressive strength with the age of M30 grade concrete prepared using the various proportions of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF).

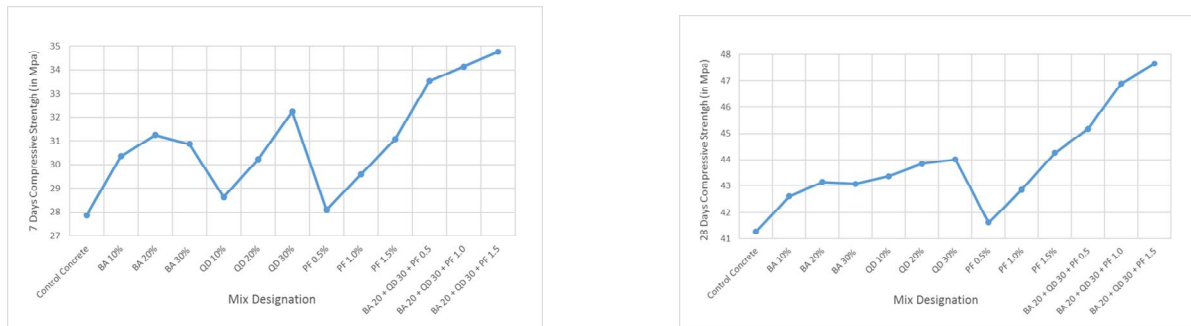
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Fig 2 shows the variation of 7 – Days and 28 Days Compressive Strength of Concrete with various proportions of Bottom Ash (10%, 20% & 30%), Quarry Dust (10%, 20% & 30%) and Polypropylene Fibre (0.5%, 1.0% & 1.5%).



(i) 7 Days Compressive Strength

(ii) 28 Days Compressive Strength

Fig. 2. Variation of 7 – Days & 28 Days Cube Compressive Strength of M30 Grade Concrete for different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF).

## 4.20 SPLIT TENSILE STRENGTH

The variation of the Split Tensile strength of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF) is shown in Fig.3. The Split tensile strength of Control concrete is 4.06 MPa. It is observed that all the replacements & admixtures exhibits improved Strength Characteristics compared to Control Concrete, But the Optimum mix of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) resulted in significant improvement with 10.35% more than Control Concrete.

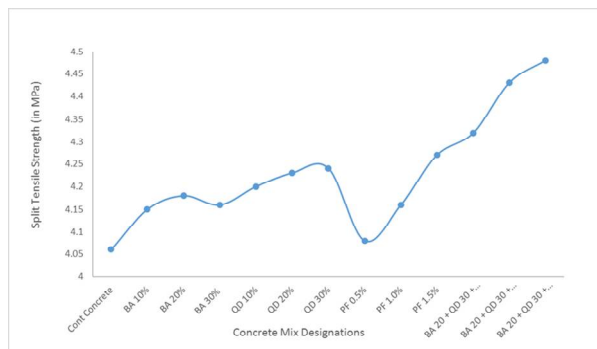


Fig. 3. Variation of Split Tensile strength of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF).

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## 4.30 FLEXURAL STRENGTH

The variation of the Flexural strength of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF) is shown in Fig.4. The Flexural strength of Control concrete is recorded as 6.29 MPa. It is observed that all the replacements of Fine Aggregates i.e. Bottom Ash (10%, 20% & 30%), Quarry Dust (10%, 20% & 30%) & Admixture i.e. Polypropylene Fibre individually exhibits improved Flexural Strength Characteristics compared to Control Concrete. It can be noted that combined proportion of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) resulted in enormous improvement with 10.01% more than Control Concrete

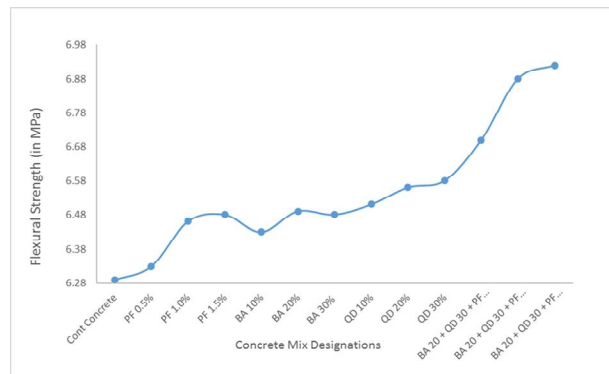


Fig. 4. Variation of Flexural strength of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF).

## 4.40 MODULUS OF ELASTICITY

The variation of the Modulus of Elasticity of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF) is shown in Fig.5. The Modulus of Elasticity of Control concrete is recorded as 27.42 GPa. It is observed that all the replacements of Fine Aggregates i.e. Bottom Ash (10%, 20% & 30%), Quarry Dust (10%, 20% & 30%) & Admixture i.e. (Polypropylene Fibre) individually exhibits improved Flexural Strength Characteristics compared to Control Concrete. It can be noted that combined proportion of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) resulted in notable improvement with 6.75% more than Control Concrete

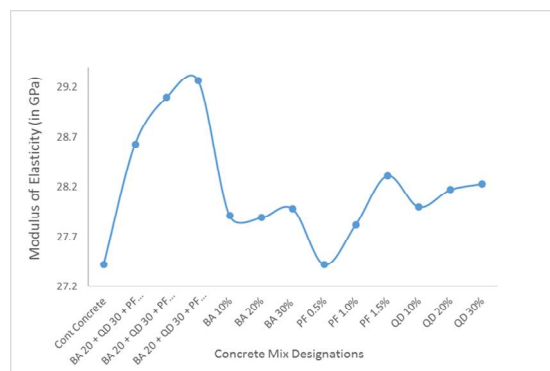


Fig. 5. Variation of Modulus of Elasticity of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF)



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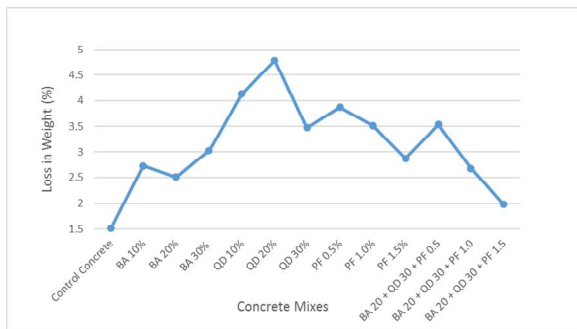
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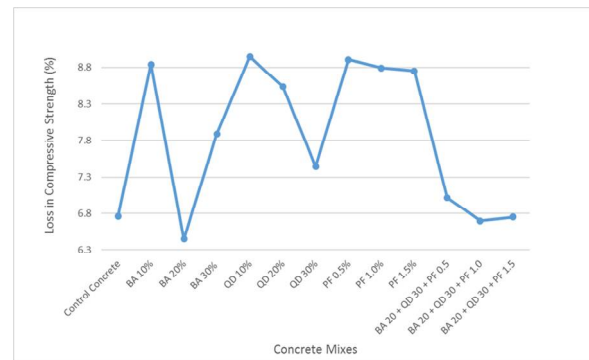
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## 4.50 SULPHATE RESISTANCE

The variation of the Loss in Compressive Strength & Loss of Weight of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF) is shown in Fig.6. The Loss of Weight (%) is minimum for combined proportion of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) when compared to other proportions and Control Concrete. It can also be observed that only Concrete with 20% Bottom Ash (BA) has lesser % Loss of Compressive Strength compared to other mixes.



(i) % Loss in Weight



(ii) % Loss in Compressive Strength

Fig. 6. Variation of Loss in Compressive Strength & Loss of Weight of M30 grade concrete prepared using the different percentages of Bottom Ash (BA), Quarry Dust (QD) and Polypropylene Fibre (PF)

## V. CONCLUSIONS

With Polypropylene Fibre as admixture exhibits more strength than the control mix. Combined application of Bottom Ash (20%), Quarry Dust (30%) & Polypropylene Fibre (1.5%) shows 20.27% improved Compressive Strength compared to Controlled Concrete. It is observed that all the replacements of Fine Aggregates i.e. Bottom Ash (10%, 20% & 30%), Quarry Dust (10%, 20% & 30%) & Admixture i.e. (Polypropylene Fibre) individually exhibits improved Flexural Strength Characteristics compared to Control Concrete. It can be noted that combined proportion of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) resulted in notable improvement with 6.75% more than Control Concrete. Similar pattern is observed for split tensile and Flexural strength. The Loss of Weight (%) is minimum for combined proportion of Bottom Ash (20%) + Quarry Dust (30%) + Polypropylene Fibre (1.5%) when compared to other proportions and Control Concrete. It can also be observed that only Concrete with 20% Bottom Ash (BA) has lesser % Loss of Compressive Strength compared to other mixes.

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