Fly Ash – An Eco – Economical Material in Road Constructions

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Abstracts

Fly ash is an important industry by-product that comes from combustion of coal. India is the world's largest producer of fly ash. Its production may soon reach the figure of 150 million tonnes per year. In our country only a small percentage of fly ash is used for construction of Technical Projects, while the rest is stockpiled, causing serious problems because of its great availability and it's low cost, further possibility of its usage should be investigated in this project clay, soils, natural and crushed sand gravel are stabilized with different quantities of fly ash for the creation of durable roads. It has been found that stabilization of soil with fly ash improves the natural and mechanical characteristics of soil like plasticity, compressive strength and particle size distribution. Therefore, utilization of fly ash in geotechnical and highway applications such as embankments of roads, bridge approaches, filling of low lying areas to develop sites for residential and industrial buildings etc. should be exploited properly. Fly as reduce the water absorption capacity and compressibility of the soils, if fly ash is used in sub grade in place of soil for flexible pavements. In rigid pavements fly ash can be used to replace the part of cement or sand or both. Hence fly ash has tremendous application in the field of highway construction nowadays. However environmental and human safety perspectives, utilization of waste and waste-amended materials in civil engineering construction is limited. The usage of fly ash has gained greater importance for the preservation of natural resources as it replaces primary materials where ever it is used, roads concrete or cement.

Keywords: Stabilization, base, sub- base, pavements, environment

1. Introduction

Fly ash is fine grained residue of coal combustion in thermal production station of electrical energy. It is extracted by precipitators in smokestacks of coal burning power plant. About 130 coal based thermal power stations in India are producing 150 million tones fly ash per year. So our major concern is to use this fly ash in various construction purposes.

Fly ash earlier been used for stabilization of roads due to its high content of calcium and silicate oxides which give puzzolonic properties and thus high compression strength. The frost thawing properties and Bearing capacity of road material here also been increased when fly ash is used.

Through the stabilization of high plasticity with fly ash, it has been found mechanical properties were improved, compressive and shear strength were increased and volume expansion of soil was controlled which was good for highway pavement.

It has been found fly ash can be successfully used as an additive for the base and sub-base layer construction of pavement, as well as for construction of embankment in compressed soils.

Researchers have proven that mixtures of ash with inert materials reach 50%-70% of strength of corresponding fly ash reduce the necessary pavement thickness and construction cost.

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India is largest producer of fly ash. At many places fly ash is used in forest roads, rural roads, PMGSY (Pradhan Mantry Gram Sadak Yojna) roads etc. National Thermal Power Corporation (NTPC) having 20% of country installed capacity of power produced 39 million tonnes of ash out of which 20.8 million tonnes was gainfully utilized in various applications in manufacturing of bricks, cement, construction of road embankments, mine filling, development of low lying areas etc. NTPC is determined to play a leading role in achieving the ash utilization targets set by Ministry Of Environment and Forests and help the country to achieve its goal.

Table 1: Fly ash Generation and Utilization in Different Countries

S. No	Country	Annual ash production (million tonnes)	Ash Utilization (%)
1	India	150	39
2	China	100	45
3	USA	75	65
4	Germany	40	85
5	UK	15	50
6	Australia	10	85
7	Canada	6	75
8	France	3	85
9	Denmark	2	100
10	Italy	2	100
11	Netherland	2	100

Fly ash utilization in India has picked up and reached to 51 million tonnes from meager quantity of 1 million tonnes in 1994. Still there are certain potential areas which need special attention for full utilization of fly ash. Fly Ash use to be mandatory in all construction in Nagpur according to Fly Ash Utilization Policy Of State Government. All Civic Bodies including Nagpur Municipal Corporation, Nagpur Improvement Trust have included this condition to use fly ash in construction. Fly ash use will be mandatory in cement roads as per new Fly Ash Utilization Policy by State Government. The Maharashtra State Power Generation Company Limited has implemented the Policy and is ensuring effective implementation of Policy.

2. Laboratory Studies and Results

Fly ash in road Construction for Highways

1. Fly ash can be used for construction of roads and embankments. Fly ash coal fired is used. Fly ash when mixed with road constituents that are compatible with compaction by rolling performed very well. When fly ash is used with other road constituents it makes Fly Ash Bound Mixtures (FABM). FABM can be specified and formulated to meet sub-base and base requirements of all classes of roads.

Fly ash is main constituent of binder with lime. Cement can substitute for lime but it is not effective in mobilizing the full puzzolonic properties of ash like flexibility and autogenous healing.

Table 2 is showing compressive strength in N/mm^2 of treated fly ash with lime and cement.

1:1 specimen cured at 20C	Fly ash with 2.5% lime	Fly ash with 5% lime	Fly ash with 7% cement	Fly ash with 9 % cement
7 days	1.3	2.0	3.0	4.5
28 days	4.0	4.5	4.0	7.5
90 days	5.5	7.0	5.5	8.5

Compared to mixtures based on lime and cement. FABM with lime are slow setting, slow hardening and self healing. FABM have extended handling time and thus versality of unbound granular pavement materials. FABM are autogenous, in that they possess a puzzolonic reserve which allow them to re-heal, should say cracking occur under differential settlement. In long terms FABM with lime develop significant stiffness and strength with performance and durability of bituminous and cement bound mixtures. It is found that if quicker hardening is required, addition of gypsum or partial or complete replacement of lime with cement can be done. FABM based on cement do not have advantage of laying flexibility and autogenous healing.

2. The fly ash in 10%, 15%, 20% in combination with road material were characterized before stabilization of road for optimum water ratio, density and compressive strength.

Table 3 shows variation of moisture density relationship of sand gravel treated with different percentage of fly ash.

Standard Proctor Test Method

Sand Gravel with Fly ash	Max. Dry Density in(g/cc)		Optimum Moisture (%)	
Fly ash (%)	Sample 1	Sample 2	Sample 1	Sample 2
10	2.190	2.200	9.5	9.0
15	3.250	s 3.210	15.0	15.5
20	5.100	5.200	20.0	19.5

Table 4 Compressive Strength Test of fly ash and sand gravel mixture after 7, 8, 90 days.

Strength in N/mm^2 or MPa

Fly ash (%)	7 days	28 days	90 days
10	5.0	6.0	7.0
15	5.2	7.5	8.6
20	5.3	8.0	8.8

The 3 mixtures with 10, 15, 20% of fly ash had almost similar initial compressive strength. After hardening of samples after 90 days the compressive strength was enhanced with increased amount of ash in sample. So it is determined to use mixture of 20% fly ash and 80% road material.

3. Environmental impact of Fly ash

Use of fly ash in roads and in concrete imparts several environmental benefits and thus it is eco-friendly. The usage of fly ash has gained greater importance for the preservation of natural resources as it replaces primary materials where ever it is used, roads concrete or cement. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Manufacture of cement is high energy intensive industry. In the manufacture of one tone of cement, about 1 tonne of CO_2 is emitted and goes to atmosphere. Less requirement of cement means less emission of CO_2 result in reduction in greenhouse gas emission. Fly ash from Thermal power plants are stored in ash pond areas. The ash ponds acquire large areas of agriculture land. Use of fly ash reduces area requirement for pond, thus saving of good agricultural land.

4. Conclusion

Fly ash has numerous benefits when used in road construction, whether for embankment construction, for concrete in roads and bridges, for stabilizing general roads, for sub-base material as in Fly Ash Bound Mixtures. Where fly ash replaces virgin aggregates or act as a cementitious binder, significant reduction in overall carbon dioxide emission are possible to benefit the environment. In addition if we go for stock piling of fly ash a large mineral reserve for future generations ensuring sustainable construction of our road infrastructure. By maximizing use of pulverized fly ash, this will reduce virgin aggregates depletion and leave resources for future without exploitation.

The addition of ash increased the optimum moisture content in the compaction test showed the result that due to greater specific surface and decreased maximum dry density because of its lower specific weight. The increase of optimum moisture content contributes to increase of the stabilized soil and sand gravel capability. The usage of fly ash for clay soil stabilization is a successful operation that can initiate the manufacture of a construction material that can be used to help improvement of forest road network and rural road network with a very low cost.

In combination with the use of inert material, on one hand, and exploitation of hazardous industrial by product other way we can understand the important of such operation, in protection of forest ecosystem and natural environment. The result that coincide with results of other researches will constitution the beginning o the stabilization

application of base, sub-base of roads, for construction of new, financially viable and durable pavement.

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