INVESTIGATION ON SUITABILITY OF MSW-ASH AS A REPLACEMENT TO CEMENT

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Abstract - *Cement is the most widely used construction material because of its mould ability into any structural form and shape due to its fluid behaviour at early stages. In the combustion process of municipal solid waste (MSW), bottom ash (BA) represents the major portion of the solid residue. Since BA is composed of oxides, especially SiO_2 and CaO, the feasibility of its application in concrete as a substitute for cement was tested. This paper reports a study on the use of municipal solid waste incineration ash as a replacement to the cement to calculate the properties of the design mix composition. Four design mix compositions comprising 10%, 20%, 30% and 40% replacement of MSWI ASH with cement were formulated and the tests like initial setting time, final setting time, consistency, sound ness, specific gravity, and strength of cement were carried out for those proportions It is found that at the age of 28 days the strength of samples are satisfactory and are as per the standards of Indian codes.*

***Key Words*: Cement, fine aggregates, coarse aggregates, water, and MSWI-ASH, Concrete.**

1.INTRODUCTION

In the last few decades of the 20th century it became obvious that the large quantities of waste produced by the modern consumer society cause serious environmental damage when they are disposed of without any treatment. While a small portion of waste (less than 1%) is hazardous and requires expensive treatment, Municipal waste, although classified as non-hazardous, still causes air, water and soil pollution during decay. Hence, modern landfills for municipal solid waste (MSW) have a complex design and should be able to carry out several processes such as leachate and gas management and monitoring. This makes the disposal space for a volume unit of waste rather expensive. In order to minimize disposal space, it has become common practice to sort, reuse and incinerate waste materials.

1. MATERIALS AND PROPERTIES

1.1 CEMENT

Cement plays vital role in concrete. One of the important criteria tri-calcium aluminates (C3A) content, tri-calcium silicate (C3S) content, di-calcium silicate (C2S) content etc. It is also necessary to ensure the compatibility of chemical and mineral admixtures with cement. This study, Ultratech 53 grade Ordinary Portland Cement conforming to IS: 12269–1987 was used for the entire work. The cement was purchased from single source and was used for casting of all specimens. The physical properties of cement are furnished in Table-1

Table-1 properties of cement

S.No	Characteristics	Test results	Requirements as per IS 12269-1987
1	Fine Ness	6%	<10%
2	Normal	33%	--
3	Initial Setting Time	90 Min	30 Min (Minimum)
4	Final Setting Time	340 Min	600 Min (Maximum)
5	Expansion In Le-Chatelier Method	4 Mm	10 Mm (Maximum)
6	Specific Gravity	3.11	3.10 - 3.25

1.2 Fine aggregates

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with 90% particles passing through a 9.5mm sieve. As with coarse aggregates these can be from Primary, Secondary or Recycled sources. The selection of fine aggregate is also on important factor as it directly affects the strength of concrete with the varying utilization of water. Fine aggregate with harsh surface requires high amount of water, so fine aggregate with smooth surface and rounded shape is being used as it requires low amount of water and hence produces high strength concrete. Fine aggregate, those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand is be used in combination as fine aggregate conforming to the requirements of IS 383- 1970. The river sand is washed and screened, to eliminate deleterious materials and

over size particles. Specific gravity, water absorption and gradation of sand (FM) test were carried out as per IS 2386 (part I and Part III) - 1963. Physical test for specific gravity, water absorption, bulk density were carried out for coarse aggregate as per IS -2386 (I, II & IV) 1963 Properties of the fine aggregates given in Table-2

Table-2 physical properties of fine aggregates

S.No	Tests Conducted	Results obtained		Permissible limits as per IS 383
1	Specific Gravity	2.67		2.5 – 3.0
2	Fineness Modulus	3.05		---
3	Bulk Density	Loose State	1450 kg/m^3	1400 – 1750 kg/m^3
		Compacted State	1520 kg/m^3	
4	Water Absorption	1.09		Max – 3%
5	Sieve Analysis	Zone-II		---

1.3 water

Water used for mixing and curing shall be clean and free from injurious quantities of alkalis, acids, oils, salts, sugar, organic materials, vegetable growth (or) other substance that may be deleterious to bricks, stone, concrete, or steel. Potable water is generally considered satisfactory for mixing. Water acts as a lubricant for the fine and coarse aggregates and acts chemically with cement to form the binding paste for the aggregate and reinforcement. Less water in the cement paste will yield a stronger, more durable concrete; adding too much water will reduce the strength of concrete and can cause bleeding. Impure water in concrete, effects the setting time and causing premature failure of the structure. To avoid these problems quality (potable) water must be proffered in construction works and PH value of water should be not less than 6. And also Quantity of water to be taken is important.

1.4 Municipal Solid Waste Incinerated Ash (MSWI-ASH)

The municipal solid waste was collected from waste to energy plant in Bangalore. The chemical composition of MSWI-ASH was obtained by conducting XRF and the obtained chemical composition was listed belo

Constituent	Value (%)	Constituent	Value (%)
CaO	52	MgO	6.0
SiO_2	24	Fe_2O_3	3.0
Al_2O_3	13.4	Na_2O	0.42
K_2O	0.3		

2.0 Experiments and results

2.1 consistency test

The basic aim of consistency test is to find out the water content required to produce a cement paste of standard consistency as specified by the IS 4031 (part-4) – 1988. The principal is that standard consistency of cement is that consistency at which the vicat plunger penetrates to a point 5-7 mm from the bottom of the vicat mould.

Weigh approximately 400g of cement and mix it with a weighed quantity of water. The time of gauging should be between 3 to 5 minutes. Fill the Vicat mould with paste and level it with a trowel. Lower the plunger gently till it touches the cement surface. Release the plunger allowing it to sink into the paste. Note the reading on the gauge. Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7mm.

S.No	Type of material	Consistency limit	Penetration depth
1	Normal cement (N.C)	33	6
2	10% MSWI-ASH + 90% N.C	36	5
3	20% MSWI-ASH + 80% N.C	36	6
4	30% MSWI-ASH + 70% N.C	37	5
5	40% MSWI-ASH + 60% N.C	38	5

2.2 Initial and Final Setting Time Test

We need to calculate the initial and final setting time of the cement as per the IS: 4031 (part-5) – 1988. To do so we need vicat apparatus.

Prepare a cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Start a watch the moment water is added to the cement, Fill the Vicat mould completely with the cement paste gauged as above, the mould resting on a non-porous plate and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

S.No	Type Of Material	Initial Setting Time	Final Setting Time
1	Normal cement (N.C)	28	510
2	10% MSWI-ASH + 90% N.C	25	525
3	20% MSWI-ASH + 80% N.C	24	516
4	30% MSWI-ASH + 70% N.C	24	510
5	40% MSWI-ASH + 60% N.C	21	520

2.3 specific gravity of cement

The specific gravity of the cement was calculated was using the density bottle and kerosene as cement is react able with water so that kerosene was used specific gravity is very important to know the behaviour of the material in water.

Specific gravity is the ratio of the density of the substance to the density of a reference substance at a fixed temperature. On the other words it is the ratio of the mass of a substance to the mass of a reference substance.

S.NO	Type of material	Soundness Of Cement
1.	Normal cement (N.C)	4
2.	10% MSWI-ASH + 90% N.C	4
3.	20% MSWI-ASH + 80% N.C	5
4.	30% MSWI-ASH + 70% N.C	4
5.	40% MSWI-ASH + 60% N.C	6

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S.NO	Type of material	Specific gravity Of Cement
1.	Normal cement (N.C)	3.13
2.	10% MSWI-ASH + 90% N.C	3.11
3.	Normal cement (N.C)	3.13
4.	10% MSWI-ASH + 90% N.C	3.11
5.	20% MSWI-ASH + 80% N.C	3.03

2.4 strength of the cement

Strength of cement is the most important of all the cement properties. Grades mentioned in the cement bags are 53/43 grade opc/ppc in fact represent the strength of the cement (compressive strength at 28 days). The cubes are casted with cement mortar in 70.6mm x 70.6mm x 70.6mm, these cubes are cured for 28 days in water at a temperature of 27^0c. After curing the cubes will be tested under the compressive testing machine.

S.No	Type of material	Strength of cement
1	Normal cement (N.C)	55 N/mm^2
2	10% MSWI-ASH + 90% N.C	58 N/mm^2
3	20% MSWI-ASH + 80% N.C	61 N/mm^2
4	30% MSWI-ASH + 70% N.C	54 N/mm^2
5	40% MSWI-ASH + 60% N.C	51 N/mm^2

3. Conclusions

1. MSWI-ASH have good physical and chemical quality for the replacement of cement for concrete production.
2. The chemical composition of the MSWI-ASH is calculated through XRF.
3. The MSWI-ASH highly consists of CaO (52%) which is nearly equal to the Cao (62% - 64%) percentage of the cement.
4. The initial setting time of the cement mixes where decreased with increase in percentage of MSWI-ASH.
5. The final setting time of the cement is in as per the limits of IS standards.

6. The soundness of the cement was within the limits mentioned by the Indian standards less then 10mm.

7. The specific gravity of the cement was decreased with increase in percentage of replacement of ash so that the final density or weight will be decreased.

8. The strength of the cement mortar at 28 days curing gives the satisfactory results.

9. The strength with 20% replacement yields the maximum strength, the strength was increased gradually up to 20% replacement and the strength was decreased with further replacement.

4. References

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