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A REVIEW ON FLY ASH CONCRETE

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ABSTRACT

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. Infrastructural Development is at its peak all over the world and is a symbol of growth for any country. The most popular construction material, involves use of cement which is responsible for 7% of total world's carbon dioxide emissions. Carbon dioxide is the main threat in causing global warming of the environment. The attempts have been made to reduce CO_2emissions 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. The paper aims at discussing the use of fly ash concrete in construction as a solution to address two environmental problems - one, disposal of huge amounts of fly ash, by production of thermal power plants, causing environmental degradation through large areas of landfills and two, high percentage of carbon dioxide emissions in atmosphere from cement industry.

Key Words : Cement, fly ash, Concrete, fly ash concrete, Environment.

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 huskThe 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.

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.

LITERATURE REVIEW

Chatterjee,(2011) reported that about 50 % of fly ash generated is utilised with present efforts. He also reported that, one may achieve up to 70% replacement of cement with fly ash when high strength cement and very high reactive fly ash is used along with the sulphonated naphthalene formaldehyde superplasticizer. He reported improvement in fly ash property could be achieved by grinding and getting particles in submicrocrystalline range.

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.

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 a 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 superplasticizers in reducing green house 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.

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. Analysing 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.

Hwang, Noguchi &Tomosawa, (2004) based on their experimental results concerning the compressive strength development of concrete containing fly ash, the authors concluded that the pores in concrete reduce by addition of fly ash as replacement of sand.

(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.

Namagg&Atadero, (2009) described early stages of a project to study the use of large volumes of high lime fly ash in concrete. Authors used fly ash for partial replacement of cement and fine aggregates. Replacement percent from 0% to 50% was tested in their study. They reported that concrete with 25% to 35% fly ash provided the most optimal results for its compressive strength. They concluded that this was due to the pozzolanic action of high lime fly ash.
(Jones & McCarthy, 2005) made an extensive laboratory based investigation in to unprocessed low lime fly ash in foamed concrete, as a replacement for sand. For a given plastic density, the spread obtained on fly ash concretes were up to 2.5 times greater than those noted on sand mixes. The early age strengths were found to be similar for both sand and fly ash concrete, the 28-day values varied significantly with density. The strength of fly ash concrete was more than 3 times higher than sand concrete. More significantly while the strength of sand mixes remained fairly constant beyond 28 days, those of fly ash foamed concrete at 56 and 180 days were up to 1.7 to 2.5 times higher than 28 days values respectively.

(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.

(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.

(Neville, 2009) In general, the aggregate cement ratio is only a secondary factor in the strength of concrete but it is found that, for a constant water cement ratio, a leaner mix leads to higher strength for higher aggregate cement ratio. A large amount of aggregate absorbs a greater quantity of water. It reduces the effective water cement ratio increasing the strength. The most likely explanation, however, lies in the fact that the total water content per cubic meter of concrete is lower in a leaner concrete. As a result, in a leaner mix, voids form a smaller fraction of total volume of concrete, and it is these voids that have an adverse effect on strength.

(Pofale, &Deo, 2010) with their study indicated about 20% increase in compressive strength and about 15% increase in flexural strength of concrete over control concrete by replacing 27% of sand with low lime fly ash. In study fly ash based Portland pozzolana cement was used. They had also reported about 25% increase in workability of the fly ash based concrete over control concrete.
Out of large number of papers studied papers only found very relevant are included for putting forward present objectives. Literature discussed has shown partial replacement of scarce sand with fly ash had shown higher strength from 3rd day as compared to control concrete. Long term strength was about 20% higher than the control concrete. Along with increase in strength, increase in workability and durability of concrete by partial replacement of sand with fly ash is very encouraging.

Analysing the results it may be seen that due to ball bearing and pore filling effect, dispersion of cement particles and pozzolanic reactivity of fly ash as partial replacement of sand workability and strength also increased. This additional strength and workability offered by partial replacement of sand with fly ash could offset loss of 28days strength of high volume fly ash concrete

MATERIALS

Cement

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 is the fine residue produced from the combustion of pulverized coal in electric and steam generating plants. 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 million tons of fly ash are being produced annually from thermal power plantsin India. However, only 40 million tons of flyash 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 outmainly 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 abilityand long term durability. The use of fly ash in concrete has increased in last 20 years considerably.

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. It is must to shift contractors focus on economical and durable fly ash concrete even if higher days of curing are required.

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