

Literature Review on partial replacement of cement by fly ash on strength of concrete

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ABSTRACT

The objective of this paper is to explore the feasibility and effect of replacement of coarse natural aggregates with blast furnace slag and partial replacement of cement by silica fume and fly ash in different percentage proportions. This will help in conserving the natural resources and keeping ecological balance to fulfill present demand of construction material in infrastructure development sector which is increasing at alarming rate. Therefore it is required to reduce the use of natural aggregates and cement to meet the future demand which will enhance the utility of waste materials and at the same time minimize the demand for natural aggregates and cement.

1. Introduction

Concrete is a composite product obtained by mixing cement, water and an inert matrix of sand and gravel or crushed stone. It undergoes a number of operations such as transportation, placing, compacting and curing. The elements of the concrete can be characterized into two gatherings to be specific dynamic and latent in which dynamic gathering comprises of bond and water and idle gathering includes fine and coarse aggregates. The latent gathering contains fine and coarse aggregates are additionally called as dormant lattice. The phenomenal obstruction of cement to pressure looks like the foremost normal for regular stone. It is most generally utilized development material because of its better designing properties, amazing imperativeness and capacity to get formed in any shape and size. In any case, it is feeble in strain and has low effect opposition [1].

The properties like functionality, quality and concreteness are fundamental execution parameters of cement. This has prompted the work which was at first restricted to High Strength Concrete (HSC), at that point stretched out to High execution Concrete (HPC). HPC blend is planned with mineral and concoction admixtures alongside other typical elements of cement having low water-bond proportion. Expansion of mineral admixtures to concrete decreases warmth of hydration because of diminished bond substance and expands strength by adding to pore refinement [2].

There is developing acknowledgment all through the world that crude materials assets utilized in the generation of concrete are limited and non-inexhaustible. The need to moderate materials for future ages has emphasized the noteworthiness of growing new structure materials. With the goal of accomplishing supportable development a concrete pattern supporting the expanded utilization of admixtures in cement is rising all through the world. The mineral admixtures are essentially the waste results of mechanical procedures, delivered to the tune of a huge number of tons whose transfer is an incredible concern. Fly fiery remains from coal based power plants is one such waste which is liberally accessible in the various pieces of India. Cement can fill in as the most secure home of fly cinder and

has an enormous potential for its use. Fly powder or pummeled fuel fiery debris, a modern misuse of coal based warm power plants, comprises of finely separated round particles of silicate glass adjusted with aluminum and iron and can be utilized in cement because of monetary and specialized favorable circumstances. Conconcreteation of fly fiery debris results in impressive upgrades in concrete properties. Fly fiery remains is the most generally utilized pozzolan on the planet [3].

Benefits of Air Cooled Blast Furnace Slag

Different types of slags find different uses in the industry. The air-cooled BF slag is crushed, screened and used mainly as road metal and bases, asphalt paving, railway ballast, landfills and concrete aggregate. The extended or frothed slag ties well with bond and is utilized chiefly as aggregate for lightweight cement. In any case, it isn't created by residential steel plants. Granulated BF slag is utilized as a pozzolanic material for creating portland slag bond. It is additionally utilized for soil molding. BF slag is utilized in making mineral fleece for protection purposes. Steel slag has discovered use as an obstruction material solution for waste destinations where substantial metals will in general drain into the encompassing condition. Steel slag powers the substantial metals to drop out of arrangement in water overflow on account of its high oxide mineral substance. Steel slag has been utilized effectively to treat acidic water releases from deserted mines. Slags are valuable elective crude material for clinker creation and such use can diminish a bond plant's fuel utilization and by and large emanation of carbon dioxide per ton of concrete. The granulated slag got from different steel plants is dried in slag dryer. The clinker is ground in ball factory with 40-half dry slag 19 and 6% gypsum. The resultant item is Portland slag bond. Portland impact heater slag concrete contains up to 60% ground granulated slag from steel creation forms. Slag concrete has low warmth of hydration, low salt aggregate response, high protection from chlorides and sulfate and it can substitute the utilization of 43 and 53 evaluations of common Portland bond. For other expending segments like street making, land filling and ballasting, the cooled slag is smashed by machines or broken physically by sledges into little pieces and provided to the different end-use purchasers [5].

2. Literature Review

This paper manages the audit of the distributed writing on cement containing fly fiery debris. Its dangers, transfer, ecological perspectives and usage are additionally examined. Basic properties of fly fiery remains concrete and quaternary cement containing fly powder, air cooled impact heater slag and silica fume have been inspected in a word and accentuation has been laid on Compressive quality and flexural quality of cement containing fly cinder, air cooled impact heater slag and silica smolder.

Fly fiery debris concrete is acquired by supplanting a piece of bond by a proper measure of fly powder in the concrete. In region of elite cement (HPC), significant progressions have been to a great extent saw with the concreting of mineral admixture like fly fiery remains. The utilization of silica fume and air cooled impact heater slag what's more with fly cinder has demonstrated successful in upgrading the mechanical properties of new and concreteified cement as it were. Expansion of silica fume improves the quality, toughness and pressing thickness of concrete, which prompts its improvement in opposing synthetic assault, porousness and so forth [6].

Accumulation of Fly Ash

Amid the ignition of pummeled coal in suspension-terminated heaters of present day warm power plants, matters which are unstable in nature are vaporized and most of the carbon is singed off. The mineral issue related with the coal, similar to earth, feldspar and quartz crumble or slag. These slag particles and unburned carbon are gathered as cinder. The coarser particles fall in the base of the heater and are gathered as base powder or otherwise called evaporator slag. Some better particles escape with vent gases, are gathered as fly fiery remains utilizing violent wind separators, electrostatic precipitators or sack houses.

Contingent on the gathering framework fluctuating from mechanical to electrical precipitators or sack houses and texture channels, around 85 to 99.9% of the fiery remains from the pipe gases is recovered as fly slag. Fly powder, represents 75 to 85% of the all out coal cinder, and the rest of the 15 to 25% is gathered as base fiery debris or kettle slag [7].

Fly fiery remains is for the most part pozzolanic due to its fine molecule estimate, mineralogical arrangement, and nebulous character and sometimes additionally self cementitious. The base fiery debris and evaporator slag are a lot coarser and are not pozzolanic in nature. Along these lines perceive that all the fiery debris isn't fly powder and the fly cinders created by various power plants are not similarly pozzolanic and, consequently they are not constantly appropriate for use as mineral admixture in cement.

Fly slag produced in coal consuming force plants is a characteristically factor material as a result of a few variables. Among these are mineralogical creation of the coal, level of coal pummeling, kind of heater and oxidation conditions including air-to-fuel proportion, and the way wherein fly fiery remains is taken care of, gathered and put away before use. Since there are no two utilities or plants may share these variables for all

intents and purpose, thusly, fly fiery remains from different power plants is distinctive [8].

The fly cinder properties may likewise differ inside a similar plant due to stack conditions over a twenty four hour time frame. This non consistency in fly powder is a genuine inconvenience and some of the time is the principle obstacle in the compelling and wide scale usage of fly fiery debris as a pozzolona or a cementitious segment in bond and cement. For gathering of the fly fiery remains in an essential sum from close-by steel plant 12-15 plastic packs were masterminded. The fly fiery debris container was opened and the fly cinder was permitted to straightforwardly fall into the plastic pack. At that point the sack of powder was shut and tied with a rope firmly so the fiery debris inside ought not interact with the outer dampness. The sacks were transported from the plant to research center and further consideration was taken to keep the cinder from interacting with different synthetic substances and dampness [9].

Specifications

Pozzolans are siliceous and aluminous materials which themselves have practically no cementitious incentive in finely partitioned structure and within the sight of dampness, it responds artificially with calcium hydroxide at surrounding temperature to shape mixes with cementitious properties (ASTM Standard C618-80). Fly fiery remains is a strong, fine-grained material coming about because of the ignition of pounded coal in heaters of intensity station. The subsequent material is gathered in mechanical or electrostatic separators. The buildup extricated from the base of boilers isn't called fly cinder. Fly powder fit for responding with $\text{Ca}(\text{OH})_2$ at room temperature can go about as pozzolanic materials. The pozzolanic movement of fly fiery remains is credited to the nearness of SiO_2 and Al_2O_3 in nebulous structure. As indicated by ASTM C618-93 detail (1993) for —F1y Ash and Raw or Calcined Natural Pozzolan —for use as Mineral Admixture in Portland Cement Concrete, pozzolans are characterized as —siliceous and aluminous materials which in themselves have practically no cementitious esteem however it will, in finely partitioned structure and within the sight of dampness, it synthetically responds with calcium hydroxide at normal temperatures to frame mixes having cementitious properties [10].

Ravina and Mehta (1986) examined the impact of supplanting 35 to 50 % of bond by fly cinder, on the compressive quality of lean cement blends utilizing two ASTM class F and two ASTM class c fly fiery remains .tests results demonstrated that, contrasted concrete with 35 with half supplanting with fly powder achieved the required quality at 35 to 170 days, contingent upon the substitution rate and properties of fly slag.

Hobbs, Berry and Malhotra (1986) announced that both the quality at a given age and the rate of concreteness increase of fly fiery remains concrete were influenced by the attributes of the fly powder (properties, concoction arrangement, molecule estimate, reactivity), the bond with which it was utilized, the extents of each utilized in the concrete, the temperature and

other relieving conditions, just as the nearness of different added substances [11].

Parrott L.J. (1987) announced the rate at which concrete carbonates was a component of the accompanying elements: dimension of compaction, carbon dioxide focus/level, time of sodden relieving, penetrability, surrounding temperature and mugginess conditions, blend extents, level of immersion (dampness content), and the mass of calcium hydroxide accessible for response. The primary factor that could be utilized to confine the rate of carbonation is W/CM. All in all a decrease in W/CM extraordinarily diminished the deliberate profundity of carbonation. Moderate responding frameworks, for example, those with fly fiery remains advantage more from delayed clammy relieving in light of the fact that the bond in the surface layers of drying concrete will essentially quit hydrating if the inner relative moistness drops to about 80%. This brought about a high porosity and a high penetrability in the surface layers and expanded the rate of carbon dioxide dispersion [12].

Faltering (1989) researched the impact of supplanting bond (0 to 55%) by the fly fiery debris, he took three arrangement of cement blends with water-cementitious material proportion of 0.3, 0.4, 0.5 individually and reasoned that fly cinder contributed little quality at early ages. At 3 days, contrasted with portland bond concrete, the compressive quality diminished by 16% in normal for a 15% fly fiery debris substitution, and 66% for 55% fly slag substitution. At 28 days, the quality of fly slag blends was somewhat lower (4% in normal) than portland concrete blends, albeit 55% fly fiery remains substitution still brought about a 44% quality decrease. At the later ages, the commitment of fly slag to compressive quality improvement ended up noteworthy [13].

Sivasundereram V., Carette, G.G. also, Malhotra, V.M. (1990) revealed that unreasonable measurements of the naphthalene — based superplasticizer utilized in HVFC to get the required functionality brought about postponed setting of specific cements particularly, in those with high cementitious material substance. Rao, MVS et al. [52] announced that usefulness of fly powder concrete was more than that of controlled cement even at 60% fly fiery remains content [14].

3. Experimental Methodology

This paper outlines the experimental programme planned for this investigation in detail. The basic properties of the various constituents of concrete such as cement, fine aggregates, coarse aggregates, fly ash, silica fume, air cooled blast furnace slag and water have been presented in this paper. Concrete mixture details along with method of casting and curing have also been reported. The main parameters studied are compressive strength test and flexural strength test of quaternary mix containing fly ash, air cooled blast furnace slag and silica fume. The prime objective of this study was to evaluate the performance of binary, ternary and quaternary mix concrete in terms of above parameters and to compare them with results of plain cement concrete [15].

Test programme

The test program as follows was planned to investigate the compressive strength and flexural strength test of binary, ternary and quaternary mix.

- To obtain the properties of constituent materials of concrete like cement, fine aggregate, coarse aggregate as per relevant Indian Standard Codes of Practice, wherever applicable used in this investigation.
- To design concrete mix (M30) for selecting reference mix as per IS 10262-2009.
- To proportion binary, ternary and quaternary concrete mixes incorporating varying percentages of fly ash, air cooled blast furnace slag and silica fume.
- To cast and cure the specimens.
- To conduct compressive strength test on reference mix, binary mix containing fly ash, ternary concrete mix containing both fly ash and silica fume and quaternary mix containing fly ash, silica fume and air cooled blast furnace slag. To conduct flexural strength test on reference mix, binary mix containing fly ash, ternary concrete mix containing both fly ash and silica fume and quaternary mix containing fly ash, silica fume and air cooled blast furnace slag.

Physical Properties of Materials used

The properties of materials used for making concrete are determined in laboratory as per relevant codes of practice. The various materials utilized in the present investigation were bond, fine aggregate, coarse aggregate, water, fly cinder, air cooled impact heater slag, superplasticizer and silica smolder. Research facility tests were led on these materials and their properties have been accounted for in the accompanying segments [16]:

Concrete

Concrete is a fine ground material, which can be made into a glue for the most part by the expansion of water which gives restricting medium to fixings and set the glue into a strong mass. Portland bond is most generally utilized around the world. It is a grayish in shading gotten by finely granulating the clinker made by emphatically warming blend of calcareous and argillaceous minerals. Limestone, silica, alumina and iron-oxide are the fundamental crude material of bond.

In the present examination, Ordinary Portland bond (OPC) of 43 Grade (Ultratech) from a solitary bunch was utilized for all the concrete blends. The evaluating of concrete fluctuates because of the nearness of top notch limestone, present day hardware, better molecule measure circulation, better pounding and better pressing. Bond taken was new and with no protuberances with consistency in its shading. The bond was tried according to May be: 8112-1989 for its typical consistency, Initial and Finals setting time, Specific gravity and compressive quality for 3, 7 and 28 days, the aftereffects of different tests directed are accounted for in the table 1. Test esteems are contrasted and codal values [17].

Table 1: Physical Properties of Cement

Sr. No.	Properties	Experimental value	Specified Value as per IS: 8112- 1989
1	Consistency of Cement	30%	-
2	Specific gravity	3.12	3.15
3	Initial setting time	110 minutes	>30 minutes
4	Final setting time	265 minutes	< 600 minutes
5	Compressive Strength (N/mm ²) 3 days 7days 28 days	30.4 41.16 48.82	>23 >33 >43

Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and affects economy. The aggregate consist of inert and course materials. Fine aggregate in concrete helps with creating functionality and consistency in blend. The fine aggregate likewise helps the bond glue to hold the coarse aggregate particles in suspension. This activity advances pliancy in the blend and counteracts the isolation of the glue and coarse aggregates. The coarse aggregates are utilized fundamentally to give mass to the concrete. IS: 383-1970 characterizes that the fine aggregate are aggregates the greater part of which go through 4.75 mm IS strainer. The coarse aggregates are characterized as aggregates the greater part of which are held on 4.75 mm IS strainer.

Coarse Aggregates

Smashed stone and regular rock are normal material utilized as coarse aggregate for cement. Regular rock are by and large quarried from pits though coarse aggregates are

acquired by smashing different sorts of stone, schist, gneiss, crystalline hard lime stone and great quality sand stones. For high quality cement fine grained stone is best aggregate. Coarse grained rocks make brutal cement, and need high extent of sand and high water bond proportion to get sensible level of usefulness. Additionally the material held on 4.75mm sifter is named as coarse aggregate [18].

In the present work, locally accessible smashed stone aggregates going through 20 mm is strainer was utilized. Most extreme size of aggregates utilized is 20mm. The aggregate were first sieved through 10 mm sifter and after that through 4.75 mm strainer. They were then washed to expel residue and earth and were dried to surface dry condition. Sifter examination and different tests for coarse aggregates were performed in research facility. The properties of aggregates were found to accommodate the prerequisites of IS: 383-1970. The aftereffects of sifter investigation, proportioning of aggregates and different physical properties of coarse aggregate are introduced in Table 2 to 3.

Table 2: Sieve Analysis for Coarse Aggregates (Max. Size 10mm)

IS-Sieve Designation	Weight Retained on Sieve (gm)	Cumulative Wt. Retained (gm)	Cumulative %age Wt Retained	%age Passing	IS 2386:1963 (Part-I) requirement
80 mm	Nil	Nil	Nil	100	100
40 mm	Nil	Nil	Nil	100	100
20 mm	Nil	Nil	Nil	100	100
10 mm	738	738	14.76	85.24	85-100
4.75mm	4200	4938	98.76	1.24	0-20
2.36mm	50	4988	99.76	0.24	0-5
Pan	12	5000	-	-	-

Table 3: Sieve Analysis for Coarse Aggregates (Max. Size 20mm)

IS-Sieve Designation	Weight Retained on Sieve (gm)	Cumulative Wt. Retained (gm)	Cumulative %age Wt Retained	%age Passing	IS 2386:1963 (Part-I) requirement
80 mm	Nil	Nil	Nil	100.00	100
40 mm	Nil	Nil	Nil	100.00	100
20 mm	9	9	0.18	99.82	85-100
10 mm	4891	4900	98.00	2.00	0-20
4.75mm	92	4992	99.80	0.20	0-5
Pan	8	5000	-	-	-

4. Conclusions

The present paper outlines the major conclusions drawn from the study. The partial replacement of cement by fly ash and of coarse aggregates by ACBFS resulted in decrease in compressive strength of concrete at all ages i.e. 7 and 28 days. A maximum decrease of 46% compared to control mix in compressive strength at 7 days was observed for the mix containing 25% of fly ash and 60% ACBFS. However, percentage decrease in compressive strength at 28 days was

found to be less as compared to 7 days for all the mixes. The addition of silica fume of as partial replacement of fly ash in the concrete mixes containing fly ash resulted in increase in compressive strength at all the ages as compared to concrete containing fly ash and ACBFS. However maximum increase in compressive strength was observed for mix M16 containing 17.5% fly ash and 7.5% silica fume with replacement of 60% coarse aggregate by ACBFS at 28 days.

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