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Effect of Fly Ash and Silica Fumes on Strength, Stress Strain Behaviour of M_{25} Concrete Mix

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Abstract: **Concrete pavement has long been considered an environmentally and economically sustainable pavement choice for its longevity. This hallmark of concrete pavements ensures that the desirable performance characteristic of the pavement remains essentially intact for several decades. Concrete pavement mixtures incorporate industrial byproducts i.e., (fly ash and silica fumes) which lower the disposal needs, reduces the demand on virgin materials, and conserves natural resources. The design and properties of this type of concrete, which could be applied by using conventional equipment, are presented in this project. The technical characteristics of the concrete which includes local Fly Ash and Silica Fumes are well described including durability performance observation. The usage of these industrial by products to replace the cement is because the production of cement emits carbon dioxide gas in to atmosphere by increasing the effect of global warming.**

To enhance the strength properties of the ordinary Portland cement (OPC), industrial by products such as Fly Ash and Silica Fumes can be utilized. The effect of Silica Fumes and Fly Ash as a partial replacement of Ordinary Portland Cement on compressive strength, split tensile strength and stress strain behavior of concrete has been studied. To study these properties of concrete, it was categorized in to two groups with two water cement ratios of 0.3 and 0.35. Five types of mix proportions were used to cast the test specimens for both groups. The replacement levels of OPC by silica fumes were 0%, 10%, 20%, 25%, and 30% where replacement levels by Fly Ash were 0%, 10%, 20%, 25% and 30%. All these specimens are tested for 28 days strength. 20% of silica fumes and 20% of fly ash where found to be optimum for maximum compressive strength, maximum split tensile strength at low cost than that of conventional concrete which reduces the consumption rate of cement by 173 kg per cubic meter. Hence by reducing usage of amount of cement the cost of construction can be decreased which leads to low cost concrete pavements with high efficiency.

Keywords: **Fly Ash and Silica Fumes, Ordinary Portland cement (Opc).**

1. INTRODUCTION

In conventional method of concrete pavement construction natural resources like sand, stone metal are used which causes ecological imbalances. The use of Fly Ash and silica fumes in concrete pavement construction will save such resources. The costly ingredient in concrete is cement; some portion of the cement is replaced by silica fumes and fly ash which results in reducing the cost of the concrete without any change in strength. The usage of industrial wastages such as Fly Ash and Silica Fumes will solve the problem of disposal and automatically reduces the cost of the pavement construction. Properly designed and constructed concrete structures are favorable compared to the other material like steel and timber. So we can obtain low cost concrete mix with partial replacement of mineral admixtures such as Fly Ash and Silica Fumes.

1.1 METHODS OF INCORPORATING MINERAL ADMIXTURES IN CONCRETE:

The mineral admixtures such as silica fumes and fly ash can be introduced in to concrete by two methods. They are

- A blended cement containing fly ash and silica fumes may be used in place of ordinary Portland cement.
- Fly ash and silica fumes may be introduced as an additional component at the concrete-mixing stage.

In this project we use mineral admixture as blended cement containing fly ash and silica fumes used in place of ordinary Portland cement. Thus admixtures have generally been considered to be a replacement for cement, rather than a component that complements the functions of the cement, sand, or water. The trend now is to consider the components of fly-ash, silica fumes concrete as a whole and to treat it as a unique material without reference to an equivalent plain-concrete mixture.

1.2 MECHANICSM IN THE CEMENT-MINERAL ADMIXTURE SYSTEM:

Mineral admixtures enhances the properties of concrete by several physical mechanisms, including increasing the strength of the bond between the paste and aggregate by reducing the size of the CH crystals in the region by: (1) providing nucleation sites for the CH crystals so they are smaller and more randomly oriented, and (2) reducing the thickness of the weaker transition zone. Physical mechanisms also include increasing the density of the composite system due to the filler packing effect and by providing a more refined pore structure. For the above mechanisms to take place, it is essential that admixture particles be well dispersed in a concrete mixture.

2. LITERATURE SURVEY

Manmohan and Mehta studied that durability to chemical attack is improved with the use of most fly ash and slag mainly due to the pore refinement of concrete made with such materials. Experiments have shown that cement pastes containing10-30% low calcium fly ash causes significant pore refinement in the 28 to 90 day curing period.

Gebler and Klieger said that High dosages of silica fume can make concrete highly cohesive with very little aggregate segregation or bleeding. With little or no bleed water available at the concrete surface for evaporation, plastic cracking can readily develop, especially on hot, windy days if special precautions are not taken. Proper curing of all concrete, especially concrete containing supplementary cementing materials should commence immediately after finishing. At seven-day moist cure or membrane cure should be adequate for concretes with normal dosages of most supplementary cementations materials. As with Portland cement concrete, low curing temperatures can reduce early-strength gain. The impact resistance and abrasion resistance of concrete are related to compressive strength and aggregate type. Supplementary cementing materials generally do not affect these properties beyond their influence on strength. Concretes containing fly ash are just as abrasion resistant as Portland cement concretes without fly ash.

L. Lam, Y.L. Wong, and C.S. Poon in their studied entitled Effect of fly ash and silica fume on compressive and fracture behaviors of concrete had concluded enhancement in strength properties of concrete by adding different percentage of fly ash and silica fume.

Roy, found that the hydration rates are greatest in silica fumes paste, followed by OPC pastes and fly ash pastes it was found that the degree of reaction of silica fumes is much greater than fly ash pastes even at 90 days primarily due to silica fumes high specific area and that the overall reaction with class c ash is greater than the class F after a few days.

Campbell, strum, and Kosmatka,The, The amount of carbonation is significantly increased in concretes with a high water-cementing materials ratio, low cement content, short curing period, low strength, and a highly permeable or porous paste. The depth of carbonation of good quality concrete is generally of little practical significance. At normal dosages, fly ash is reported to slightly increase carbonation, but usually not to a significant amount in concrete with short (normal) moist-curing period

3. SCOPE AND OBJECTIVE

- The scope of this paper is to study the effect of mineral admixtures on strength characteristics of low cost concrete.
- The objective is to study the mechanical characteristics of concrete such as compressive strength split tensile strength and modulus of elasticity by varying the percentage of mineral admixtures i.e., fly ash and silica fumes with 0,10 ,20, 25, 30 percentage replacement at two water-cement ratios of 0.3 and 0.35.

4. EXPERIMENTAL PROGRAM

The experimental program was designed to investigate the strength of the low cost concrete by replacing cement with mineral admixtures like silica fumes and fly ash at 0%, 10%, 20%, 25%, 30%. The experimental program was aimed to study the compressive strength, stress strain relationships.in this M25mix is considered the size of the cylinder is 150 mm diameter and 300 mm height.

5. MATERIALS USED

The materials used in this project are

5.1 CEMENT: cement used in this investigation was 53 grade OPC conforming IS 12269:1987

5.2 FINE AGGREGATE: In this project locally available river sand this is conforming to Zone II of IS: 383-19707 was used as fine aggregate with specific gravity 2.76

5.3 COARSE AGGREGATE: In this project we are considering angular shaped aggregate of maximum size , 20 mm are tested as per IS: 383-1970. It is crushed granite stone obtained from the local quarry having specific gravity of 2.76.

5.4 FLY ASH Fly ash is a byproduct of the combustion of pulverized coal in thermal power plants. A dust-collection system removes the fly ash, as a fine particulate residue, from combustion gases before they are discharged into the atmosphere. The types and relative amounts of incombustible matter in the coal used determine the chemical composition of fly ash. More than 85% of most fly ashes is comprised of chemical compounds and glasses formed from the elements silicon, aluminum, iron, calcium, and magnesium.

5.5 SILICA FUMES: Silica Fumes, also known as micro silica or condensed silica fume is another material that is used as artificial mineral admixture. It is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. In the manufacture of silicon or ferrosilicon alloy, high purity quartz is reduce in electrical arc furnace which results in the production of Silica Fumes.

Silica Fumes that we have used in this project work was contributed by ‘AASTRA CHEMICALS’ in CHENNAI. Its properties are mentioned below.

6. CASTING OF CYLINDER SPECIMEN

Casting of the specimen is done as per IS: 10086-1982, material preparation, requirement of materials and casting of cylinders. The mixing, compacting and curing are done according to IS 516: 1959. After casting the cylinder mould is left for 24 hours for air drying. Then the cylinder is demoulded and the cylinder is placed in the curing tank for 28 days.

7. STRESS STRAIN RELATION SHIP

1. After 28 days of curing period the specimens are removed from the curing tank and wipe out the excess water from the surface.
2. Let the specimen dry in atmospheric temperature for 24 hrs. before testing.
3. The air dried specimen is placed in the compressive strength testing machine in such way that the load of the machine is applied on the opposite faces of the cylinder.
4. The cylinder is positioned properly on the base plate of the machine.
5. The piston of the machine is adjusted so that it touches the top surface of the specimen.
6. The frame consisting of a dial gauge is fixed to the cylinder to calculate the deformation values with respect to the load.
7. Load is applied gradually without any impacts at a rate of 140kg/cm^2 /minute until the specimen fails.
8. At regular intervals of deformation calculate the respective loads.
9. At the point of failure note down the maximum load value.

7.1 CALCULATIONS AND RESULTS:

Size of the specimen = 150mm in diameter and 300mm long

Fig: specimen set up to find stress strain behavior

Area of the specimen = 17671.45 mm^2

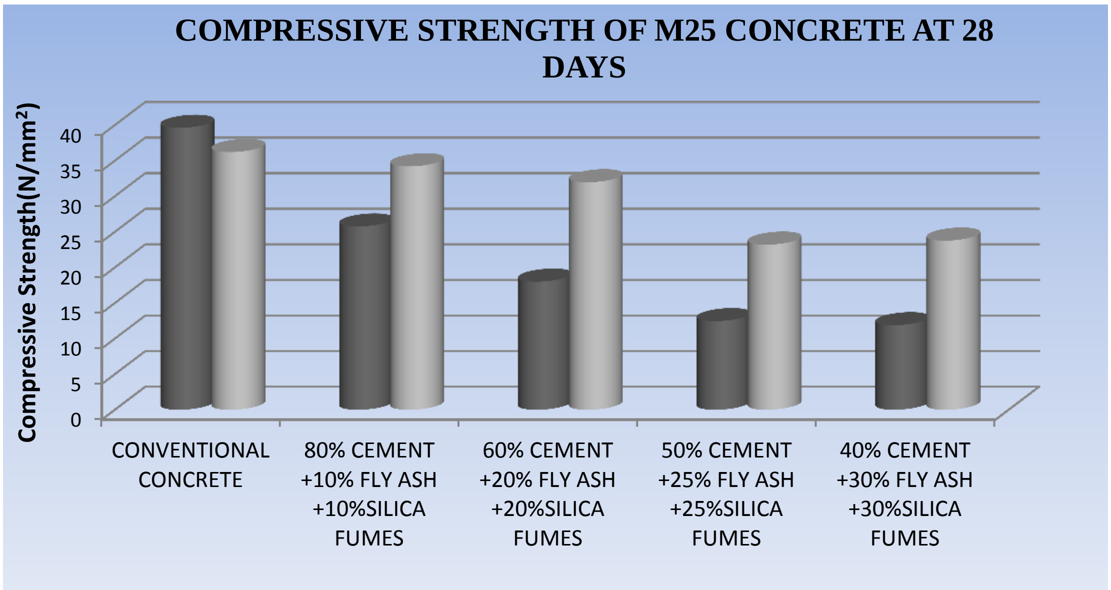
Compressive stress = $\frac{load\ in\ N}{area\ in\ mm^2}$ ……… N/mm^2

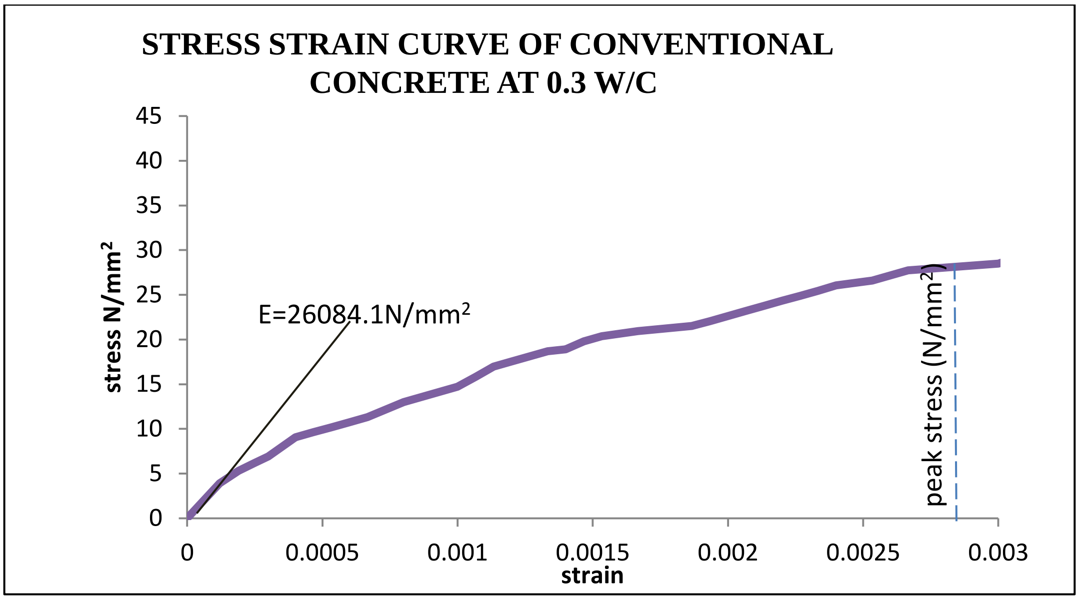
Strain = $\frac{deformation\ in\ mm}{original\ length\ in\ mm}$ ……….NO UNITS

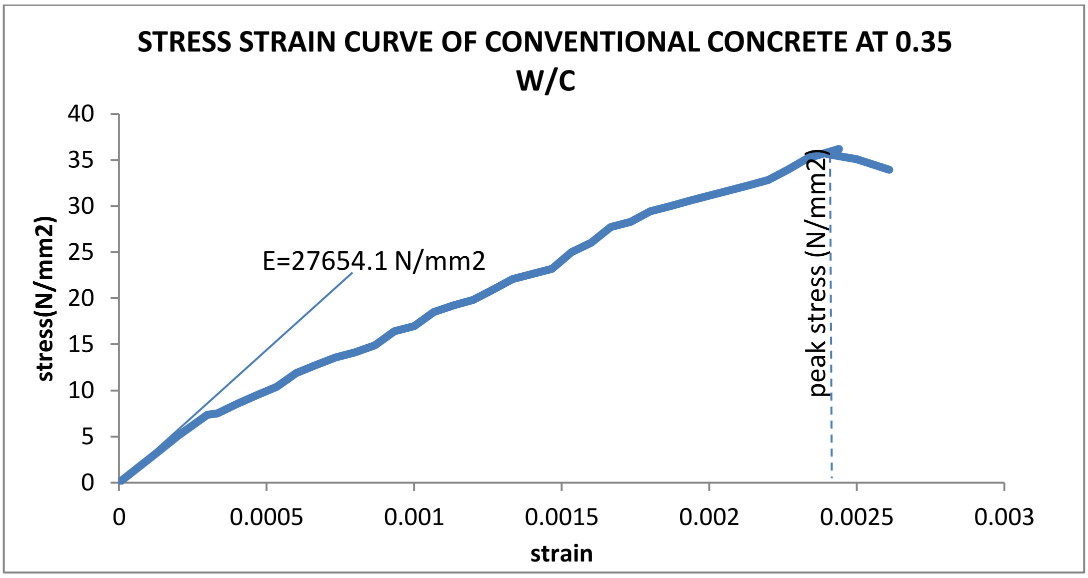
8. RESULTS AND DISCUSSION

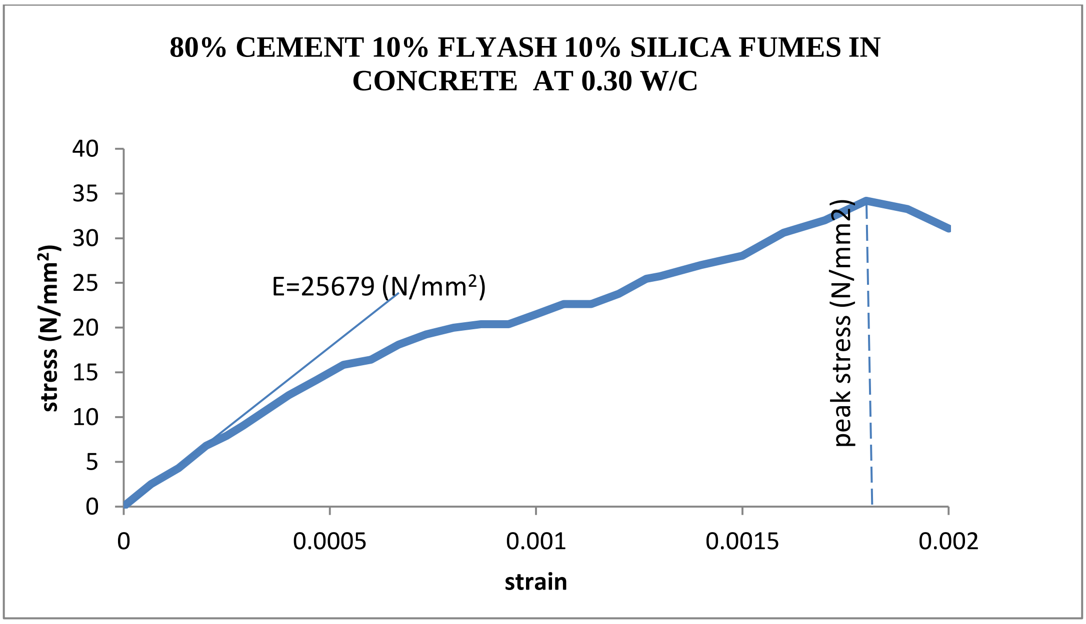
Table 8.1compressive strength of M 25 concrete at 28 days

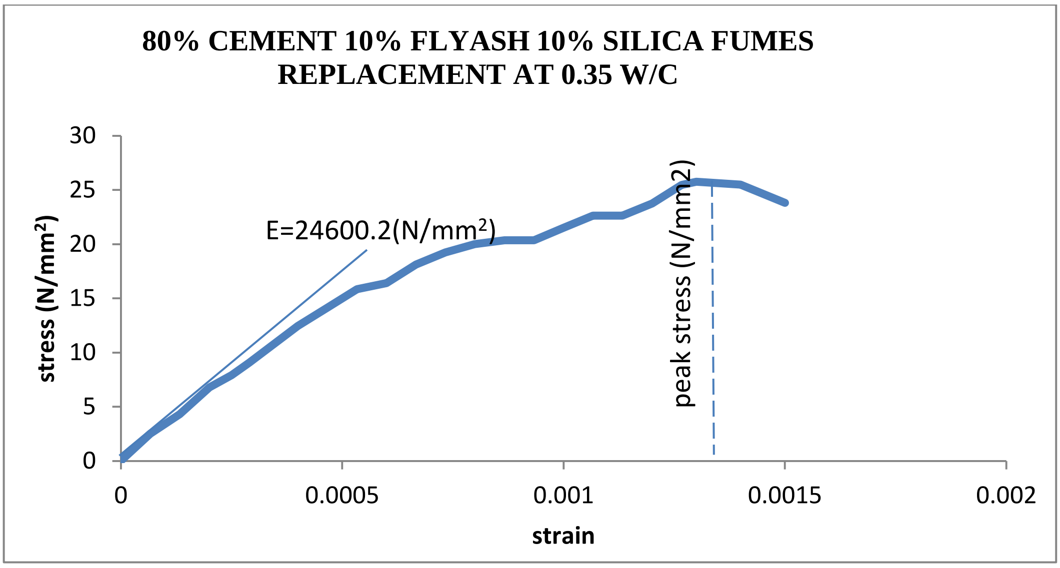
S NO	DESIGNATION	W/C ratio	AVERAGE COMPRESSIVE STRENGTH(N/mm2)
1	CONVENTIONAL CONCRETE	0.3	39.6115
		0.35	36.21
2	80% CEMENT +10% FLY ASH +10%SILICA FUMES	0.3	25.745
		0.35	34.2
3	60% CEMENT +20% FLY ASH +20%SILICA FUMES	0.3	18
		0.35	31.672
4	50% CEMENT +25% FLY ASH +25%SILICA FUMES	0.3	12.449
		0.35	23.201
5	40% CEMENT +30% FLY ASH +30%SILICA FUMES	0.3	11.883
		0.35	23.766

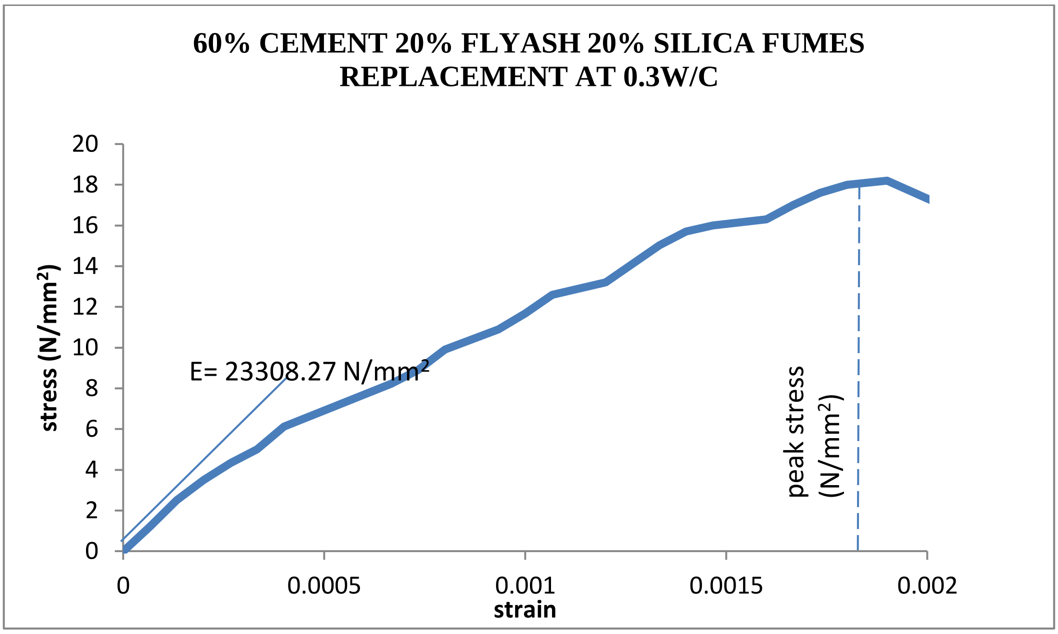


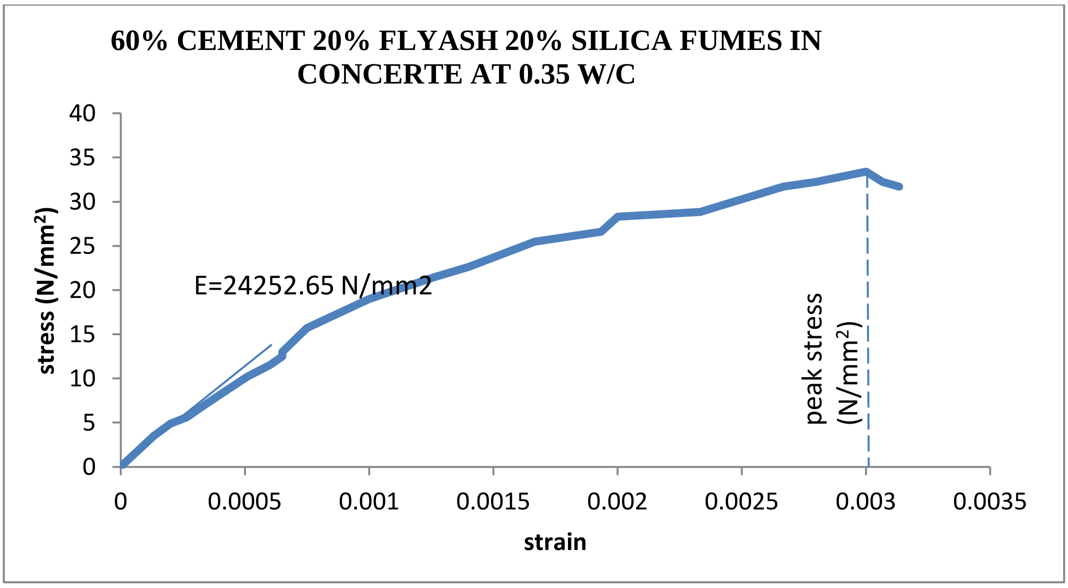

STRESS STRAIN CURVE OF CONVENTIONAL CONCRETE AT 0.3 W/C
stress N/mm²
E=26084.1N/mm²
peak stress (N/mm²)
strain
0
5
10
15
20
25
30
35
40
45
0
0.0005
0.001
0.0015
0.002
0.0025
0.003

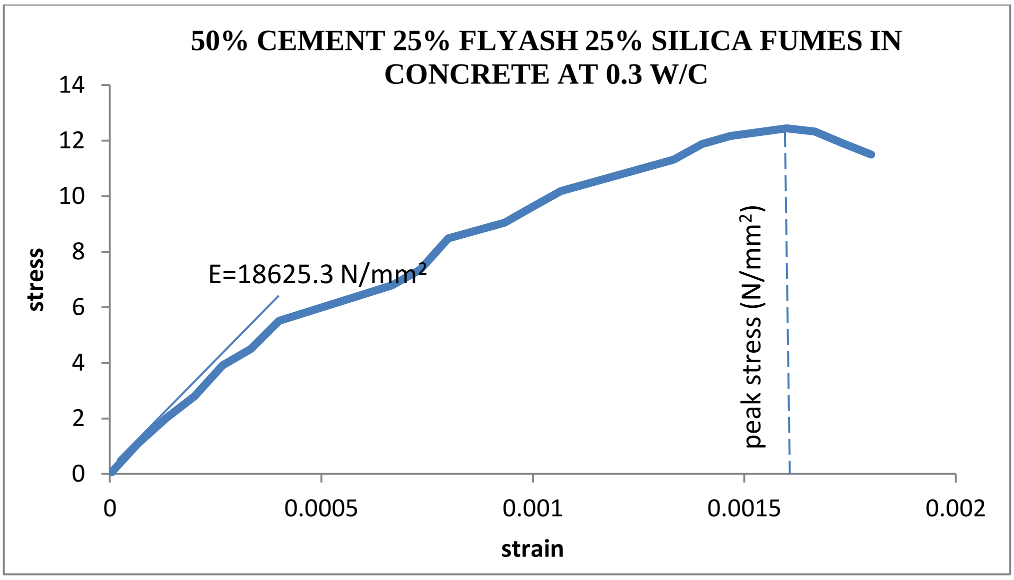

STRESS STRAIN CURVE OF CONVENTIONAL CONCRETE AT 0.35 W/C
stress(N/mm2)
E=27654.1 N/mm2
peak stress (N/mm2)
strain
0
5
10
15
20
25
30
35
40
0
0.0005
0.001
0.0015
0.002
0.0025
0.003

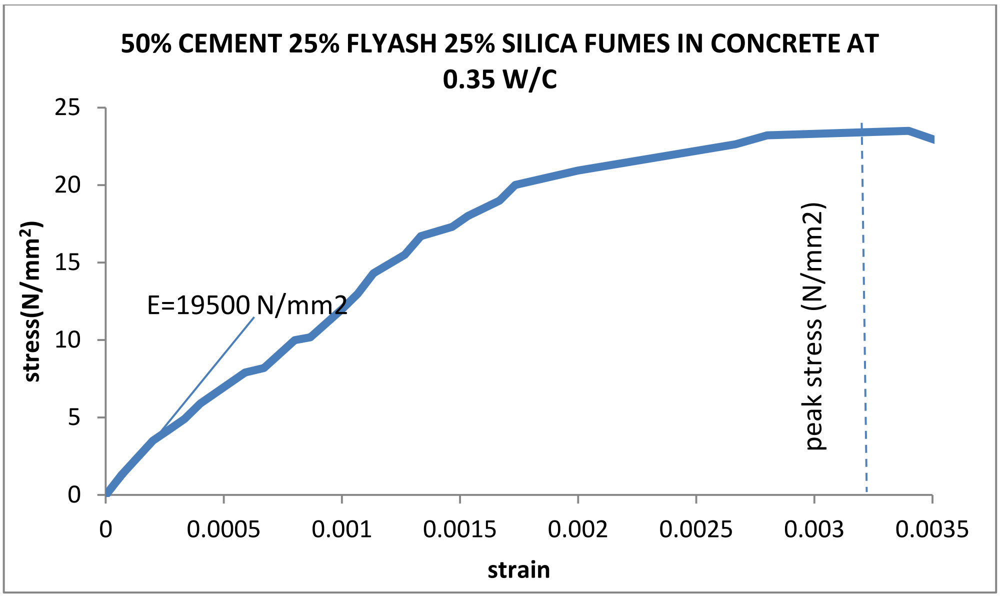

80% CEMENT 10% FLYASH 10% SILICA FUMES IN CONCRETE AT 0.30 W/C
stress (N/mm²)
E=25679 (N/mm²)
peak stress (N/mm2)
strain
0
5
10
15
20
25
30
35
40
0
0.0005
0.001
0.0015
0.002

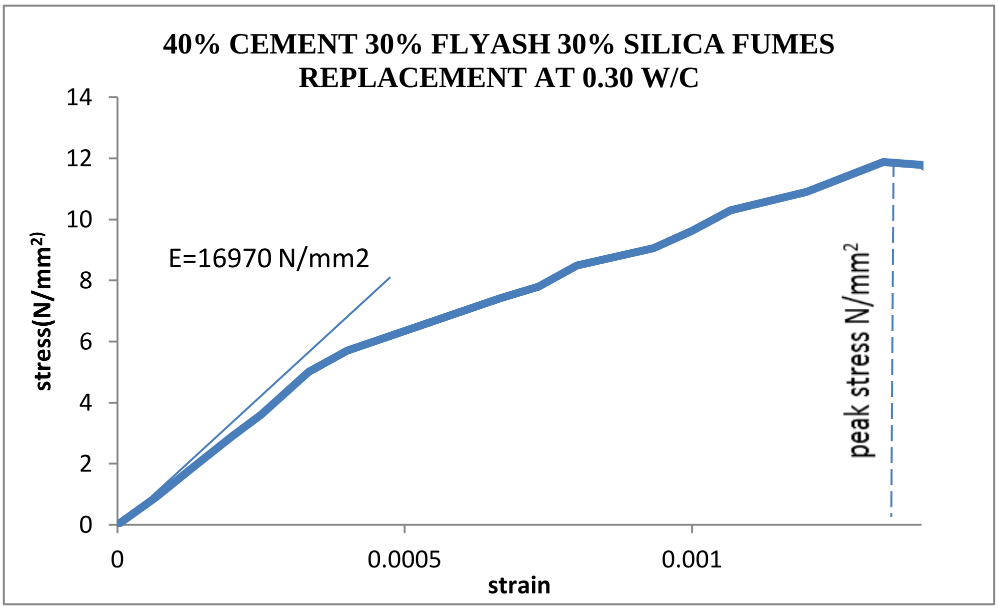

80% CEMENT 10% FLYASH 10% SILICA FUMES REPLACEMENT AT 0.35 W/C
30
25
20
15
10
5
0
stress (N/mm²)
E=24600.2(N/mm²)
peak stress (N/mm2)
0
0.0005
0.001
0.0015
0.002
strain

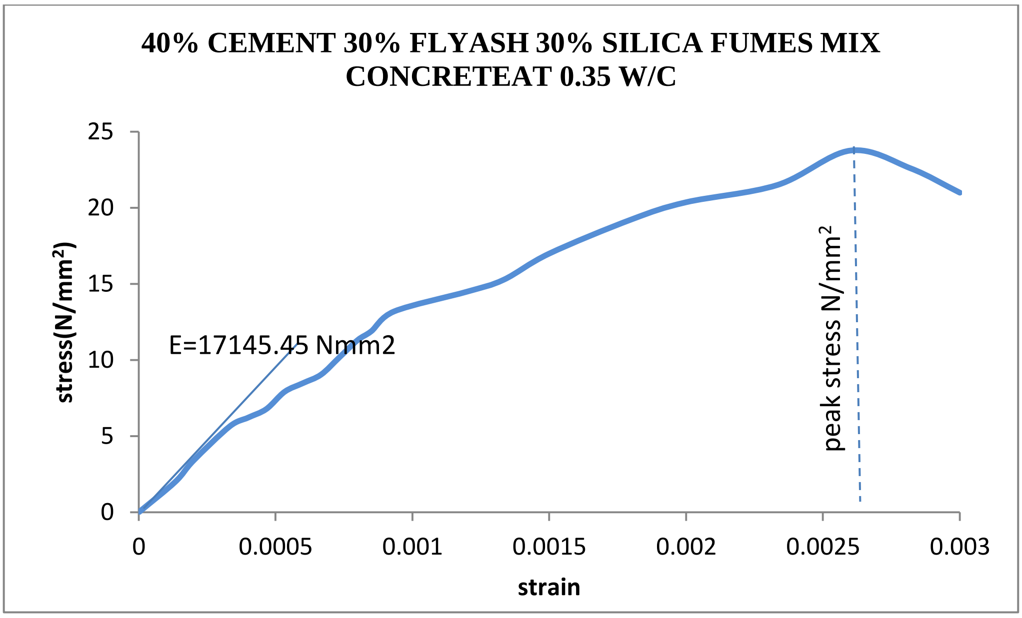

60% CEMENT 20% FLYASH 20% SILICA FUMES REPLACEMENT AT 0.3W/C
20
18
16
14
12
10
8
6
4
2
0
stress (N/mm²)
E= 23308.27 N/mm²
peak stress (N/mm²)
0
0.0005
0.001
0.0015
0.002
strain


60% CEMENT 20% FLYASH 20% SILICA FUMES IN CONCERTE AT 0.35 W/C
40
35
30
25
20
15
10
5
0
stress (N/mm²)
E=24252.65 N/mm2
peak stress (N/mm²)
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035
strain


50% CEMENT 25% FLYASH 25% SILICA FUMES IN CONCRETE AT 0.3 W/C
stress
strain
E=18625.3 N/mm²
peak stress (N/mm²)
14
12
10
8
6
4
2
0
0
0.0005
0.001
0.0015
0.002


50% CEMENT 25% FLYASH 25% SILICA FUMES IN CONCRETE AT 0.35 W/C
stress(N/mm²)
strain
E=19500 N/mm2
peak stress (N/mm2)
25
20
15
10
5
0
0
0.0005
0.001
0.0015
0.002
0.0025
0.003
0.0035


40% CEMENT 30% FLYASH 30% SILICA FUMES REPLACEMENT AT 0.30 W/C
stress(N/mm²)
strain
E=16970 N/mm2
peak stress N/mm²
14
12
10
8
6
4
2
0
0
0.0005
0.001



9. CONCLUSIONS

1. Based on the experimental investigations, mechanical properties of concrete like compressive strength, tensile strength durability aspects and stress strain behavior of low cost concrete (with fly ash and silica fumes). The following conclusions are drawn
2. At 28 days the compressive strength of conventional concrete and low cost concrete of mix (60% cement+20% Fly Ash+20% Silica Fumes) is similar to that of the target compressive strength of M25 mix.
3. The stress-strain behavior for conventional concrete and low cost concrete with various proportions of fly ash and silica fumes is observed to be similar. This shows addition of mineral admixture to optimum values does not affect the stress strain behavior.
4. The peak stress values for low cost concrete are similar to that of conventional concrete only varies by 0.2%.

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