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Experimental Study of Bottom Ash as an Admixture in M30 Concrete Mix

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Abstract-

To Reduce the usage of the Concrete content we are studying the different types of materials strength as an admixture and later if we are getting good results the studies will be forwarded to partial replacement and finally if possible the complete replacement of cement. This is the study with of the continuation of the Influence of thermal dust as an admixture with 0%,2% and 4% admixture and the continuation is carried forward. The experimental study of bottom ash on normal strength concrete grade for 6% ,8% and 10% replacement cube were also prepared respectively.

Key words: Bottom ash, Compressive Strength, Environmental Benefits

1. INTRODUCTION:

Any Material can be used in our Construction with proper test results Bottom ash consists of heavier particles that fall to the bottom of the furnace. The ash is also composed primarily of amorphous or glassy aluminosilicate materials derived from the melted mineral phases. Most bottom ash is produced in dry-bottom boilers, where the ash cools in a dry state, Boiler slag is a type of bottom ash collected in wet-bottom boilers (slag tap or cyclone furnaces, which operate at very high temperatures), where the molten particles are cooled in a water quench. Fly ash is composed mainly of amorphous or glassy Aluminosilicate fly ash particles are typically silt-sized spheres, ranging from 1 to 100 microns in diameter.

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1.1 Physical Properties

Ash Type	**Bottom Ash**			**Boiler Slag**		
Sieve Size	**Glasgow, (WV)**	**New Haven, (WV)**	**Moundsville, (WV)**	**Willow Island, (WV)**	**Rockdale, (TX)**	**Moundsville, (WV)**
38 mm (1-1/2 in)	100	99	100	100	100	100
19 mm (3/4 in)	100	95	100	100	100	100
9.5 mm (3/8 in)	100	87	73	99	100	97
4.75 mm (No.4)	90	77	52	97	99	90
2.36 mm (No.8)	80	57	32	85	88	62
1.18 mm (No.16)	72	42	17	46	42	16
0.60 mm (No.30)	65	29	10	23	10	4
0.30 mm (No.50)	56	19	5	12	5	2
0.15 mm (No.100)	35	15	2	6	2	1
0.075 mm (No.200)	9	4	1	4	1	0.5

Table 1 **- Particle Size distribution of bottom ash and boiler slag:**

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Bottom ash have angular particles with a very porous surface texture. Bottom ash particles range in size from fine gravel to fine sand with very low percentages of silt-clay sized particles. The ash is usually a well-graded material, although variations in particle size distribution may be encountered in ash samples taken from the same power plant at different times. Bottom ash is predominantly sand-sized, usually with 50 to 90 percent passing a 4.75 mm (No. 4) sieve, 10 to 60 percent passing a 0.42 mm (No. 40) sieve, 0 to 10 percent passing a 0.075 mm (No. 200) sieve, and a top size usually ranging from 19 mm (3/4 in) to 38.1 mm (1-1/2 in). Table 4-1 compares the typical gradations of bottom ash and boiler slag.

Boiler slags are predominantly single-sized and within a range of 5.0 to 0.5 mm (No. 4 to No. 40 sieve). Ordinarily, boiler slags have a smooth surface texture, but if gases are trapped in the slag as it is tapped from the furnace, the quenched slag will become somewhat vesicular or porous. Boiler slag from the burning of lignite or sub bituminous coal tends to be more porous than that of the eastern bituminous coals. Boiler slag is essentially a coarse to medium sand with 90 to 100 percent passing a 4.75 mm (No. 4) sieve, 40 to 60 percent passing a 2.0 mm (No. 10) sieve, 10 percent or less passing a 0.42 mm (No. 40) sieve, and 5 percent or less passing a 0.075 mm (No. 200) sieve. The specific gravity of the dry bottom ash is a function of chemical composition, with higher carbon content resulting in lower specific gravity. Bottom ash with a low specific gravity has a porous or vesicular texture, a characteristic of popcorn particles that readily degrade under loading or compaction. Table 4-2 lists some typical physical properties of bottom ash and boiler slags

Property	Bottom Ash	Boiler Slag
Specific Gravity	2.1 - 2.7	2.3 - 2.9
Dry Unit Weight	720 - 1600 kg/m^3 (45 - 100 lb/ft^3)	960 - 1440 kg/m^3 (60 - 90 lb/ft^3)
Plasticity	None	None
Absorption	0.8 - 2.0%	0.3 - 1.1%

Table 2 Typical physical properties of bottom ash and boiler slag.

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1.2 Chemical Properties:-Bottom ash and boiler slag are composed principally of silica, alumina, and iron, with smaller percentages of calcium, magnesium, sulphates, and other compounds. The composition of the bottom ash or boiler slag particles is controlled primarily by the source of the coal and not by the type of furnace. Table 1.3 presents a chemical analysis of selected samples of bottom ash and boiler slag from different coal types and different regions.

Ash Type:	**Bottom Ash**					**Boiler Slag**		
Coal Type:	**Bituminous**			**Sub-bituminous**	**Lignite**	**Bituminous**		**Lignite**
Location	**West Virginia**		**Ohio**	**Texas**		**West Virginia**		**North Dakota**
SiO_2	53.6	45.9	47.1	45.4	70.0	48.9	53.6	40.5
Al_2O_3	28.3	25.1	28.3	19.3	15.9	21.9	22.7	13.8
Fe_sO_3	5.8	14.3	10.7	9.7	2.0	14.3	10.3	14.2
CaO	0.4	1.4	0.4	15.3	6.0	1.4	1.4	22.4
MgO	4.2	5.2	5.2	3.1	1.9	5.2	5.2	5.6
Na_2O	1.0	0.7	0.8	1.0	0.6	0.7	1.2	1.7
K_2O	0.3	0.2	0.2	-	0.1	0.1	0.1	1.1

Table 1.3 Chemical composition of selected bottom ash and boiler slag samples:-

Bottom ash or boiler slag derived from lignite or sub-bituminous coals has a higher percentage of calcium than the bottom ash or boiler slag from anthracite or bituminous coals. Although sulphates is not shown in Table 4-2, it is usually very low (less than 1.0 percent), unless pyrites have not been removed from the bottom ash or boiler slag.Due to the salt content and, in some cases, the low pH of bottom ash and boiler slag, these materials could exhibit corrosive properties. When using bottom ash or boiler slag in an embankment, backfill, sub base, or even possibly in a base course, the potential for corrosion of metal structures that may come in contact with the material is of concern and should be investigated prior to use.

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2.3.3 Mechanical Properties:Table lists some typical values for bottom ash and boiler slag compaction characteristics (maximum dry density and optimum moisture), durability characteristics (Los Angeles abrasion and sodium soundness), shear strength and bearing strength characteristics (friction angle and), and permeability. The maximum dry density values of bottom ash and boiler slag are usually from 10 to 25 percent lower than that of naturally occurring granular materials. The optimum moisture content values of bottom ash and boiler slag are both higher than those of naturally occurring granular materials, with bottom ash being considerably higher in optimum moisture content than boiler slag.Boiler slag usually exhibits less abrasion loss and soundness loss than bottom ash because of its glassy surface texture and lower porosity. In some power plants, coal pyrites are disposed of with the bottom ash or boiler slag. In such cases, some pyrite or soluble sulphate is contained in the bottom ash or boiler slag, which may be reflected in higher sodium sulphate soundness loss values. Reported friction angle values are within the same range as those for sand and other conventional fine aggregate sources

Property	Bottom Ash	Boiler Slag
Maximum Dry Density kg/m^3	1210 - 1620 (75 - 100)	1330 - 1650 (82 - 102)
Optimum Moisture Content, %	Usually <20 12 - 24 range	8 – 20
Los Angeles Abrasion Loss %	30 – 50	24 – 48
Sodium Sulphate Soundness Loss %	1.5 – 10	1 – 9
Shear Strength (Friction Angle)	38 - 42° 32 - 45° (<9.5 mm size)	38 - 42° 36 - 46° (<9.5 mm size)
California Bearing Ratio (CBR) %	40 – 70	40 – 70
Permeability Coefficient (cm/sec)	10^{-2} - 10^{-3}	10^{-2} - 10^{-3}

Table 1.4:- for Typical mechanical properties of bottom ash and boiler slag.

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2.LITERATURE REVIEW:

INFLUENCE OF THERMAL DUST AS AN ADMIX IN CONCRETE MIX: The utilization of waste material such as thermal dust in concrete increases the strength parameters , The compression strength increases with the increase in the percentage of admixture in Thermal dust.Thermal dust is in the powdered form the compressive strength is high .The workability of concrete is satisfactory thermal dusts are added.The compressive strength of plain M30 grade concrete for 28days is 33N/mm2 and is been increased to 38N/mm2 when 2% of thermal dust is added to concrete mix and also been to 44N/mm2 when 4% of the thermal dust is been added. The tensile strength of plain M30 grade concrete is been increased from 2.4N/mm2 to 2.9N/mm2 when 2% of thermal dust is been added a 3.5N/mm2 when 4% of thermal dust is been added. The waste product can be used in the construction and from the above results the strength is obtained is also good. Hence at minimum cost the life of the structure will be more. (et al., I. Siva Kishore).

Influence of glass powder on properties of concrete: Glass powder is used as a binder with partial replacement of cement which takes some part of reaction at the time of hydration; also it is act as a filler material. Present days most of the ways glasses have been dumped in to landThe advantages of adding WGP to concrete can be one or more of the following:It reduces the cost of production, workability of the mix due to fineness of particles, Reduces the dosage of super plasticizer to achieve target workability. the comparison between the compressive strengths of concrete cubes with different percentages of waste glass powder. that finely glass powder is an excellent filler and may have sufficient properties to serve ,Because the glass powder has more tendency to fill the voids in concrete more effectively, where as in the case of coarse aggregate it doesn't happened. The maximum compressive strength of the concrete cubes was found in concrete yields ideal results, The performance of design mix and properties of materials are good. (et al**., Dr. Niranjan kumar)**

Strength and durability properties of concrete containing quarry rock dust as fine aggregate:The consumption of cement content, workability, compressive strength and cost of concrete made with Quarry Rock Dust were studied by researchers Babu K.K. , Nagaraj T.S. and Narasimahan .The mix design proposed by Nagar shows the possibilities of ensuring the workability by wise combination of rock dust and sand, use of super plasticizer and optimum water content using generalized lyse Rule. Sahu A.K.reported significant increase in compressive strength, modulus of rupture and split tensile strength when Quarry Rock Dust replaces 40 percent of sand in concrete. Ilangovan and Nagamani reported that Natural Sand with Quarry Dust as full replacement in concrete as possible with proper treatment of Quarry Dust before utilization. the usage of Quarry Rock Dust as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Quarry Rock Dust for three different proportions and five different methods. Durability Studies were done for concrete with Quarry Rock Dust and compared with the Conventional Concrete.(et al., **R. Ilangovana**)

Influence of glass powder on the properties of concrete:Today the construction industry is in need of finding cost effective materials for increasing the strength of concrete structures. Glass powder finer than 600 μ is reported to have pozzolanic behaviour. they made an attempt to investigate the possibility of using the waste glass powder in Portland cement in concrete. Concrete by adding glass powder of cement by5%, 10%, 15% and 20% were produced and properties of this concrete has been compared with concrete of control mix with no replacement. Cube specimens of 24 numbers were cast, cured and tested for 7 day and 28 days strength. Compression test was conducted and the results were compared. The Findings revealed an increase in compressive strength with the increase in the replacement of cement by glass powder. (et al., **Veena V. Bhat)** the constituent compounds. It is the most commonly used construction material.

3. EXPERIMENTAL WORK:-

The experimental program consisted of casting and testing of concrete cubes, cylinders, of sizes as mentioned below. The complete details of test samples are given in table form gives the various % replacement of cement adopted for the experimental program for M30 Grade Concrete.

Percentage added	Size of cubes (mm)	Size of cylinders (mm)	No of cubes	No of cylinders
0%	150*150*150	150dia,300ht	6	6
6%	150*150*150	150dia,300ht	6	6
8%	150*150*150	150dia,300ht	6	6
10%	150*150*150	150dia,300ht	6	6

Table 2.1: Percentage of Thermal Dust added.

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Materials:

Materials and Feasibility

The constituent materials that used in this study are as follow:

- Ordinary Portland Cement (OPC)
- Coarse aggregate (size 20mm
- Fine aggregate
- Quarry dust
- Thermal dust
- glass dust
- Water

MIX PROPORTIONS- M30

Cement - 375 kg/m^3

Sand - 574 kg/m^3

Coarse - 1118 kg/m^3

Water - 176 lts

Ratio : Cement : Fine aggregates : Coarse aggregate : Water

375 : 574 : 1118 : 176

MIX RATIO

1 : 1.53 : 2.98 : 0.47

4.EXPERIMENTAL RESULTS AND DISCUSSIONS:-

Percentage of admixture added	W/C Ratio	7 Days Compressive Strength(N/mm^2)	14Days Compressive Strength(N/mm^2)	28 Days Compressive Strength(N/mm^2)	28 Days Tensile Strength(N/mm^2)
6%	0.45	36.2	44	46.4	3.89
8%	0.45	37.3	46.5	47.6	4.02

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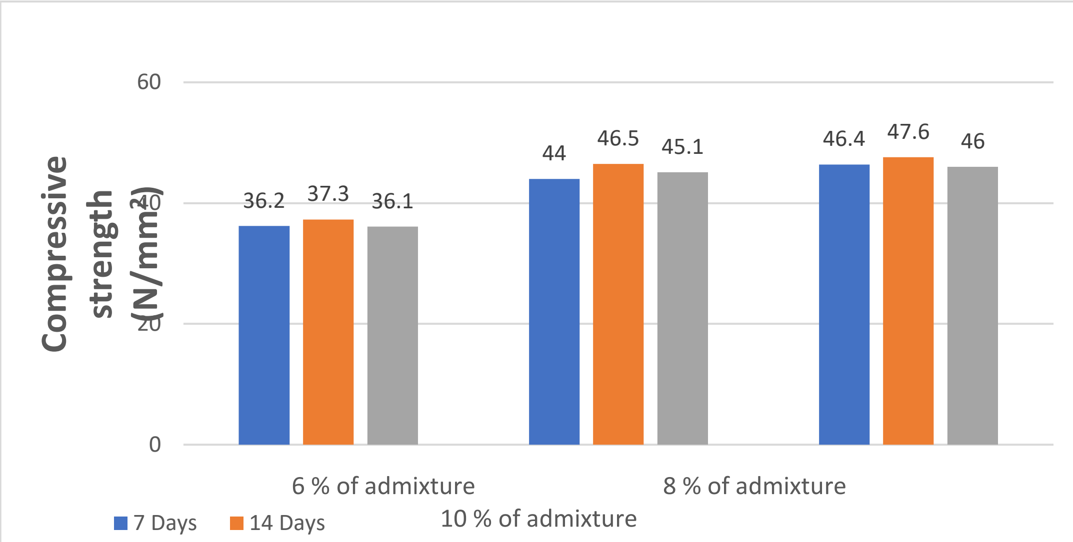
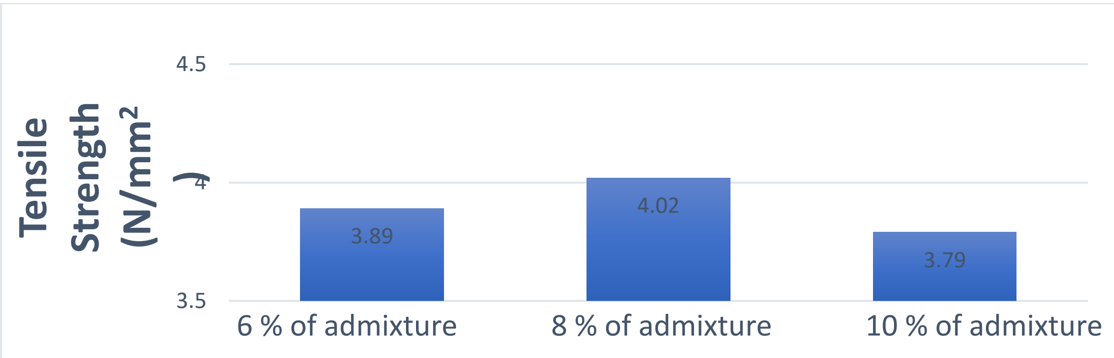
10%	0.45	36.1	45.1	46.0	3.79

Table 3.1- Showing compressive strength and split tensile strength values



Graph 3.5:-Comparisons of compressive strength values



Graph 3.6:- Comparisons of Split Tensile Strength values

5. CONCLUSIONS:

Based on the test results obtained from the study, the following conclusions are drawn:-

- We can observe that the compression strength and split tensile strength increases with the increase in the percentage of admixture upto 8 % and slightly varied for 10%.
- Bottom Ash has high compressive strength
- As the percentage of admixture increased the strength of the concrete is also increased but upto 8% only it was observed as good,later for 10% gradual decrease is there.

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- The waste product can be used in the construction and from the above results the strength is obtained is also good. Hence at minimum cost the life of the structure will be more.
- But as per this study its preferable upto 8% only, later in futher studies why its been decreased for 10% and the reasons will be identified.

Figure: 4.1 Cubes with thermal dust

Figure: 4.2 Before testing

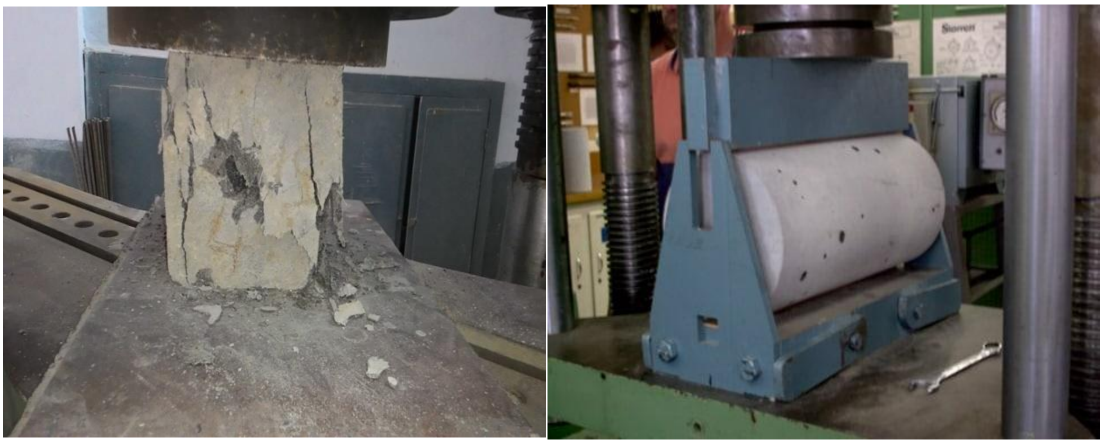

Figure: 4.3 After **testing Compression test Split tensile testing**

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