Utilization of fly ash as cement replacement Material to increase productivity of concrete

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Abstract- *Using fly ash as supplementary cementitious material in concrete has been know almost since the last century. Fly ash concrete has economical and environmental advantages. It also makes concrete sustainable. In India presently less than 60% 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 the 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 CO2emissions in the 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. In present study aims preparing concrete by replacing ordinary Portland cement with the fly ash in various proportion like- 0%,10%,20%,30%,40%,50% & 60% fly ash as a mass. And to test various properties of concrete such as compressive strength, workability, standard consistency, specific gravity, initial setting time.*

Keywords- Compressive strength, Fly ash concrete, Workability

I. INTRODUCTION

Concrete is the most widely used construction material and the second most consumed resource in the world . As demand for concrete as a construction material increases the production of Portland cement will also increase. However, production of Portland cement liberates a considerable amount of greenhouse gas as a result of decarbonation of limestone in the kiln during manufacturing of cement and the combustion of fossil fuels. Furthermore, Portland cement is also among the most energy intensive construction materials, after aluminium and steel. Efforts have, therefore, been made to promote the use of pozzolans to replace part of Portland cement. Fly ash is thought to be good candidate for source materials because it is the residue from coal burnt in a thermal power plant and regarded as a waste product. The coal- based thermal power plants generates the fly ash as a byproduct. Fly ash been generally considered a waste material in the past and disposal of which has posed numerous ecological and environmental problems. But, recent researches have shown that fly ash has potential to act as invaluable ingredient in cement and concrete if used within the framework of prescribed specifications and quality systems. The fly ash is now considered as a resource material rather than a waste in civil engineering and material science. In today's Era energy planners are aiming to increase the use of Oil, Gas, Nuclear and also Renewable Energy sources to meet the electricity demand in India. But till now coal-based thermal power plants are the major source of electricity generation and they will continue to dominate in the next few decades too. Disposing of Fly Ash is One of the major problem in front of coal-based thermal power plants. It was earlier considered as a total waste and an environmental hazard, thus its use was limited, without much understanding. Fortunately, its useful properties have now begun to be known as raw material for various applications. Fly ash from the thermal plants is available in large quantities in fine and coarse form.. Thermal power plant in India are primarily dependent on the combustion of high-ash bituminous coal in pulverized fuel- fired system that typically have ash contents of 30-45%. A lot of research has been done over using fly ash as additive in cement, admixture in concrete and cement replacement material in concrete. The concrete Compressive strength at different proportions of cement being replaced by fly ash has been checked and results have been found effective and applicable. But most of the research has been limited to few percentages of cement replacement or less grade of concrete. Therefore, there borne a need to carry out an extensive research on compressive strength of different grades of concrete, different proportions of fly ash and different curing periods. Hence, a comparative study can be done and use of fly ash as a cement replacement in concrete can be analyzed and compared through various methods.

II. CLASSES OF FLY ASH

According to ASTM C-618 Fly ash is broadly classified into two major categories: Class F and Class C fly ash. The chief difference between these two classes is the amount of calcium, silica, alumina, and iron content. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned i.e., anthracite, bituminous, and lignite.

Classes "F" fly ash- The burning of old anthracite and bituminous coal typically produces Class F fly ash which contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class "F" Fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively the addition of a chemical activator such as sodium silicate (water glass) to a Class "F" ash can lead to the formation of a geo-polymer.

Class 'C' Fly ash -Class "C" Fly ash produced from the burning of younger lignite or sub bituminous coal generally contains more than 20% lime (CaO). This type of ash does not require an activator & the contents of Alkali and sulfate (SO4) are generally higher as compare to the Class "F" Fly ash.

III. OBJECTIVE OF STUDY

1. To find out the various parameter of cement viz. Initial setting time, standard Consistency test after replacing fly ash with the cement
2. To know the effects on various parameters of concrete viz. Compressive strength test, Tensile strength test, workability test by replacing concrete with fly ash.
3. To find out result for higher percentage of fly ash replacement with cement compare with no fly ash concrete.

IV. METHODOLOGY

Following materials were used in the experimental work:

- Cement: Ordinary Portland cement (Ultra-Tech Cements of 53 grades) was used having specific gravity: 3.15.
- Fly ash:. It was obtained from thermal power station.
- Fine Aggregate: Natural sand with maximum size of 4.75 mm was used (zone II) with specific gravity 2.62.
- Coarse Aggregate: Natural aggregates with maximum size of 20 mm were used with specific gravity of 2.7.

V. RESULTS AND DISCUSSION

Normal concrete Mixes as well as concrete Mixes made using fly ash as partial replacement of OPC at different replacement levels were tested for their workability, compressive strength after 7, 14 and 28days. Results for the workability and compressive strength discussed are discussed below.

1. Workability

The workability of OPC concrete was determined by the slump test. Workability can be define as the ease or difficulty with which the concrete is mixing, compacting and placing between the forms with minimum loss of homogeneity. The slump test used for workability shows the behavior of a compacted concrete cone under the action of gravitational forces. Slump test were used to gauge the workability of mixed concrete. The slump values of concrete for different percentage of fly ash.

Table 1. Workability of concrete Vs. percentage of fly ash

Workability test result		
Grade of concrete	M30	M40
Percentage of fly ash	Slum (in mm)	Slum (in mm)
0	15	10
10	20	15
20	25	22
30	35	30
40	40	36
50	45	40
60	50	45

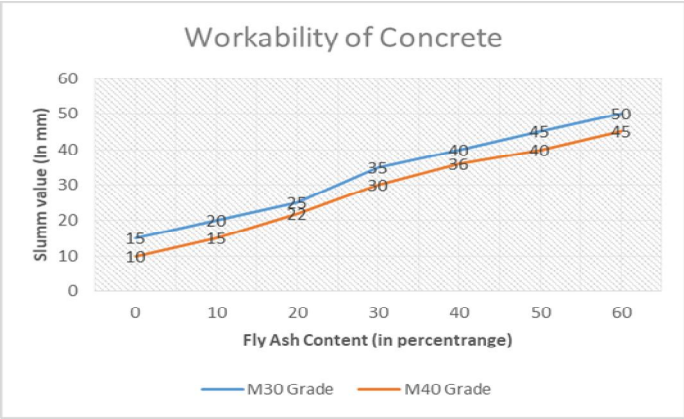

Figure 1. Workability of concrete vs. percentage of fly ash

2. Compressive strength

Compressive strength is defined as the ratio of the load per unit area. Compressive strength is estimated by

dividing the maximum load by the original cross-sectional area of a specimen in a compression test.

The compressive strength of different specimens for the same concrete mix is different, so the average compressive strength of three specimen sample was used for strength calculation. The Compressive strength of normal concrete as well as concrete made using fly ash as partial replacement of OPC is shown in table below.

Table 2. Compressive strength for M30 Grade concrete vs. percentage of fly ash

Sr No.	% of fly ash	M30 Grade compressive strength (N/mm²)			
		7 days	14 days	28 days	56 days
1	0	21.33	24.14	32.65	34.57
2	10	20.45	25.18	33.12	35.45
3	20	21.23	23.43	35.54	37.54
4	30	18.37	22.15	34.21	38.58
5	40	15.64	23.74	28.63	32.45
6	50	13.74	15.63	21.32	27.45
7	60	9.8	11.23	18.56	25.45

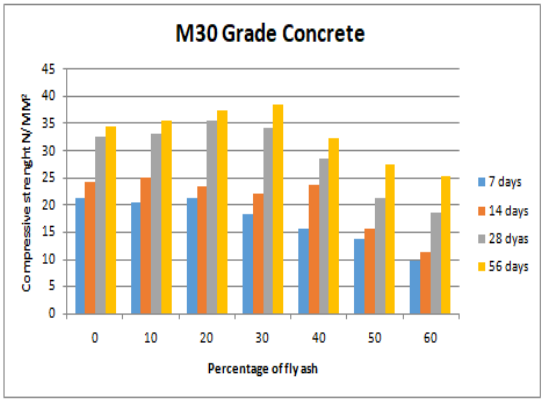

Figure 2. Compressive strength for M30 Grade concrete vs. percentage of fly ash

Table 3. Compressive strength for M40 Grade concrete vs. percentage of fly ash

Sr No.	% of fly ash	M40 Grade compressive strength (N/mm²)			
		7 days	14 days	28 days	56 days
1	0	28.89	36.14	42.75	43.56
2	10	29.58	36.45	43.21	44.56
3	20	27.65	35.65	44.54	46.54
4	30	26.36	33.54	43.45	47.14
5	40	20.45	25.74	32.45	39.54
6	50	17.74	22.4	26.87	30.14
7	60	13.8	19.6	23.65	27.24

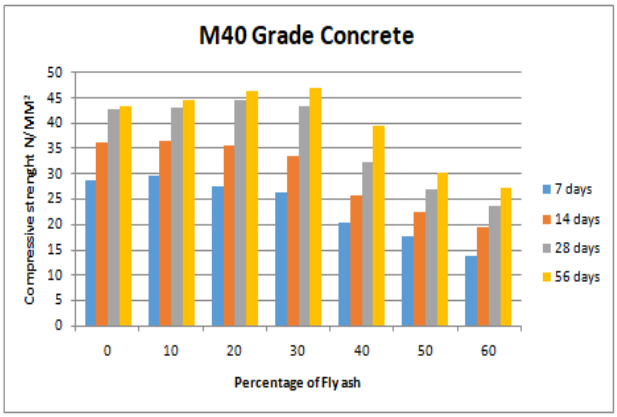

Figure 3. Compressive strength for M40 Grade concrete vs. percentage of fly ash

3. INITIAL SETTING TIME OF CEMENT

The time at which cement paste loses its plasticity is called initial setting time. Initial setting time test is important for transportation, placing and compaction of cement concrete. Initial setting time duration is required to delay the process of hydration or hardening.

Table 4. Initial setting time of cement replace with fly ash

Fly ash (In percentage)	Weight of cement in (gram)	Weight of fly ash (grams)	Initial setting time (Minute)
0	400	0	45
10	360	40	52
20	320	80	58
30	280	120	65
40	240	160	75
50	200	200	90
60	160	240	110

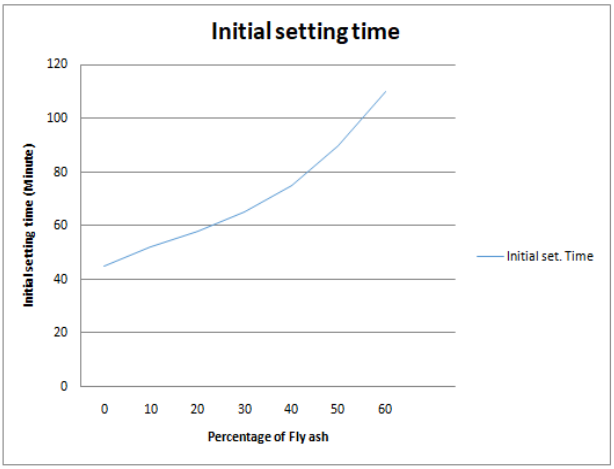

Figure 4. Initial setting of cement vs. percentage of fly ash

4. STANDARD CONSISTENCY TEST

The standard consistency of a cement paste is defined as that consistency which will permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould.

Table 5. Standard consistency test

Fly ash (In percentage)	Weight of cement in (gram)	Weight of fly ash (grams)	Consistency % (P)
0	400	0	33.0
10	360	40	32.0
20	320	80	32.0
30	280	120	31.0
40	240	160	30.0
50	200	200	30.0
60	160	240	29.0

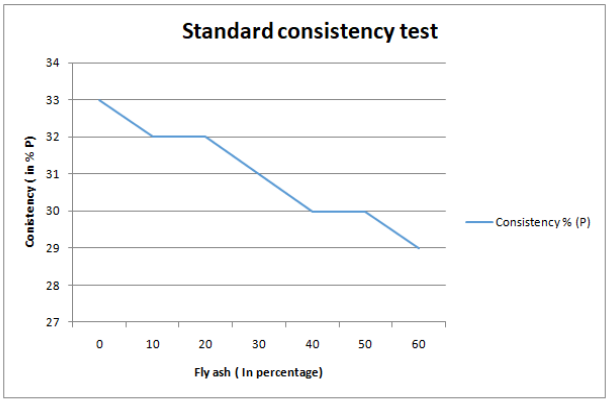

Figure 5. Standard Consistency of cement vs. percentage of fly ash

V. CONCLUSION

1. From the compressive strength result, it is found that use of fly ash in concrete decrease the early strength of concrete. But as the age of concrete goes on increasing there is increase in strength 28 day & 56 day indicating that fly ash has an adverse impact on early strength of concrete.
2. There is increase in slum value, for 30% replacement of cement slum value was found 1.33 times more than normal concrete. And this value further increase for 60% replacement of fly ash with concrete slum value found to be 2.33 times more than normal concrete.
3. Therefore at very low W/C ratio concrete with fly ash replacement will have higher workability.
4. From standard constituency test, it is conclude that use of fly ash in cement decrease the standard constancy of cement i.e. less water is required to make cement paste consistent.
5. A 20%-30% replacement of fly ash gives the most optimum result for compressive strength at 45 days a beyond 30% replacement of fly ash in concrete, there is decrease in the rate of gain of compressive strength.
6. From the result obtained above it is also found that replacing higher percentage fly ash with higher grade of concrete such as M40 give same or more compressive strength result compare with M30 grade of concrete with low percentage of replacement of fly ash. Therefore, it is observed that the M40 with 40% fly ash gives more 28 day strength and than M30 with 30% fly ash replacement.

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