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# AN EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE USING FLY ASH AND GLASS PARTICLES

**N.Gurumoorthy*[1] and C.Jaideep[2]**

*[1,2] Assistant Professor in Civil Engineering, PSNA College of Engineering and Technology, Dindigul, Tamilnadu

## ABSTRACT

Concrete is a widely used vital material in the construction world. Producing cement in huge amount in factories directly influences the greenhouse gases emission. Reductions in getting good quality limestone directly affect the production of good quality cement. The cost of construction also gets escalated and also leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. In studying the compressive strength and split tensile strength of concrete made by using fly ash and glass particles to ordinary conventional concrete. This reports the results of an experimental investigation carried out to study the effects on fly ash and glass particles, on strength development of concrete. Fly ash is added with cement and glass particles is added to the fine aggregate with some percentage in the mixture of concrete to determine the compressive strength and split tensile strength of concrete at 7 & 28 days. The comparison was made between conventional concrete, concrete with fly ash and glass particles. Cement and fine aggregate is partially replaced with 10, 20, 30 and 40% of fly ash and glass particles respectively by weight. The results of the tests showed that the compressive strength of 10% and 20% of fly ash and glass particles replacement is same that of conventional concrete.

***Keywords-*** *Flyash, Glass particles, compressive strength, flexural strength, split tensile strength.*

## I. INTRODUCTION

Concrete is a widely used as vital material in the construction world. More than 88 million tonnes of fly ash is generated in India each year. Most of the fly ash is of Class F type. Fly ash can be partially replaced in ordinary Portland cement (OPC) normally ranges from 15 -35% in practical applications.

Concrete is a composite building material made from the combination of aggregate and a binder such as cement. The most common form of concrete is Portland cement concrete, which consists of mineral aggregate (generally gravel and sand), Portland cement and water. In concrete mix, cement and water form a "paste" or "matrix" which fills the voids of the fine aggregate and binds them together. The matrix is usually 22 – 34% of the total volume. After mixing, the cement hydrates and eventually hardens into a stone-like material. When used in the generic sense, this is the material referred to by the term concrete.

Concrete has been the predominant building material in this modern age due to its longevity, formability, and ease of transport. It is strong in compressive strength only. For a concrete construction of any size, as concrete has a rather low tensile strength, it is generally strengthened by using steel rods or bars (known as rebar). This strengthened concrete is then referred to as reinforced concrete. In order to minimize any air bubbles that would weaken the structure, a vibrator is used to eliminate any air that has been entrained when the liquid concrete mix is poured around the ironwork.

## II. EXPERIMENTAL PROGRAMME

### 2.1 Materials

Ordinary Portland (43 grade) cement was used. It was tested as Per the Indian Standard Specifications IS: 8112-1989 [8]. Fly ash was obtained from Tuticorin and glass particles near Madurai. Fine aggregate was natural sand having a 4.75 mm nominal size. The coarse aggregate used in this investigation was 20 mm nominal size. Both aggregates were tested according to BIS: 383-1970[9].

### 2.2 Flyash

Fly ash is a by-product from coal-fired electricity generating power plants. The coal used in these power plants is mainly composed of combustible elements such as carbon, hydrogen and oxygen (nitrogen and sulfur being minor elements), and non-combustible impurities (10 to 40%) usually present in the form of clay, shale, quartz, feldspar and limestone. As the coal travels through the high-temperature zone in the furnace, the combustible elements of the coal are burnt off, whereas the mineral impurities of the coal fuse and chemically recombine to produce various crystalline phases of the molten ash. The molten ash is entrained in the flue gas and cools rapidly, when leaving the combustion zone (e.g. from 1500°C to 200°C in few seconds), into spherical, glassy particles. Most of these particles fly out with the flue gas stream and are therefore called fly ash. The fly ash is then collected in electrostatic precipitators or bag houses and the fineness of the fly ash can be controlled by how and where the particles are collected. Fly ash is a fine, glass powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. The difference between fly ash and Portland cement becomes apparent under a microscope. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures.

### 2.3 Glass particles

Nowadays the usage of glass has been increased which result in increase in glass wastes. Also we experience the fine aggregate scarcity. Hence the use of glass in concrete as a replacement for fine aggregate would be useful. Recycling waste glass as an aggregate is effective for environmental conservation and economical advantage. There are two types of waste glasses; coloured and colourless. Most colourless waste glasses are recycled effectively. Coloured waste glasses with their low recycling rate are generally dumped into landfill sites Since the glass is not biodegradable, landfills do not provide an environment-friendly solution. Therefore, there is strong need to utilize waste glasses.

### 2.4 Mixture proportions

Control mixture M-1 (0%) was proportioned to have 28-day compressive strength of 20MPa according to BIS: 10262-2009 [10]. The ratio of concrete mix proportion was 1:1.5:2.96; 1 part cement, 1.5 part fine aggregates, and 2.96 part coarse aggregates. Four additional concrete mixtures (M-2, M-3, M-4 and M-5) were proportioned where cement was replaced with 10%, 20% 30% and 40% Fly ash with cement and glass particles with fine aggregate by mass respectively. All mixtures had constant water-to-cement ratio of 0.5. The slump of all mixtures was 90 ± 5 mm. Details of mixtures, and values of slump determined as per BIS: 1199-1959 [11]

### 2.5 Specimen's preparation and casting

150 mm concrete cubes were cast for compressive strength, and 150 mm diameter x 300 mm high cylinders for splitting tensile strength. All the specimens were prepared in accordance with BIS: 1199-1959 [11]. Soon after casting, test specimens were covered with plastic sheets, and left in the casting room for 24 h at a temperature of about 26 ± $1^0$C. They were demolded after 24 h, and were put into a water-curing room until the time of testing.

### 2.6 Hardened concrete properties

150mmm cubes were tested for compressive strength and 150x 300 mm cylinders for splitting- tensile strength. Tests were performed at the ages of 7 and 28 days in accordance with the provisions of Indian Standard specifications BIS: 516- 1959[12]

## III. RESULTS AND DISCUSSION

### 3.1 Compressive strength

The test results are also presented in Table 1. By increasing the mixture proportions the compressive strength values of concrete tends to increase at each curing age. This trend can be attributed to the fact that flyash possess cementing properties. It is also as much effective in enhancing glass particles for replacement of fine aggregate. Furthermore, the mean strength of concrete mixes with flyash and glass particles was same that of control concrete. However, there is a slight decrease in compressive strength value concrete mix when 40% replacement is used, as compared with that of 30% mix.

**Figure 1.Determination of compressive strength of cube**

**Table 1. Compressive strength test results**

| Percentage of Replacement | Compressive Strength in N/mm² | |
|---|---|---|
| | 7Days | 28Days |
| 0 % | 13.86 | 20.50 |
| 10% | 13.56 | 21.52 |
| 20% | 13.40 | 21.95 |
| 30% | 12.35 | 19.53 |
| 40% | 10.53 | 18.68 |

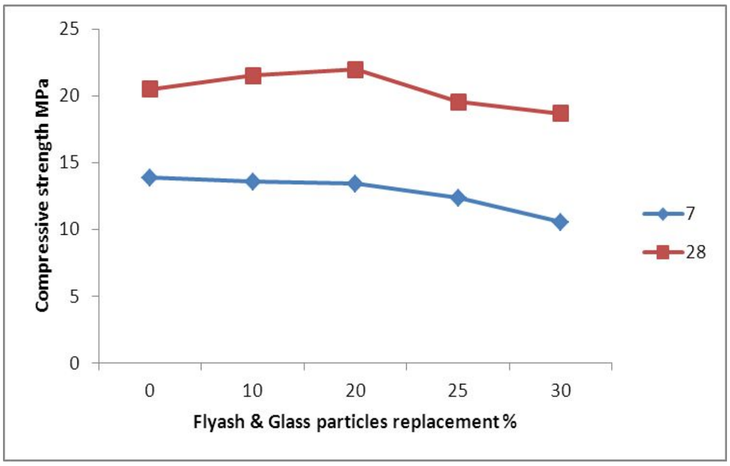


**Figure 2.Compressive strength in relation to Mix proportion and curing age.**

### 3.2 Split tensile strength

Split Tensile strength of concrete is tested on cylinders at different percentage of flyash and glass particles content in concrete. The strength of concrete has been tested on cylinder at 7 and 28 days. 7 days test has been conducted to check the gain in initial strength of concrete. 28 days test gives the data of final strength of concrete at 28 days curing. Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested.

**Figure 3. Determination of Split tensile strength of cube**

**Table 2: Split tensile strength test results**

| Percentage of Replacement | Split tensile strength $N/mm^2$ | |
|---|---|---|
| | 7 Days | 28 days |
| 0% | 2.22 | 3.23 |
| 10% | 2.20 | 3.18 |
| 20% | 2.12 | 3.11 |
| 30% | 1.96 | 3.02 |
| 40% | 1.92 | 2.92 |

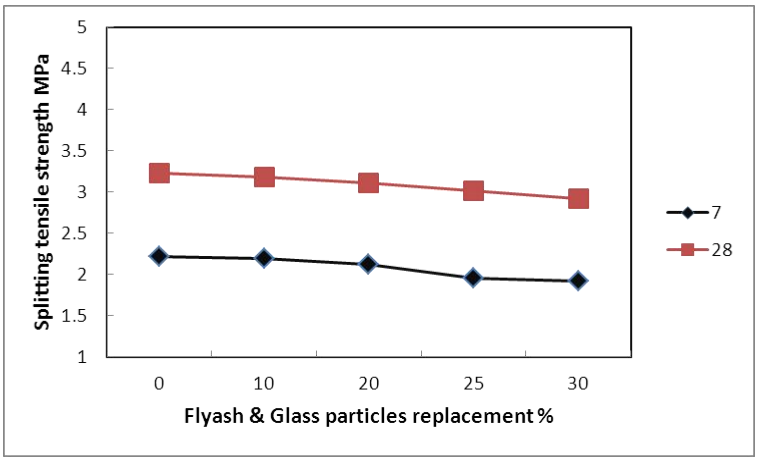


**Figure 4. Split tensile strength in relation to Mix proportion and curing age.**

## IV. CONCLUSION

- The Compressive strength and Split Tensile strength are will be same with addition of fly ash and glass particles up to 30% replacement when compare to control mixture.
- Further any addition of mixes the compressive strength and Split Tensile strength are decreased.
- Therefore , we conclude that the most suitable percentage replacement of flyash and glass particles in concrete is 30%.

- Thus we found out the optimum percentage for replacement of fly ash with cement and a glass particle with sand is almost 30% for cubes and cylinders.
- Result of this investigation that flay ash and glass particles could be conveniently used in making good quality concrete and construction materials.

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