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APPLICATION OF FLY ASH IN THE INDUSTRIAL AND AGRICULTURAL ERA: A REVIEW

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Abstract
This paper presents a general review of the applications of the so-called 'fly ash' derived from the combustion of fossil coal for energy production. The application of fly ash is then discussed, with particular reference to disposal as well as to civil engineering, chemical industries, agricultural, environmental, and soil stabilization applications of fly ash. The study is based on secondary data based on the various articles, journals, books, and government websites that have been used. It is observed that the replacement of cement in any proportion lowers the compressive strength of concrete as well as delays its hardening. This provides an environmentally friendly method of fly ash disposal. In the future, fly ash can be used as a substitute for materials and remains a potential low-cost adsorbent. From the review of various applications of fly ash, it can be concluded that it is a very good alternative to conventional activated carbon and can replace activated carbon in many processes to minimize the cost.

Keywords—Fly Ash, Cement Industries, Chemical Industries, Environmental and Soil Stabilization.

Introduction

In India, coal-fired thermal power plants have been in operation for more than 50 years, yet creating environmentally appropriate solutions for fly ash utilisation is a key challenge today. Fly ash is a notorious waste product of coal-fired thermal power stations, recognised for its negative impacts on agricultural land, surface and subsurface water pollution, soil and air pollution, and diseases to humans. Researchers have developed a few methods for utilising fly ash in several uses. One of the most prevalent uses for fly ash is in cement concrete. Overall, fly ash utilisation in India is quite low, at roughly 15% of the tonnage created. Fly ash products offer various advantages over conventional products. The usage of cement in the fabrication of building materials can be lowered by substituting fly ash. While the use of cement cannot be avoided, certain goods, such as tiles, can be substituted up to 50%. Because of significant savings on raw materials, these goods are recognised to be stronger and more cost-effective. Full utilisation of generated fly ash in India will create employment opportunities for 3000 persons.

Objective

Analyse the application of Fly Ash from the combustion of fossil coal for energy production

Fly Ash in cement industries

By enhancing concrete durability, fly ash in concrete extends the life of concrete roadways and structures. When fly ash is used to replace or displace made cement, it reduces energy consumption, greenhouse gas emissions, and other negative air emissions. Fly ash can be utilised to improve the performance of Portland cement concrete. Portland cement is made from calcium oxide (CaO), part of which is liberated during hydration. During the hydration of 100 pounds of cement, up to 20 pounds of free lime are released. This liberated lime is required for the reaction with fly ash silicates to generate strong and lasting cementing compounds, increasing many of the qualities of the concrete.

Some of the benefits are: being disposed of in landfills and conserving other natural resources and materials. Fly ash is typically used to replace 15 to 30% of the Portland cement. Fly ash is suitable for road and embankment construction. This approach has numerous advantages over traditional procedures. It conserves topsoil that would otherwise be utilised and avoids the formation of low-lying areas (by the excavation of soil for embankment building). It also minimises the demand for land for the disposal/deposition of fly ash, which would otherwise not have been used for the embankment's construction.

Fly Ash in Agriculture

For several years, universities and research organisations around the country have been conducting studies on the agricultural applications of fly ash. When applied scientifically to agricultural fields, the same fly ash that causes harm when it lands on leaves can also be beneficial. It can act as a soil modification, increasing moisture retention and fertility. Soil stabilisation refers to the permanent physical and chemical modification of soils to improve their physical qualities.

Stabilisation can improve a subgrade's load-bearing capacity to sustain pavements and foundations by increasing shear strength and/or controlling shrink-swell qualities. Stabilisation can be used to treat a variety of sub-grade materials, ranging from expansive clays to granular materials.

Several chemical additions, such as lime, fly ash, and Portland cement, as well as byproducts such as lime-kiln dust (LKD) and cement-kiln dust (CKD), can be used to stabilise the soil. Any stabilisation project must include proper design and testing.

Flyash in Chemical Industries

Fly Ash-Based Polymer Composites as a Wood Substitute Fly ash-based composites were created by using fly ash as filler with jute cloth as reinforcement. The treated jute fabric is then fed into the matrix for lamination. Specific temperatures and pressures are used to cure the laminates. The number of laminates necessary to achieve the desired thickness.

The fly ash Polymer Composite technology that uses Jute cloth as reinforcement for wood substitute material can be used in a variety of applications such as door shutters, partition panels, flooring tiles, ceilings, and so on.

In terms of wood alternative products, it should be emphasised that the produced components/materials are stronger, more durable, corrosion-resistant, and, most importantly, cost-effective when compared to the conventional material, i.e., wood.

The Regional Research Laboratory in Bhopal developed this technology in partnership with the Building Materials and Technology Promotion Council (BMTPC) in New Delhi and the Technology Information, Forecasting, and Assessment Council (TIFAC) in New Delhi. A commercial factory based on this technique has also been established near Chennai.

Experimentation

Properties of fly ash: Various tests were done to find out the physical and chemical properties of fly ash which are illustrated in Table 1.

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Table no. 1: Physical-chemical properties of fly ash

Parameter	Observed Value	Permissible value as per IS 3812-2003
Specific Surface Area	340-360 m^2/kg	>250 m^2/Kg
Particles retained on the 45-micron sieve	28.9%	<35%
Compressive strength at 28 days	44-48 N/mm^2	>39-43 N/mm^2
Soundness	0.014 to 0.018%	<8%
Silica + Alumina + iron oxide Content	88-91%	>70%
Silica	58-60%	35%
Sulfur as SO_3	0.26-0.32%	<0.3%
MgO	0.26-0.34%	<0.5%
Loss on ignition	0.9-1.05%	<1.5%
Available alkalies as Na_2O	0.16-0.02%	1.5%
Chlorides	0.016-0.02%	0.05%

It can be seen that all parameters are within permissible limits.

Cement fly ash blends: Fly ash is blended into cement at a rate ranging from 10% to 50% by weight of cement, in 10% increments. The cement-fly ash blends are then tested for consistency, setting time, soundness, workability, and compressive strength by IS 546-2003.

Concrete Mix Design: In this investigation, M20 grade concrete with a nominal mix according to IS 456-2000 was used. The concrete mix proportions (cement: fine aggregate: coarse aggregate) are 1:1.5:3, with a water-cement ratio of 0.5. The fly ash is blended into cement at a rate of 5 to 25% by weight of cement in 5% increments. Determination of compressive strength: In this test, a sample of concrete is placed in a 15cm x 15cm x 15cm mould, and the top of the mould is struck off. There was a total of 18 cubes cast. Fly ash is used in place of cement in concrete in six different percentages, beginning with 0% and up to 25% at 5% intervals. For 24 hours, the specimens are wrapped in moist gunny bags. The sample is then removed and placed in the curing tank to cure. The sample is retrieved and examined promptly at the end of the curing period. Yama Engineers Kolhapur's Universal Testing Machine model number UTM 40 is used for the testing. The weight is applied gradually and smoothly. The crushing loads are recorded, and the average compressive strength for three specimens is calculated, as shown in Table 2.

Table 2. Compressive strength for three specimens

Compress Strength(N/mm$^{2)}$						
% Fly Ash	**3 Days**	**7 Days**	**21 Days**	**28 Days**	**60 Days**	**90 Days**
0	8.44	11.55	21.77	26.06	37.10	37.99
5	8.00	12.44	24.15	24.88	29.00	36.99
10	7.55	7.77	20.14	20.29	31.33	40.44
15	5.77	7.99	15.55	19.86	26.21	35.41
20	4.44	8.44	14.22	19.10	30.22	39.88
25	5.59.	6.21	11.84	18.66	23.33	33.77

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Results and Discussion

As described in the above table, various properties of fresh concrete are determined. Considering space limitations.

The consistency of cement has increased with the addition of fly ash from 32% for 0% fly ash to 48% for 50%fly ash.It may be attributed to the increased fly ash blend due to finer particles of the latter. The initial setting time (IST) has increased from 155 minutes for 0% fly ash. This may be attributed to fly ash's retardation of cement hydration. The workability of cement concrete mix has increased from 25 mm (for 0% fly ash) to 120 mm (for 25%fly ash).This may be attributed to the articles in the concrete. The characteristic compressive strength of various blends of concrete is presented in table no. 2.

Figure 2 shows the graphical representation of data in Table 2. The curves in Figure 2 show the rate of compressive strength development of various blends of fly ash. It can be seen that 0% fly ash i.e., concrete with no replacement of cement with fly ash, has the maximum rate of compressive strength development at 60 days and after it becomes nearly constant. 5% fly ash has the development of 21 days and then after its rate decreases. Strength development at a later stage is negligible. The rate of strength development is large for up to 21 days for 10% fly ash and then after its rate becomes negligible for a few days and after 28 days it increases uniformly. Its final strength development is also maximum than any other fly ash blend. After 90 days of storage, the concretes containing 10 % of fly ash, related to cement mass, gained a compressive strength about 6 % higher than the concrete addition for Ordinary Portland cement. For fly ash blends greater than 10% fly ash, the rates of strength development, as well as final strengths both, reduce with the addition of fly ash. In the long term, concrete with higher proportions of fly ash gains comparable with that of pure concrete. It is important to note from Table 2 that the strength of concrete decreases with the increase in % of replacement of cement with fly ash at 28 days. But, at 90 days we get maximum strength for 10% fly ash addition.

Conclusion

This study proves that fly ash can be successfully used in cement concrete in minor amounts as an additive. Considering the intangible cost of the disposal problem of fly ash and the hidden cost of environmental protection, the methodology appears to be indeed successful. Fly ash is solid waste. So, it is priceless. If it can be used for any purpose then it will be good for both environment and economy. The use of this fly ash as a raw material in Portland cement is an effective means for its management and leads to the saving of cement and the economy consequently. Hence it is a safe and environmentally consistent method of disposal of fly ash. However, the rate of strength development is less, due to the lesser rate of strength. It can be concluded that power plant waste is extensively used in concrete as a partial replacement for cement and an admixture. However, given the higher cost of activated carbons and difficulties associated with regeneration, attempts have been made by various workers to use fly ash as low-cost material and it remains a potential low-cost adsorbent for the future.

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