

# Concrete Mix Design by Partial Surrogation of Conventional Aggregates with Fabrigated Aggregates

Shital Mohanrao Bhandare, J.S.R Prasad, Venu Malagavelli

**Abstract:** *Since the invention of concrete in the early 18<sup>th</sup> century, there has been a constant rise in efforts to increase the productivity of this material so that it becomes more economical. The economy of concrete also depends on the use of products that are abundantly available in the near vicinity, at the least processing costs. One such material is the coal ash. It is an unavoidable residual yield of the thermal power plants which are the major electricity producers in India. The 120 power plants produce 120-150 million tons of fly ash per year. The disposal of this fly ash is a complicated task as it takes a very large space to dump, also this causes air pollution and harmful health conditions when inhaled. Many attempts have been made to utilize this material in the recent past. One such attempt is the use of fly ash in concrete. It has been found that fly ash can be used as an important constituent of concrete in the form of aggregates. The market for fly ash aggregate has one of the most intriguing opportunity for business owners as use of fly ash has no seasonal problems, as it could be stored for a very long time in open surroundings without the risk of losses, environmental hazard or freeze-thaw condition complications. The use of fly ash aggregates is a very good application for the disposal of fly ash.*

**Keywords:** *Fly ash aggregate, Fly ash, Compressive strength, split tensile test, flexural strength*

## I. INTRODUCTION

Concrete is produced with mixing materials such as cement, aggregates and water in predetermined proportions. These materials are all either directly obtained from nature or processed before using after obtaining from nature. There has been an effort to replace some of these materials by recycled cheaper materials which would not only reduce the carbon foot print but also solve the waste disposal problem to some extent. One such material is the fly ash that is a residual of thermal electricity generation. In general, the disposal of Fly Ash is done in both dry and wet condition. The constituents of it are Arsenic, Chromium, Nickel, Cadmium, Lead, Antimony, etc. which possesses respiratory problems, cancers, blood iron decrement and skin irritations [1]. Another major concern is that Indian coals produce high amounts of ash comparatively which has already increased the problem [2].

### Revised Manuscript Received on January 5, 2020

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The main problem of concrete with only fly ash is that it has a strength at early stage but on the advantage side of fly ash is that compressive strength is improved as a result the sulfate durability increases and also the resistance to sulphates [3]. The artificial aggregate production in our country didn't get much response from the investors even though research has been done in recent past by many on the topic. The reason behind this maybe the relatively high cost of production, natural resources shortage, and energy curing process of artificial aggregates [4]. The fly ash aggregate's prominent advantage is that it could be stored for any amount of time and it is quite cheap and easy to manufacture as compared to its artificial counterparts.

## II. METHODOLOGY

The concrete was tested and a base line for the tests such as Compressive concrete strength, Split tensile and Flexural strength of concrete was done replacing the coarse aggregates with 0% of fly ash aggregate to 50% fly ash aggregate with an interval of 10% between consecutive mixtures. In all 162 cubes were casted from which 54 were cubes of dimensions 150\*150\*150mm<sup>3</sup> which were used for testing compressive strength of concrete. For the split tensile strength 54 cylinders were casted of dimensions 300mm in height and 150mm in diameter. Flexural strength was tested using 54 prisms of dimensions 100\*100\*700mm<sup>3</sup>. For testing the workability the tests namely, slump cone test, compaction factor test and vee bee test were done.

### Casting and curing of test specimens

The sizes of standard cubes [150mm x 150mm x 150mm], Standard prisms [100mm x 100mm x 700mm] and standard cylinders [150mm diameter x 300mm height] were made.

**Batching:** In batching process, concrete mix ingredients are processed either by mass or by volume and then added to the mixture. Usually batching is considered by volume but now mass mix is regarded as more accurate and also is preferred for accurate mixes. Batching when done correctly affects workability by reducing the bleeding and segregation in the mix. It also provides a smooth surface of the concrete. It helps in speedy construction and decreases the wastage of material. Hence, batching is considered as an essential step while preparing concrete mix.

**Mixing of concrete:** Measured quantities of coarse aggregate, fine aggregate and cement were spread out over an impervious concrete floor. Fly ash aggregates were added randomly while mixing the concrete. The mixture was rolled over and over until uniformity of color was achieved the time of mixing was between 10 to 15 minutes.

**Placing and compacting:** The mould sections were coated with oil and a thin coating of oil was applied between the contact surfaces of the bottom of the moulds and the base plate to create a water tight boundary. Then the concrete is filled in the moulds layer wise by proper compaction. And finally the moulds were leveled once they fully filled the slurry paste was applied to remove any voids.

**Curing:** The specimens namely cubes, prisms and cylinders were stored on the platform such that it was away from any vibrations, and at a temperature of  $27 \pm 2c$  and at 90% of relative humidity in moist air for 24 hours  $\pm \frac{1}{2}$  hour from the time of mixing of water to the dry constituents. Then the concrete cubes, prisms and cylinders are removed from

moulds and placed for curing for 7 , 14 , and 28 days.

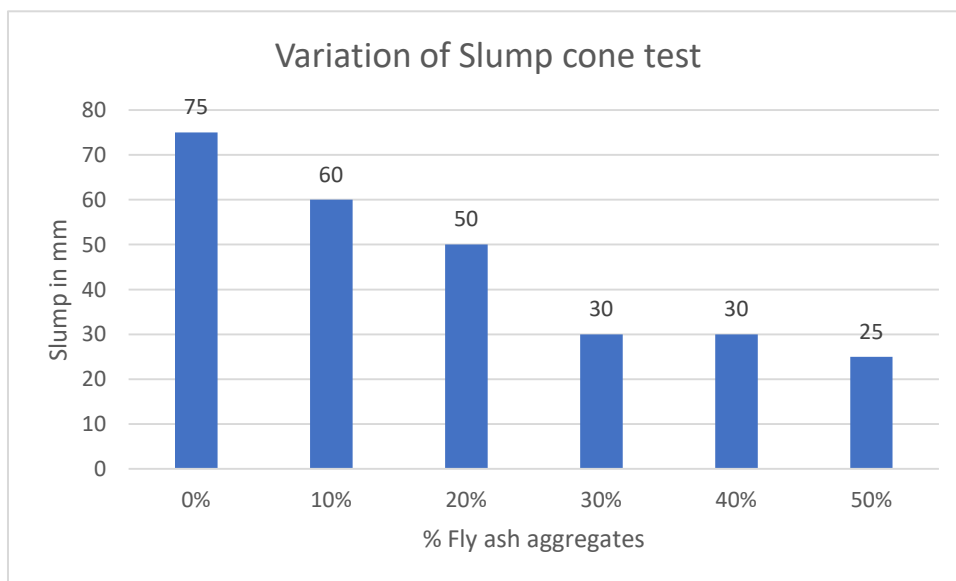
**III. RESULTS AND ANALYSIS**

**Workability of concrete:**

**Slump cone test:** In this test we measure the behavior of a inverted cone that is compacted concrete under self weight due to gravity. The slump test was done with increasing the percentage of fly ash aggregates from 0% to 50% taking an interval of 10%. The results were tabulated and a bar chart was plotted.

**Table 1: Slump test of concrete**

| Sr. No | % Fly ash aggregates | Slump in mm |
|--------|----------------------|-------------|
| 1      | 0%                   | 75          |
| 2      | 10%                  | 60          |
| 3      | 20%                  | 50          |
| 4      | 30%                  | 30          |
| 5      | 40%                  | 25          |
| 6      | 50%                  | 25          |

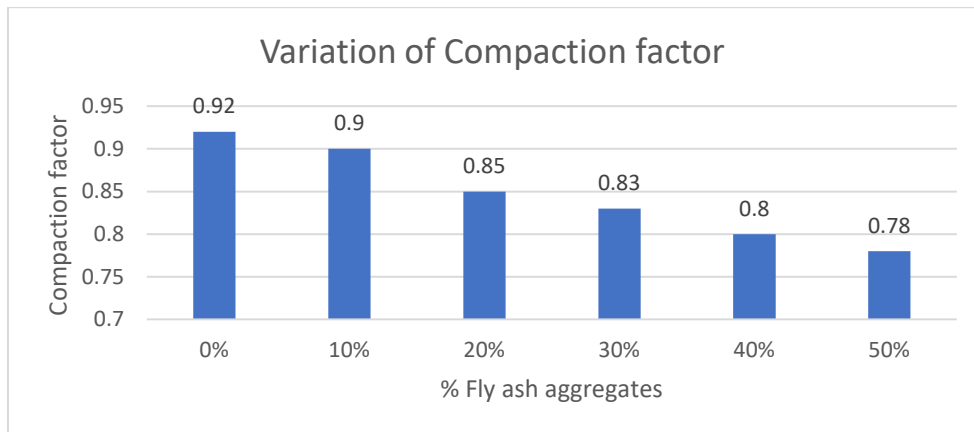


**Fig 1: Slump test of concrete**

**Compaction factor test:** It is the ratio of weight of a partially compacted concrete mix to fully compacted concrete mix. The test was conducted with fly aggregates in a proportion of 0% minimum to a maximum of 50%.

| Sr. No | % Fly ash aggregates | Compaction factor |
|--------|----------------------|-------------------|
| 1      | 0%                   | 0.92              |
| 2      | 10%                  | 0.89              |
| 3      | 20%                  | 0.85              |
| 4      | 30%                  | 0.83              |
| 5      | 40%                  | 0.81              |
| 6      | 50%                  | 0.78              |

**Table 2: Compaction factor of concrete**



**Fig 2: Compaction factor of concrete**

**Vee bee test:** In this procedure, the relative effort done by the concrete to change from one definite shape to another definite shape under the influence of vibrations is checked. In this test also the fly ash aggregates was increased from 0% to 50%. The results were tabulated as well as graphically represented in a bar chart.

| S.no | % Fly ash aggregates | Vee bee sec |
|------|----------------------|-------------|
| 1    | 0%                   | 3           |
| 2    | 10%                  | 5           |
| 3    | 20%                  | 8           |

|   |     |    |
|---|-----|----|
| 4 | 30% | 11 |
| 5 | 40% | 21 |
| 6 | 50% | 25 |

Table 3: Comparison of Vee bee time

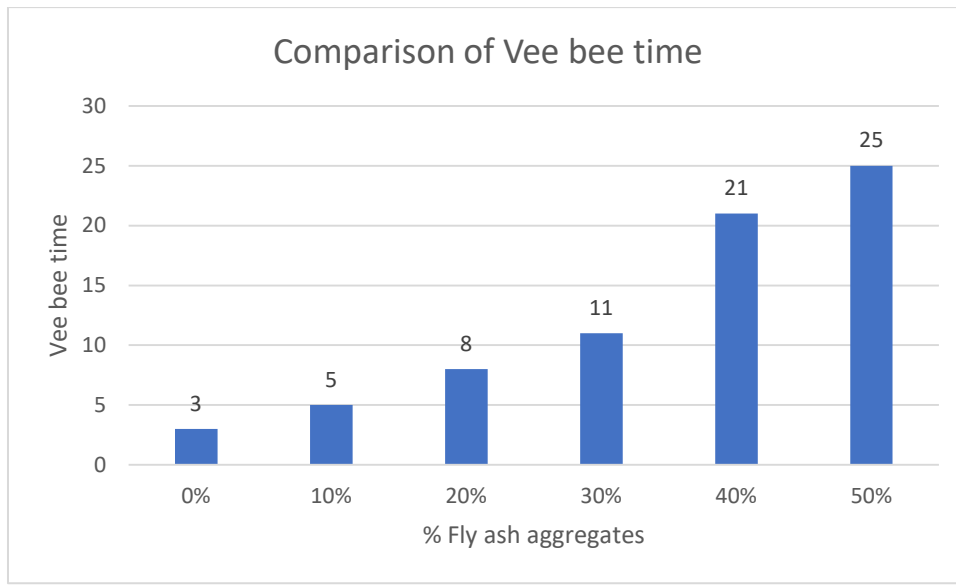


Fig 3: Comparison of Vee bee time

**Tests on Strength of concrete:**

**Compressive strength:** In this test the cubes were casted of dimensions 150mm×150mm×150mm and checked for compressive strength at intervals of 7, 14 and 28 days. Cubes were casted with increasing percentage of fly ash aggregates ranging from 0% to 50% with an interval of 10%. The results were tabulated and also in the form of bar chart separately for intervals of 7, 14 and 28 days.

| Sr. No | % Fly ash aggregates | Compressive strength of concrete |         |         |
|--------|----------------------|----------------------------------|---------|---------|
|        |                      | 7 Days                           | 14 Days | 28 Days |
| 1      | 0%                   | 25.77                            | 35.55   | 38.22   |
| 2      | 10%                  | 27.11                            | 36.88   | 38.88   |
| 3      | 20%                  | 29.55                            | 38.66   | 40.22   |
| 4      | 30%                  | 30.66                            | 40.44   | 41.5    |
| 5      | 40%                  | 27.77                            | 38      | 39.11   |
| 6      | 50%                  | 26.22                            | 36.22   | 38.44   |

Table 4: Compressive test of concrete

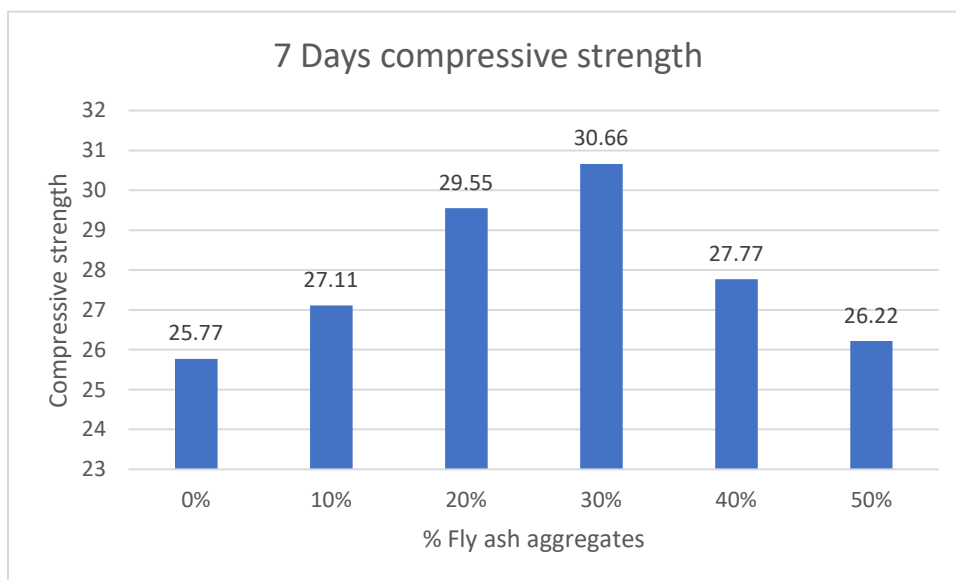


Fig 4: Compressive test of concrete at 7 days

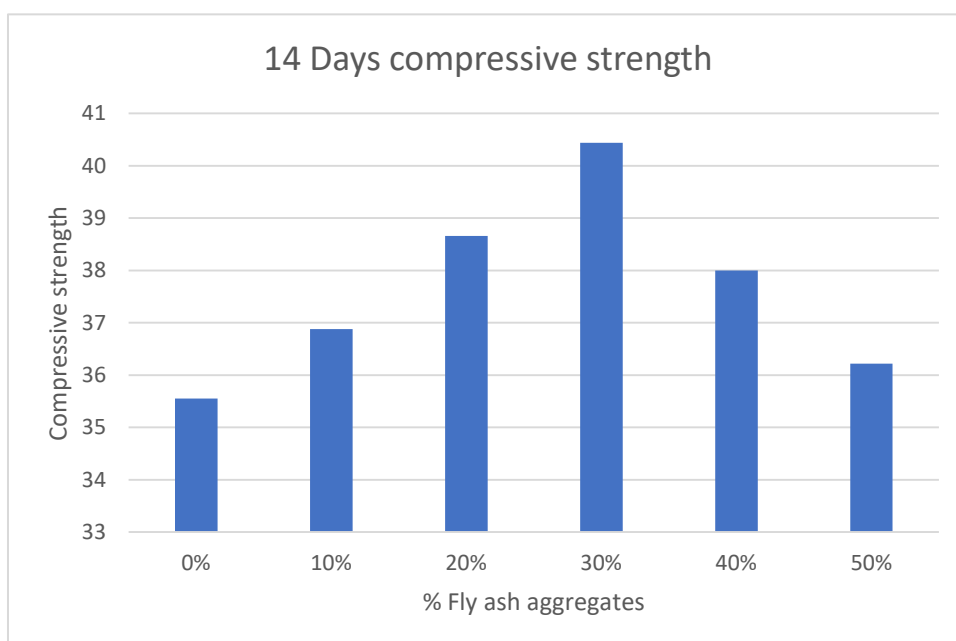


Fig 5: Compressive test of concrete at 14 days

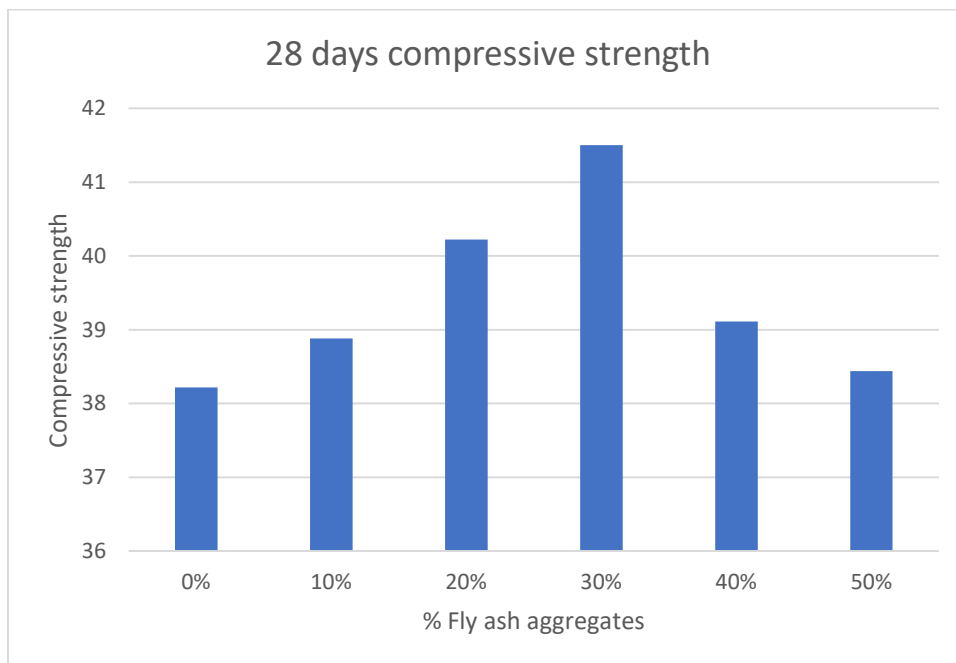


Fig 6: Compressive test of concrete at 28 days

**Spilt tensile strength:** The concretes compatibility to withstand the pulling force (Tensile Stress) without breaking is called the Tensile Strength of concrete. Its unit is (N/Sqmm or Mpa). The split tensile strength is calculated as loading condition such that the load is applied on top and bottom of the cylinder on its lateral surface, to the area equal to the lateral surface area of the cylinder. The split tensile strength =  $(2P/\pi dl)$  N/mm<sup>2</sup>. The split test was done on cylinders with dimensions 300mm height and 150mm diameter.

| S.No | % Fly ash aggregates | Split tensile strength of Concrete |         |         |
|------|----------------------|------------------------------------|---------|---------|
|      |                      | 7 Days                             | 14 Days | 28 Days |
| 1    | 0%                   | 3.20                               | 4.81    | 5.30    |
| 2    | 10%                  | 3.68                               | 5.16    | 5.59    |
| 3    | 20%                  | 4.17                               | 5.37    | 5.87    |
| 4    | 30%                  | 4.53                               | 5.73    | 6.15    |
| 5    | 40%                  | 3.82                               | 5.09    | 5.52    |
| 6    | 50%                  | 3.32                               | 4.88    | 5.37    |

Table 5: Split tensile strength of Concrete

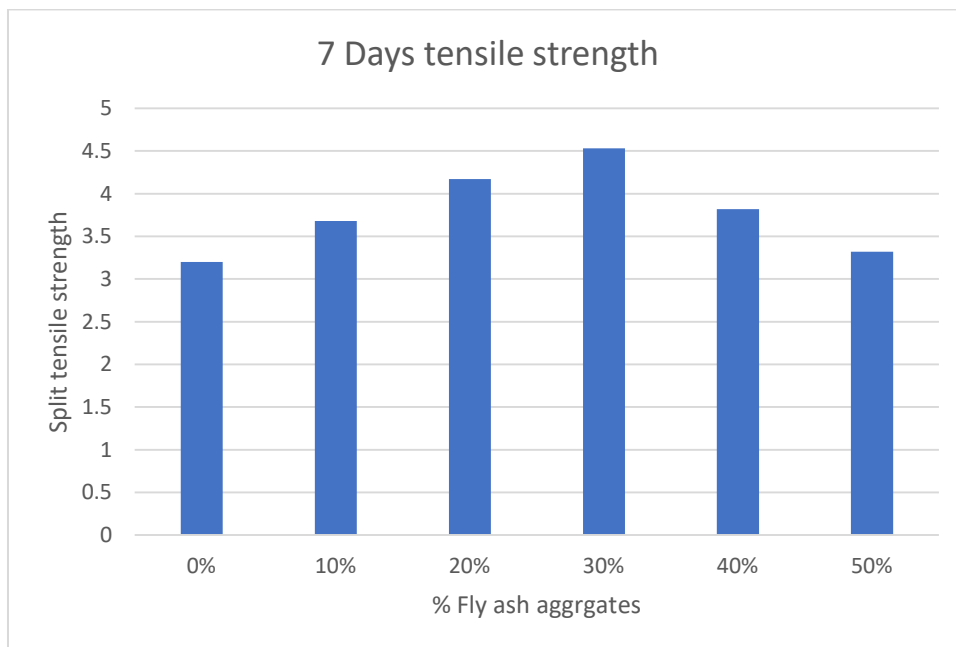


Fig 7: Split tensile strength of Concrete at 7 days

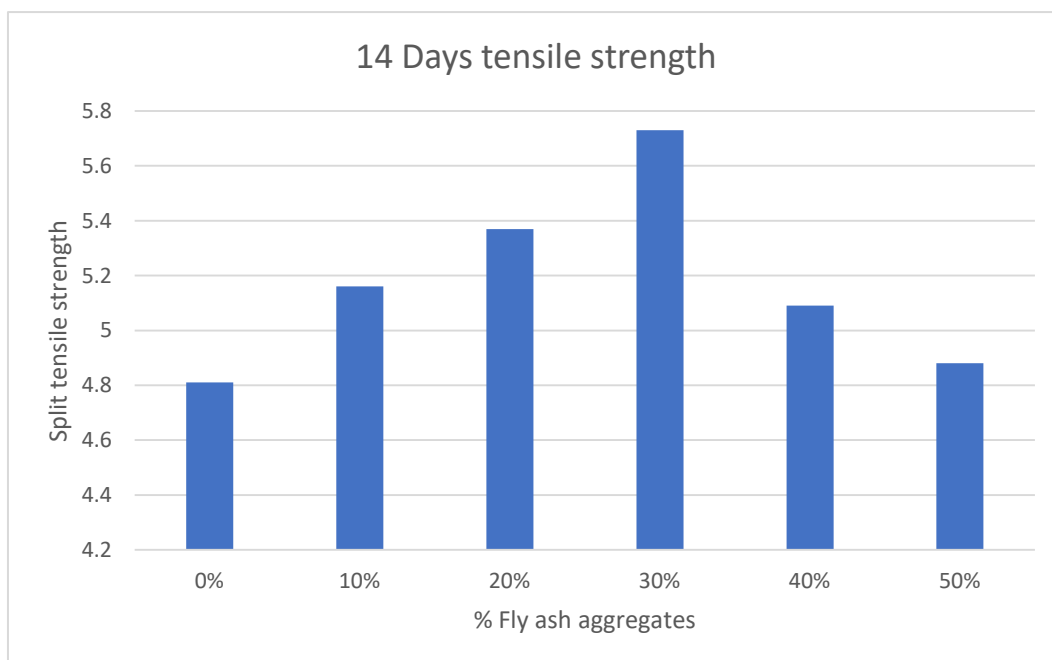


Fig 8: Split tensile strength of Concrete at 14 days

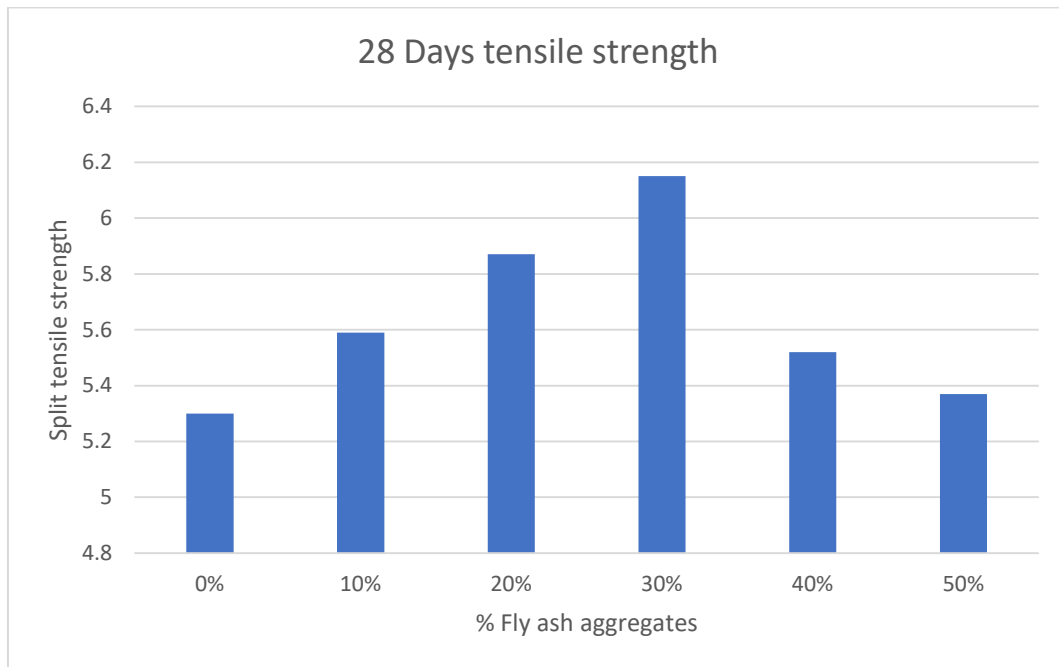


Fig 9: Split tensile strength of Concrete at 28 days

**Flexural strength:** The Flexural strength is an important property of concrete it is also called as modulus of rupture, it is defined stress per unit area at the time of yielding. It is the maximum amount of stress just before the rupture of concrete. For this test square prisms of 100mm×100mm×700mm were used to test on universal testing machine.

| Sr. No | % Fly ash aggregates | Flexural strength of Concrete |         |         |
|--------|----------------------|-------------------------------|---------|---------|
|        |                      | 7 Days                        | 14 Days | 28 Days |
| 1      | 0%                   | 4.15                          | 4.97    | 5.80    |
| 2      | 10%                  | 4.77                          | 4.60    | 6.42    |
| 3      | 20%                  | 5.80                          | 6.63    | 7.46    |
| 4      | 30%                  | 7.26                          | 7.88    | 8.50    |
| 5      | 40%                  | 6.63                          | 6.01    | 6.63    |
| 6      | 50%                  | 5.60                          | 5.18    | 6.01    |

Table 6: Flexural strength of Concrete



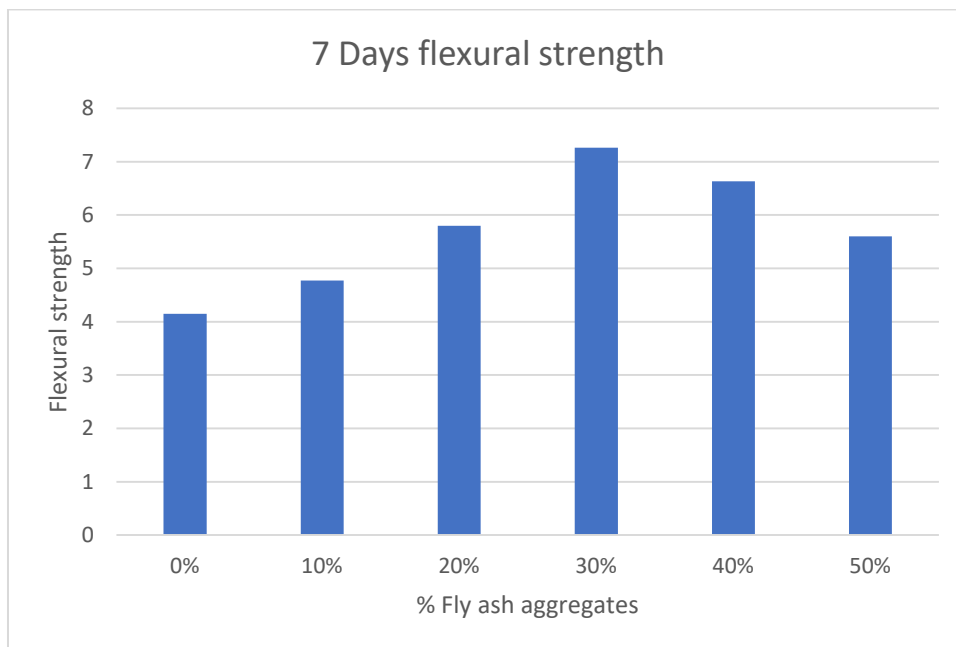


Fig 10: Flexural strength of Concrete at 7 days

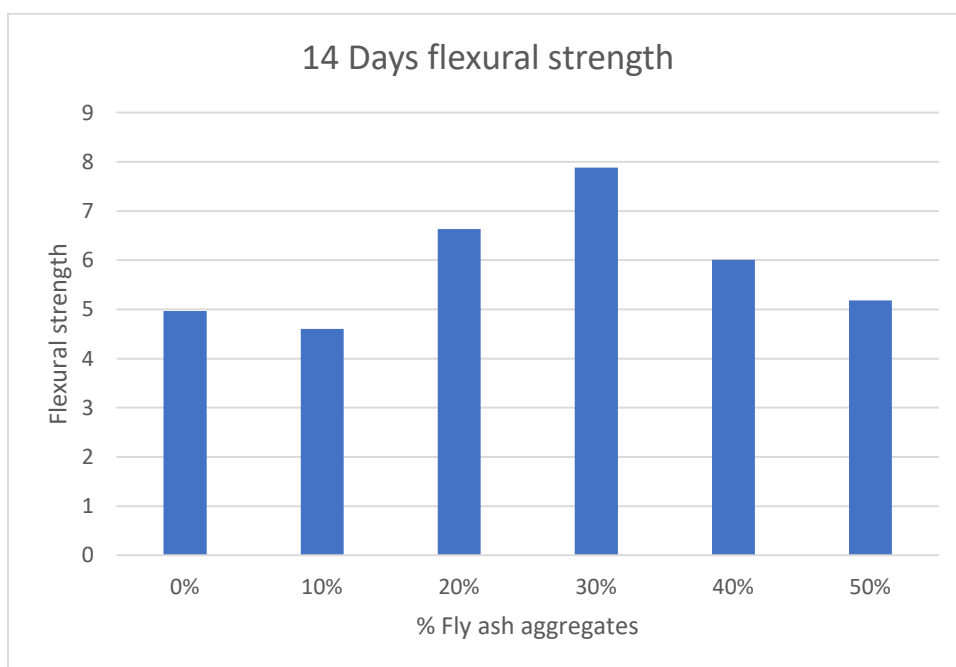


Fig 11: Flexural strength of Concrete at 14 days

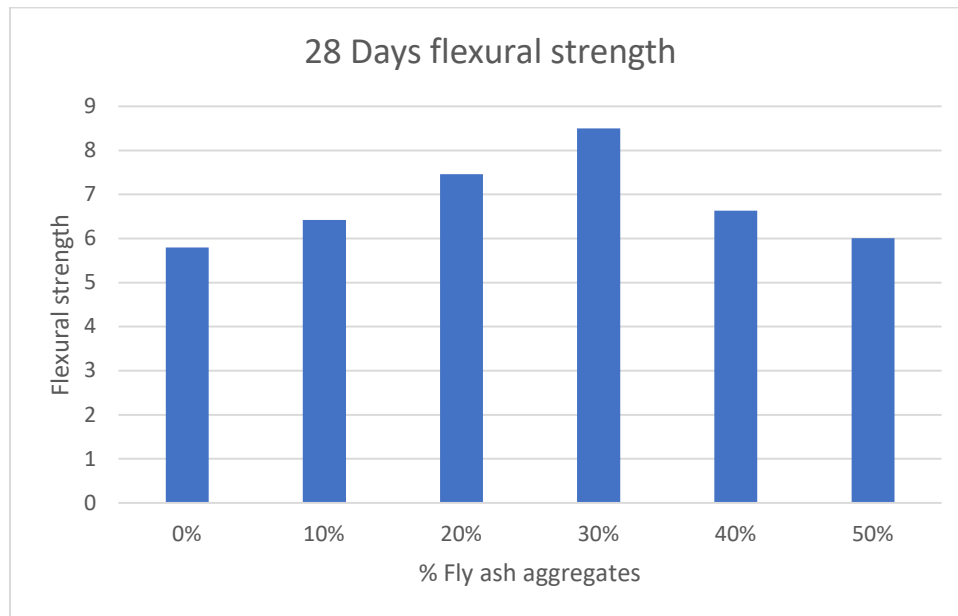


Fig 12: Flexural strength of Concrete at 28 days

#### IV. CONCLUSION

1. The round fly ash aggregates gave better workability compared to the natural gravel angular aggregate.
2. The value of slump decreased as the percentage of fly ash aggregates from increased from 0% to 50%.
3. The value of compaction factor decreased as the percentage of fly ash aggregates increased from 0% to 50%.
4. The value of vee bee time increased with the percentage of fly ash aggregates from 0% to 50%.
5. The optimal value of compressive strength was observed at 30% fly aggregates for 7days, 14 days and 28 days. After 30% fly ash aggregates the compressive strength of concrete decreases.
6. The optimal value (maximum value) of Split tensile strength was observed at 30% fly aggregates for 7days, 14 days and 28 days. Similar to the compressive strength split tensile strength decreases with increase in the percentage of Glass powder and Wood powder.
7. The optimal value (maximum value) of Flexural strength was observed at 30% fly aggregates 7days, 14 days and 28 days. After 30% fly aggregates the Flexural strength of concrete decreases.

#### REFERENCES

1. Manas Ranjan Senapati, 'Fly ash from thermal power plants waste management and overview' Current science, vol. 100, no. 12, 25 june 2011, pp. 1791-1794
2. Priyadarshini P, Mohan Ganesh.G, and Santhi.A.S, 'Experimental study on Cold Bonded Fly Ash Aggregates', International Journal of Civil and Structural Engineering Volume 2, No 2, 2011, pp. 493-501.
3. Mehta P. K. and Monteiro P.J.M. 2006. Concrete - Microstructure, Properties, and Materials. The Indian Concrete Institute, Chennai, India
4. Niyazi Ugur Kockal, and Turan Ozturan, 'Durability of lightweight concretes with lightweight fly ash aggregates', Journal of Hazardous Materials, Volume 179, Issues 1-3, 15 July 2010, Pages 954-965

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