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Feasibility of "Pulverized Fuel Ash or Fly Ash" Environmental Aspects

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Abstract : **Fly Ash is Fine powder in grey color, it is a by-product from coal based thermal power plant (TPPs), Fly Ash bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks. Some of the problems associated with Fly ash are large area of land required for disposal and toxicity associated with heavy metal leached to groundwater. Fly ash, being treated as waste and a source of air and water pollution till recent past, is in fact a resource material and has also proven its worth over a period of time. It is the action of human beings that determines the worth of any material. Materials having potential for gainful utilization remain in the category of waste till its potential is understood and is put to right use. Fly ash is one such example, which has been treated as waste materials, in India, till a decade back, and has now emerged not only as a resource material but also as an environment savor. Fly ash material is solidified while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 100 µm. They consist mostly of silicon dioxide (SiO2), aluminum oxide (Al2O3) and iron oxide. Fly ash concrete was first used in the U.S. in 1929 for the Hoover Dam, where engineers found that it allowed for less total cement. It is now used across the world. Its Having no virtual odor ,Non – Toxic ,Non – Flammable ,Non - Explosive Fly ash does not have any adverse health effects, however when the exposure to fly ash is more than the recommended limits, the necessary protective equipment for respiratory / eye / hand / skin protection to be used. This paper presents different ways of using Fly ash in various sectors of civil engineering construction industry in India.**

Keywords: Fly Ash, Tpps, Filter Bags, Toxic, Pulverized Flue Ash, Coal Ash

1. INTRODUCTION

FLG-G(Fly- Ash-lime Gypsum)

FAL-G is not a brand name, but a product name like Ordinary Portland Cement (OPC). This name is given for easy identification of its ingredients. FAL-G stands for Fly-Ash-Lime-Gypsum. In recent days, Lime-Gypsum is being replaced by OPC cement as it is cheap and also quick setting. The process itself is concept development based on a cement theory called "Crystallo-Mineral Combination or setting behavior" in technical jargon. In a recent development it was found that use of OPC in many places is not only economical but also it provides quick setting, faster curing, improved strength, and overall better quality (including strength) The general Fly ash bricks fall in the strength zone of 60-250 Kg/Cm^2, thus is much stronger than conventional Bricks. These bricks gain strength over a period of time up to 2 years, whereas the conventional bricks tend to lose strength over a period of time.

These green bricks can attain very regular and uniform shapes. As no burning is involved, so the shape also remains unchanged. As a result, the final Brick work with these green bricks consumes less mortar to build, less mortar to plaster. Further, the FAL-G being artificial cement itself, it forms a more uniform bond with cement, giving almost a homogeneous structure. Not only this, even exposed brickwork (without plastering) is a good durable structure. So people prefer to leave the Green Bricks Brickworks in garages, boundary walls etc. un-plastered. These bricks are suitable for use in masonry construction just like common burnt clay bricks. Production of pulverized fuel ash-lime bricks has already started in the country and it is expected that this standard would encourage production and use on mass scale. This stand lays down the essential requirements of pulverized fuel ash bricks so as to achieve uniformity in the manufacture of such bricks. Fly ash is a naturally-cementations coal combustion by-product. It is extracted by the precipitators in the smokestacks of coal-burning power plants to reduce pollution. About 120 coals based thermal power stations in India are producing about 112 million tone fly ash per year. With the increasing demand of power and coal being the major source of energy, more and more thermal power stations are expected to be commissioned/ augment their capacities in near future. Fly ash has been considered as a "Pollution Industrial Waste"

2. RAW, MATERIALS, SOURCES AND AVAILABILITY.

Fly Ash s the inorganic mineral residue obtained after burning of coal/lignite in the boilers. Fly Ash is that portion of ash which is collected from the hoppers of ESP's and pond ash is collected from the ash ponds. Bottom ash is that portion of ash which can be collected fro the bottom portion

of the boilers. The characteristics of fly ash depend upon the quality of lignite/coal and the efficiency of boilers.

India depends upon primarily on coal for the requirement of power and her power generation is likely to go up from 60,000MW in the year 2010.The generation of fly ash is also likely to increase. The fly ash generation in India Thermal Stations is likely to shoot up to 170 million tons in 2010 from the present level of 100 million tones. The disposal of fly ash in the present method will be a big challenge to environment, especially when the quantum increases from the present level.The proposed unite will be using both type of fly ash depends upon the availability

2.1. Fly-Ash:

Fly-Ash Raw material is freely available in Thermal Power plants. There are no taxes on this item whatsoever. Transportation charges are only to be attended by the entrepreneur. However, the proposed Unit will get Fly Ash from locally available Thermal Power plants, which is having best quality fly ash not only in the country, but also in the whole world

2.2. Lime/OPC: Lime used in this process is known as Hydrated Lime, which can be obtained by Calcining Brunt Lime. One KG of Brunt Lime gives 2.2 Kgs of Hydrated Lime after Calcining. Brunt Lime can be obtained from Kuddur, Andhra Predesh where Lime Kilns and High Quality Brunt Lime are pettily available. Alternatively Hydrated lime is available as an industrial by-product of Paper Mills.

2.3. Gypsum: This too is an industrial waste. This is available at Fertilizer Plant as in industrial wastes. Hydrated calcium sulphate is called gypsum. ($CaSo4\ 2H_2O$).

2.4. Sand / Crusher / Dust: Sand is used as an economizer and to increase the strength of bricks to some extent. Sand is procured locally. Crusher dust can also be successfully used in place of sand.

2.5. Characteristics of Fly ash

2.5.1. Characteristics:

Specific Gravity	2.54 to 2.65 gm/cc
Bulk Density	1.12 gm/cc
Fineness	350 to 450 M2/Kg
Drying Shrinkage	0.15%

2.5.2. Water Absorption: The bricks, when tested in accordance with the procedure laid down in IS-3495 (Part-2):1976, after immersion in cold water for 24 hours, shall have average water absorption not more than 20%. Water is an essential but temporary constituent of fly ash bricks. If is needed to form them but is subsequently eliminated during drying.

Name of Thermal Power Plant

Sl.No	Name Of Thermal Power	Finener S.S.M By Blaine Method	Lime Reactive Kg/Cm^2
1	Bandal	6247	57
2	Basin Bridge	4080	56.8
3	Bokaro	6140	--
4	Chandarpura	4700	50
5	Delhi	3595	63.8
6	Durgapur	4480	--
7	Ennore	5283	51.6
8	Hardwagani	3780	52.7
9	Kanpur(Panki)	6091	54
10	Neyveli	3509	62.43
11	Palondh (A.P.)	3800	58
12	Badarpur	3300	54
13	Faridabad	3900	52

2.5.3. Chemical Properties:

Silica	35-59 %
Alumina	23-33%
Calcium Oxid	10-16%
Losson ignition	1-2%
Sulphur	0.5- 1.5%
Iron	0.5-2.0%

2.5.4. Classification:

The fly ash-lime	Bricks shall be of the following four classes depending upon Their average compressive strength :	
Class (N/mm^2)	Average Compressive Strength	
	Not less than	Less Than
7.5	7.5	10
10	10.5	15
15	15	20
20	20	0

3. TYPES OF FLY ASH

3.1 Class "F" fly ash

The burning of old anthracite and bituminous coal typically produces Class F fly ash which contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class"F" Fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementations compounds. Alternatively the addition of a chemical activator such as sodium silicate (water glass) to a Class "F" ash can lead to the formation of a geo polymer**.**

3.2 Class C Fly ash

Class "C" Fly ash produced from the burning of younger lignite or sub bituminous coal generally contains more than 20% lime (CaO). This type of ash does not require an activator & the contents of Alkali and sulfate (SO4) are generally higher as compare to the Class "F"

3.3 Fly Ash- Sand-Lime-(Gypsum /Cement)

Fly Ash can be used in the range of 40-70%. The other ingredients are lime, gypsum /cement, sand, stone dust/chips etc. Minimum compressive strength (28 days) of 70 kg/cm^2 can easily be achieved and this can go up to 250 Kg/cm^2

Fig (3i) typical ash colors (Class "F"&"C" Fly ash)

4. MARKET SURVEY

180 billion tones of common burnt clay bricks are consumed annually approximately 340 billion tones of clay-about 5000 acres of top layer of soil dug out for bricks manufacture, soil erosion, emission from coal burning or fire woods which causes deforestation are the serious problems posed by brick industry. The above problems can be reduced some extent by using fly ash bricks in dwelling units. Demand for dwelling units likely to raise to 80 million units by year 2015 for lower middle and low income groups, involving an estimated investment 0f $670 billion, according to the associated chamber of commerce and industry. Demand for dwelling units will further grow to 90 million by 2020, which would require a minimum investment of $890billion.

4.1 Indian Housing Sector:- at present faces a shortage of 20million dwelling units for its lower middle and low income groups which will witness a spurt of about 22.5million dwelling units by the end of Tenth plan period. There is ample scope for fly ash brick and block units.In Chennai alone 1 core bricks are required for constructional activities in every day. But good quality of bricks as well as required quantity is not available moreover during the rainy seasons supply of clay bricks are very difficult. Therefore, in order to fulfill the required demand there will be a great chance to start more units in the field of fly ash bricks. At present 20nos units are engaged and 40 lakes no's of bricks per month are manufactured in our state. And there will be scope to start near about 100 units, which will be produced more than 2 cores no of bricks per month in future. Thus marketing of these product are well shinning. In the state of Orissa there is not a single unit engaged in the manufacture of fly ash lime bricks. However, at present 3 SSI units are engaged in the manufacture of Fal-G (Fly ash-lime-gypsum) bricks with low investment.

4.2 National Aluminums Company Ltd.:-(NALCO) in Orissa is encouraging prospective entrepreneurs to go for the manufacture of fly ash-lime bricks by With the rise in population and increase in the constructional activities considering the improvement in the standard of living, the demand for building bricks is increasing day by day. Fly ash lime building bricks are not only the substitute for clay burnt building bricks but also are considered superior in comparisons to clay burnt bricks. In Orissa at present people are switching over to cement concrete hollow and dense bricks and blocks and fly ash-lime-gypsum bricks manufactured inside the state. Most of the people are also not aware of the advantages of using the fly ash lime bricks. In future days the manufacturers of fly ash based bricks will dominate over the manufacturers of clay burnt bricks in the market.

4.3 CPWD: - CPWD use approx 100% Fly Ash Bricks in their all constructions- directly or through contractors. This factor will help the marketability of this product immensely.

5. ADVANTAGES & ENVIRONMENTAL ASPECTS

5.1. Advantages

1. Environmental friendly: Consumes Fly ash
2. Environmental friendly: Saves invaluable top soil
3. Environmental friendly: needs no burning/backing.
4. Strength: Higher Strength Bricks.
5. Uniform Shape: Easier and faster Brick working.
6. Uniform Shape: Less Mortar in Brick work.
7. Uniform Shape: Less Mortar in Plaster.
8. Artificial Cement: Gains strength over time.
9. Artificial Cement: Walls can be left exposed/un plastered.
10. Better heat & sound insulation compared to red Bricks Far Lesser brakeage during handling & transportation. Better Vibration resistance compared to red Brick The bricks are uniform in shape, size,
11. Therefore require less mortar in brick work. Plaster thickness required will be less compared to clay bricks, this saving of cement it uses fly ash, which is by-product of thermal power stations saves agricultural land which is used for manufacturing clay bricks.
12. Less energy intensive compared to clay bricks and helps in keeping clean environment It can be manufactured at construction site also.

5.2 Environmental sustainability impacts

Fly ash is a cocktail of unhealthy elements – silica, aluminum,ironoxides, calcium, magnesium,arsenic, mercury, and cadmium, and poses serious environment and health hazards for a large population. But the brick is better off, for fly ash changes into a non-toxic product when mixed with lime at ordinary temperature as the calcium silicate hydrates and forms a dense composite inert block. Thus having the potential as a good building material, while offsetting about 100million tone's of fly ash annually produced in India by the numerous thermal power plants, which could cause serious contamination of land, groundwater and air.

5.3 Build ability, availability and cost

The blocks have an easy workability and high compressive strength eliminates breakages/wastage during handling giving a neat finish, with lower thickness of joints and plaster. The construction technique remains the same as regular bricks ensuring easy change of material, without requiring additional training for the masons. Though these bricks are abundantly available closer to thermal power plants all over the country for obvious reasons, finding dealers in all major cities and towns wouldn't be a problem.

5.4. Applicability

The blocks being available in several load bearing grades are suitable for use: -

A. Load bearing external walls, in low and medium size structures.
B. Non-load bearing internal walls in low and medium size structures.
C. Non-load bearing internal or external walls in high-rise buildings

6. SUMMARY

6.1. Appearance

These bricks have a pleasing color like cement, are uniform in shape and smooth in finish, also, they require no plastering for building work. The bricks are of dense composition, uniformly shaped with/without a frog, free from visible cracks, warp-age, organic matter, pebbles and nodules of free lime. They are lighter in weight than ordinary clay bricks and less porous too. The color of fly ash bricks can be altered with the addition of admixtures during the process of brick making. They come in various sizes, but generally are similar to the sizes of clay bricks.

6.2. Structural Capability

These bricks can provide advantages being available in several load-bearing grades, savings in mortar plastering, and giving smart looking brickwork. High compressive strength eliminates breakages/wastages during transport and handling, the cracking of plaster is reduced due to lower thickness of joints and plaster and basic material of the bricks, which is more compatible with cement mortar. Due to its comparable density the bricks do not cause any extra load for design of structures and provides better resistance for earthquake loads due to panel action with high strength bricks. Compressive strength of fly ash sand lime bricks is av. 9.00 N/mm2 (as against 3.50 N/mm2 for handmade clay bricks).

6.3. Thermal properties

Thermal conductivity is 0.90-1.05 W/m2 ºC (20-30% less than those of concrete blocks). These bricks do not absorb heat; they reflect heat and gives maximum light reflection without glare

6.3.1. Fire and vermin resistance

Fly ash bricks have a good fire rating. It has no problems of vermin attacks or infestation.

6.3.2. Durability and moisture resistance

These blocks are highly durable, after proper pointing of joints, the bricks can be directly painted in dry distemper and cement paints, without the backing coating of plaster. Rectangular faced with sharp corners, solid, compact and uniformly Water absorption is 6-12% as against 20-25% for handmade clay bricks, reducing dampness of the walls.

6.3.3. Toxicity and Breath-ability

There are no definite studies on the toxic fume emissions or the indoor air quality of structures built with flyash bricks, though claims of radio active emissions by these blocs have been made at some scientific forums. Flyash as a raw material is very fine and care has to be taken to prevent from being air-borne and causing serious air pollution as it can remain airborne for long periods of time, causing serious health problems relating to the respiratory system. Though block manufactured from flyash has no such problems.

7. CONCLUSIONS

Fly Ash has become an important raw material for various industrial and construction applications. It‟s widely used in manufacturing of bricks, cement, asbestos-cement products and roads/embankments. The studied are carried out for improvement of agricultural crops, wastelands, and zeolites. This waste has found application in domestic and wastewater treatment, purification, paint and enamel manufacturing. In future, large-scale application of this waste product may be possible for recovery of heavy metals, reclamation of wasteland, and floriculture. The detailed investigations carried out on fly ash elsewhere as well as at the Indian Institute of Science show that fly ash has good potential for use in highway applications. Its low specific gravity, freely draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties, etc. can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures, etc. It can be also used in reinforced concrete construction since the alkaline nature will not corrode steel. This not only solves the problems associated with the disposal of fly ash (like requirement of precious land, environmental pollution, etc.) but also helps in conserving the precious top soil required for growing food. The future poses challenges to the scientists, technologists, engineers towards sound management of fly ash disposal & deposition technologies. The problem is not due to lack to technical competence but more of adoption, implementation and better management of improved & appropriate technologies. On the basis of studies carried out on fly ash utilization, it is sighted that use of fly ash in building

construction posses great gains. Either fly ash used in brick manufacturing or in concrete mixes, it gives very good results in almost every aspect including good strength, economically feasible and environment friendly. The guideline for all thermal power stations as regards disposal techniques/ strategies should ensure minimum adverse impact on the flora & fauna of a particular place. The attempt should be to consciously reduce environmental damage to ensure more effective management of fly ash which India needs'

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Fig.(3ii) Pulverized Fuel Ash or Fly Ash or Coal Ash

Fig. (3iii) Fly Ash Bricks