Fly Ash Utilisation for Value Added Products
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Light-weight aggregates for advanced civil engineering

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ABSTRACT

Currently, Indian Thermal Power Stations generate collectively around 80 million tonnes of coal ash annually, which is slated to touch a staggering level of 110 million tonnes by the turn of the century, in the process of threatening to sterilise huge tracts of scarce agri-land, besides the associated environmental degradation. To address this challenging situation, MOE&F, GOI, has issued Gazette Notification for mandatory utilisation of coal ash by Power Utilities over a specified time span, ensuring future bulk coal ash utilisation. It is a natural corollary, therefore, that concept of the use of fly-ash as construction material emerged as a major route for the recycling of fly-ash and, in the process, a thorough global technology search yielded Sintered Light Weight Aggregates which consist of as high as 99.3% fly-ash.

Key words : Light weight aggregates, Flyash utilisation, Construction material

1.0 INTRODUCTION

Light-weight Aggregate (LWA), a versatile construction material, is produced by pyro-processing of fly-ash and is formed as a result of agglomeration which occurs as the ash particles fuse and bond together.

The production of LWA from fly-ash has been long established. With the advent of technology, new processes have been developed. Of these processes, the LYTAG technique is most widely accepted. This method has been in operation in UK for the last 37 years. The LYTAG technology is being sought for light-weight aggregate production in many parts of the world including the UK, Netherlands, Poland, the USA, Australia and, now in India.

2.0 THE PROCESS

2.1 Ash supply & mixing

A typical LWA factory is normally installed in the vicinity of thermal power station. As the process is continuous, the plant should run on a 24 hours per day, 7 days per week basis.

Dry Fly-ash is transferred pneumatically from power station to storage silos of the

factory. To ensure continuous production and smooth out supply fluctuations from the power plant these silos are sized for 48 hours production.

From the factory silos, the ash can be directed to number of identical production lines. On any particular line, a system of screw feeders transfers the ash to a mixer at a controlled rate of flow.

At this point, water and if necessary, additional fuel in the form of high carbon fly-ash or coal is added and mixed with dry ash. These additions produce a homogeneous material containing sufficient energy to raise the temperature of the ash to the sintering point later in the process.

2.2 Pelletizing

The moisture "conditioned ash" is now introduced to large diameter flat disc pelletizers. On these slowly rotating inclined pans, the small particles of ash impact on each other. The pellets gradually grow in size due to compaction forces as they fall across the pan.

The surface tension effects of further water addition in a fine spray, complete the agglomeration process.

This is a critical point in the production of the finished aggregate. The pellets must not grow too large or become too wet if they are to be strong enough to withstand the next stage of the process. Constant monitoring of the pelletizers ensures that the pellet formation is optimised. As the finished pellets fall from the pelletizer they are led to a moving steel conveyor - the sinter strand.

2.3 Sintering

The pellets are placed in a loose layer 200 to 250 mm thick. The sinter strand speed is automatically adjusted to ensure an even layer across and down its length. The pellets are immediately subjected to a temperature of 1000-1100*C depending on the softening point of Fly-ash being used.

This heating is done in the ignition hood of the sinter strand which uses reprocessed oil as fuel. Despite great thermal shock, the degradation of the pellets is very small.

The strand moves forward and the material emerges from the ignition chamber. The burning is pulled down slowly through the full depth of pellet bed by down draft air.

The burning of the fuel and the loss of moisture lead a cellular structure bonded together by the fusion of fine fly-ash particles. The voids formed are generally interconnected and occupy 40% of the body of the round inert pellet.

When the mass of sintered pellets falls from the end of sinter strand it is in a relatively cool state at 100 to 200°C.

2.4 Grading & Storage

At the end of the sintering strand, the finished pellets are mechanically separated by

primary and secondary screens to remove oversized material (>12 mm) and dust (<0.5 mm) and to grade the remaining pallets to market or customer specification (normally 0.5-2mm, 2-4mm, 4-8mm, 6-14mm).

The finished product is normally stored in the open in all weathers.

2.5 Quality Control

The finished aggregate is subjected to a regular quality control procedure through daily testing schedule.

The principal properties like strength, density and moisture content are checked frequently. Other low variation parameters such as LOI, sulphates, chmical composition etc. are tested on weekly or monthly basis.

3.0 PROPERTIES OF LIGHT WEIGHT AGGREGATES

3.1 Shape, Colour and Texture

The pelletizing action provides a rounded, spherical shape to the finished aggregate. The external brown colour and the internal black core are related to the carbon content and oxidation state of the iron present.

Surface texrure is defined as smooth, but on the micro-scale it is relatively rough with open pores which allow moisture to enter and exit the aggregate. When mixed in concrete, these pores are filled with cementitious products.

3.2 Internal voids

The internal structure is a honeycomb one of generally interconnected voids of varying size and shape amounting to about 40% of the volume. These air voids act as insulant, enhancing the thermal properties of resulting concrete.

3.3 water absorption and curing

Sintered fly-ash aggregate absorbs 12% by weight of water within 30 seconds. Prolonged soaking in water results in 15% moisture absorption.

3.4 density and stregth

The typical oven dry bulk density of sintered fly-ash aggregates lies in the range 750 to 1,100 kgs/m^3. The larger the size of the pellets, the lower the bulk density and, more importantly, the lower the strength of the aggregate.

In general, the strength of LWAs can be related to the resulting concrete strength and is often referred to as a 'ceiling strength'.

With the higher strength aggregates such as Lytag-LWA, a practical limit of 70 N/mm^2 may be assumed when using an 'all lightweight' aggregate in the concrete mix. It should be noted that, with sand replacing the fine aggregates and the use of suitable additives, strengths of 100N/mm^2 have been achieved in the laboratory.

3.5 chemical properties

The majority of manufactured LWAs are considered chmiucally inert in that they are free of harmful substances and do not show deleterious reactions. It is recognised, for example, that LWAs do not contribute to the alkali content of a concrete mix when alkali-silica reactive components are being assessed.

4.0 USE AND APPLICATION OF LIGHT WEIGHT AGGREGATES

Aggregates and fillers are important ingredients for the concrete industry. Concrete and many corresponding products have four major ingredients, viz, Aggregate, sand, cement and water, all of which have a specific task to fulfill in the mixture. Given the purpose concrete is expected to fulfill (strength, density, durability, green strength), a well-chosen mix of ingredients will prove to be economical without sacrificing quality or suitability. The Market share of fly ash in Europe (application area and that of light weight aggregates are shown in figure 1 and 2 respectively).

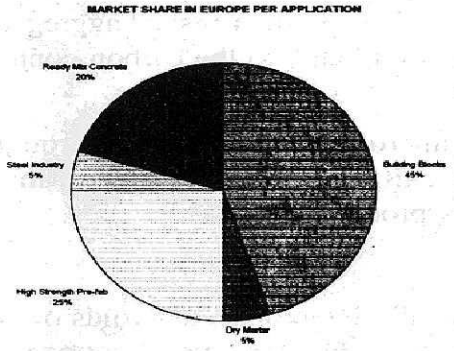

Fig. 1 : Re-use of fly ash in Europe

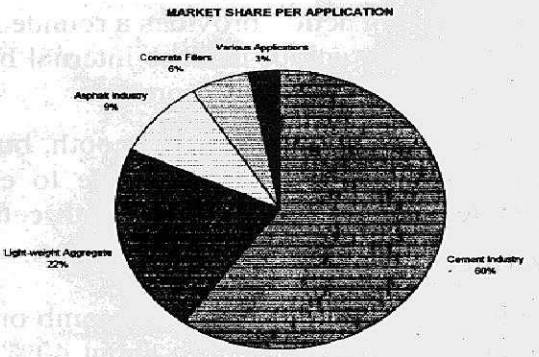

Fig. 2 : Light weight aggregate

4.1 Concrete

Lytag-lwa has been successfully used in lconcrete applications in a wide variety of constructions like housing projects, structural concrete, etc. A glowing example of the use of lwa in heavy civil engineering is the construction of a bridge in the 6-lane motor-way in the Netherlands and the construction of 85,000 gravity base tank for storage of oil.

LWA, when used, results in a concrete mix which is 20% lighter in weight when compared to 'natural gravel concrete'. A comparative study is shown in the table 1.

Experience has shown good results in the pre-fab industry, where it is used for pre-stressed high-strength concretes and normal concretes.

Apart from the above advantages, use of lwa drastically reduces drilling and cutting costs. The qualities of lwa concrete regarding carbonation chlorination of reinforcement and cracking are found to be superior to natural gravel concrete. A comparison of

suitability of light weight aggregates Vs natural stavel in various applications in indicate in table. 2.

Table 1 : A comparative study of LWA-concrete mix and natural gravel concrete mix

Lytag-LWA concrete mix (4-12)			Natural gravel concrete mix (4-16)		
Cement PC	102 x 3,15 =	320 kg		102 x 3.15 =	320 kg
w.e.f. 0,55	176	176 kg		176	176 kg
Sand 40%	283 x 2.65 =	750 kg		283 x 2.55 =	750 kg
Lytag-LWA (dry) 60%	425 x 1,41 =	599 kg	Gravel	425 x 2.65 =	1126 kg
Water absorption	15%	90 kg			- kg
Air	14	- kg		14	- kg
Total for 1000 litres = 1935 kg			Total for 1000 litres = 2372 kg		

Table 2 : Comparison of the suitability of Lytag-LWA vs. Natural gravel in various applications

	Strength	Dimension	Creep	Durability	Colour
Blocks	0	0	0	0	—
Prefab plain concrete	0	—	0	0	—
Pre-stressed concrete	- 0	—	0	0	0
Ready mix, portion ≥ 20% Sand	0	0	0	0	0
Mortar dry	0	++++	0	++	0
Mortar wet	0	++++	0	++	0
Asphalt	—	—	0	- 0	0
Steel Industry**		++++++			

** In the steel industry, Lytag-LWA is used as an isolator, replacing higher priced isolating imaterials.

0 Gravel ++++ Better than gravel — Worse than gravel

4.2 Block Making

Due to its light-weight and good isolation properties, lytag-lwa is also widely used in the block-making industry. The relatively dry mixture of Lytag-lwa, cement and sand/ Lytag-lwa dines is easy to compact and gives an excellent partial hollow building block with a strength of approx. 10 N/mm2 and a weight of approx. 1100 kg/m3. Walls made of Lytag-lwa concrete blocks have very good water absorption properties and are easy to drill and cut.