Leaching of Sulphate and Chloride from the Blended Cubes under Dynamic Condition of Aggressive Environment

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Abstract - *Thermal Power plant produces large amount of fly ash and bottom ash during the coal combustion to produce power. Disposal of this bottom ash or fly ash may lead to the leach of toxic metals to the environment either in dry or wet condition. This is an environmental problem that causes pollution. The leaching of toxic metals may enter the soil, ground water and surface water which cause environmental pollution. The increase in the lack of availability of the sand will made high use of the alternate material as mineral admixtures in the concrete materials as partial replacements in constructions of the civil engineering structures. But any how the use of coal bottom ash as partial replacement will shown to be raising environmental problem. As it will lead to the leaching of sulphate and chloride into the soil, surface water and ground water. Which cause pollution and makes the formation of acid rain. This study shows the detail work made on the leaching of sulphate, chloride, zinc and chromium metals from the blended cubes which uses coal bottom ash as partial replacement with fine aggregate from zero to hundred percent replacement in the mix of the blended cubes.*

Key Words: Coal Bottom Ash, Leaching of Sulphate, Chloride, Zinc and Chromium

1. INTRODUCTION

Bottom ash is a residual or incombustible material produced or generated after the combustion of the coal or lignite in the furnace at a temperature of 1300°C. It is took out as slag from the bottom of the furnace [1]. Bottom ash atoms are very much coarser than that of the atoms of the fly ash. It is a coarse, angular material of permeable surface texture preponderantly sand sized. This material is comprises of alumina, iron, silica and less amounts of magnesium, calcium and sulphates, grain size generally ranges from fine sand to gravel in size [2]. The Coal bottom ash and fly ash production has increased day to day. As this can be produced by coal combustion process during the power generation in the thermal power plant. The disposal of slag bottom ash is an environmental problem. The bottom ash has many toxic contents in it, if it directly disposing may cause pollution to the environment. But now these can also be utilizing in the concrete mixes. This can be used in the partial replacement of concrete materials. But utilizing this in the concrete also a risk to the environment such as the more percentage used of bottom ash in the concrete may leach up the heavy metals into the surroundings, and it enters surface water, ground water and soil which cause pollution.

2. LITERATURE REVIEW

Abdus *et al*. (2014) [3] investigated a work in the surveying the workability of the coal base ash remains as a total substitution in low quality concrete. Coal base ash remains is utilized as a part of the rate as 0, 20, 40, 60, and 80%. Magnesium sulfate is the curing media in the concentration of 5% arrangement of $MgSO_4$. The cubes were immersed in the magnesium sulfate is tested to the compressive strength during 7 and 28 days of curing. It is expressed that as the expansion in the coal base ash remains in the cube of concrete will prompts the high porosity which brings down the durability of the concrete, which assistant results in the lessening of the strength of the concrete.

Balasubramaniam *et al*. (2015) [4] made a study on the experimental investigation on the mechanical properties of the bottom ash concrete. In his work quarry sand is to be considered as a 100% replaced to the river sand. Portland pozzolana cement is replaced by the silica fume and hyper plasticizer with the different percentage by weight of the binder. To decrease the waste generation in the power plants it has a study to reuse the bottom ash as a substituent of sand from 10 to 50%. It is to be worked for the M60 concrete with parameters as split tensile strength, flexural strength, compressive strength and the elastic modulus of the concrete. Result gives to be increase in the strength gain of the concrete.

Remya *et al*. (2014) [5] has stated on the study that strength performance of concrete using bottom ash as fine aggregate. Coal bottom ash is utilized as a partial substitution of sand, whereas here 2 form of the mix design is made as mix1 and mix2 for comparing the best compressive strength of the concrete. For mix1 0, 5, 10, 15, 20 and 30% of the sand is replaced with the bottom ash and mix2 about 0, 4, 6, 8, 10, 12 and 15% of the sand is changing with the bottom ash. Water is the main curing media. The cubes cured for 7 and 28 days and there after the strength of the concrete were finded. It is concluded that the workability of the concrete is completely diminishes as the coal bottom ash percentage replacement increases. Compressive strength of the concrete also decreases with increase in the addition of the bottom ash in the concrete.

Bruder H. *et al.* (2002) [6] studied on the usage of the sequential extraction procedure for the extraction of the contents from the municipal solid waste incineration bottom ash. The study uses the sequential extraction of metals include as Cu, Cr, Pb, Zn and Mn. There will be a 3 step procedure with strong acid for the extraction of the materials from the bottom ash. The reports shows that all parts of the Chromium and manganese were extracted with the strong acid that leads to the less possible quality of the elements from the bottom ash where as in case of the Copper is extracted in oxidizing condition and zinc with lead are with acidic condition.

Lokeshappa *et al.* (2012) [7] studied a work on the Behavior of Metals in the Coal Fly ash ponds. The coal fly ash has a very high concentration of the metals that may lead to the release during the burning process in the thermal power plant. Disposal of this under open or seamless condition creates a environmental problems because of high metal concentrations in the fly ash and leaching into the soil and ground water. Fate of metals translated in three fly ash ponds include separate characteristics from three thermal power plants to environment in shown in this study. The arsenic and chromium increased in FA1 and FA3 than in FA2. Whereas other metal concentration has decreased with increase in time.

3. MATERIALS AND METHODOLOGY

3.1 Materials used

Cement:

The cement of 53 Grade ordinary Portland cement used for the casting of the blended cubes. Table 1 shows cement properties.

Table 1: Cement Properties

Sl.no.	Parameters	Results
1.	Colour	Grayish
2.	Specific gravity	3.12
3.	Fineness of cement (m^2/kg)	310

Sand:

The second material used for this study is the Sand. Here sand confirming to IS 650:1991 [8] grades were used which is free from all the organic pollutants. Here three type grade sand are used in equal proportion for mix. Grade1, grade 2 and grade3 which has a specific gravity of 2.68, 3.10 and 2.88 respectively. Table 2 shows the sieve analysis of sand and coal bottom ash.

Table 2: Sieve analysis of the sand and coal bottom ash

Sl.no.	Size of sieve (mm)	% Passing			
		Grade 1 sand	Grade 2 sand	Grade 3 sand	Coal Bottom Ash
1.	4.75	100	100	100	86.80
2.	2.00	100	100	100	79.80
3.	1.00	99.80	100	36.0	73.40
4.	0.60	99.20	53.0	1.00	69.60
5.	0.30	5.80	0.40	0	47.0
6.	0.15	5.20	0.20	0	18.40
7.	0.075	0	0.20	0	7.00
8.	pan	0	0.20	0	0

Coal Bottom Ash:

The coal based ash remains utilized for the study is collected from the Thermal Power Plant, close Kudithini, Bellary. It has a specific gravity of 2.37. The sieve analysis is as shown in Table 2.

3.2 Methods

The methods used for the study is as shown in the Table 3.

Table 3: Methods followed for the study

Sl.no.	Parameter	Method	Equipment
1.	Sulphate	Turbidity method	Turbidity meter
2.	Chloride	Argentometric method	Titration apparatus
3.	Zinc	Spectra analytical	Atomic absorption spectroscopy
4.	Chromium	Spectra analytical	Atomic absorption spectroscopy

5.	Compressive Strength	Curing	Unconfined compression testing machine

Casting of the blended cubes:

The cube of size 25x25x25mm is used for the casting of the blended cubes. The materials needed for the casting is cement, sand, coal bottom ash and water. These are weighed with the weighing balance then the materials are mixed together with the travel. The dry mix is done first then the water is added with known volume as 7ml per each cube mix. The blend is mixed thoroughly such that there will be no air voids present in that mix. The mix is done by hand with the travel. After mixing the mixed paste is slowly added in three parts of the mould which is oiled first prior to fill the mix. The mortar is added and it is subjected to the vibrating machine such a way that the material sets equally inside the cube and to remove air voids. The blended cube casted is get to fix the bar bending wire for each of the cube at the centre point of the each cube, this is because for the leaching experiment it need to be in the suspension. Fig -1 shows the casting of blended cubes.

Fig -1: Casting of blended cubes

Experimental setup for the leaching metals:

The casted blended cubes are now put for the curing process which is intern used for the sample collection as a leaching from the blended cubes. The cube is put in a suspension in the 0.11M acetic acid solution and the water as a leaching media for the blended cubes as well as the curing media for the same. The leaching media of 500ml solution is taken in a 500ml beaker then the cube is put in a suspension such that it hangs with the bending wire and the set up is placed on the magnetic stirrer such that to make the uniform concentration of the leaching media. The each sample is collected after 24 hours of curing in the leaching media. For continuous 4 days the leaching media is collected as samples for every 24 hours. Each time the leaching media is changed that is for each day new fill in the leaching media. These samples are collected in the plastic bottles and used for the analysis of sulphate, chloride, zinc and chromium ions. The Fig -2 shows the Experimental setup of curing.

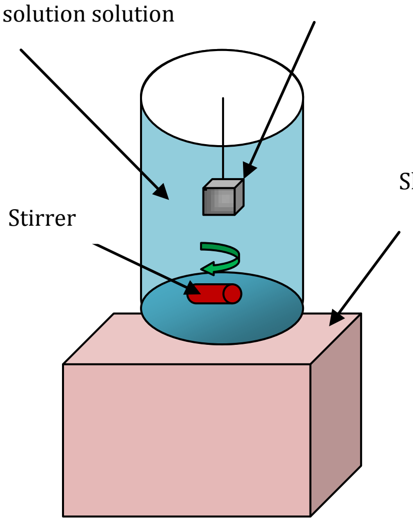

Fig -2: Experimental setup of curing

4. RESULTS AND DISCUSSIONS

The samples collected from the leaching site are to be subjected to the sulphate and chloride, zinc and chromium analysis. After sample collecting the cubes are subjected to compression test to find the compressive strength of the blended cubes. The results of compressive strength are as shown in the Table 4.

Table 4: Compressive strength (C.S) of the blended cubes

Sl.no.	Cube detail	C.S of acid cured cubes (N/mm^2)	C.S of water cured cubes (N/mm^2)
1.	0% BA	1.25	1.70
2.	10% BA	1.52	2.60
3.	20% BA	1.72	2.23
4.	30% BA	2.52	1.73
5.	40% BA	2.54	1.38
6.	50% BA	1.04	1.22
7.	60% BA	1.00	0.16
8.	70% BA	1.17	0.19
9.	80% BA	0.69	0.04

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10	90% BA	0.39	0.04
11.	100% BA	0.36	0.04

Chart -1 shows the sulphate leaching concentration of water cured samples. And the same for acid cured is shown in Chart -2.

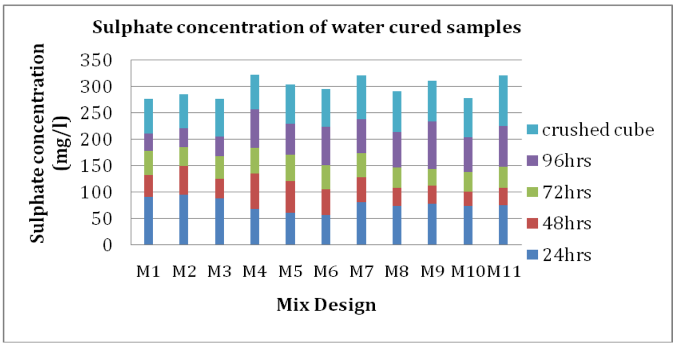

Chart -1: Sulphate leaching conc. of water cured samples

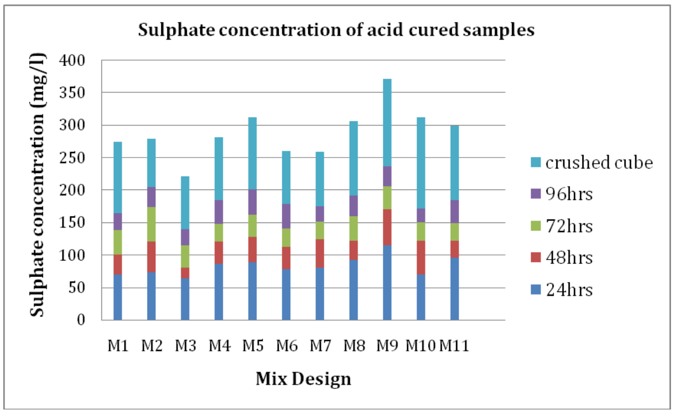

Chart -2: Sulphate leaching conc. of acid cured samples

The leaching concentration increases with the increase in the percentage of the coal bottom ash in the blended cement mortar cube for both acids cured and water cured. The leaching concentration of 24hrs collected sample has reached more in sulphate of acid cured than for the water cured samples and as the duration of collection leaching samples increases the leaching gets decreases for both sulphate results. Here for the crushed cube sample it says to be more increase in the acid cured than that of the water cure. Means the crushed cube concentration of the 0.11M acetic acid reach as 110 mg/l for Mix M1 and the same for water cure it is 65 mg/l. in both the cases the concentration of the sulphate in the crushed cube increases with increase in the percentage mixture of coal bottom ash. Chart -3 and Chart -4 shows the chloride leaching concentration of water and acid cured samples.

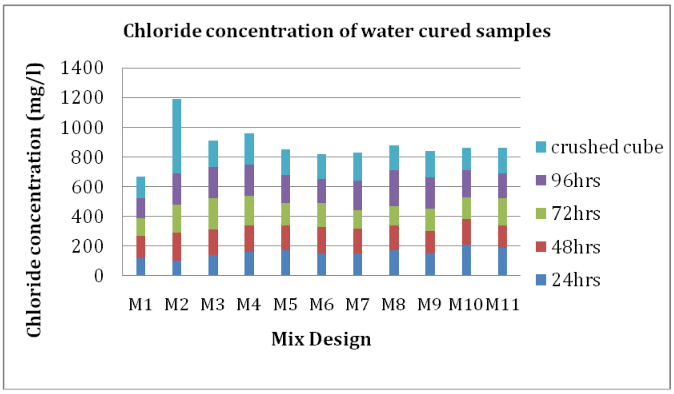

Chart -3: Chloride leaching conc. of water cured samples

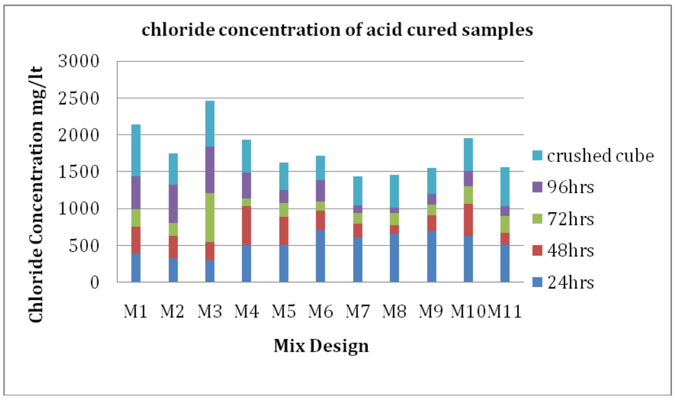

Chart -4: Chloride leaching conc. of acid cured samples

The results are slight similar to the procedure of the sulphate but different concentrations. The acid cured samples shows more leaching than that of the water cured. As the mix proportion of the coal bottom ash increases, the leaching concentration of the chloride increases in acid cured as well as water cured. Crushed cube concentration shows more in the acid samples than that of water samples. As the duration of sample collection increases the leaching of the chloride gets decreases. Chart -5 and Chart -6 shows the zinc leaching concentration of the water and acid cured samples .

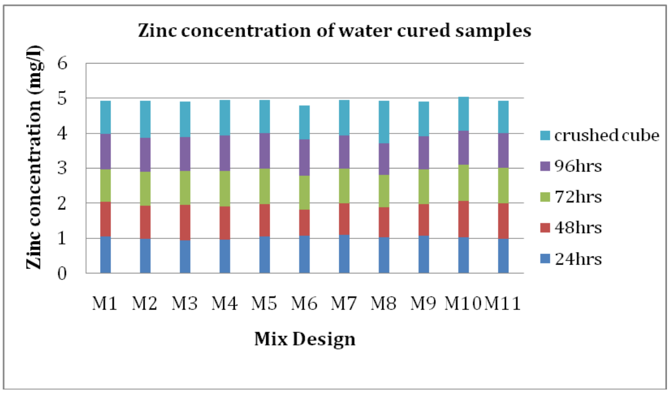

Chart -5: Zinc leaching conc. of water cured samples

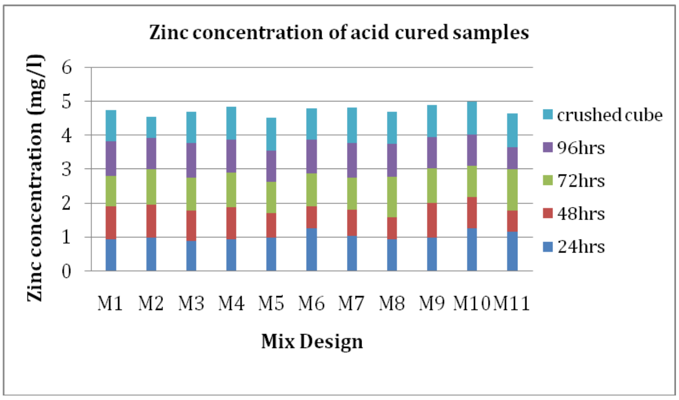

Chart -6: Zinc leaching conc. of acid cured samples

The Zinc leaching is in very less concentration than with comparison of sulphate and chloride. However as the number of sample collection increases the leaching of the zinc in acid media and water media curing gets decreases. Similarly with increase in the percentage mix with the coal bottom ash in the mix of blended cubes cause slight increase in the concentration for both 0.11M acetic acid and water as curing media. Chart -7 and Chart -8 shows the chromium leaching concentration of water and acid cured samples.

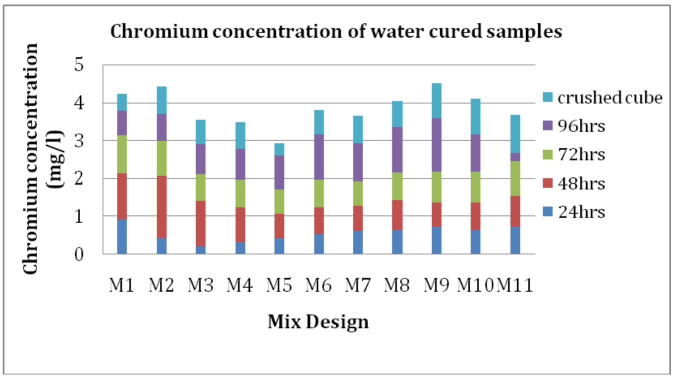

Chart -7: Chromium leaching conc. of water cured samples

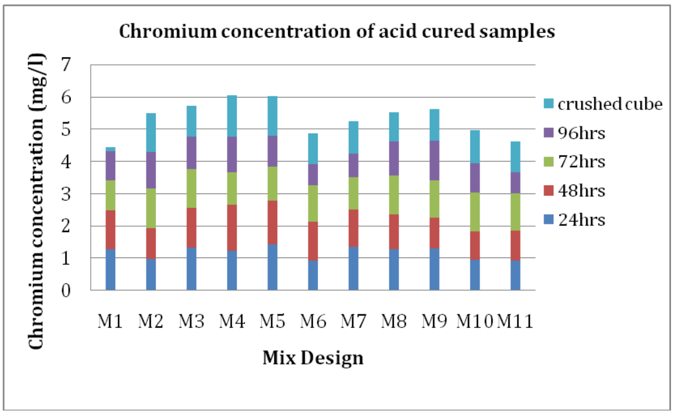

Chart -8: Chromium leaching conc. of acid cured samples

The Chromium also shows the same result with varying concentrations. The crushed cube samples of water cured has increased with increase in the mix proportion, but for the acid cured it is increased with lower concentration compared with water cured samples. The compressive strength of the blended cubes is finded after the leaching process that is after 96hrs. Chart -9 and Chart -10 shows the graphical representations of compressive strength of the 0.11M acetic acid cured and water cured blended cubes.

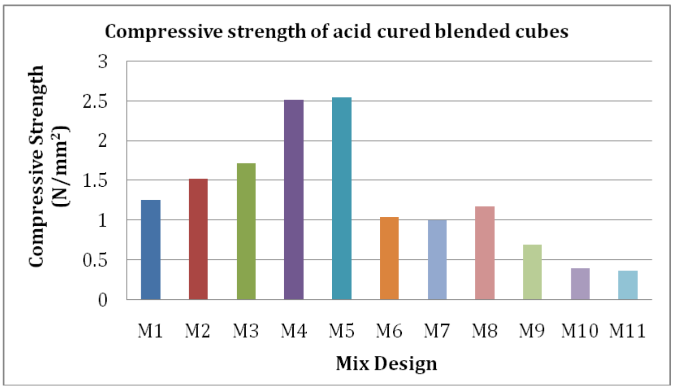

Chart -9: Compressive strength of the acid cured blended cubes

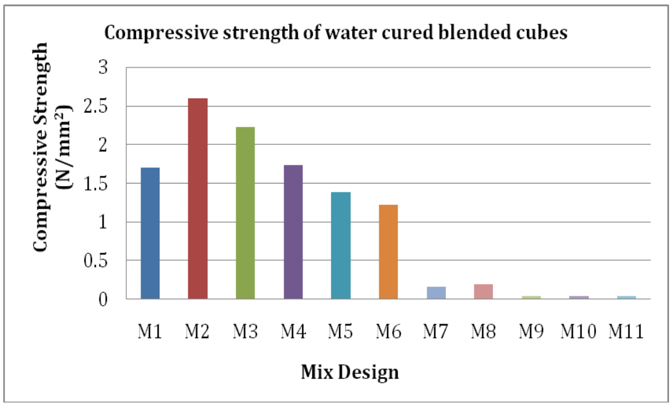

Chart -10: Compressive strength of the water cured blended cubes

The compressive strength of the water cured blended cubes shown to be gaining a high strength up to 2.60 N/mm² than that of acid cured cube for 10% replacement of mix. As the addition of the Coal Bottom ash in the blended cube mix increases, the compressive strength of the cube gradually decreases. The coal bottom ash up to 10% replacement with sand shows better result for water cured cubes and similarly the acid cured cubes show gain in strength up to 40% of replacement with sand.

The coal bottom ash and fly ash has cementitious properties it can be used in the partial replacement of the cement and sand. Mostly the bottom ash is used for the replacement of sand and fly ash is used in the cement. But the more or increase in the percentage replacement may lead to the decrease in the strength of the cement mortar, failure of the structure takes place. Also the bottom ash has many toxic compounds which leach out during the contact with the water and cause environmental pollution. The cubes when water cured the strength will be achieved maximum. But in acid cured the strength decreases. For both acid and water cured condition, if percentage mix of the bottom ash increases the compressive strength of the blended cement mortar cubes gradually decreases. The result for the 100% replacement gives the least strength which directly gives the failure of the structure. It is compared for the curing period such that longer cured cubes anyhow achieve strength but more bottom ash less will be the strength of the blended cement mortar cubes. M5 and M2 design mix of the acid cured and water cured blended cubes shows highest strength in this study that is the 40% of the bottom ash with acid cure and 10% of the bottom ash with water cure shows better result in achieving strength of the blended cubes.

5. CONCLUSIONS

The following conclusions are drawn from the present investigation.

- The water cured blended cement cubes has shown to be higher compressive strength than that of with the 0.11M acetic acid cured blended cubes that is 2.6 N/mm^2 compressive strength achieved for 10% coal bottom ash as in the Mix 2 for water as curing media in the other side for 0.11M acetic acid as curing media it was 1.52 N/mm^2 for the same Mix.
- Up to 10% of the coal bottom ash can be replaced with fine aggregate for water as a curing media. This has seen to be better in gaining strength of the concrete.
- Up to 30% of the coal bottom ash can be replaceable with 0.11M acetic acid as curing media. It shows considerable compressive strength of the concrete.
- As the percentage mix of the coal bottom ash in the blended cement increases, the compressive strength of the cubes gradually decreases.
- As the percentage of coal bottom ash mix in blended cement increases, the concentration of the leaching for sulphate, chloride, zinc and chromium also gets increases.
- If the leaching of metals from the blended cement mortar increases, the strength of the cube gets decreases.

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