© 2019 IJSRSET | Volume 6 | Issue 4 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : https://doi.org/10.32628/IJSRSET19647

Development and Study for the Conversion of Silo Ash into Aggregate of Different Fraction

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ABSTRACT

In This Study, The Strength and Productivity of Artificial Aggregate of Different Fraction Made Utilizing Fly Ash (Silo Ash), Silo Fly Ash Has Been Used and The Attempt Has Been Made to Cast the Finished Product in The Form of Aggregate of Different Fraction. The Measured Properties of Artificial Aggregate Were Crushing Strength, Fineness Modulus, Leach ability Test or pH, Fine Wastage, Specific Gravity, Density and Water absorption

Keywords: Artificial Aggregate, Waste to Wealth, Industrial Waste Utilization, Geo Polymeric Aggregate, Synthetic Aggregate, Eco Friendly Product, Sand Alternative

I. INTRODUCTION

Usage of concrete around the world is second only to water. Fine aggregates are the main component for making concrete. Growing demand for fine-aggregates in construction (Nearly 65-80% of the volume of concrete and screed mixes is made up of sand / aggregates) has led to Injudicious sand mining .River sand is a product of natural weathering of rocks over a period of millions of years. Continuous depletion of natural aggregate sources have led to the implementation of new environmental/land use legislations which has made the procurement of natural sand difficult and expensive. Sand dredging is heavily taxed/ banned in many parts of the world. Sand researchers world over are in continuous research to find an alternative for river sand, which narrowed down on manufactured sand popularly known as M- Sand.

Various research were done by replacing natural sand with fly ash partially ,however it was found that to make it economical and fully environmental beneficiary full replacement is required. This research focused on the preparation of the geopolymer flash sand and its incorporation into the mortar and concrete as a complete replacement of river sand.

In the recent past, geopolymer concrete are widely researched as a replacement to traditional OPC, about 26-45% emission of CO_2 is reduced due to replacement. Geopolymer are mainly composed of inorganic alumina-silicate network formed by the dissolution of material having silica and alumina in an alkaline solution containing sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) or potassium hydroxide (KOH) and Potassium silicate (K_2SiO_3) yielding polymeric Si-O-Al-O bonds.

Agglomeration technique and hardening methods are generally followed for synthesis of artificial aggregates from fly ash. In agglomeration technique the pellet is formed in two ways either by agitation granulation and compaction.

Sintering, autoclaving and cold bonding are three different processes to harden the green pellet. The process mainly depends upon the type of pelletizer for the pelletization process. Disc type pelletizer is most commonly used in the production of artificial aggregates with good efficiency. Research has been carried out on the production of light weight aggregates using disc type pelletizer and curing has been done in cold bonding technique.

Some process uses fly ash mixed with water and in some cases small volume of additives are also added to the mix. Study has been made in past where fly ash was mixed with cement, Na-bentonite and powdered limestone as binders for pelletization.

In Europe after years of intense research technology was developed where carbon content was adjusted to a fixed and proper level prior to pelletizing for sintering operations.

The choice of geopolymeric sand as replacement of river sand has been supported in the previous studies. But limited work has been carried out on the use of geopolymer in the production of geopolymer aggregates which can an alternative for natural sand.

Generally with the increase in the temperature range from 100° to 900°, a drastically increase in the mechanical strength and durability properties. How ever most of the studies as well as our is reported that heat curing is required to activate geopolymer.Where as some researcher reported a gradual increase in strength of geopolymer concrete at ambient curing temperature. Geopolymer binder have contributed significantly towards resistance to sulphate, acid and fire exposures .Many researcher were done by replacing OPC cement with geopolymer however only few researcher have focused on replacing geopolymer with natural sand

In the study conducted S Rao at laboratory trial were conducted to produce flyash geopolymer sand as a replacement the natural river sand in concrete . Various properties such as specific gravity,particle size distribution, pH,TDS,XRD,SEM and mortar properties of flyash geopolymer sand. In this study,they have used sodium hydroxide and duration of curing time required for flyash geo polymer sand was (100°C for 7 days). Hence the current research firstly, focused on examining the usefulness of geopolymer flash sand as a replacement to natural river sand ,secondly on the reduction of curing period ,thirdly, on the use of industrial grade of sodium hydroxide. An alternative environmental friendly as well as techno-economical material to replace the depleting natural river sand and also to utilize abundant fly ash in the country

II. METHODS AND MATERIAL

2.1 MATERIAL

Aggregate is prepared from fly ash specially silo ash with help of NaOH solution in water. The fly ash used in aggregate preparation through Geopolymeric route is drive from Mouda Nagpur plant of NTPC. Detailed Physico-chemical characterization of fly ash such as pH, Loss On Ignition, Bulk Density, Specific Gravity is determine in Table-1.Through Energy Dispersive Spectrometer analysis ,Major and Minor Chemical Constituents of flyash such as SiO_2,Al_2O_3,Fe_2O_3,Cao,Mgo,Tio_2 was found in Table-2, On the basis of SiO_2 = 52.32%, Al_2O_3 = 26.29%, Fe_2O_3 = 4.96% and CaO = 1.83% content the fly ash was identified as class-F fly ash as per ASTM (C618 08) and Size analysis in Table-3. The NaOH use for the study is procured from kerela ,India has 90% purity in pellet form.

Table-1

Sample	pH	Loss on Ignition (%)	Bulk Density (ms/CC)	Specific Gravity
Fly Ash	6.1	0.39	1.01	2.01

Table-2

Constituents	Range (%)
SiO_2	49-50
Al_2O_3	24-27
Fe_2O_3	3-5
CaO	1-1.2
MgO	0.81-0.89
TiO_2	1.5-2.1

Table-3

S.No	Sieve size	Weight retained (gm) (fly Ash)
1.	+1.18 mm	5
2.	-1.18mm/+600 micron	2
3.	-600/+300 micron	30
4.	-300/+150 micron	365
5.	-150 /+75 micron	90
6.	-75 micron	8

2.2 OPTIMISING MOLARITY AND TEMPERATURE

Preliminary trials were conducted in order to optimize the temperature and Morality (5M-12 M) of sample which leads to formation of different fraction of aggregate after crushing in roller crusher .Parameter adopted for optimising is crushing value as per IS:2386 part-IV(1963) and Deleterious materials as per IS:2386(Part II)-1963 of aggregate prepared from sample at different temperature and Morality. Grading of fine aggregates, zone grading as per IS 383.) of crushed sample and Determination of Specific gravity, density and absorption as per IS;2386 (part III)- 1963 of optimized sand zone.

2.3. PREPARATION OF AGGREGATE FROM SAMPLE

For the preparation of sample ,fly ash is taken with NaOH solution which consist of water and NaOH pellets of 90% purity in pan mixer .NaOH is taken as 40gm in 1 litres .flyash and NaOH ratio is 5:1 to produce workable sample for oven drying . mix for 15 mint in pan mixer with gradually pouring NaOH solution. Wet sample is oven dry for 100° for 1 day. The dried sample after one day crushed in roller crusher followed by jaw crusher and sieved for15 mints. The mix was sieved through using sieve 4.75mm,36mm, 1.18mm,600micron, 300micron, 150micron, 75micron after roller crusher and jaw crusher Tests such as crushing valve specific gravity, water absorption, Fineness Modulus, Leachability test or pH were performed

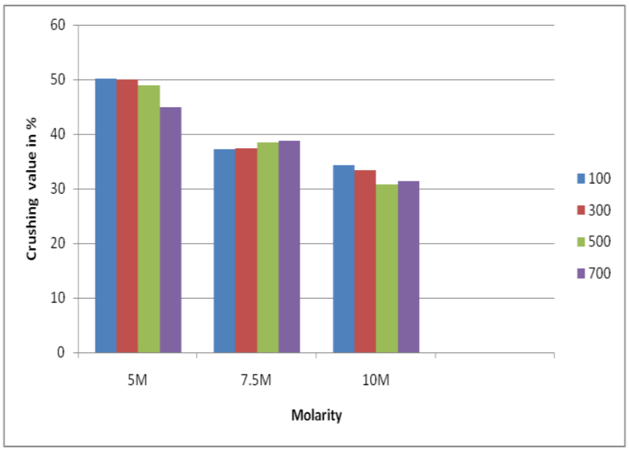
Figure 1. Mixing of Fly ASH with NaOH solution

III. RESULTS AND DISCUSSION

3.1 CRUSHING VALUE OF AGGREGATE

The strength of coarse aggregate is assessed by aggregate crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive strength. Crushing value as per IS:2386 part-IV(1963) is a measure of the strength of the aggregate. The aggregates should therefore have minimum crushing value. The test sample: It consists of aggregates sized between 12.5mm to 10.0 mm(minimum-3kg). passing 12.5mm IS sieve and retained on a10mm IS sieve are selected , Put the sample in 3 layers, each layer being subjected to 25 strokes using the tamping rod. Apply load at a uniform rate so that a total load of 40T is applied in 10 minutes. Sieve the material with 2.36mm IS sieve. Change in weight defines the crushing strength of aggregate. We observed that while increasing Molarity of NaoH solution and increasing Sintering temperature for paste containing NaOH+water+flyash for preparing aggregate. Which leads to increase in Crushing strength of aggregate,Comparison between temperature and Molarity is shown in Fig.3.1(a)

Figure 2. Crushing apparatus

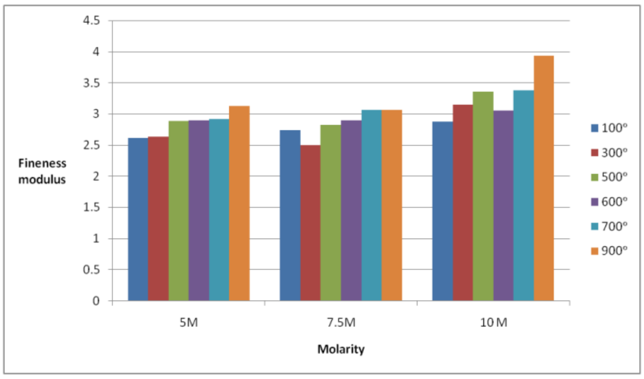


Graph 1 Comparison of crushing value of aggregates made from different concentration of NaOH

3.2 FINENESS MODULUS

Fineness modulus is generally used to get an idea of how coarse or fine the aggregate, More fineness modulus value indicates that the aggregate is coarser and small value of fineness modulus indicates that the aggregate is finer as per IS:2386 (Part I)-1963. Sieve the fine aggregate using sieves ranging from 4.75 mm to 150 micron. Calculate the cumulative percentage of retained aggregate on each sieve.Add all the values of Percentage of retained on each sieve.Divide the sum, calculated as above, by 100. The aggregate above 4.75 is crushed many times to brought it below 4.75mm.Generally natural sand fineness modulus lies between 2.2 to 3.2 either coarse or fine aggregate. Synthetic sand manufactured from fly ash also lies nearly, varies from 2.6 to 3.9 as you see in Fig 3.2(b)

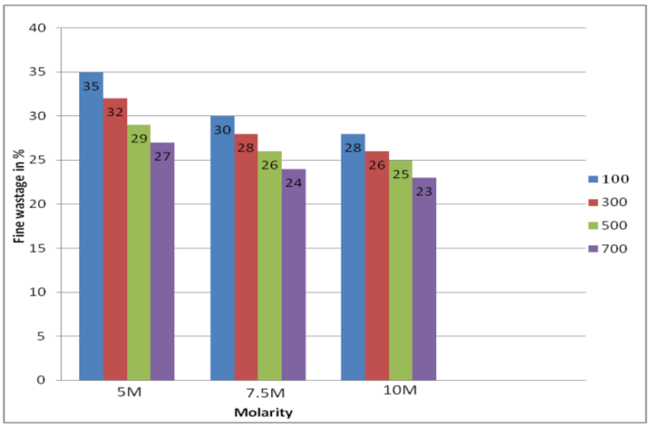
Figure 3. Seive Shaker



Graph 2 Relation of Fineness modulus with Varying Temperature and Molarity

3.3 FINE WASTAGE

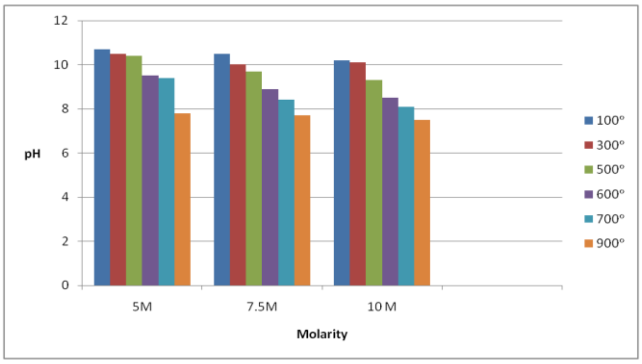
The fine wastage materials were obtained after crushing the sample in Jaw crusher and pulveriser followed by sieve analysis. The material left below 150 micron size sieve are considered as fine wastage material. Fine wastage is crushed into size of flyash (source material) therefore it is deducted in final product. Fine wastage material was found in less quantity for materials sintered at higher temperature and prepared with high Molarity. Results shown in Fig 3.3(a) shows the variation of temperature with molarity for sample



Graph 3 Relation of Fine wastage with Varying Temperature and Molarity

3.4 RELATION OF PH WITH VARYING TEMPERATURE AND MOLARITY

The final aggregate after crushing and sieving is test for leachability test with the help of pH paper . It is found that increasing molarity alkalinity increases but as temperature is increases to sinter it at high temperature the material will become inert .The pH values of samples treated at higher temperature were near to neutral side on the pH table but the values of pH of sample treated at lower temperature were towards alkaline side due the residual sodium hydroxide.



Graph 4 Relation of pH with Varying Temperature and Molarity

3.5 BULK DENSITY,

Bulk density of aggregate of sand size is calculated (As per IS: 2386(Part III) 1963) with the help of density basket .Three layer of artificial sand is pour in basket and compacted with 20 strokes in each layer with help of steel rod. Determination of weight and volume gives density of aggregate. Weight is divided by volume generally measures in gm/cc as shown in table 4

Figure 4. Density Basket

Table 4 Relation of Bulk Density with Varying Temperature and Molarity

Concentration of NaOH	Treated Temperature (in °C)	Bulk density (gm/CC)
5M	100°	0.99
	900°	0.93
7.5M	100°	1.00
	900°	0.93
10 M	100°	1.05
	900°	0.94

3.6 SPECIFIC GRAVITY

Specific Gravity is defined as the ratio of Weight of Aggregate to the Weight of equal Volume of water. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. This property helps in a general identification of aggregates. Specific gravity is calculated (As per IS: 2386(Part III) 1963). It is shown in Table5

Figure 5. Pycnometer test

Table 5 Relation of Specific gravity with Varying Temperature and Molarity

Concentration of NaOH	Treated Temperature (in °C)	Specific Gravity
5M	100°	2.09
	900°	2.01
7.5M	100°	2.04
	900°	2.00
10 M	100°	2.15
	900°	2.11

3.7 Water absorption

The water absorption of aggregate of sand size is calculated with the help of Oven drying method. Weight before and after of oven drying of aggregate about 100°C for 24 hour (As per IS: 2386(Part III) 1963) is shown in Table 6

Table 6 Relation of water Absorption with Varying Temperature and Molarity

Concentration of NaOH	Treated Temperature (in °C)	Water Absorption (%)
5M	100°	5.47
	900°	2.11
7.5M	100°	3.25
	900°	1.09
10 M	100°	3.98
	900°	0.83

IV. CONCLUSION

Sieve Analysis followed by calculations for fineness Modulus show that the synthetic aggregate of sand size is medium to coarse in size. Samples treated at lower temperature are graded in zone II and III while those treated with higher temperature falls in zone I and II. Grading results shows that the sample will suit for concrete works.

The aggregate crushing value results showed that aggregate made from 5 M treated NaOH at temperature range of 100°C to 900°C had value (50% to 42%) It is observed that samples treated with 7.5M NaOH and 10M NaOH at 100°C and 900°C showed crushing value of 31% to 37% which is recommended for wearing surface utilisation like road and Pavement.

Deleterious materials like Iron, pyrites, coal, shale , mica and other organic and harmful impurities are not reported as the aggregate is synthetic in nature however the sample below 75 microns were more in 5 M NaOH treated sample (4% to 10%) whereas it was less for 7.5MNaOH and 10M NaOH treated sample (2% to 5%).

The Bulk density of the synthetic aggregates varied from 0.93 to 1.03gms/CC. As the treatment temperature increased to 900°C the sample became light weight. The pH values of samples treated at higher temperature were near to neutral side on the pH table but the values of pH of sample treated at lower temperature were towards alkaline side due the residual sodium hydroxide.

Geopolymer aggregate of sand size prepared by using 10 M NaOH and as geopolymer liquid solu-tion and fly ash in proportion of 1:5 respectively had similar prop-erties as that of natural river sand. While comparing the properties of the geopolymeric aggregate and natural aggregate , they exhibited nearly similar properties in terms of specific gravity, particle size distribution and crushing strength.

Sandparticles achieved a specific gravity ranges from 2.01 to 2.11 which was com-parable with natural sand (2.67), however they exhibited a higher specific gravity than fly ash (2.12) due to the bonding provided by the Si-O-Al-O units. In spite of Geopolymeric aggregate exhibiting higher pH value (12.2) and water absorption (5% to 0.83 %) as compared to Natural aggregate like sand with 8.16 pH value and 0.82% water absorption, With this study, it may be concluded that the Fly ash aggregate could be used suitably as an partial alternative to Natural river sand in construction activities.

V. ACKNOWLEDGEMENT

The authors gratefully acknowledge the Technical support of Samrat Ashok Technological Institute,vidisha-M.P,India Faculty as well as AMPRI. Grateful to Principal Scientist,Dr.Akram Khan for his precious time and knowledge as well as Senior Technical officer,Dr. Prabha Padmakaran for providing guidance during writing.The experimental work was carried out in the concrete technology laboratory of the Civil Engineering Depart-ment at the Samrat Ashok Technological Institute, Vidisha as well as AMPRI civil department . The assistance of the laboratory staff is acknowledged here. I am grateful to Er Rakesh kumar Chhalotre and Kumud Deshmukh for their co operation in working.

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Cite this article as :

Zohaib Uddin, Dr. Prabha Padmakaraan, Dr. Ak Saxena, "Development and Study for the Conversion of Silo Ash Into Aggregate of Different Fraction", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 4, pp. 99-111, July-August 2019. Available at doi : https://doi.org/10.32628/IJSRSET19647
Journal URL : http://ijsrset.com/IJSRSET19647