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STUDY OF DRYING SHRINKAGE AND COMPRESSIVE STRENGTH ON PARTIALLY REPLACEMENT OF CEMENT WITH FLY ASH IN MORTAR

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Abstract – In the recent time, the importance and use of fly ash in mortar has grown so much that it has almost become a common ingredient in mortar, particularly for making high strength and high performance mortar. The new Indian Standard on mortar mix proportions (IS 4031-1988) are already incorporated fly ash as a supplementary material to cement. Extensive research had been done all over the world on the advantage of fly ash as a supplementary. Analysis of compressive was obtained from the experimental results from the average of 3 samples in each batch. There are 3 batches of replacement of cement with fly ash for mortar specimens conducted. The influence of fly ash, its different specific gravity and different fineness i.e. coarser to finer of five hopper at Khaperkheda power plant on the compressive strength and drying shrinkage are investigated. Replacement of fly ash with cement in mortar containing 1:3 ratio by an amount of 12.5%, 25% and 37.5% for the age of 7 days, 28 days and 90 days for compressive strength and drying shrinkage measure for 7days to 35 days i.e. 28 days for same percentage of replacement. And at last study the relation between compressive strength and drying shrinkage.

Keywords- Fly Ash, shrinkage

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INTRODUCTION

Fly ash is a burnt and powdery derivative of inorganic mineral matter that generates during the combustion of pulverized coal in the thermal power plant. . The burnt ash of the coal contains mostly silica, alumina, calcium and iron as the major chemical constituents. . In India at present produces around 120 Million Ton of Ash per annum. The requirement of power in the country is rapidly increasing with increase in growth of the industrialization. . The classification of thermal plant fly ash is considered based on reactive calcium oxide content as class-F (less than 10 %) and class-C (more than 10 %). Indian fly ash belongs to class-F. The calcium bearing silica and silicate minerals of ash occur either in crystalline or non-crystalline structures and are hydraulic in nature; they easily reacts with water or hydrated lime and develop pozzolanic property. The utilisation of fly ash in making building materials like fibre cement sheets largely depends on the mineral structure and pozzolanic property.

Shrinkage is a reduction in volume, and in concrete, it is mainly caused by the loss of water. In most cases, shrinkage is measured by monitoring longitudinal strain. When tensile stresses due to restrained volume contraction exceed the tensile strength of concrete, the shrinkage leads to cracking, which is called shrinkage cracking. Shrinkage is classified based on the causes of volume change and the state of concrete.

Fly ash was use because of:

- Fly ash in the mix replaces Portland cement, producing big savings in concrete materials costs.

- Fly ash is an environmentally-friendly solution that meets or exceeds performance specifications. Fly ash can contribute to LEED (Leadership in Energy and Environmental Design) points.

1. STUDY OF MATERIALS

a. Ordinary Portland Cement:

43 Grade Ordinary Portland Cement (as per IS: 8112 1989 - Reaffirmed 2005) are manufactured by intimately mixing together calcareous and argillaceous and /or other silica, alumina or iron oxide bearing materials, burning them at clinkering temperature and grinding the resulting cement clinker with natural or chemical gypsum so as to produce cement capable of complying the IS specifications. Fly ash up to 5% conforming to IS: 3812 part 1 can be used as a performance improver in the manufacturing of these cements. The grades of this Ordinary

Portland Cement are designated based on its 28-days average compressive strength requirement.

b. Sand:

As hydraulic cement is commonly mixed with certain proportions of sand, when used in construction, the nature and quality of sand used, and the method of manipulating the materials in forming the mortar have quite as important, an effect upon the final strength of the work as the quality of the cement itself.

c. Fly Ash

Class F type Fly ash with various fineness obtained from Khaparkheda thermal power plant, conforming to IS 3812-Part 1-2003

Table: specific gravity and fineness of all hopper fly ashes

Physical test	specific gravity(gm/cc)	Fineness
Hopper 1	2.13	309
Hopper 2	2.13	448
Hopper 3	2.07	609
Hopper 4	2.133	652
Hopper 5	2.2	693

d. Water

Water used for mixing and curing is clean and free form injurious amounts of oils, acids , alkalis, salts , sugar , organic material or other substances that may be deleterious to concrete or steel. Water is one of the important material for the mortar. The quality of the water must best on the BS3148. The criterion of portability of water is not absolute.

2. SHRINKAGE: DEFINITION AND CLASSIFICATION

Shrinkage is a reduction in volume, and in concrete, it is mainly caused by the loss of water.

Plastic shrinkage is the shrinkage that occurs due to loss of moisture from fresh concrete. This loss may in be in form of surface evaporation or moisture loss to the subgrade, for slabs on the ground. The loss of moisture leads to the formation of menisci. These menisci generate negative capillary pressures, which cause a volume reduction in the cement paste (Mindess, Young, and Darwin 2003).

Autogenous Shrinkage (also known as chemical shrinkage) is a volume change that occurs without moisture loss to the surrounding environment. It occurs when water in cement paste is consumed by the hydration reactions, and results due to self desiccation of the concrete. This type of shrinkage mainly occurs in the mixes with low water-cement (w/c) ratios and may be increased by the use of reactive pozzolans.

Drying shrinkage occurs due to the loss of moisture from hardened concrete. Among the different types of shrinkage, drying shrinkage usually results in the largest volume change. Moisture loss causes volume changes based on three mechanisms that result in changes in capillary stress, disjoining pressure, and surface free energy. Capillary stress occurs between relative humidities of 45 and 95 percent, when a meniscus forms in the pore water within pores in cement paste.

3. EXPERIMENTAL PROGRAM

A. Study of compressive strength of mortar:

The standard (IS 4031: 1988-Part 7) covers the procedure for determining the strength of masonry cement as represented by compressive strength tests on 50 mm mortar cubes. For the quantity of mixing of material are given in table which contains 1:3 proportion of cement to sand.

The amount of water used for gauging shall be such as to produce a flow of 110±5 percent with 25 drops in 15 second

Table: water requirement of fly ash of all five hoppers.

Physical test	Water Requirement (%)
Hopper 1	103% @ 14% water
Hopper 2	106% @ 14% water
Hopper 3	105% @ 14% water
Hopper 4	101% @ 14% water
Hopper 5	107% @ 13% water

B. Study of Drying Shrinkage of Mortar:

- The materials for the standard test mortar shall be cement and standard sand in the proportion of 1:3 by mass blended intimately.

- The amount of water for gauging shall be equal to that required to give a flow between 100 and 115 percent with 25 drops in 15 second, as deter- mined above in compressive strength of fly ash mortar.

- The materials for moulding each batch of test specimens shall be mixed separately using the quantities of dry materials, conforming to the proportions 1:3 and the quantity of water as determined in accordance to give a flow of 100 to 115 percent with 25 drops in 15 seconds. Mixing shall be done mechanically.

- Immediately following the completion of mixing, the test specimen shall be moulded in Beam mould of 25 x 25 mm size and 280 mm internal length in two layers, each layer being compacted with the thumbs and forefingers by pressing the mortar into the corners, around the reference inserts and along the surfaces of the moulds until a homogeneous specimen is obtained.

- After the top layer has been compacted, the mortar shall be leveled off flush with the top of the mould and the surface smoothed with a few strokes of the trowel. During the operations of mixing and moulding, the hands shall be protected by rubber gloves.

- After filling the moulds, place them immediately in a moist room or moist closet for 24±2 hr. Then remove the specimens from the moulds and immediately immerse in water at 27±2°C and allow them to remain there for six days.

Figure: drying shrinkage mould specimen (source: google)

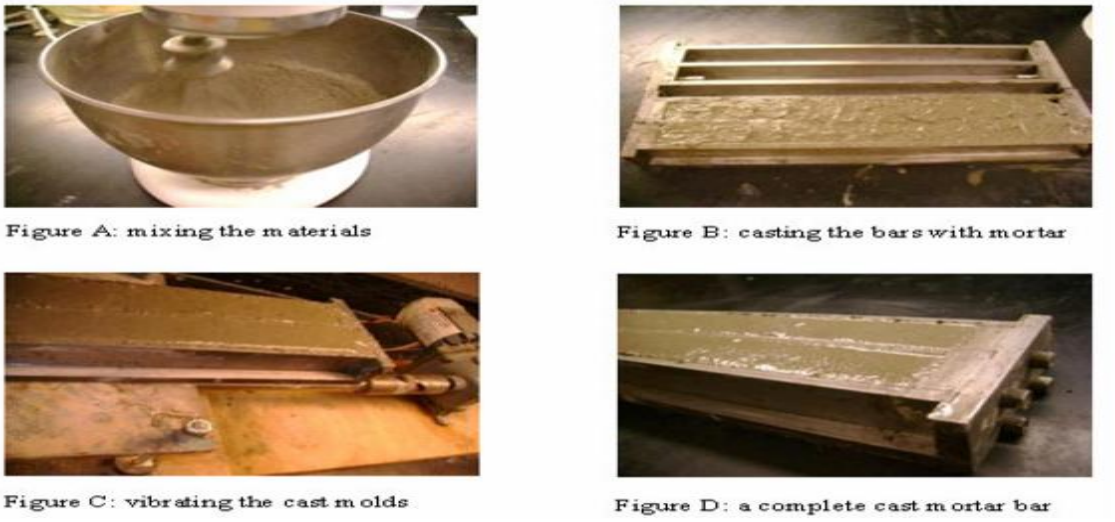


Figure: procedure of making mortar bar (source: google)

- Remove the specimens from the water and measure its length using a length comparator. Protect specimens against loss of moisture prior to reading for initial length. The temperature of the test specimens at the time of initial measurement shall be 27±2°C Store the specimens in a control cabinet maintained at 27±2°C and 50±5 percent relative humidity.

- Measure the length of the specimens again 28 days after the initial measurement. Place the specimens in the comparator with the same end uppermost with respect to the position of the specimens as when the initial measurement was made.

- When making the measurements, the specimens, the comparator, and the reference bar shall be at a temperature of 27±2°C.

- After the specimens at the age of 7 and 35 days, calculate the average difference in length of three specimens to the nearest 0.01 percent of the effective gauge length and report this difference as the drying shrinkage

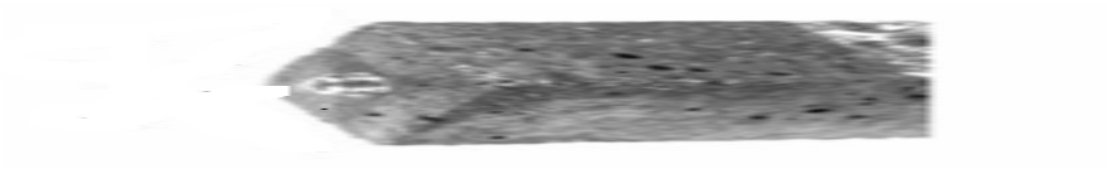
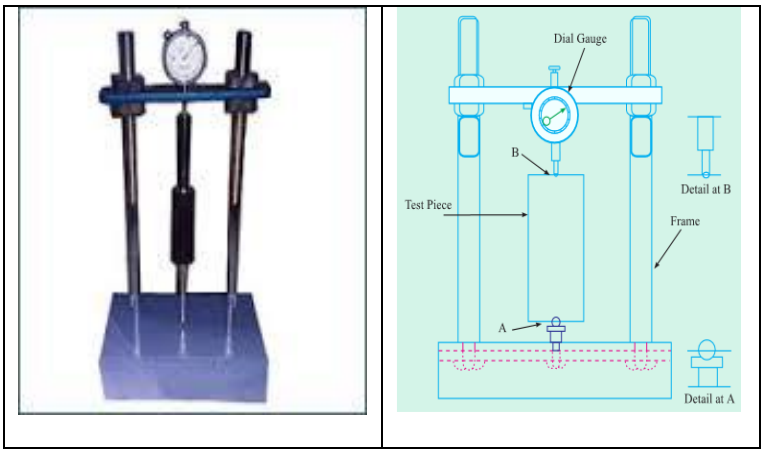
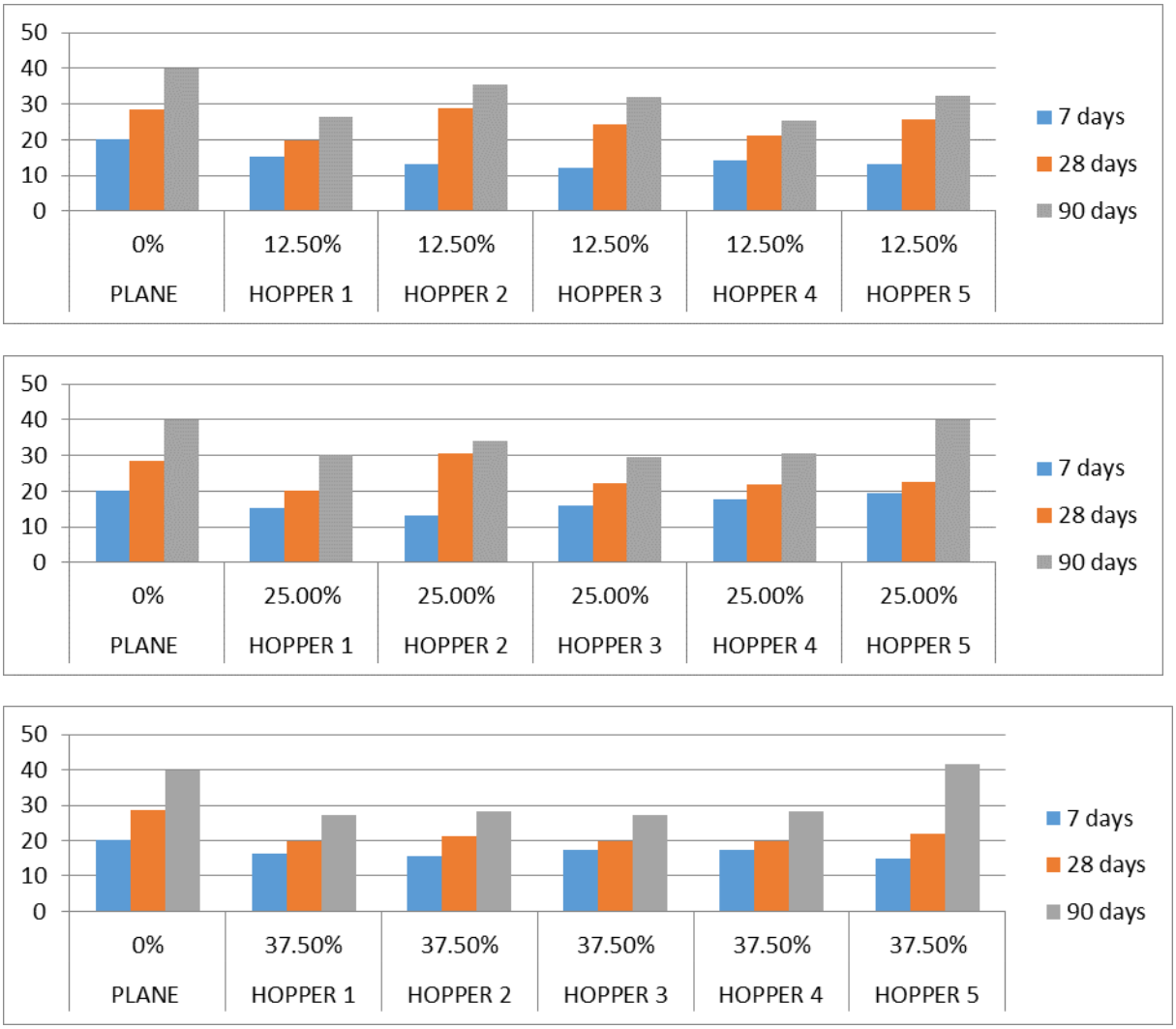


Figure: specimen of mortar bar (source: google)

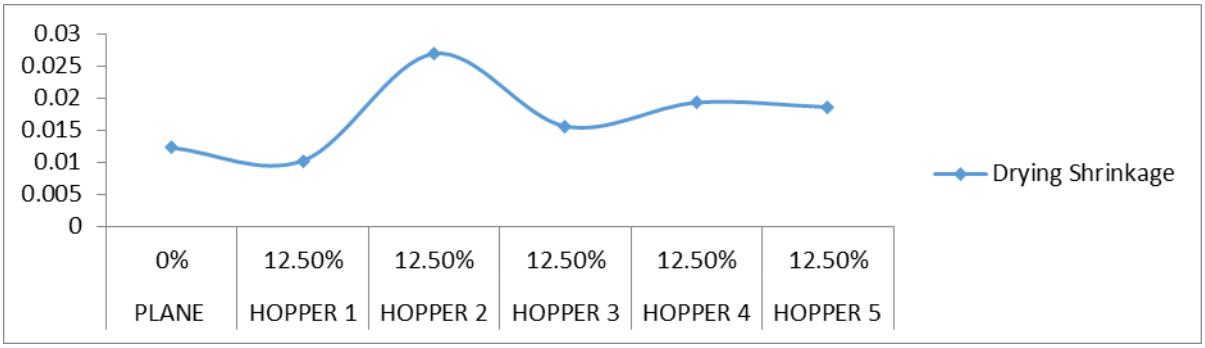


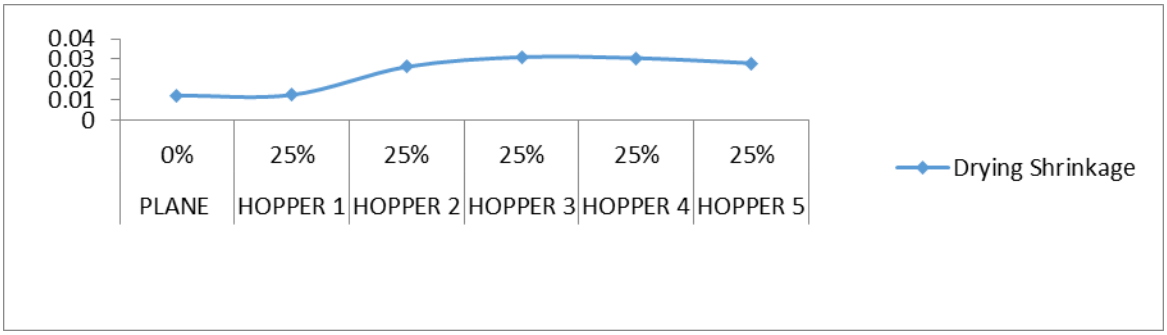
5. TESTING RESULTS AND DISCUSSION

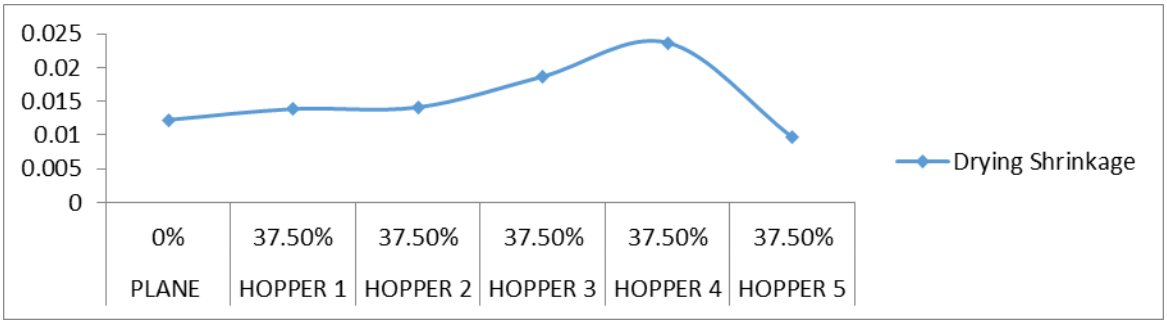
The specimen for each cast with different percentage of FA with gradual increase of fine fly ash 12.5%, 25% and 37.5%, of hopper 1 to 5 replacing with cement by weight. Three specimens, preferably from different batches, is made for testing at each selected age. The testing for compressive strength carried out for 7, 28, and 90 days of age.



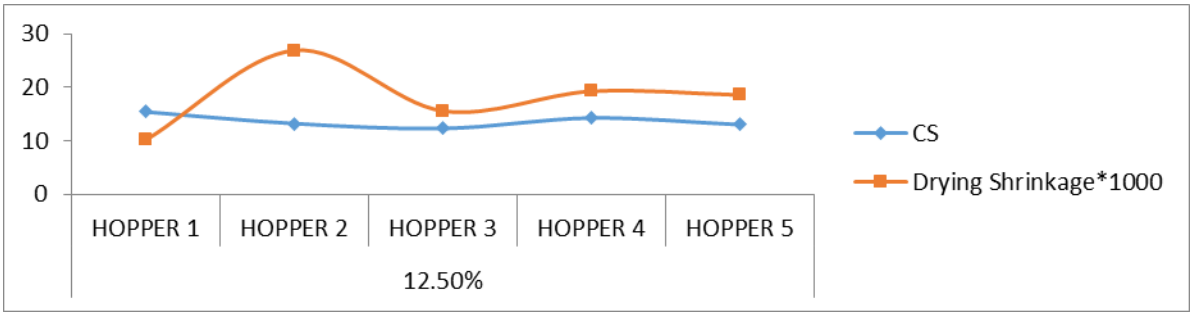
Graph: Compressive strength result for varying percentage of fly ash for different fineness

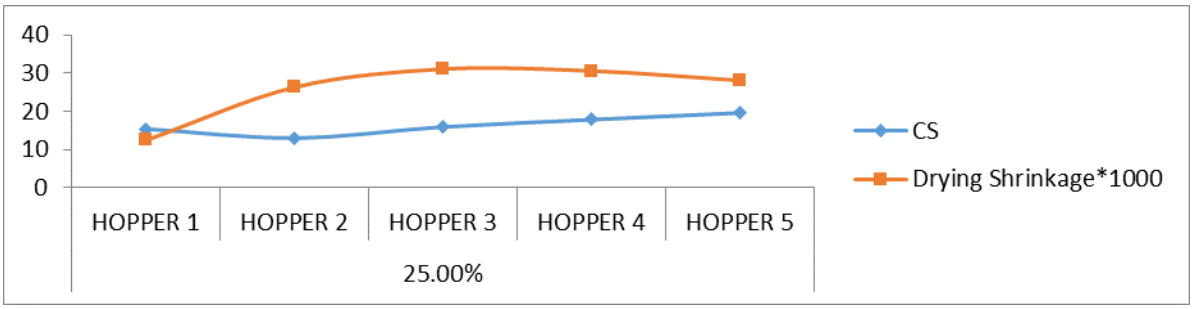


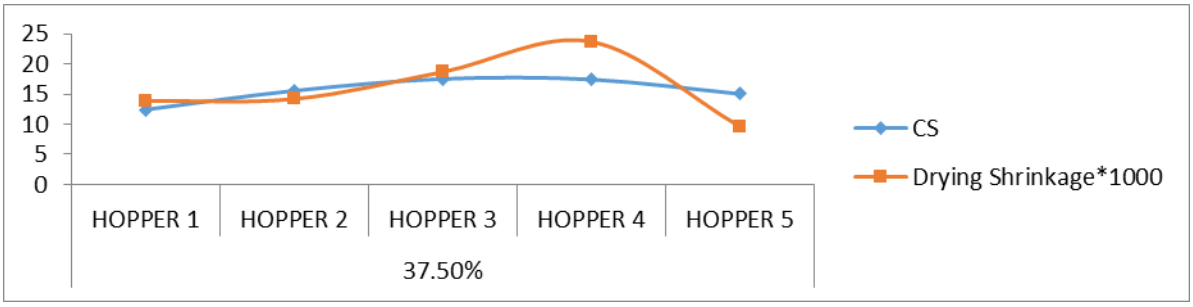




Graph: Drying Shrinkage result for varying percentage of fly ash for different fineness.







Graph: Relation between Compressive Strength and Drying Shrinkage for varying percentage of fly ash for different fineness.

6. CONCLUSION:

- From the above graph, drying shrinkage and compressive strength will increases from hopper 1 to 5 of 0% to 25% replacement later on i.e. for 37.5% replacement strength will increases but shrinkage will decreases.

- It shown that as drying shrinkage increases then compressive strength also increases.

- For the 7 days compressive strength, In hopper 4 and 5 compressive strength for 25% replacement of fly ash is greater than 37.5% replacement. And in hopper 1 to 3 as percentage of fly ash replacement increases strength also slightly increases.

- Drying shrinkage in various percentages is increases from hopper 1 to 5. For 12.5%, in hopper 2 drying shrinkage is more as compared to other.

- In hopper 3, 4, and 5 as percentage of replacement of fly ash increases upto 25% shrinkage will be increases and for 25% to 37.5% shrinkage will decreases.

- Drying shrinkage and compressive strength will increases from hopper 1 to 5 of 0% to 25% replacement later on i.e. for 37.5% replacement strength will increases but shrinkage will decreases.

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