Partially replacement of cement with flyash and silica fumes

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ABSTRACT

The concrete industries are facing the environmental impact of the cement production by the emission of carbon dioxide. Partial replacement of cement has been tried by low, medium and high volume with pozzolanic waste materials that include flyash, silica fume, rice husk ash, furnace slag having high silica and cementitious contents. Total replacement of cement is also of current interest by the emerging new material called geopolymer concrete. Among all the replacement materials for cement, flyash has been identified which is being produced in large quantities comparatively is recommended for use in concrete. A good quantum of research has been made on flyash utilisation including the development of geopolymer concrete but, most of them are confined to the utilisation of low calcium flyash called class C flyash. Only limited research has been done and reported about the utilisation of high calcium flyash called class C flyash which is the waste, based on lignite burning in thermal power stations. Class C ash being more cementitious in nature compared to class F ash, the high calcium content is a problem for the rebar corrosion and concrete deterioration. However, it is believed that if the microstructure is suitably modified with the incorporation of silica based additives to flyash based concrete it could be materialized with the development of bulk utilisation of high calcium flyash concrete.

Keywords*— Flyash, Silica fumes,Compressive Strength,Workability;*

INTRODUCTION

The impacts of substitute building technologies on energy and environment have made an inventive thinking to consume industrial wastes for meeting its demand. The greatest challenge of this century that the concrete industry faces is to achieve a sustainable pattern of growth. The task is formidable, but the ideas and experience show that it can be accomplished if we make a paradigm shift from the culture of accelerating construction speeds to the conservation of energy and material. Cement requires enormous heat in its manufacturing, making it expensive to the environment. For every ton produced, half a ton of CO2 is released by fuel burning andclinker forming, making responsible for more than 8% of all the greenhouse gasesreleased. The net cement production in the world by 2015 is nearly 3 Billion MetricTonnes and growing at 5% annually. The replacement of cement is a must and for the replacement materials among which flyash seems tobe more effective.

Concrete constituents are becoming scarce and researchers are in search ofalternatives for them. The replacement with flyash for Portland cement was realisedas an effective means to reduce greenhouse gas emissions while also advance sustainable development. Consisting mostly of silica, alumina and iron, flyash is a pozzolan, a substance containing aluminous and siliceous material that forms cementin the presence of water. When mixed with lime and water it forms a compoundsimilar to Portland cement. The spherical shape of the particles reduces internal friction thereby increasing the consistency of concrete and also mobility. The recent development of geopolymer concrete technology involves the 100 percentreplacement of cement with ash materials. An activating solution is used to havepolymerisation process, finally resulting in a hard concrete with other conventionalingredients.The main precautions associated with the use of flyash in concrete can include slowerearly strength development, extended initial setting time, difficulty in controlling aircontent, seasonal limitations during winter months, and quality control of flyashsources. The 28 days strength is reached normally in 40-45 days depending on the fraction of flyash used. This problem can be solved by adding admixtures to flyash concrete. Steam curing can also be recommended particularly for precast products.Flyash reacting with available lime and alkalis generate additional cementitiouscompounds that act to block bleed channels, filling pore space, and reducing thehydraulic conductivity of hardened concrete (Mullick, 2005). The pozzolanic reactionconsumes Ca(OH)2 (calcium hydroxide), which is leachable, replacing it withinsoluble calcium silicate hydrates (CSH). The increased volume of fines and reducedwater content also play a role in reducing hydraulic conductivity. Flyash is a preconsumed supplementary cementitious material (SCM) which is awaste stream of a manufacturing process and there are mainly two types of flyash asclass C and class F mentioned in the construction industries based on the CaOcontent. The bituminous, semi bituminous or lignite and coal based fed in the thermalpower stations (TPS) contribute the different types of flyashes. The development ofnatural lignite formation can be well understood (Stadhouders, 2010). Many authors distinguished the salient features between Class Cand F types of flyash in different countries which are very useful for realization.

OBJECTIVES

The salient objectives of the present study have been identified as follows:

1. The main objective of the present work is to develop structural concrete.
2. The determination of the possibilities of directly using the flyash replacing a high % of cement
3. The scope of the present work is limited to the feasibility study

NEED FOR THE PROPOSED WORK

Necessity and importance of the study on bulk utilization of high calcium flyash in structural concrete.

i) Strength and durability characteristics
ii) Analysis and discussion on the investigation.
iii) Decrease the cost of making concrete.
iv) The qualitative and quantitative conclusion.

LITERATURE REVIEW

The information presented here are a worldwide collection of research activities. The research works reported aremostly on the utilisation of low calcium (class F) flyash only. The reported works onhigh calcium (class C) flyash is comparatively very much limited.Flyash was first recognized as a mineral admixture for concrete in the 1930s, fly ashhas been the subject of worldwide study as researchers work to maximize itseconomical and environmental benefits (Ramesh et al, 1997). Investigations havefocused on the physical, chemical and mineralogical characteristics of fly ash andtheir specific correlation to the performance of concrete. A complete review of theadvantages of fly ash as a mineral admixture to concrete, including strengthdevelopment and improved chemical resistance durability is available. A review ofthe current international standards on fly ash usage is provided, in addition to anextensive reference list and a complete survey of various other fly ash products, suchas bricks, mineral wool, and gypsum wall boards, as well as the use of fly ash in wastemanagement. Lignite if formed from peat is exposed to pressure and heat over long periods of time(Stadhouders, 2010). The longer the exposure period, the lower the moisture and ashcontent of the resulting coal and the higher its fuel quality. Lignite is a young type ofcoal, and is therefore considered to be of a low-rank fuel quality. Lignite is not ahomogeneous product. There are quality variations within and between the lignitelayers (Adamidou et al. 2007). These differences also translate in the LFA quantitiesand composition. Large variations in the composition make processing morecomplicated. To control the burning process within the lignite power plant a constantblend of various lignite qualities is fed into the plant. This consequently also ensures amore constant composition of the LFA. A major environmental concern associated with fly ash is the mobilization of traceelements that may contaminate water. To better evaluate proper use of fly ash,determine appropriate disposal methods, and monitor post disposal conditions, it isimportant to understand the speciation of trace elements in fly ash and their possibleenvironmental impact. The speciation of selenium, arsenic, and zinc was determinedin five representative class C fly ash samples by Yun Luo et al (2011). This workdemonstrates that residual carbon in fly ash may reduce potential selenium (Se)mobility in the environment by retaining it as less soluble elemental Se instead of Se(IV). Further, suggests that arsenic (As) and zinc (Zn) in class C fly ash will displaysubstantially different release and mobilization behaviors in aquatic environments.Release of As will primarily depend upon the dissolution and hydrolysis of calciumpyroarsenate and Zn release will be controlled by the dissolution of alkalinealuminosilicate glass in the ash.

Pistilli and Majko (1984) described the results of five different concrete mixes havingclass C flyash containing 9-12%, 15% and 25-30% CaO and reported the optimisedamount of flyash as 20-50% replacement of cement. It is also reported that properlyair-entrained, showed excellent freeze-thaw durability (85 to 95% relative durabilityfactor [RDF]) and good air-void parameters even at high flyash contents. The settingtimes for the flyash mixtures were longer by 4 to 6 h in the presence of a waterreducer and very high flyash contents. Subasi (2009) investigated the estimationability of the effects of utilizing different amount (0, 5, 10, 15 and 20%) of the class Cflyash in cement on the mechanical properties of mortar, like compressive andflexural tensile strength using artificial neural network and regression methods withusing ash content and reported that the multilayer feed-forward neural network models prediction was better than regression techniques.

Experimentation

Strength
Characteristics
1. Cube Compression
2. Cylinder Compression
3. Split Tensile Strength
4. Flexure Strength

Workability Characteristics

1.Slump value

The workability property is measured by conducting slump cone test in accordance with IS: 1199 – 1959. The trails are carried out to improve the workability and cohesiveness of the fresh concrete by incorporating a superplasticizer. Marsh cone test is carried out to select the better combination of water, cementitious materials and chemical admixtures

STRENGTH CHARACTERISTICS OF FRESH CONCRETE

The details of total number of specimens for M30 grade with and without flyash, silica fume and superplasticizer are given in the Table 4.12 to test for various strength and durability characteristics. The types of specimens cast for strength testing are presented

No	Properties (Specimen)	Age of Testing (Days)
1	Compressive Strength (Cube)	7,14, 28,
2	Split Tensile Strength	7,14, 28,
3	Flexural Strength	7,14, 28,

MIX PROPORTIONING OF CONVENTIONAL M30 GRADE CONCRETE

With the determined properties of the concrete constituents, concrete grade of M30 isdesigned by IS method as detailed in Table 4.10. Based on the trial mixes a correctproportion is arrived. The worked out quantities for various types of concrete arepresented in Appendix E. Initially maintained w/c ratio of 0.42 is and then is reduced to0.3% and the dosage of SP is adjusted.

Water	Cement	Fine Aggregate	Course Aggregate
203.6	484.76	514.49	1148.58
0.42	1	1.06	2.36

Table 4.10 Mix Details of M30 grade Conventional Concrete by IS method

Characteristics of Conventional M30 Concrete

With the design proportions of conventional M30 concrete, tests are conducted to for the workability and strength characteristics. Weigh batching and machine mixing are adoptedfor preparing concrete. Slump, compaction factor and flow table tests are conducted. Two mixes, one without plasticizer other with plasticizer are considered. The workabilitycharacteristics are presented in Table 4.11 and the views are presented in Appendix F.

Parameters	Slump mm	Compaction Factor	Flow Percentage
Without Plasticizer	46	0.80	10.10
With Plasticizer	48	0.86	11.30

Table 4.11 Workability Characteristics Conventional Concrete

RESULTS

Experimental Results

Compressive and Tensile Strength Tests

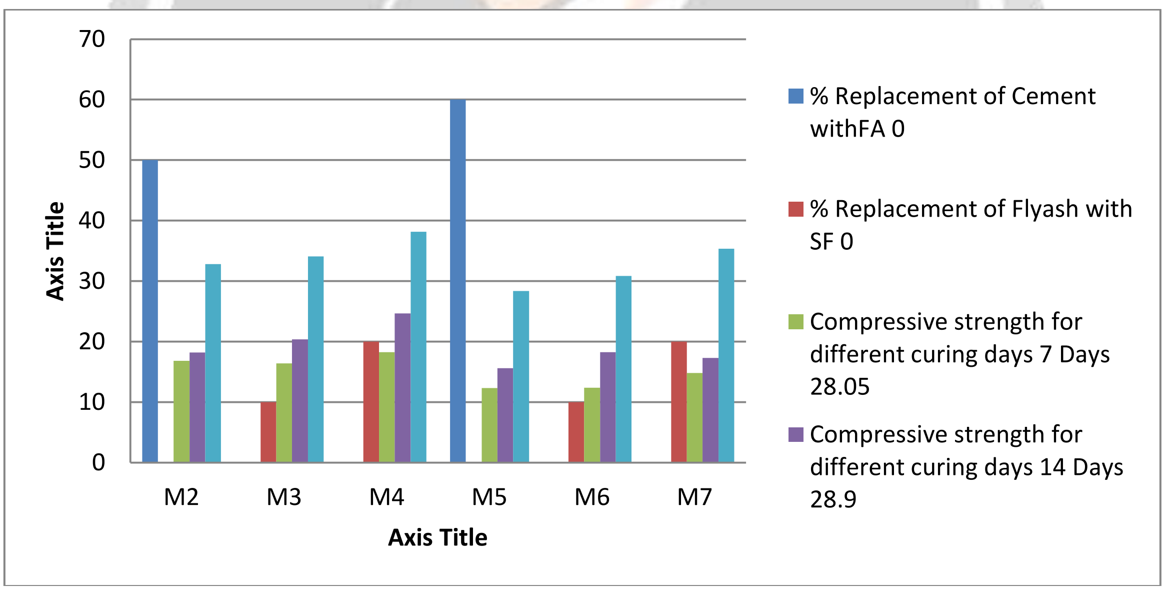
Cube specimens 100mm size and 100×200mm cylindrical specimens are tested for compressive strength in the respect to the age of curing in a standard manner as per as per IS: 516 – 1959. For each mix combination, three identical specimens were tested at the ages of 7, 14, 28 days. Results is presented As the compressive strength for cement replacement more than 60% is not satisfactory, the cement replacement of 50% and 60% are considered for further study.

Mix	% Replacement of		Compressive strength for different curing days		
	Cement withFA	Flyash with SF	7 Days	14 Days	28 Days
M1	0	0	28.05	28.90	36.4.
M2	50	0	16.80	18.19	32.80
M3		10	16.41	20.38	34.05
M4		20	18.26	24.65	38.15
M5	60	0	12.32	15.60	28.33
M6		10	12.36	18.22	30.85
M7		20	14.80	17.30	35.36

Cube Compressive Strength Concrete without SP

Mix	% Replacement of		Compressive strength for different curing days		
	Cement withFA	Flyash with SF	7 Days	14 Days	28 Days
M1S	0 0.6%SP	0	29.40	32.90	39.40
M2S	50 1.2%SP	0	16.87	20.19	34.80
M3S		10	18.41	21.38	36.65
M4S		20	20.36	24.35	39.15
M5S	60 1.5%SP	0	12.22	16.60	31.33
M6S		10	12.36	18.02	32.85
M7S		20	15.80	17.30	36.36

Cube Compressive Strength of Concrete with SP



Compressive Strength Results

CONCLUSIONS

Compared with conventional cement concrete, the flyash based concrete is more workable and still more with the additions of silica fume. However, slump value is slightly reduced (0 to 20mm) with the intention of improving the strength which is indirectly proportional to the water-cement ratio. For M30 grade concrete even though studies are made for concrete with and without SP, the concrete with SP showed better overall performance in workability, strength and durability characteristics in general. Compared with conventional cement concrete w.r.to cube compressive strength: Compressive strength of concrete for 50% and 60% cement replacement with flyash is satisfactory and other replacement levels are not so even with the addition of silica fume with the normal conditions.

SUGGESTIONS FOR FURTHER RESEARCH

Cement replacement up to 50% by weight of class C flyash is recommended with admixtures compulsorily and 10% of flyash replaced with silica fume. Cement replacement up to 60% by class C flyash is recommended for NLC flyash with admixtures compulsorily and 20% of flyash replaced with silica fume. Further, for more than 60% utilisation of flyash for replacing cement, substance like rice husk ash or nano-silica may be added in conjunction with silica fume which is the best additive for cement replacement.

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