International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.8, pp 127-133, 2017

Partial Replacement of Fine Aggregate through Household Waste Ash in Concrete

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Abstract : Municipal solid waste ash is the byproduct produced from the combustion of household waste. The waste when burns in incinerator possess various cementitious and strength properties. In this project, the fine aggregate is being replaced by these municipal solid waste ash and as a form of admixture to achieve the conservation of resources and to make concrete economical. The physical and chemical composition of municipal solid wasteash is determined. The concrete mix of M25 grade is being designed by partially replacing the fine aggregate with municipal solid wasteash. The fine aggregate is replaced in various proportion of 10%, 20%, 30% and 40% by mass. All the test is carried out on thegrade of concrete at 28 days. The effect of municipal solid waste ash on strength properties of concrete such as compressive strength, split tensile strength and workability characteristics is to be investigate. As landfill space for the disposal of ash from Municipal Solid Waste Incineration (MSWI) becomes scarce, it becomes more attractive to reduce the volume of materials being disposed there. A further reduction in land filling, though, can be realized by developing a beneficial use for the ash. One of the possibilities is to use Municipal Solid Waste Incineration (MSWI) ashes in concrete production, as it is done with coal combustion products.

Keywords : Municipal Solid Waste Incineration, Compressive strength, Split tensile strength, Workability and land filling.

1.0 Introduction

1.1 General

At present, world produces around approximately 2378 Million Tons of Municipal solid waste ash. While India at present uses about 256 Million Tons of as has base material for pavement and used as a replacement in concrete and other application[7]. The beneficial use of Municipal solid waste ash in road construction is the preferable option for safe and economical utilization of millions tons of Municipal solid waste ash. The remaining had to be disposed of as waste and landfill[4]. Disposal of Municipal solid waste ash in this manner is not only wasteful but it is costly because of the lack of landfill space and stringent environmental policy. Municipal solid waste ash contain less amount of harmful substances and pollutants[1,6]. Even though it affects the environmental condition while depositing in an open ground. On the other hand, construction activity can be increased day by day through various construction techniques methods as well as materials can be improved.

1.2 Solid Waste

The amount of municipal solid waste incinerator ash (MSWI) is increasing day by day over the recent years due to the availability of large quantity of municipal solid waste[2]. Most of the times the municipal solid waste ashcan be placed in a open areas or dumped into the landfill sites. These both methods are not desirable because municipal solid waste ash makes environment unfriendly. There is a huge potential for using municipal solid waste ash in road construction and the municipal solid waste ash is easily available at very few which makes in road construction economical as well as reduce impact on environment. When municipal solid waste ash are used in road construction, cost will be minimized as possible[3,5]. The municipal solid waste incinerator (MSWI) ash can exhibit characteristics similar to that of soil on the other hand the present challenge to road engineer is to produce high performance of sub-base materials also economically as well as less used of natural resources or material. Municipal solid waste ash is partly used with soil without disturbing its properties at lowest possible rates. The dumping of municipal solid waste is shown in Figure 1.

Figure 1. Dumping of Municipal Solid waste

1.3 Objective of The Work

- To find out the engineering properties of MSWI ash to overcome the high utilization of fine aggregate due to developing infrastructure
- To determine the strength of concrete by replacing fine aggregate with MSWI ash which in turn avoids the landfill disposal waste.

1.4 Application of Ash Concrete

Municipal Solid Waste Incinerator (MSWI) Ash has been investigated for its suitability for utilization in major areas as building material and other civil engineering sectors. The areas mentioned below have tremendous scope of large scale use of MSWI ash.

- Building bricks and blocks.
- Road construction, Drainage media and Sound insulating walls.
- It is used in mining mortar in such application as rock stabilization or filling of cavities.
- It is used as a construction material for highway and pavement.
- It is used for pressure grouting in concrete highways and for other purposes viz, tunnel lining.
- It is used as mineral filler in asphalt roads to minimize void content and increase the stability of bituminous wearing course during road construction.
- It is used along with bottom ash as a growing media for plants.
- It is used as a light weight synthetic aggregate in block and concrete.
- In concrete, bottom ash is used as replacement of fine aggregate in which concrete has advantageous properties like improved resistance to chemical attack.

2.0 Material Used

2.1 Cement

Ordinary Portland Cement (OPC) is now available in three grades namely 33, 43 and 53 grades. The number indicating the compressive strength of standard cement sand mortar cubes in MPa after 28days of curing.The most common cementused currently in construction is Portland cement. The typical fineness of cement ranges from 350 to 500m^2/kg respectively. More than 500Kg/m3 cement can be dangerous and increase the shrinkage. Less than 350 Kg/m^3 may only be suitable with the inclusion of other fine filler, such as fly ash, pozzolona. Concrete produced from Portland cement is one of the most versatile construction materials available in the world. In this study, Ordinary Portland Cement (OPC) of 53 grade conforming to IS: 12269 (2013) was used. The properties of Cement is tabulated in Table 1.

Table 1.Physical Properties of Cement

S.No	Properties	Values
1	Specific Gravity	3.15
2	Bulk Density	1440 kg/m^3
3	Surface area	225 m^2/kg
4	Initial setting time	19 min
5	Final setting time	260 min
6	Consistency	30.5%

2.2 Fine Aggregate

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size being finer than gravel and coarse than silt. Sand can also refer to a textural class of soil or soil type. Clean and dry river sand available locally confirming to IS 383-1970was used. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Fine aggregate used for cement mortar used be properly graded to give minimum void ratio and be free from deleterious material like clay, silt content and chloride contamination, etc. Grading of fine aggregate should be such that it does not cause increase in water demand for the concrete and should give voids so that the fine cementitious particles fill the voids. Hence it is desirable to use coarser variety of fine aggregate having a high fineness modulus for making workable and strong concrete. The Specific gravity of fine aggregate used is 2.63.

2.3 Coarse Aggregate

Crushed angular aggregate with maximum grain size of 20mm is used normally. The specific gravity and fineness modulus was found to be 2.74 and 2.75 respectively. Coarse aggregate is the strongest and the least porous component in concrete. It is also chemically stable material. Presence of coarse aggregate reduces drying shrinkage and other dimensional changes occurring on account of movement of moisture. Coarse aggregate contributes to impermeability concrete provided that graded and the mix is suitably designed. Ordinary blue granite crushed stone aggregate confirming to IS: 383-1970 was used as a coarse aggregate in concrete. Optimum size of the coarse aggregate in most situations about 20mm was adopted. The Specific gravity of coarse aggregate used is 2.7.

2.4 MSWI Ash

The composition of municipal solid waste varies over time and from country to country due to the differences in lifestyle and waste recycling processes of a country and the ash content will vary too. Generally, the chemical and physical characterization of ash will depend on the compositions of the raw MSW, the operational conditions, the type of incinerator and air pollution control system design. The chemical composition shows that the major elements are Si, Al, Fe, Mg, Ca, K, Na and Cl. Further, SiO_2, Al_2O_3, CaO, Fe_2O_3, Na_2O, K_2O are the common oxides found in CaO is the most abundant compound that exists in MSWI ash, which constitutes up to 46%, but SiO_2 is the most abundant compound that exists in MSWI bottom ash, containing up to 49%.Ash used for cement mortar to be properly graded to give minimum void ratio and be free from deleterious material like clay, silt content and chloride contamination, etc. Grading of ash should be such that it does not cause increase in water demand for the concrete and should give voids so that the fine cementitious particles fill the voids. The Specific gravity of and Moisture

content of MSWI ash is found to be 0.905 and 6 %. The Specific gravity test and MSWI ash is shown in Figure 2 and 3 respectively.

Figure 2.Specific gravity testFigure 3. MSWI ash

3.0 Mix Proportion

The grade of concrete adopted for this study is M25 and the design mix is obtained as per the Indian Standards IS10262:2009. For this design, Minimum and maximum cement content is adopted as 320 kg/m^3 and 450 kg/m^3 and Maximum water cement ratio is fixed as 0.5. The mix proportion for replacement of fine aggregate is tabulated in Table 2.

Table 2. Replacement of fine aggregate partially with MSWI ash

% Replacement	Cement (kg/m^3)	Mswiash (kg/m^3)	Fine Aggregate(kg/m^3)	Coarse Aggregate(kg/m^3)
10	450	77.19	771.90	990.84
20	450	154.38	617.52	880.675
30	450	231.57	540.33	770.588
40	450	308.76	463.14	660.504

4.0 Results and Discussions

4.1 Hardened Properties of Concrete:

The hardened properties of concrete for various replacement percentages of MSWI ash are determined. The mechanical properties of concrete of concrete are determined by conducting the following tests at 7 and 28 days.

- Compressive strength
- Split tensile strength test
- Flexural strength test

4.1.1 Compressive Strength Test:

Compressive strength tests are carried out on cubes of size150 mm X 150 mm X 150 mm. The specimens are tested after keeping it for curing at the age of 7 and 28 days. The results obtained are compared with the results of a control mix specimens. The results are tabulated below in Table 3 and the compressive strength test results were plotted in the Figure 4.

Table 3. Compressive strength test results for MSWI ash replacement

S.NO	% REPLACEMENT	COMPRESSIVE STRENGTH (N/mm²)	
		7 DAYS	28 DAYS
1	0	17.77	28.44
2	10	16	28
3	20	18.22	29.77
4	30	13.33	21.77
5	40	11.11	20

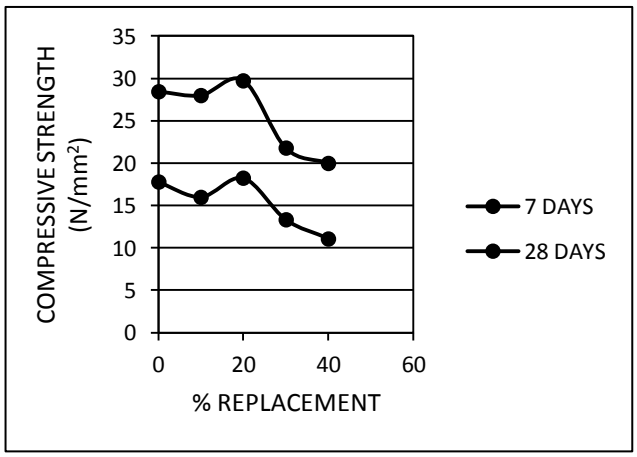

Figure 4. Compressive strength test result for various % replacement of MSWI ash

4.1.2 Split Tensile Strength Test:

For the determination of split tensile strength test of concrete cylinder specimens of diameter 150 mm and height 300 mm were casted. The cylinders were casted for 0%,10%, 20%, 30%, and 40%. The tests were conducted on cylinders at an age of 7 and 28 days. The results are tabulated below in the Table 4 and the Split tensile strength test results were plotted in the Figure 5.

Table 4. Split tensile test results for MSWI ash replacement

S.NO	% REPLACEMENT	SPLIT TENSILE STRENGTH (N/mm²)	
		7 DAYS	28 DAYS
1	0	3.39	3.86
2	10	2.82	3.25
3	20	3.25	3.67
4	30	2.4	2.68
5	40	2.12	2.4

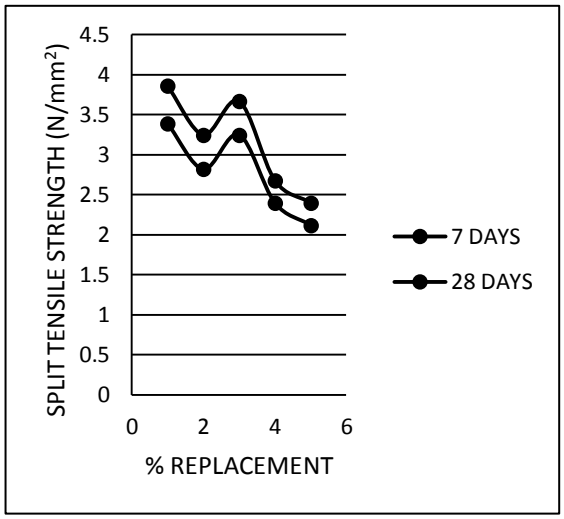

Figure 5. Split tensile strength test result for various % replacement of MSWI ash

4.1.3 Flexural Strength Test Results

Flexural strength test is carried out on prism specimens of dimensions 100 mm X 100 mm X 500 mm. The test is carried out by applying two point loading on the prism at the age of 7 and 28 days. The tests are carried out at various percentages ofash replacement at 30%, 40% and 50% and bottom ash for fine aggregate at 10%, 20% and 30%. The results are tabulated below in the Table 5 and the flexural strength test results were plotted in the Figure 6.

Table 5. Flexural strength test results for MSWI ash replacement

S.NO	% REPLACEMENT	FLEXURAL STRENGTH (N/mm²)	
		7 DAYS	28 DAYS
1	0	2.22	2.68
2	10	1.98	2.47
3	20	2.28	2.64
4	30	1.51	1.98
5	40	1.48	1.87

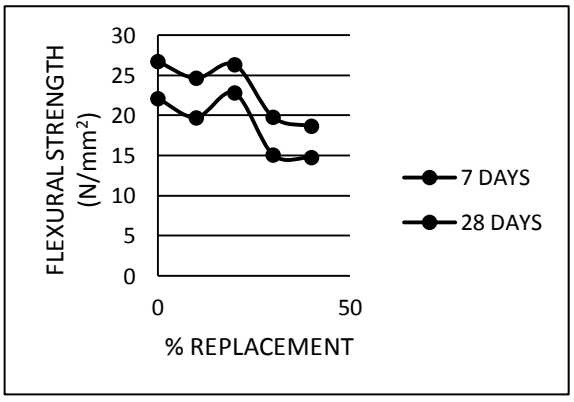

Figure 6. Flexural strength test result for various % replacement of MSWI ash

5.0 Conclusion

Based on the study on strength of partial replacement of fine aggregate with MSWI Ash in concrete followings are concluded.

- Partial replacement of fine aggregate on MSWI ash with varying percentages like 10%, 20%, 30% and 40% on M-25 concrete mix design is done.
- Optimum percentage for replacement of MSWI ash founded based on review of literature we can be replaced upto 20%.
- In order to reduce the usage of fine aggregate partial replacement of MSWI ash percentage is increased to get good strength based on the replacement.
- The drawback experienced is the foul smell of the MSWI ash while mixing of concrete.
- The expected workability cannot be achieved with the determined water to cement ratio for the partial replacement of MSWI ash concrete.

Abbrevation : MSWI-Municipal Solid Waste Incineration

6.0 References

1. Jnyanendra Kumar Prusty, Sanjaya Kumar Patro& S.S. Basarkar, 2016 "Agro-Waste as Fine Aggregate for Sustainable Built Environment High demand of Natural Resources due to Rapid Urbanization and the Disposal problem of Agricultural Wastes ", International Journal of Sustainable Built Environment (2016) vol 5, 312–333 , No 12 june 2016
2. Gaurav Singh , Souvik Dad, AbdulazizAbdullahi Ahmed , Showmen Sahab, Somnath Karmakar, 2015 "Study of Granulated Blast Furnace Slag as Fine Aggregates in Concrete for Sustainable Infrastructure" World Conference on Technology, Innovation and Entrepreneurship , Procedia - Social and Behavioral Sciences 195 (2015) 2272 – 2279
3. Manoj Kumar Das &Sanjaya Kumar Patro , "Sustainable use of industrial-waste as partial replacement of fine aggregate for preparation of concrete" International Journal of Sustainable Built Environment (2016) vol 5, 484–516
4. V. Alivelu Mangamma ,2016 "Effect on compressive strength of concrete with partial replacement of cement by Municipal Solid Waste incineration Ash ".International Journal Of Engineering Sciences &ResearchTechnology, ISSN: 2277-9655,DOI: 10.5281/zenodo.46984
5. Remyaraju, mathews m. Paul & k. A. Aboobacker, "Strength Performance of Concrete using bottom Ash as fine Aggregate", International Journal of Research in Engineering & Technology, Vol. 2, Issue 9, Sep 2014, 111-122
6. S.Deepak & Dr.V.Ramesh "Properties of Municipal Solid Waste Incinerator Ash in Concrete", International Journal Of Engineering And Computer Science ISSN:2319-7242 , Volume 4 Issue 6 June 2015, Page No. 12322-12326
7. Meenakshi Dixit , Atishaya Jain & Dinesh Kumawat "Replacement of Fine Aggregate in Concrete with Municipal Solid Waste Bottom Ash from Incinerator", SSRG International Journal of Civil Engineering (SSRG-IJCE) volume 3 Issue 7 – July 2016

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