AN ARTICLE ON FLY ASH CONCRETE

Fly ash- environment sustainable material

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***Abstract*—Fly ash, a waste generated by thermal power plants is as such a big environmental concern. Fly ash is used as a supplementary cementitious material (SCM) in the production of Portland cement concrete. Fly ash is a by-product of burning pulverized coal in an electrical generating station. Specifically, it is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic separators. Fly ash concrete has economical and environmental advantages. It also makes concrete sustainable. In India presently less than 50% of fly ash produced is consumed. Carbon dioxide is the main threat in causing global warming of the environment. The attempts have been made to reduce CO2emissions in environment by all possible ways, but cement has not found a suitable replacement for it till date. Fly ash Concrete is an effort in reducing cement content of construction.**

***IndexTerms*—Fly ash, Cement, Fly ash concrete, environment.**

I. INTRODUCTION

In the present era of growth and development, progress is taking place in all the fields. But, in the light of progress, man is ignoring nature and harming it. Construction area, with the use of virgin materials like cement, is also posing the threat of global warming and environmental degradation. The challenge in front of civil engineering community is to provide sufficient, economical and comfortable infrastructure without causing any hardship for environment.

Taking sustainable development in view, an attempt has been made to reduce the use of cement in concrete by replacing it with otherwise waste materials such as fly ash, slag, silica fume and rice husk . The use of fly ash in concrete has been encouraged all over the world .Though this has been tried at some places in India but the percentages replacements of cement by fly ash are very small and only less than 25% of total fly ash produced is being utilized. A confidence is required to be built up in developing countries like India to make use of fly ash concrete in various fields of construction.

Fly ash is very much similar to volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term “pozzolan”. A pozzolan is a siliceous or siliceous / aluminous material which when mixed with lime and water forms a cementitious compound. Fly ash is the best known, and one of the most commonly used, pozzolans in the world. Fly ash is the notorious waste product of coal based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind. Researchers have proposed few ways of reusing fly ash for variety of application. One of the most common reuse of fly ash is in cement concrete. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete. These materials greatly improve the durability of concrete through control of high thermal gradients, pore refinement, depletion of cement alkalis, resistance to chloride and sulphate penetration, and continued micro structural development through a long-term hydration and pozzolanic reaction. The utilization of by-products as the partial replacement of cement has important economical, environmental and technical benefits such as the reduced amount of waste materials, cleaner environment, reduced energy requirement, durable service performance during service life and cost effective structures.

Presently all the efforts of Indian construction industry are focused on early removal of shuttering and fastest possible completion of construction work. Industry is more focused on 3 hour strength for early removal of formwork. This is leading to high heat of hydration cracks and lower durability of structures. (IS 456, 2000) recommends at least 10 days of curing where mineral admixtures are used. However for sustainability focus must be shifted to long term strength and durability over short term gain. Hence at least 28 days of curing should be made mandatory for high volume fly ash concrete.

Properties of fly ash: The fly ash particles are generally glassy, solid or hollow and spherical in shape. The hollow spherical particles are called as cenospheres. The fineness of individual fly ash particle rage from 1 micron to 1 mm size. The fineness of fly ash particles has a significant influence on its performance in cement concrete. The fineness of particles is measured by measuring specific surface area of fly ash by Blaine's specific area technique. Greater the surface area more will be the fineness of fly ash. The other method used for measuring fineness of fly ash is dry and wet sieving. The specific gravity of fly ash varies over a wide range of 1.9 to 2.55.

II. LIERATURE VIEW

Poon, Lam & Wong, (1999) from their experimental results concluded that replacement of cement by 15% to 25% by fly ash results in lower porosity of concrete and plain cement mortars.

Literature discussed has shown improvement in the workability and durability of concrete by partial replacement of cement with fly ash. However 28 days strength was reported to be lower by replacement of cement with fly ash, than concrete without replacement of cement with fly ash. Analyzing the literature it is seen than grinding of fly ash is less effective. This may be due to destruction of spherical shape of fly ash which is helpful in increasing workability and reducing voids. Grinding cost also offsets partial cost advantage of cheaper fly ash over cement.

Low reactivity of low lime Indian fly ashes as compared to high lime fly ash restricts use of higher volumes of fly ashes for cement replacement. Lower reactivity of fly ash makes it urgent to develop a method for replacing higher volumes of cement with fly ash without grinding or activation of fly ash.

Papadakis, 1999) used a typical low calcium fly ash as additive in mortar replacing, part of volume either of Portland cement or aggregate. In both cases 10, 20 and 30% addition to the cement weight was done. A very important finding was that when the compressive strength of mix in which aggregate was replaced by fly ash were similar to that of control mix at 3 and 14 days, but were higher from 28 days and later. The strength increase is due to higher content of calcium silicate hydrate. There is reasonable distribution of the strength increase according to fly ash content but after 91 days there is no difference between 20% and 30% replacement. When fly ash replaces cement the strength is reduced, at first due to lower activity of the fly ash, but as time precedes this gap is gradually eliminated.

Bhanumathidas, &Kalidas, (2002) with their research on Indian fly ashes reported that the increase in ground fineness by 52% could increase the strength by 13%. Whereas, with the increase in native fineness by 64% the strength was reported to increase by 77%. Looking in to the results it was proposed that no considerable improvement of reactivity could be achieved on grinding a coarse fly ash. Authors also uphold that the study on lime reactivity strength had more relevance when fly ash is used in association with lime but preferred pozzolanic activity index in case of blending with cement.

Siddique, 2003) carried out experimental investigation to evaluate mechanical properties of concrete mixes in which fine aggregate (sand) was partially replaced with class F fly ash. Fine aggregate was replaced with five percentages (10%, 20%, 30%, 40% and 50 %) of class F fly ash by weight. The test result showed that the compressive strength of fly ash concrete mixes with 10% to 50% fine aggregate replacement with fly ash were higher than control mix at all ages. Also the compressive strength of concrete mixes was increasing with increase in fly ash percentages. This increase in strength due to replacement of fine aggregate with fly ash was attributed to pozzolanic action of fly ash. The splitting tensile strength also increased with increase in percentage of fly ash as replacement of fine aggregate. The tests on flexural strength and modulus of elasticity also showed improvement in the results as compared to control concrete.

Rebeiz, Serhal& Craft, 2004) reported investigation on the use of fly ash as replacement of sand in polymer concrete. In the weight mix design 15% sand was replaced by fly ash. This replacement of 15% sand with fly ash by weight increased compressive strength by about 30%. Also there was improvement in the stress strain curve. They also reported good surface finish due to addition of fly ash as replacement of sand which also reduce permeability and have an attractive dark colour. Flexural strength of steel reinforced polymer concrete beams was increased by 15%. When subjected to 80 thermal cycles polymer concrete with fly ash exhibits slightly better thermal cycling resistance (about 7% improvement) than polymer concrete without fly ash.

Rao, 2004) discussed the need to use about 650 kg/cu.m of fine material to make self-compacting concrete. This also requires fine aggregates more than 50% of total aggregate so that coarse aggregate can float in the fine material. This requirement of fine materials can be easily fulfilled by use of fly ash.

Subramaniam, Gromotka, Shah, Obla& Hill, (2005) investigated the influence of ultrafine fly ash on the early age property development, shrinkage and shrinkage cracking potential of concrete. In addition, the performance of ultrafine fly ash as cement replacement was compared with that of silica fume. The mechanisms responsible for an increase of the early age stress due to restrained shrinkage were assessed; free shrinkage and elastic modulus were measured from an early age. In addition, the materials resistance to tensile fracture and increase in strength were also determined as function of age. Comparing all the test results authors indicated the benefits of using ultrafine fly ash in reducing shrinkage strains and decreasing the potential for restrained shrinkage cracking.

Malhotra, (2005) discussed the role of supplementary cementing materials and super plasticizers in reducing greenhouse gas emissions. Author also discussed different ways of reducing CO_2 emission. With emphasis on developing countries the author discussed that their infrastructure needs lead them to use huge amounts of cements. This huge need of cement can be reduced by replacing cement with easily available good quality of fly ash from the thermal power stations. Author also mentions the development of high performance; high volume fly ash concrete that incorporates large dosages of super plasticizer which enhances the durability of concrete. The paper also discussed about different cementing materials that can be used in concrete making as replacement of cement to reduce the cement consumption and also reduce the CO_2 emission to atmosphere.

III. MATERIALS

Cement: A cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material.Cements used in construction are usually inorganic, often lime based, and can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water.Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It is resistant to attack by chemicals after setting.Hydraulic cements (e.g., Portland cement) set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack.

The most popular construction material till date is cement in the form of concrete. The use of cement in construction is very old. Cement has proved its efficiency in terms of its sufficient strength, economic cost, less time of construction and finally good durability. Moreover, the growth of a country is adjudged through its infrastructural facilities. Hence, construction industry has always been in boom and has seen rapid development in recent past. Cement Concrete with large volumes of fly ash needs to be used in construction activities for the benefits discussed later in this paper.

Fly ash: Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is one of the coal combustion products, composed of the fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

In India, thermal power plants are the main source for producing electricity. Though attempts are being made to find solutions for cleaner production of electricity, but still there is a long way to go and we may depend on traditional coal burning thermal power plants for quite some more time (50-100 years). As a rough estimate, approximately 115 milliontons of fly ash are being produced annually from thermal power plants in India. However, only 40 million tons of fly ash are used annually in various engineering applications. The use of small percentages of fly ash in a variety of civil engineering works is being carried out mainly for economical reasons. Fly ash, being available, at negligible or no cost is taking place of cement, a costly construction raw material with the aim - one, to solve the problem of disposal of fly ash in environment and two, to get some financial benefit. However, researchers abroad, especially in developed countries, have proved that fly ash in high volumes can safely be used in concrete and results in better pump ability and long term durability. The use of fly ash in concrete has increased in last 20 years considerably.

IV. CONCLUSION

Fly ash concrete is most important building material for the sustainable construction and consumption of large volumes of fly ash. Literature discussed in the present paper has given an overview of advantages of fly ash concrete to increase workability and durability of concrete. The literature surveyed has also listed the slower strength gain at early ages as major problem in making fly ash concrete very popular in the Indian construction industry which is only focused on short term strength gain. A detailed mix design procedure along with conformation of results for designing fly ash concrete to achieve required strength at 28 days is needed. This study proves that Deep Nagar fly ash can be successfully used in the cement concrete in minor amount as an additive. Considering the intangible cost of disposal problem of fly ash and hidden cost of environmental protection, the methodology appears to be indeed successful. Fly ash is actually a solid waste. So, it is priceless. If it can be used for any purpose then it will be good for both environment and economy. Use of this fly ash as a raw material in Portland cement is an effective means for its management and leads to saving of cement and economy consequently. Hence it is a safe and environmentally consistent method of disposal of fly ash.

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