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Use of Bottom Ash as Road Construction Material: Geotechnical Perspective

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Abstract - *Municipal Solid Wastes (MSW) are generated in huge quantities every year. Quite a large amount of solid rubbish is contributed by our households in the form of domestic wastes which constitute heaps of municipal refuse poses serious disposal problems. If these wastes are not properly disposed off, this can prove perilous and environmental hazard. Such places often become a home for rats, flies, bacteria, mosquitoes and a large number of vectors, having the potential of causing many human diseases. The waste is dumped in the streets awaiting transport to the disposal sites and into the river. The damage to the environment by the uncontrolled disposal of solid wastes can be clearly visualized. Study of properties of municipal solid waste bottom ash is thus important for studying the various methods which can be used for proper disposal of waste. Our study revolves around study of various geotechnical properties of municipal solid waste incineration bottom ash. These properties are required to find out an alternative use of bottom ash. The aim of developing the proposed database on MSW is to recommend for laboratory engineering tests that can be used to assess the suitability of MSW for use in geotechnical – related applications.*

Key Words: Municipal Solid Waste, Bottom Ash, Incinerator, Waste Generation, WTP, Geotechnical Properties

1. INTRODUCTION

1.1. India's Situation

During the previous two-and-a-half decades, India's economic growth has been among the most rapid in the world with experiencing tremendous growth in urban areas. This increased urbanization associated with growing economy has posed a significance stress on the environment. The scenario in India is also alarming as MSW is expected to increase from 85 million tons in 2011 to 300 million tons by 2047(Ministry of Urban Development, 2000). Studies have shown that per capita waste generation in India is increasing by about 1.3% per year. The urban population is growing at the rate ranging between 3 to 3.5% per annum; which will lead to increase in overall quantity of solid waste by about 5% (Ministry of Finance, 2009).

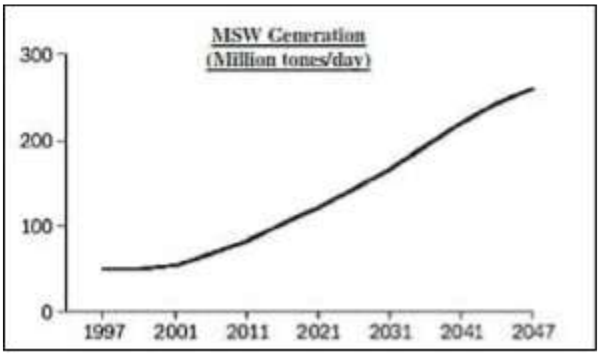

Fig -1: Waste Generation Rate in India (MoF,2009)

1.2. Municipal Solid Waste

MSW refers to the one, which is being generated from different sources like household and public places, construction site etc. The waste which arises from the above sources include plastic, vegetables and putrescible matter, textile, tree leaves, papers and boards, metals, glass pieces, rubber dust, cinders, wood etc. Quite a large amount of solid rubbish is contributed by our households in the form of domestic wastes which constitute heaps of municipal refuse poses serious disposal problems.The quantity of MSW generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons. Data on quantity variation and generation of MSW are useful in planning for collection and disposal systems.

1.2.1.Characterization of Solid Waste

Solid waste is characterized as shown in fig 2. In the below pie diagram plastic is 5%, 'chat' stalk is 3%, paper is 7%, glass is 2%, other is 1% and garbage is 82%.

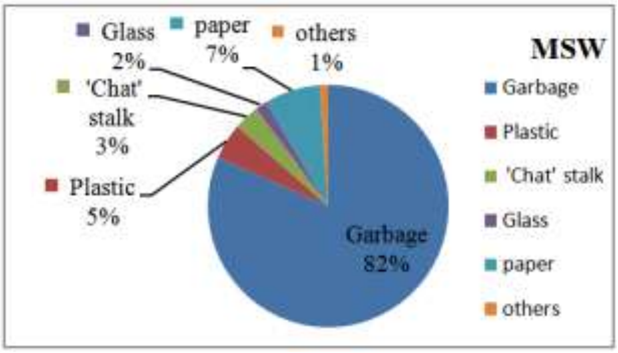

Fig -2: Characterization of solid waste

1.2.2. MSW Bottom ash

MSWI reduces the volume of waste and its mass by about 70%. Deciding to incinerate waste instead of dumping it, takes careful consideration of the criteria for success. Incinerator ash from combustion of solid waste consists mainly of bottom ash and fly ash. It consists of the noncombustible and un-combusted fractions of the waste. It is usually very inhomogeneous. It is generally coarse sandy in appearance with a diameter varying between 0.1mm and 100mm. Physical and chemical properties of the incinerated bottom ash vary depending on the type and source of the solid waste. It is the largest residue stream from the incineration process, typically 150-300 kg/ton of waste incinerated and accounting for 85-95% of all the residues generated. The high cost of treatment or disposal, the shortage of landfill space and increased environmental awareness have prompted incinerator managers and federal or state agencies to find other uses of the incinerator bottom ash other than disposal.

2. Literature Review

In the recent year various studies related to the properties of solid waste have been carried out by renowned researchers. Incineration of municipal solid waste (MSW) with energy recovery and Management of MSW ashes have been receiving a growing attention around the world.Many European countries beneficially utilize MSWI bottom ash as a sustainable transportation material with environment criteria set by their strategic regulation. In U.S., MSW are being produced more than any other country in the world; however, the recycling rate is considerably low. The total MSW generation in U.S. has increased up to 65% since 1980, to the current level of 250 million tons per year with 53.6% landfilled, 34.7% recycled and composted, and 11.7% incinerated with energy recovery. The total of 86 MWS Waste to Energy(WTE) plants are being operated in 24 states of U.S. as of 2010, where major users of MSWI plants are connecting, New York, New Jersey, Pennsylvania, and Virginia.

3. Methodology

3.1. Data Collection

The basic information about waste generation, collection and then its disposal was gathered from World Wide Web. Case study of the previous published papers related to the topic gave us the technical information and a broad mindset of the required area.

3.2. Literature Review

The basic information about the topic that is use of bottom ash as road construction material is collected in data collection, with the help of this data we have to create the literature review by studying it. The problem which are arising is also identified and analyse in present situation.

3.3. Design of Incinerator

The incinerator is simply called as a waste recycling unit. We have rounded shell in which combustion process is carried out. We have the drum(barrel) in we provide two opening first one is for to put garbage and another one is for to collect the bottom ash sample in between two opening we have to provide sieve which separates out unburnt material form MSW.

Fig -3: Incinerator

3.4. Collection of Bottom ash Sample

After MSW incineration in the incinerator the residue substance is settle at the bottom of incinerator this is called as bottom ash.

3.5. Experimental Work

3.5.1. Sieve Analysis

Particle gradation can be carried out using the sieve analysis test. In this test the waste sample is passed through a set of sieve of different size.The sieves used for carrying out the tests are of sizes 5.6mm, 4.75mm, 4mm, 2.8mm, 1.4mm, 1mm, 710μ,600 μ,500 μ,425 μ,355 μ,300 μ,250 μ,212 μ,180 μ,150 μ,125 μ,90 μ,75 μ.The sieve analysis test can be carried out using mechanical shaker or by manual means also. To determine grain size distribution by sieve analysis for MSW bottom ash sample plot the particle size distribution curve.In this curve, percentage finer is taken as ordinate on natural scale and particle diameter(D) on logarithmic scale as the abscissa. The curve gives idea about type and gradation of ash.The ratio of D_{60} to D_{10} is called as coefficient of uniformity

$$CU= D_{60}/ D_{10}$$

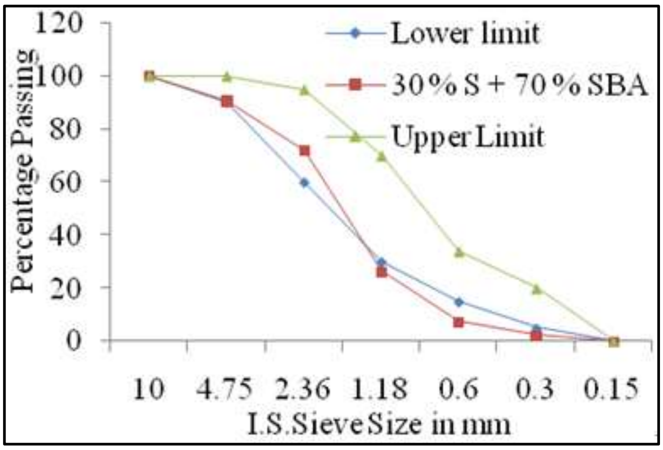

Fig -4: Grain Size distribution curve

3.5.2.Specific gravity test

The specific gravity of municipal solid waste bottom ash is found out using pycnometer apparatus. In this test various apparatus used are pycnometer, weighing balance, glass rod. Initially during the experiment clean and dry pycnometer is weighed(M1).Then the sample is filled in the pycnometer upto 1/3rd of its height.Then the weight of pycnometer is again taken(M2).Then rest of the pycnometer is filled with water and then weight is taken(M3).After this, again the pycnometer is completely filled with water only and the weighed(M4).Then specific gravity of municipal solid waste is given by the formula:

G= (M2-M1)/[(M2-M1)-(M3-M4)]

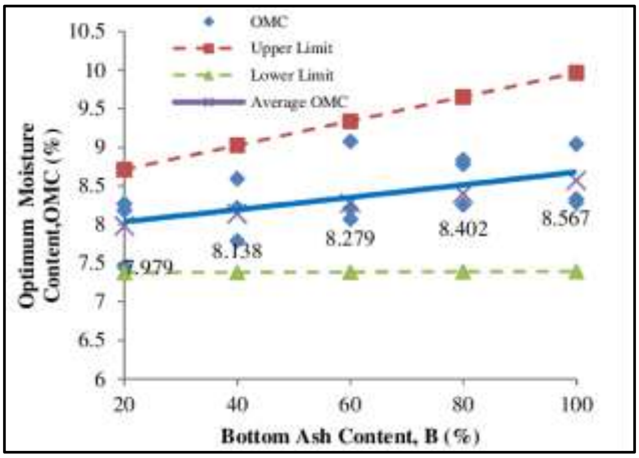

Fig -5: Optimum Moisture Content

3.5.3. Standard Proctor Test

To assess the amount of compaction and water content required in the field compaction tests are done on the bottom ash in laboratory. A mould of internal diameter 100mm,height 127.3mm and 1000ml capacity called the proctor mould,A rammer of 2.6kg is use for compaction.3 kg sample is taken and 4%water is added to the sample. For every 4% addition of water content to the sample, the dry density is determined.Initially the sample is compacted in three layers with desired water content and then the weight of the sample is calculated. For each sample the moisture content is determined and then a graph of dry density v/s water content is drawn .Thus the optimum moisture content at maximum dry density.

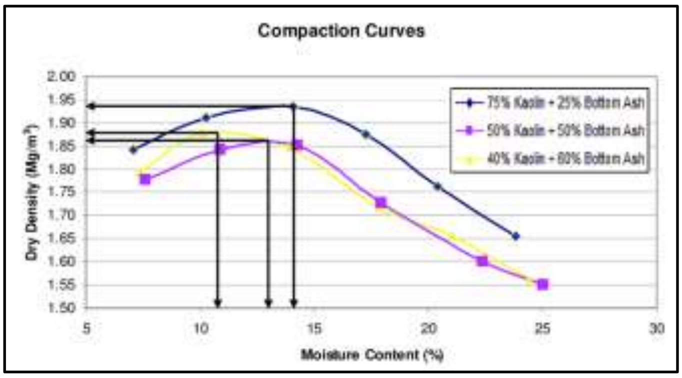

Fig -6: Compaction curve

3.5.4. California Bearing Ratio Test

For the calculation of cbr from load penetration curve Plot the load penetration curve in natural scale, load on Y -axis and penetration on X – axis. If the curve is uniformly convex upwards although the initial portion of the curve may be concave upwards due to surface irregularities make correction by drawing a tangent to the upper curve at the point of contra flexure as below Take the intersection point of the tangent and the X – axis as the origin. Calculate the CBR values for penetration of 2.50mm and 5.00mm. Corresponding to the penetration value at which CBR is to be desired, take the corrected load values from the load penetration curve and calculate the CBR from the equation :

PT x Cf CBR= --- x 100.

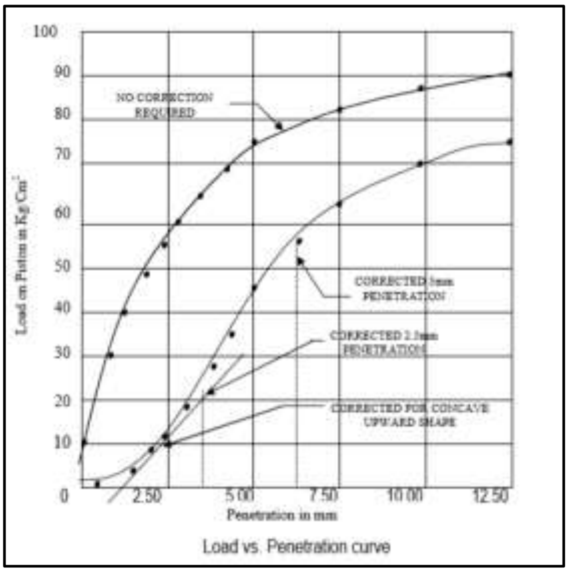

Fig -7: Penetration Curve

4. Conclusion

Based on the results of laboratory experiments on bottom ash,the following conclusions are drawn:It has been shown that bottom ash is to be suitable for various uses in geotechnical applications. Bottom ash is non-plastic material. Specific gravity of bottom ash is 1.96, which is lower than that of conventional earth material. value of cohesion increases with addition of clay in bottom ash and it further increases with the increase in cement content. This increase in cohesion is due to the bonding of particles by cement. Thus, the present study brings out the two-fold advantage; first, to avoid the tremendous environmental problems caused by large scale dumping of bottom ash, and second, to help in sustainable development of environment.

5. References

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[5]Washington DC.ards Institution (BSI), London, England, UK.