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Influence of Alkali Binder Dosage on the Efficiency of Pelletization of Aggregates from Iron ORE Tailing and Flyash

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***Abstract:*— The present study focused on the production of artificial aggregates by means of pelletization. Factors affecting the efficiency of pelletization process are type of binder, moisture content, process duration and alkali binder dosage. The various alkali binder dosages to assist the iron ore tailing and fly ash particles coagulation within to produce the artificial aggregates pellets were investigated with other parameters as constant. The produced artificial aggregates were analysed for the pelletization efficiency of pellets produced through sieve analysis. It was observed from the test results that the pelletization efficiency of different aggregates was found to vary with increase in dosage of alkali solution to binder ratio. The pelletization efficiency also found to be varying with the change in proportion of flyash and iron ore tailing.**

***Index Terms* :-- Pelletization, Iron ore tailings, flyash, alkali binder, Pelletization efficiency.**

I. INTRODUCTION

The pelletization theory was developed in 1940's. Pelletization of fine powders has grown greatly in importance as an industrial process and particularly in the metallurgical industry [1]. Even it is a known technique in the production of artificial aggregates, it has not been extensively used in construction sector. The pelletization process is used metallurgical industry and produced the pellets about 435 million tons in 1985, while use in construction sector for production of lightweight aggregate was only about 1.2 million tons in 1989 [2]. The reason behind it was availability of natural resource and production costs relatively high for the production of artificial aggregate when compared to natural aggregate.
A large number of Coal/Lignite based thermal power plant 90 Nos (Central Electricity Authority – CEA: 2011-12) is setup for providing electric power to rapidly growing industrial as well as agriculture sectors. In which 70 percent of the electricity generated is from coal based thermal plants. A recent report from the CEA in December 2013 presented that fly ash production in India is about 163.56 MT. Further, it is reported that in the year 2016 -17 fly ash production is expected to be increase by around 300 - 400 MT per year. Such a huge quantity does pose a great challenge in the form of land usage, environmental threat and health hazards.

On the other hand environmental problem is not only production of flyash, but also due to the mining of minerals. During the extraction and processing of mineral resources, waste generated is one of the largest waste streams, yet to be accounted for. It normally involves materials that must be removed to gain access to the mineral resources, such as overburden, topsoil and waste rock, as well as the tailings. These huge amounts of mine tailings from mining process has led to the growing concerns about the ecological and environmental impacts such as, generation of windblown dust, contamination of surface & underground water and large area of occupational land [3-5]..

For last two decades fly ash is being used as an artificial pozzolanic material for manufacturing of Portland Pozzalona Cements or blended cements in the production of building materials such as fly ash bricks and precast units, as a suitable material in ready mixconcrete, in agriculture, construction of roads, land filling of mines and low lying areas and several other applications. Recently, it is found from the literature that fly ash can be replaced with cement even upto100% by introducing suitable polymeric binders and known as geo-polymer cement[6-7]. Geopolymer cement is an innovative material and a true alternative to conventional Ordinary Portland Cement (OPC). It relies on minimally processed natural materials or industrial by-products to significantly reduce its carbon footprint.

Production of artificial aggregates pellets from iron ore tailing and fly ash with alkali solution is considered to be a very satisfactory economic and environmental alternative, since a starting material with no value becomes a product with important industrial applications. Many researchers reported that the factors affecting the pelletization process in producing the pellet from finer particles such as raw materials, moisture content, binder type, dosage and duration of pelletization [1,8-12]. However, the efficiency and the engineering performance of produced pellets depends mostly on the binder used in the process [1,9,13].Thus, the paper discuss about influence alkali solution dosage for flyash and/or iron ore tailing fines with all other parameters as constant in the production of artificial aggregates through pelletization. The artificial aggregate can be used in construction are landfills, drainages utilities, in production of precast elements.

II. EXPERIMENTAL

A. Raw materials

Flyash was collected from M/s Udupi power plant, Padubidri, Karnataka and conforms to the requirements of siliceous fly ash of IS: 3812-2003 (Part -1). Iron ore tailings is collected from KudremukhIron Ore Company Ltd (KIOCL).Laboratory grade sodium silicate solution (Na_2SiO_3) with Na_2O/SiO_2 = 3.3 (8.0% Na_2O, 26.5% SiO_2, 52.5% H_2O by mass) and sodium hydroxide (NaOH) flakes of 99% purity supplied by Loba Chemicals were used to prepare the alkali solution.The results of the tests for determining the physical properties and chemical properties of fly ash and iron ore tailing are tabulated in Table 1.

Table 1: Physical and chemical properties of various binder materials used.

Observations	**Class – F fly ash**	**Iron ore Tailing**
Specific gravity	2.2	2.83
Blaine's fineness (m2/kg)	240	-
Fineness modulus	-	2.15
Chemical properties		
SiO_2	60.6	50.82
Al_2O_3	28.6	11.42
Fe_2O_3	3.9	33.11
CaO	2.7	-
MgO	0.8	-
SO_3	0.2	-
Na_2O	0.1	-
K_2O	0.1	-
LOI	-	2.28

B. Mix proportions

The raw flyash and iron ore tailings (passing the 600 µm sieve) were used for the production of pellets. The pelletization of the artificial aggregates pellets produced from iron ore tailing and flyash with alkali solution as binder with the following proportions (Table2).The alkali solution prepared by mixing both sodium silicate solution and sodium hydroxide solution (10M) in the ratio of 2.5 and immediately transferred to a container with air tight cap, left for at least 24 h to cool, before using the solution for the pelletization process (Hardjito et al 2004).

Table 2:Test matrix of material mix proportions for pelletization process

Proportion No	**Mix Code**	**Flyash content (%)**	**Iron Ore Tailing Content (%)**	**Alkali solution (alkali sol/binder)**
1	F100I0S1	100	0	0.271
	F100I0S2			0.292
	F100I0S3			0.325
2	F70I30S1	70	30	0.250
	F70I30S2			0.271
	F70I30S3			0.283
3	F30I70S1	30	70	0.229
	F30I70S2			0.250
4	F0I100S1	0	100	0.229
	F0I100S2			0.250

C. Pelletization

Pelletization was carried out by a laboratory disc pelletizer. A fabricated disc pelletizer as shown in Figure1 was used in this study which has a disc diameter of 450 mm and depth 100 mm. The angle of disc of disc 45° (Baykal et al 2000; Ramamurthy et al 2006; Gomathi et al 2014) and 15 min duration of pelletization is used in the process of pelletization (Gomathi et al 2014). For this investigation rotational speed of disc is maintained at 10 rotation per minute is for all mixes.

Figure 1: Laboratory disc pelletizer

Raw materials in proportions are transferred to the pelletizing disc, the alkali solution is sprayed (Figure 2). When a raw material is moisturized, a thin liquid film is formed on the surface of the grains, which forms meniscus

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between the grains, structures like bridges. The particles are rotated in a disc, then they form ball shape structures with enhanced bonding forces between grains due centrifugal and gravitational forces (Figure 3).

Figure 2: Spraying of Alkali Solution

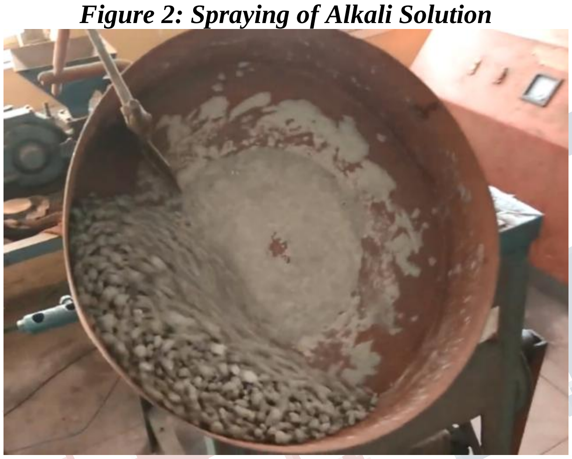

Figure 3: Pellets formation

The produced artificial aggregates left spread (Figure 4) for air curing for 3 days before further investigation for the efficiency of the pelletization and gradation of aggregates.

Figure 4: Air curing of the artificial aggregates

III. RESULTS AND DISCUSSION

A. Efficiency of pelletization

The pelletization efficiency of artificial aggregate produced for severalproportion of fly ash and iron ore tailing for different alkali dosages arepresented in Table3. The efficiency, size and shape of aggregate were affected by the dosage, as it was observed that the lower dosage the pellets were formed with perfect shape and subsequently turns into irregular shape by binding with the other pellets.

Table 3: Pelletization efficiency and fineness modulus of various proportions

Proportion No	Mix Code	Efficiency (%)	Fineness Modulus
1	F100I0S1	82.14	6.43
	F100I0S2	91.29	6.75
	F100I0S3	99.00	6.79
2	F70I30S1	89.03	6.29
	F70I30S2	95.58	6.26
	F70I30S3	97.96	6.66
3	F30I70S1	97.39	6.71
	F30I70S2	99.50	7.42
4	F0I100S1	94.23	6.13
	F0I100S2	97.15	7.32

B. Aggregate gradation

The size and shape of the aggregates is an important factor in the mix design and was determined as per IS: 2386 (Part 1, 1986). The particle size analysis is evaluated for all the proportions with standard sieve analysis as per IS standards. The particle size distribution and gradation curve for various pelletized aggregates arepresented in Figure5-8.The fineness modulus of the all the proportions of pelletized aggregates presented in Table 3.

It can be observed from the test results that the artificial aggregates produced were having a uniform round shape and the growth in size of pellets depends on the dosage of the alkali solution. For proportion 1, it is observed that the dosage of the alkali solution is more when compared other proportions. This is due the finer particles in the proportion requires the more solution to form pellets. The fineness modulus of proportion 1ranges from 6.43 to 6.79 showed that all the mixes have uniform gradation and it is clearly observed in the Figure 5.

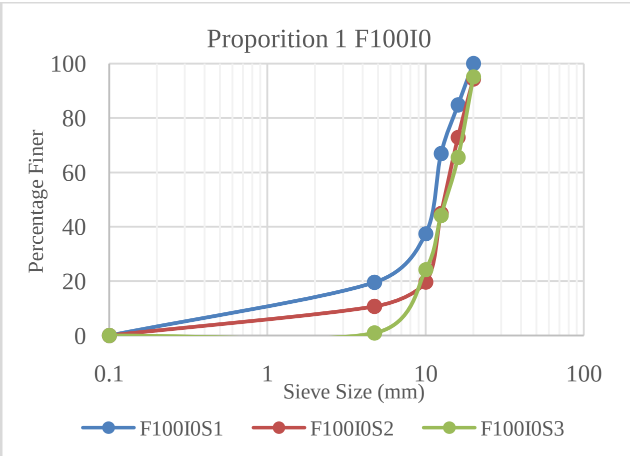

Figure 5: Particle size distribution of different types of aggregates with proportion 1

In proportion 2, the efficiency of pelletization achieved more in lower dosages. Since the introduction of iron ore tailing which is coarser then the flyash. The fineness modulus of proportion 2ranges from 6.29 to 6.66 showed that all the mixes have uniform gradationand increasein the efficiency as the dosage increased and it can be clearly observed in the Figure 6.

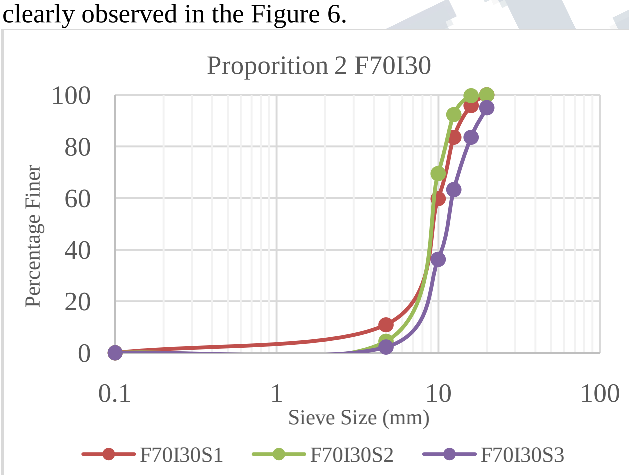

Figure 6: Particle size distribution of different types of aggregates with proportion 2

However, the further increase in iron ore tailing in proportion 3 and complete replacement in proportion 4 showed more efficiency of pelletization in lower dosages than other proportions. For proportion 3, the fineness modulus changed from 6.71 to 7.42with only small amount of change in alkali dosage, which in turns showed huge change in the gradation and it can be clearly observed in the Figure 7. Similarly, in proportion 4 the fineness modulus changed from 6.13 to 7.32 with only small amount of change in alkali dosage and it can be observed in the Figure 8.

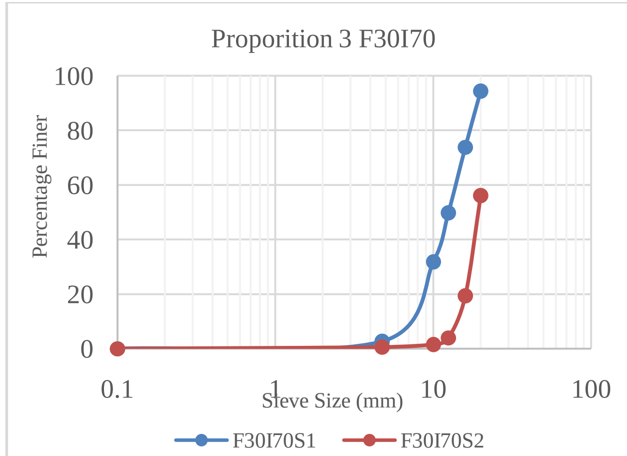

Figure 7: Particle size distribution of different types of aggregates with proportion 3

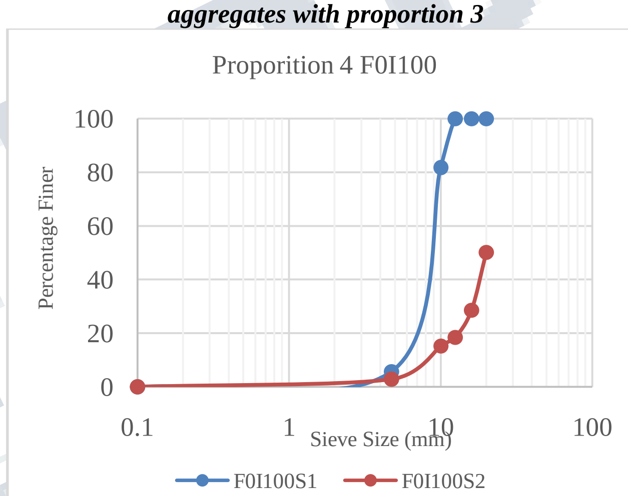

Figure 8: Particle size distribution of different types of aggregates with proportion 4

IV. CONCLUSION

Present investigation showed that the increase of alkali binder dosage increases the pelletization efficiency for combination of flyash and iron ore tailing with uniform gradation. The increase in the iron ore tailing proportion in mixes showed the huge gradation change with change in the smaller alkali binder dosage. It is mainly the proportion that influences the efficiency of pelletization process. The results showed that the alkali binder dosage is having greater influence in pelletization of iron ore tailing and flyash proportions. The efficiency of pelletization process also depends on the physical properties of the agglomerated material, the mechanical parameters and the alkali binder dosage.

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