International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.8, pp 458-464, 2017

Construction of Road Embankments and Pavement Layers by using Waste Material as an Additive with Reference to its Availability

Shanmugavadivu V. P.[1]*, Ramprasad A.P.[2], Anand Babu A.[3]

[1,3]Department of Civil Engineering, SNS College of Engineering,Coimbatore, Tamilnadu, India,
[2]Department of Civil Engineering, KPR Institute of Engineering and, Technology, Coimbatore SNS College of Engineering, Coimbatore, Tamilnadu, India

Abstract : Flyash is an important industrial by-product that comes from the combustion of coal for the production of electrical energy. In our country the production of flyash is about 150 million tonnes per annum and 600 million tonnes of flyash will be generated by 2031-2032. All out efforts are needed to utilize this fly ash not only for environmental considerations, but also to avoid land usage for fly ash dumping [1,2]. Toxicity tests have proved that there is no toxic element due to fly ash. Fly ash can become a wealth generator by making use of it for producing 'green building' materials, roads and embankments. The paper mainly focuses on the utilization of flyash in construction of roads in south India. From research it has been found that stabilization of soil of high plasticity with flyash the compressive and shear strength were increased and volume expansion of soil was controlled and also a financially viable and durable pavement was created. The beneficial use of flyash for the construction of roads is a promising solution to reduce the disposal problem in south India. In addition to that it will reduce the scarcity of construction materials. There is a thrust to investigate the feasibility of flyash in construction of roads in our country.
Keywords : Flyash, Toxicity, Green building, Utilization, Stabilization.

1.0 Introduction

Fly ash is a waste generated from the coal based thermal power stations. It is a very fine material about 60-70% of which has a size below 0.076 mm. as it is formed by the burning of pulverized coal. Major amount of flyash was generated by thermal power stations resulting in 70 million tonnes in the half yearly of 2011-2012.In south India there are about 19 thermal power stations generating 30 million tonnes per annum at present. In that only sixty percent of flyash has been successfully utilised for construction of technical projects remaining being stockpiled in the ash ponds causing serious problems to the environment. In south India huge quantity of naturally available material like soils and aggregates are being utilised for road construction in the ongoing National Highway Development Programme (NDHP) and Pradhan Manur Gram Sadak Yojana (PMGSY). This has created severe scarcity of these conventional materials. By using flyash in the construction of roads would definitely solve this problem to a greater extent and would definitely provide an alternative to the conventional

construction materials. In south India there are about 19 coal based thermal power stations producing nearly 30 million tonnes of flyash per annum. Andhra Pradesh (8 TPS), Tamilnadu (8 TPS), karnataka (3 TPS).

Flyash has the potential to be beneficially used for in roadway constructions, including embankments and pavement structural layers such as base layer, sub-base layer and shoulders for long lasting and sustainable infrastructure[3]. The use of fly ash in the Nizamuddin bridge road embankment at Delhi for about 2 Kms. and a height of 8 meters in a flood zone have demonstrated the use of fly-ash in adverse conditions. This has not only saved the top soil and used fly ash which was otherwise a waste but also saved Rs. 1.4 crores in a total of Rs. 10 crores. One of the major costs involved in road construction is the transportation of materials. To minimize this cost, the locally available materials should be used, particularly for soil. But if the soil available locally is not of good quality, it causes a major problem. This problem can be solved by the usage of locally available material such as flyash for the stabilization of soil.

Disposal of such huge quantity of waste is a problem that needs utmost attention. Utilizing this for road construction provides a valuable method for disposal. As per Government of India Gazette notification dated 14.9.1999 it is mandatory for all thermal power stations to make flyash available for such purposes free of cost. Due to the utilisation of flyash for the stabilization of soils in south India it has been found that mechanical properties, compressive and shear strength and optimum moisture content was increased. From the result it has been found that flyash utilisation in soils has the dry density of the soil and also economically viable and durable pavement surface was created. Finally, soil stabilization with the mixture of 30% ash and 8% lime decreased the deflection rate of the stabilized layer about 1.7 times in comparison to the deflection of natural soil. While the addition of ash reduces the necessary pavement thickness and at the same time the construction cost. Considering all of the above it was proved that the usage of flyash in road construction will leads to the benefit of economy and environmental protection.

2.0 Statistics

Table 1: The table gives the amount of flyash generated, utilized at thermal power stations in south India in the year 2011-2012(april-11-sept.-11) by NTPC [3]

Station	Utilization (%)	Generation (million tonnes)	Used (million tonnes)
Neyveli-1	74.08	0.13	0.10
Neyveli-1 expn	72.54	0.09	0.06
Tuticorin	61.32	1.10	0.67
Neyveli-2	29.08	0.48	0.14
Rayalseema	66.12	1.11	0.73
Kothagundam	04.38	0.92	0.04
Kothagundam-v	28.12	0.45	0.13
Vijayawada	56.44	2.00	1.13
Ramagundam	53.41	2.09	1.12
Simhadri	58.85	1.24	0.73
Kakatia	23.88	0.41	0.10
Bellary	25.56	0.28	0.7
Raichur	39.38	1.19	0.47

3.0 Results and Discussions

The tested flyash was collected from the **Tuticorin Thermal Power Station Located In Tamilnadu, South India**

Table- 2: **Stability analysis** [2]

Saturated condition	Earthquake analysis	Flyash	Soil
Partially saturated	Without	1.66	1.60
	With	1.60	1.42
1m (H.F.L.)	Without	1.45	1.45
	With	1.25	1.21
Sudden draw down	Without	1.31	1.32
	With	1.10	1.10

Table 3: **Percentages of flyash after 7, 28, 90 days curing** [1]

Soil	Flyash (%)	Strength for different days curing (µpa)		
		7 days	28 days	90 days
Clay layer (low plasticity)	5	0.48	0.70	1.20
	10	0.50	1.10	1.90
	20	0.57	1.60	3.10
Clay layer (high plasticity)	5	0.20	0.35	0.65
	10	0.30	0.50	1.30
	20	0.40	0.75	1.90

Table 4: **Variation of moisture-density relationships of soil treated with different percentages of flyash** [1]

Mix of soil and flyash	Maximum dry density (Kg m-3) unit		Optimum moisture (%)	
	Natural	Clay layer (high plasticity)	Natural	Clay layer (high plasticity)
5	2154	1630	5.6	20.5
8	2187	1600	6.0	21.4
10	2161	1570	6.6	21.8
15	2124	1550	7.4	22.0

Table 5: **Variation of moisture-density relationships of soil treated with different percentages of flyash** [1]

Mix of soil and flyash	Maximum dry density (Kg m-3) unit		Optimum moisture (%)	
	Crushed	Clay layer (low plasticity)	Crushed	Clay layer (low plasticity)
2	2212	1720	6.3	15.4
6	2275	1680	7.1	15.8
8	2262	1630	7.6	16.5
10	2200	1580	8.4	10.9

Table 6: Compressive strength test results of flyash –crushed and natural sand gravel mixture after 7, 28, 90 days curing [1]

Sand Gravel	Flyash (%)	Strength for different days curing (Mpa)		
		7 days	28 days	90 days
Crushed	5	4.0	5.1	6.0
	10	5.0	6.5	7.0
	20	7.5	8.1	8.3
Natural	5	2.2	2.3	2.4
	10	3.0	3.2	3.6
	20	3.4	3.5	3.6

Table 7: **Physical and Chemical characteristics of flyash [2]**

Physical characters	Flyash	Chemical characters	Flyash (%)
Specific gravity	2.27	Silica	58.3
		Alumina	
		Iron oxide	26.3
Loss on ignition	11.89%	Magnesium oxide	2.2
		Calcium oxide	0.3

Table 8: Geotechnical characteristics of flyash and local soil [2][3]

Types of test	Geotechnical characters	Flyash	Soil
Proctor density	Mdd,KN/m^3	12.4	19
	OMC %	21	19
Direct shear	C, KN/m^2	0	5
	Degree	31	27
CBR	CBR %	15-20	8
Permeability	m/s	2.6x10^(-6)	2.4x10^(-9)

4.0 Utilization of Flyash in Road Construction

- Many gravel roads suffer from reduced bearing capacity mainly during soil frost thawing periods. The bearing capacity is to a large extent influenced by temperature and precipitation. The expected forthcoming climate change will lead to increased average annual temperatures and rain falls. Thus the soil frost periods will become shorter which will lead to increased rutting and less bearing capacity in gravel roads. This will have implications for the forestry since the forest industry is to a large extent dependent on accessible roads main part of the year to get the timber. To avoid the reduced bearing capacity, the gravel roads may be stabilized [5]. Fly ash has earlier been used for stabilising roads due to its high content of calcium and silicate oxides which give pozzolanic properties and thus high compression strength.
- The frost thawing properties and the bearing capacity of road material have also been increased when fly ash is used.
- Embankments of fly over bridges in Delhi, roads at Raichur, Delhi, Kolkata, Dadri, Ramagundam and Vishakhapatnam have been constructed using flyash
- Indian Road Congress (IRC) has issued Guidelines (SP- 58) for use of ash as fill material in Road Embankments (March 2001)

- Indian Road Congress (IRC) has published Rural Roads Manual" wherein various methods of utilization of ash in roads and embankment construction are covered. (Feb. 2002)
- Few projects Use of fly ash in the construction of roads and embankments has been successfully demonstrated in the country. The Ministry of Surface Transport and CPWD have in principle accepted the use of flyash and have cleared / executed.
- As well as using processed fly ash for pavement quality concrete for the construction of roads, fly ash can be used in combination with other materials to produce a Fly Ash Bound Material (FABM) which is suitable for capping, sub-bases and road bases in all classes of road and airfield pavements and footways
- Many of the characteristic benefits of concrete containing processed fly ash directly contribute to increased performance of pavement quality concrete.
- FABM develop significant stiffness and strength with the performance and durability of bituminous and cement-bound materials.
- The thickness of sub grade is reduced considerably by addition by addition of fly ash. The maximum thickness reduction achieved was 45%. So we can save 9870 mt of earth for one kilometer length of the road for a six lane road

5.0 Advantages of Flyash in Technical Projects

- **Low Carbon Emission:**

One ton of Portland cement production discharges 0.87 tonnes of Carbon dioxide in the Environment. Utilization of **fly ash in cement concrete** minimizes the Carbon dioxide emission problem to the extent of its proportion in cement. Fly ash utilization has great potential to lower green house gas emissions by decreased mining activities and reducing Carbon dioxide production during manufacture of materials that can be substituted by flyash.

- **Innovative Dam Construction:**

Fly ash can substitute up to 66% of cement in the construction of dams. It is also used as a pozollanic substitute for cement in Roller Compacted Concrete dams-an innovative dam technology developed as a result of efforts to design more economical concrete dams that could be constructed rapidly with designed performance. Fly ash in R.C.C. is used not only for saving cement cost but also for enhancing strength and durability.

- **Brick Manufacture:**

180 billion tonnes of clay brick production per year consumes 540 million tonnes of clay, makes 65000 acres of land barren, and consumes 30 million tonnes of coal equivalent, generates26 million tonnes of Carbon Dioxide[3]. A 10% switchover to fly ash bricks will use 30 million tonnes of fly ash every year, save environment and coal and yield a benefit of 300 crores by way of reduction in brick cost production. Fly ash bricks do not require clay and serve the dual purpose of conserving top soil and the constructive utilization of fly ash

- **Conserving the Top Soil:**

The manufacture of conventional clay bricks requires the consumption of large amounts of clay. This depletes top soil and leads to degradation of land. The use of flyash in the manufacturing of bricks will serves as an alternate for clay and conserves the top soil.

- **Advantage of Flyash in Cement Concrete:**

- Increased strength
- Increased impermeability and durability
- High resistance against chemical attack
- Reduction in cracking
- Reduction in thermal stresses due to low heat of hydration
- Better appearance and low cost

6.0 Need for Utilization of Flyash

Flyash generated from coal based thermal power plants is usually stored in ash ponds which contaminate the top soil and water resources while also affecting the biodiversity. The World Bank has cautioned India that by 2015 disposal of coal ash would require 1000 square km or one meter square of land per person. Utilizing fly ash in roads saves top soil, avoids creation of low lying areas, does not deprive the nation of the productivity of top soil and reduces the demand of land for fly ash.

However, utilization of fly ash has the following benefits

1. Minimizing environmental impact of direct disposal of flyash
2. Enabling other uses of the land since less area is reserved
3. Procuring financial returns from the sale of the by-product
4. Replacing scarce or expensive natural resources

7.0 Conclusion

- **In this paper we indicate the utilization of flyash in south India was below 60% and it was not utilized optimum, hence there is a large gate to utilize flyash in various civil engineering fields to save the environment and economy of construction.**
- By addition of the fly ash to the expansive soils the CBR value is increased. So that the pavement thickness was reduced.
- The strength gain characteristics of fly ash are such that strength gains continue after 28 days resulting in stronger and more durable concrete in the longer term. Durability in paramount for road applications to ensure that the disruption and cost of maintenance and repair is minimized.
- The use of fly ash is now recognized as a means for providing improved resistance to both sulphate and acid attack.
- The reduced temperature rise of fly ash concrete reduces thermal movements and the risk of cracking.
- The soils that we are studied are not considered to be appropriate for embankments, nor for paving, foundation materials due to their plasticity. Nevertheless, the mixture of flyash with the fine grained soil material has improved its mechanical properties that resulting in the soil maintaining stability while increasing the moisture content.
- The increase of the optimum moisture content contributes to the increase of stabilised soil capacity.
- Flyash has high CBR value than local soil it satisfies the MORTH criteria for use in sub-grade and sub-base layer of road pavement.
- The values shown in the table 3 indicates that flyash have good drainage property, which makes it suitable for the construction of embankment and sub-grade.
- The high values of angle of internal friction indicated the suitability of flyash in the construction of embankment and sub-grade.
- The soil stabilization with flyash, compression strength and plasticity were improved, while it has been proven that flyash can be used successfully as an additive for the base and sub-base layer construction of pavement, as well as for the construction of embankments in compressed soils.
- Our former president **Dr A.P.J.ABDUL KALAM** has stated about flyash in the eve of Independence day at New Delhi that "All our efforts are needed to utilize this fly ash not only for environmental considerations, but also to avoid land usage for fly ash dumping. Toxicity tests have proved that there is no toxic element due to fly ash. Fly ash can become a wealth generator by making use of it for producing 'green building' materials, roads and embankments."
- Finally, it can see from the above that the usage of flyash for clay soil stabilization is a successful operation that can initiate the manufacture of construction materials that can be used in the construction of sustainable construction of buildings and roads. We should realize the importance of flyash in green building construction to protect our natural environment.

8.0 References

1. P.Eskioglou and N.Oikonomou (2006). Protection of environment by the use of flyash in road construction. Global nest journal 2007
2. V.G. Havanagi, A.K.Sinha, V.K. Arora, S.Mathur. Waste materials for construction of road embankments and pavement layers. International journal of environmental research. Volume 1, issue 2, 2012
3. Report on flyash generation at coal/lignite based thermal power stations and its utilisation in the country for 1st half of the year 2011-2012 (April, 2011 to September, 2011)
4. N. S. PANDIAN Fly ash characterization with reference to geotechnical Applications J. Indian Inst. Sci., Nov.–Dec. 2004
5. C. Freeda christy and d. Tensing GREENER BUILDING MATERIAL WITH FLYASH Asian journal of civil engineering (building and housing) vol. 12, no. 1 (2011)

*****