Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

Nature Environment and Pollution Technology An International Quarterly Scientific Journal	Vol. 8	No. 2	pp. 329-334	2009

Original Research Paper

Utilization of Incinerated Municipal Solid Waste Ash in the Manufacture of Cement Hollow Bricks

P. Srinivas and K. Satish Kumar*
Department of Civil Engineering, RVR & JC College of Engineering, Chowdavaram-522 019, A.P.
*Deptt. of Civil Engineering, K. L. College of Engineering, Vaddeswaram-522 502, A.P., India

Key Words:
Municipal solid waste
Incineration ash
Cement hollow bricks
Compressive strength
Recycling

ABSTRACT

There is a strong demand for environmentally safe reuse and effective disposal methods for Municipal solid waste (MSW) due to the increasing amount of waste generated by the various residential buildings, commercial establishments and various other institutions. MSW refers to the stream of garbage collected through community sanitation services. Medical wastes from hospitals and items that can be recycled and utilized for generating electricity are generally excluded from MSW. The major portion of MSW that is not recycled is typically sent to landfills after it is collected. As an alternative, MSW can be combusted in waste-to-energy combustors, which facilitates to generate electricity. The combustion of municipal solid waste results in reduction of its quantity. MSW combustion creates a solid waste called ash, which can contain any of the elements which were originally present in the waste. Using it as an engineering construction material attains the ultimate disposal of incinerated solid waste ash. The incorporation of municipal solid waste ash in the manufacturing of cement hollow bricks has been systematically investigated. The effect of proportion of incinerated municipal solid waste (ash) on the strength and quality of the brick has been investigated. The use of incinerated municipal solid waste as construction material and building material converts the waste into useful products that can alleviate the disposal problems. The present work has demonstrated a feasible way of using incinerated municipal solid waste ash as a cement replacement material to produce quality bricks. The bricks manufactured did not show any deformation or uneven surfaces and the bricks can be used for construction purposes.

INTRODUCTION

Municipal solid waste (MSW) refers to the stream of garbage collected through community sanitation services. Medical wastes from hospitals and items that can be recycled are generally excluded from MSW, which will be used to generate electricity (Masters 1998). Paper and yard wastes account for the largest share of the municipal waste stream, and much of this can be recycled directly or composted. Currently, over thirty percent of MSW generated in the United States is recycled annually. While not producing this waste in the first place is the preferred management strategy for combating the problem of disposal, recycling is preferred over any other method of disposal. The majority of MSW that is not recycled is typically sent to landfills after it is collected. As an alternative, MSW can be directly combusted in waste-to-energy combustors which facilities to generate electricity. Because no new fuel sources are used other than the waste that would otherwise be sent to landfills, MSW is often considered a renewable power source such as food, paper, and wood products, it also includes non-renewable material derived from fossil fuels, such as tires and plastics. At the power plant, MSW is unloaded from collection trucks and shredded or processed to ease handling. Recyclable materials are separated out, and the remaining waste is fed into a combustion chamber to be burned. The heat release from burning the MSW is used to produce steam, which turns a stream turbine to generate electricity (Tay & Show 1999a). The main aim of the present investigation is to study the physical and chemical properties of municipal solid waste fly ash and to study the suitability of using MSW fly ash as an alternative material for cement in the manufacturing of cement hollow bricks.

SOLID WASTE (ASH) GENERATION

The combustion of MSW reduces the creation of new landfills. MSW combustion creates a solid waste called ash, which can contain any of the elements that were originally present in waste. In most modern plants, several individual ash streams are produced, they include grate ash, siftings, boiler ash, scrubber ash and precipitator or bag-house ash. The term bottom ash usually used to refer to the grate ash, sifting, and in some cases, the boiler ash stream. The term fly ash is used to refer to the ash collected in the pollution control system, which includes the scrubber ash and precipitator or bag house ash.

Bottom ash: Approximately 90 percent of bottom ash stream consists of grate ash, which is the ash fraction that remains on the stoker (a mechanical device to tend the fire) or grate at the combustion cycle. It is similar in appearance to porous, greyish, silty sand with gravel, and contains small amounts of unburt organic material and chunks of metals. The grate ash stream consists primarily of glass, ceramic, ferrous and nonferrous metals, and minerals. It comprises approximately 75 to 80 percent of the total combined ash stream (U.S. EPA 1994).

Boiler ash and fly ash: Boiler ash, scrubber ash, precipitator or bag-house ash consists of particulates that originate in the primary combustion zone area and are subsequently entrained in the primary combustion gas stream and carried into the boiler and air pollution control system. As the combustion gas passes through the boiler, scrubber, and precipitator or bag-house, the entrained particles stick to the boiler tubes and walls (i.e., boiler ash) or collected in the air pollution control equipment (i.e., fly ash), which consists of scrubber, electrostatic precipitator, or bag-house. Ash extracted from the combustion gas consists of very fine particles. Through bag-house or precipitator ash comprises approximately 10 to 15 percent of the total combined ash stream.

However, because ash and other residues from MSW operations may contain toxic materials, the power plant wastes must be tested regularly to assure that the wastes are safely disposed off to prevent toxic substances from migrating into groundwater supplies. Under current regulations, MSW ash must be sampled and analysed regularly, which determines whether it is hazardous waste or not. Depending on state and local restrictions, nonhazardous ash may be disposed off in a MSW landfill or recycled for use in roads, parking lots or daily covering for sanitary landfills (Tay & Show 1999b).

Table 1: Physical and chemical analysis of incinerated municipal solid waste.

Property	Observation
Colour	Black
pH	9.3
Chlorides	Negligible
Sulphates	Negligable
Bulk density	0.25g/cc
Porosity	0.5
Void ratio	1.0
Specific gravity	1.869

Usage of waste materials: Nowadays, waste being recycled and using the recycled products either directly or indirectly has become common. There is a strong demand for environmentally safe reuse and effective disposal method for municipal solid waste due to the increasing amount of waste generated by the various institutions (Weibusch & Seyfried 2002). While sanitary landfills are commonly used for disposal of waste, rapid industrializa-

Table 2: 7-days compressive strength (N/mm^2) of the specimen.

Percentage of ash	Initial crack	Final crack
Standard brick	70	118
Specimen 1	65	82
Specimen 2	51	79
Specimen 3	40	74
Specimen 4	25	69
Specimen 5	19	56

Specimen 1 = 5% by weight of cement replaced by ash
Specimen 2 = 10% by weight of cement replaced by ash
Specimen 3 = 20% by weight of cement replaced by ash
Specimen 4 = 25% by weight of cement replaced by ash
Specimen 5 = 30% by weight of cement replaced by ash

Table 3: 14-days compressive strength (N/mm^2) of the specimen.

Percentage of ash	Initial crack	Final crack
Standard brick	128	166
Specimen 1	97	132
Specimen 2	76	92
Specimen 3	62	100
Specimen 4	58	89
Specimen 5	36	58

Table 4: 21-days compressive strength (N/mm^2) of the specimen.

Percentage of ash	Initial crack	Final crack
Standard brick	156	176
Specimen 1	101	125
Specimen 2	84	99
Specimen 3	78	104
Specimen 4	70	88
Specimen 5	66	82

tion and urbanization has made it increasingly difficult to find suitable landfill sites. Therefore, incineration has become one of the few alternatives available for disposal of municipal solid waste. The ultimate disposal of incinerated ash can be attained by using it as an engineering construction material. The use of incinerated municipal solid waste material and building material converts the waste into useful products that can alleviate the disposal problems (Alleman & Berman 2000).

MATERIALS AND METHODS

The MSW ash was collected from the ash collection pits on the site of the power plant. It was then subjected to physico-chemical tests in the public health and environmental engineering laboratory. The MSW ash was tested for its different chemical and physical properties like pH, chlorides, sulphates, heavy metals, bulk density, specific gravity, porosity and void ratio (Table 1).

Materials used for manufacture of cement bricks: The raw materials required in the manufacture of cement bricks (concrete block) are cement, 6 mm baby chip (kankar) and stone dust.

Preparation of material: The proportioning of cement, baby chips, stone dust for each batch was done by volume. The ingredients, taken in a ratio of 1:4:7 (in terms of volume) were mixed thoroughly in a pan mixer by adding sufficient amount of water. For every batch of concrete, the quantity of concrete was mixed in such a way that about ten percent excess was left out after moulding the desired number of test specimens.

All measuring equipments were maintained in a clean serviceable condition with their accuracy periodically checked.

Sizes of specimen used: Cement bricks of size 38cm × 20m × 20cm were cast.

Curing the specimen: The specimens were marked for identification and they were then left in the sun for drying. The specimen were cured daily with clean water for seven, twenty-one and twenty-eight days.

Testing of specimen for compressive strength: Compressive strength is defined as the ability of the material to resist compressive stress without failure. The testing was done on a compression-testing machine of 3000 tones capacity. The machine has the facility to control the rate of loading with a

Fig. 1: Cement hollow bricks.

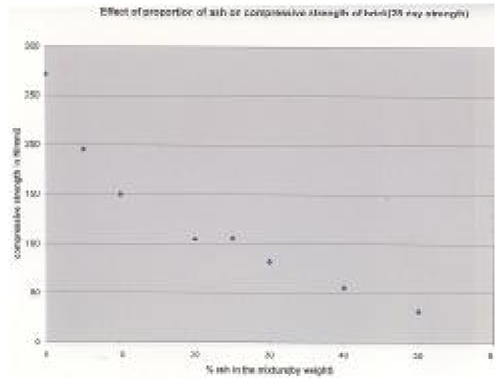

Fig. 2: Effect on compressive strength of brick.

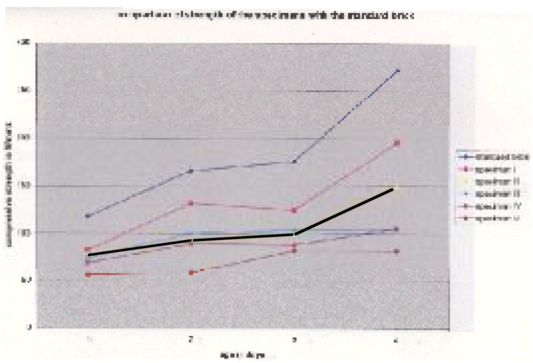

Fig. 3: Comparison of the specimen with the standard brick.

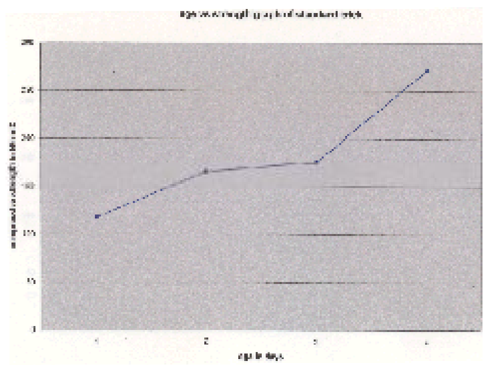

Fig. 4: Effect of age on strength of the standard brick.

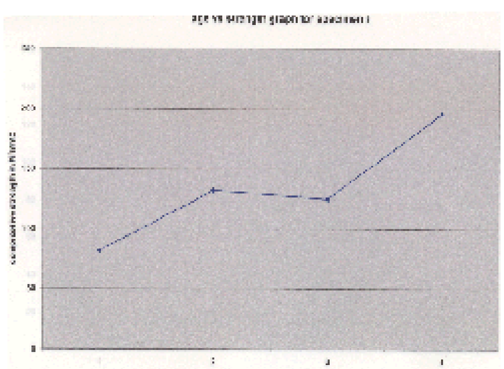

Fig. 5: Effect of age on strength of the specimen brick number 1.

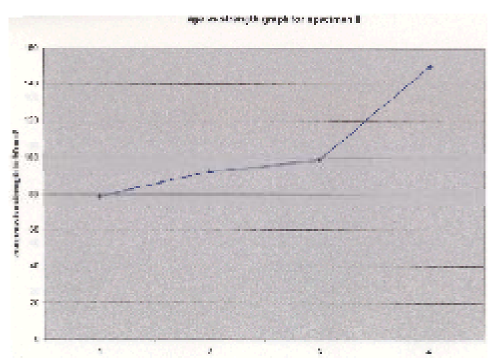

Fig. 6: Effect of age on strength of the specimen brick number 2.

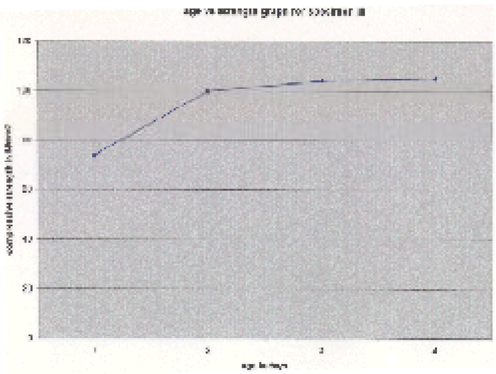

Fig. 7: Effect of age on strength of the specimen brick number 3.

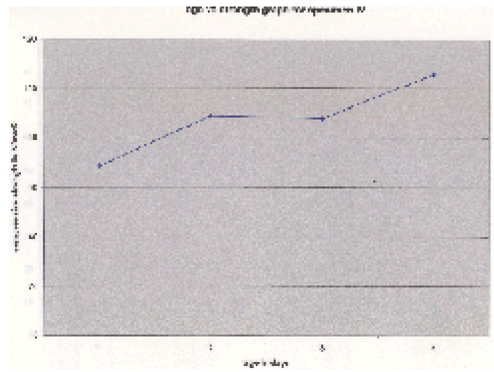

Fig. 8: Effect of age on strength of the specimen brick number 4.

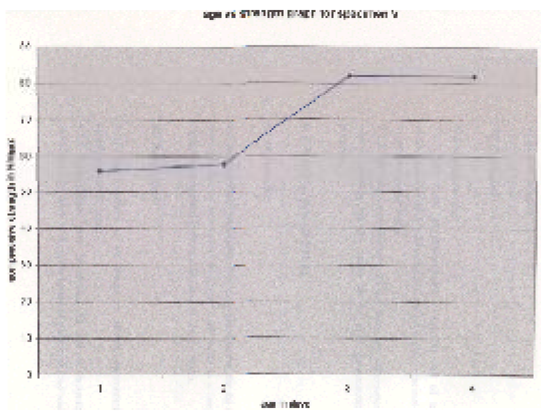

Fig. 9: Effect of age on strength of the specimen brick number 5.

control valve. The platens were cleaned; oil level is checked and kept ready in all respects for testing. After the period of curing, the specimen was allowed to dry before testing. The specimen was placed in the compression-testing machine between two metal plates to provide a smooth bearing surface and to ensure that the load is applied centrally. The plate was placed over it and the top plate of the machine was brought in contact with the specimen by rotating the handle. The oil pressure valve was closed and the machine switched on. A uniform rate of load at failure at 5KN/minute was maintained. The maximum load to failure at which the specimen breaks and pointer starts moving backwards was noted.

RESULTS AND CONCLUSIONS

The physical and chemical analysis of the incinerated municipal solid waste is presented in Table 1. The effect of percentage of ash on the compressive strength of the specimen bricks was studied, and the data after different days of curing with different percentage of replacement of cement by ash are given in Tables 2, 3 and 4. The bricks prepared from the ash are shown in Fig. 1. The graphs drawn for the effect of proportion of ash over compressive strength of bricks for various time periods are shown in Figs. 2 and 3. Graphs showing effect of age on the strength of bricks are shown in Fig. 4 to Fig. 9. Specimen 1, i.e., bricks that were cast with 5 percent of the cement replaced with municipal solid waste have shown best results with considerable strength when compared to standard bricks. The 28 days compressive strength attained by standard brick is 272 N/mm^2 and that by specimen 1 is 176 N/mm^2. The compressive strength of a traditional mud brick is around 69 N/mm^2.

The work has demonstrated a feasible way of using incinerated municipal solid waste ash as a cement replacement material to produce quality bricks. The bricks manufactured did not show any deformation or uneven surfaces and the bricks can be used for construction purposes.

REFERENCES

Alleman, J.E., and Berman, N.A. 2000. Constructive sludge management-Bio brick journal of environmental engineering, ASCE,110(2),301-311.

Masters, Gilbert M. 1998. Introduction to environmental engineering and science, pp: 555-607, 623-632.

Tay, J.H. and Show, K.Y.1999a. Constructive sludge disposal options converting sludge into innovative civil engineering materials, 7th international association on water quality (IAWQ) Asian-Pacific regional conference, Taipei, Taiwan.1023-1026.

Tay, J.H. and Show, K.Y. 1999b. Manufacture of cement from sewage sludge; Journal of materials in civil engineering, ASCE, 5(1),19-29.

U.S. EPA. 1994. Characterization of municipal solid waste, Office of solid waste, Washington, DC.

Weibusch, B. and Seyfried, C.F. 2002. Utilization of sewage sludge ash in the brick and tile Industry. Water science and technology, 36(1), P: 251-258.