AN EXPERIMENTAL STUDY ON RECYCLING AND REUSE OF MUNICIPAL SOLID WASTE IN CONSTRUCTION INDUSTRY

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***Abstract*— Huge amounts of waste are being generated, and even though the incineration process reduces the mass and volume of waste to a large extent, massive amounts of residues still remain. On average, out of 1.3 billion tons of municipal solid wastes generated per year, around 130 and 2.1 million tons are incinerated in the world and in India, respectively. Landfilling makes the valuable resources in the residues unavailable and results in more primary raw materials being used, increasing mining and related hazards. Identifying and employing the right pre-treatment technique for the highest value application is the key to attaining a circular economy. We reviewed the present pre-treatment and utilization scenarios in India, and the advancements in research around the world for realization of maximum utilization are reported in this project. With all the research evidence available, there is now a need for combined efforts from incineration and the cement industry for technical and economic optimization of the process flow.**

***Index Terms*— MSW(municipal solid waste), M25 grade concrete**

I. INTRODUCTION

The incineration of municipal solid waste has significant benefits as it can reduce the volume and the mass of the waste by about 90% and 70%, respectively. Municipal solid waste is collected and burned in an incinerator; the by-products of the combustion process are collected. Bottom ash typically accounts for 80% of the whole amount of by-products in the MSWI plants. Municipal solid waste incinerator bottom ash is the ash that is left over after waste is burnt in an incinerator. This ash contains glass, brick, rubble, sand, grit, metal, stone, concrete, ceramics and fused clinker as well as combustive products such as ash and slag. Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This necessity led to a continuous and increasing demand for natural materials. Parallel to the need for the utilisation of the natural resources emerges a growing concern for protecting the environment and need to preserve natural resources, by using alternative materials that are either recycled or discarded as a waste. One of the possibilities is to use Municipal Solid Waste ashes in concrete production.

II.LITERATURE REVIEW

Population growth, booming economy, and rapid urbanization havegreatly accelerated the solid waste generation all around the world. The annual global generation of solid waste has recently approached 17 billion tons and is supposed to hit 27 billion tons by 2050

(Laurentet al., 2014). This issue is of stinging concern to the nations, municipalities, and individuals, as it can cause significant damages to human health, natural resources, and ecosystems. Therefore, the concept of adopting green chemistry and technologies for environmental sustainability has been increasingly recognized and included in recent years.

Most notably, the traditional concept, in which waste is regarded as pollution, has been progressively shifting towards the new perspective that waste is treated as a resource. This undoubtedly can support societies to become more sustainable. For instance, the energy generated in certain thermal processes of waste materials can trim the energy generation services through conventional technologies. Likewise, the reuse or recycling of certain solid waste materials, such as metal, plastic, and paper can conserve the source of the corresponding virgin materials.

Against this scenario, the research of recycling solid waste materials into the production of construction materials has been carried out extensively (De Carvalho Gomes et al., 2019). These endeavors are intended to slim down the volume of solid waste, and also trim down the

mounting demand for natural resources in the construction industry. Heretofore, impressive achievements relevant to this field have been attained. For example, Huang et al. (2007) reviewed the successful utilization of solid waste materials (i.e., steel slag, waste glass, tires, and plastics, etc.) for the development of asphalt pavements.

Meng et al. (2018) summarized the existing research work on recycling a range of solid waste materials in the production of concrete blocks, including crushed brick, waste glass, recycled concrete, ceramic waste, and tile waste, etc. Luhar et al. (2019b) outlined the possible use of various kinds of aquacultural and agricultural farming waste as supplementary materials in concrete.

III. OBJECTIVE OF THE STUDY

The objectives of the work are stated below:

i) To develop mix design methodology for mix 25 MPa
ii) To study the effect of adding different percentages (0% - 15%) of MSW ash by the weight of cement in the preparation of concrete mix.
iii) To determine the workability of freshly prepared concrete by Slump test& compaction factor test.
iv) To determine the compressive strength of cubes at 7, 14, 28 days.
v) To determine the Flexural strength of beams at 28 days.

IV. EXPERIMENTAL PROGRAM

4.1 Materials Used

The different materials used in the investigation are:

4.1.1 Cement

Cement used in the investigation was found to be Ordinary Portland Cement(53 grade) confirming to IS : 12269 – 1987.

Figure 4.1 Cement

4.1.2 Fine Aggregate

The fine aggregate used was obtained from a near by river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

Figure 4.2 Fine aggregates

4.1.3 Coarse aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Figure 4.3 Coarse aggregates

4.2.3.1 Fineness of Cement

Aim: To Determination of the Fineness of Cement by dry sieving.
Apparatus:
a) Standard balance with 100 gm. weighing capacity.
b) IS: 90 micron sieve conforming to IS: 460-1962 and a Brush

Procedure:
a) Break down any air-set lumps in the total sample is reported.
b) Weigh accuracy 100 gm of the cement and place it on a standard 90 micron IS sieve.
c) Continuously sieve the sample for 15 minutes.
d) Weigh the residue left after 15 minutes of sieving.
e) Similar procedure follow for the finding of fineness value for MSWA.

Observation: 1
Total Weight of cement Sample =100 gm
Weight of cement Retained on 90micron Sieve =6 gm

$$\text{Fineness Modulus of cement} = \frac{weight\ of\ cement\ retaineed\ on\ 90microns\ sieve}{\text{total weight of cement sample taken}} = \frac{6}{100} * 100 = 6\%$$

Observation: 2
Total Weight of MSWA Sample =100 gm
Weight of MSWA Retained on 90micron Sieve =4 gm

$$\text{Fineness Modulus of MSWA} = \frac{weight\ of\ \text{MSWA}\ retaineed\ on\ 90microns\ sieve}{\text{total weight of MSWA sample taken}} = \frac{4}{100} * 100 = 4\%$$

Result:
The Percentage weight of residue over the total sample is reported.
Fineness Modulus of cement =6%
Fineness Modulus of MSWA =4%

4.3 Mix Design

Adopted Grade of concrete used-M_{25}

One of the ultimate aims of studying the various properties of the materials of concrete and hardened concrete is to enable a concrete technologist to design a concrete mix design for a particular strength and durability. The design of concrete mix is not a simple task on account of the widely varying properties of the materials, the conditions that prevail at the site work in particular the exposure condition, and the condition that are demanded for a particular work for which mix is designed. Design of concrete mix design requires complete knowledge of various properties of these constituent materials, the implications in case of change on these conditions at the site, the impact of the properties of plastic concrete on the hardened concrete and the complicated inter-relationships between the variables. All these make the task of mix design more complex and difficult. Design of concrete mix needs not only the knowledge of material properties and properties of concrete in plastic condition, it also needs wider knowledge and experience of concreting. Even then the proportion of the materials of concrete found out at the laboratory requires modification and readjustments to suit the field conditions.

4.3.1 Mix Design of Conventional Concrete (M25)

Cement grade = OPC 43

Specific gravity of cement =3.2

Specific gravity of fine aggregates=2.52

Specific gravity of coarse aggregates=2.68

The following procedure is followed to design the concrete

Step 1 : Target Mean Strength

$$f'_{ck} = f_{ck} + 1.65 \times \sigma = 25 + 6.6$$

$$= 31.6$$

Table 4.11: Standard Deviation Values

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm^2 (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

NOTE — The above values correspond to the site control having proper storage of cement; weigh batching of all materials; controlled addition of water; regular checking of all materials, aggregate grading and moisture content; and periodical checking of workability and strength. Where there is deviation from the above, values given in the above table shall be increased by 1 N/mm^2.

Step 2: W/C Ratio

- From the graph specified by IS10262-2019, w/c is taken as 0.47 for 31.6 N/mm^2 compressive strength of concrete.
- From the Table 5 of Is 456 -2000 , for moderate condition, w/c ratio is 0.45
- Hence, min of two values i.e., 0.45 is taken as w/c ratio.

Step 3: Water Content

From Table 2 of IS10262, assume 20mm of aggregate is been used and hence max water content is 186 kg's, slum is assumed to be 100mm and hence water should be increases by 6%

Water content = $186 \times 1.06 = 197.16$

Table 4.12: Water Content

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

Sl No. (1)	Nominal Maximum Size of Aggregate mm (2)	Maximum Water Content [1] kg (3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1] Water}content corresponding to saturated surface dry aggregate.

Table 4.13: Minimum Water Content, Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures

V. RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

5.1 Workability Test

5.1.1 Slump Test

The Slump test was performed on the MSWA concrete to check the workability of it at different replacements viz. 5 %, 10 %, 15%, 20% and the following results were obtained, according to which it can be concluded that with the increase in % of MSWA from 0 to 20 % , workability decreases. The results obtained for Slump test are shown below in Table 5.1.

Table 5.1: Results of Slump test

S.No	% of MSWA	Slump value (cm)
1	0%	11.5
2	5%	11
3	10%	10.5
5	15%	8.5
6	20%	8.2

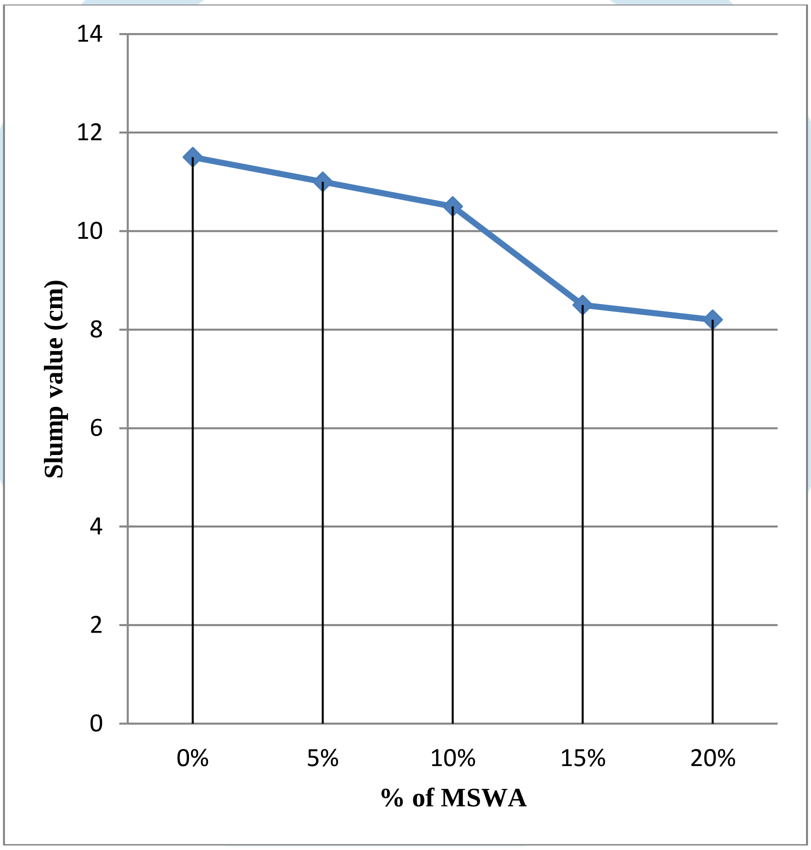

Fig 5.1 : Slump test results

Table 5.2: Results of compaction factor test

S.No	% of rubber	Wt. of partially compacted concrete (kg)	Wt. of fully compacted concrete (kg)	Value of compaction factor (%)
1	0%	9.63	11.83	0.81
2	5%	11	12.17	0.9
3	10%	10.43	12.00	0.87
5	15%	9.52	11.69	0.82
6	20%	8.76	10.92	0.80

Figure 5.2: Compacting factor test

VI. CONCLUSIONS

1. Based on the result that have carried out here as part of this research, we concluded that the replacement of ash obtained from municipal solid wastes can be used for the preparation of concrete. The best advantage of this partial replacement is reducing the over dumping of solid waste to public.
2. The compressive test results on the cement replaced municipal solid waste ash cubes did show improvement while adding 5% and 10% in the 28 days strength in comparison to the control cube, but it fall increasing the percentage of MSWA above 10%.
3. Replacement of municipal solid waste ash up to 10% is good for using construction purposes. And also solid waste incineration powder replacing mixes are also used as base coarse.
4. While increasing the percentage of MSWA in cement then $CaCO_3$ will reduces in it. As we maintain the more percentage of MSWA then add suitable amount of $CaCO_3$.
5. The untreated MSWA was used as partial cement replacement in concrete. This ash, by its chemical composition, does not fulfill the standard requirements on concrete admixtures but the prepared concrete had acceptable properties. The frost resistance of MSWA containing concrete was very good. Theprepared concrete contained relatively low content of MSWA; this approach represents a compromisebetween the ecological request on a practical utilization of MSWA and properties of the acquired product.
6. Higher ash dosage without any accompanied loss of concrete properties would be possible only when the ash would be treated in some way (e.g. by verification) but in such case there would arise additional costs suppressing the MSWA utilization attractiveness for building industry.

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