Experimental investigation of fiber reinforced concrete using septage ash

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Abstract: In this experimental investigation, the concrete has replaced with septage ash in place of cement and banana fiber is added as a percentage of the weight of cement. Concrete is one of the materials which use a maximum number of non-renewable resources. Due to the high demand for non-renewable resources in the construction industry, recent investigations are carried out to find alternative construction materials which are eco-friendly and cause some impact in reducing pollution in the environment. Septage ash or septic tank sludge is the by-product from the faecal sludge sewage treatment plant of household septic tanks. Banana fiber is the natural fiber which is obtained from the stem of the banana tree, banana fiber is mainly used in the textile industry, but a huge quantity of fiber which can't be used in the textile manufacturing is as waste. So, in this experimental investigation authors have used these two materials to find the optimum percentage that can be replaced in concrete. In this research septage ash is put back by 10%, 20%, 30%, and 40% instead of cement without and with banana fiber added 1% of the weight of cement. Compressive, tensile along with flexural strength test is conducted for 7days and 28 days and results are compared to finding the optimum percentage of septage ash with banana fiber that can be replaced instead of cement.

Key words: Banana fiber, Septage ash, Non-renewable resources, Fauclal sludge, Construction industry, Investigations, Impact.

1. INTRODUCTION

The increases in the human population and the development of new technologies, materials and processes have caused an increase in the demand for resources [2]. The mismanagement and extensive use of these natural resources cause detrimental environmental problems. The word "sustainable" is becoming a very big issue in the present world. Sustainable development is the growing demand for the construction industry. Concrete is the most broadly used construction material all over the world with innovations combination of binder material such as fine aggregate, coarse aggregate, water and Cement. Cement is the main ingredient in the production of concrete [6]; woefully production of cement involves the emission of a large amount of carbon-dioxide gas into the atmosphere, a major contributor to the greenhouse effect and global warming. Form in recent years, Construction Technology has advanced through several investigations and experiments to enhance sustainable construction activities. To study the impact of the use of some pozzolanic materials as cement replacement Sewage sludge ash is the outgrowth produced from faecal sludge treatment plant (FSTP). An alternative solution for sewage sludge disposal is incineration which makes sewage sludge to SSA (sewage sludge ash). In this process, main components are sewage sludge in the presence of high temperature (500 to 700 degree Celsius) such as SiO2, CaO, Al2O3, these pozzolanic materials can used in concrete as partial replacement of cement, which undergoes pozzolanic reaction between pozzolanic materials (SiO2, CaO, Al2O3) and cement (OPC)[3].
on the report released by the government of India in December 2015, Urban areas all around the country nearly 62,000 million litres per day (MLD) sewage is generated, but only 23,277 or 37% of total generated municipal sewage million litres per day (MLD) can be treated across India. this implies nearly 70% of sewage generated in urban India untreated. Untreated sewage just connected to open drains which cause severe water and land pollution. As well as treated sewage is not reused fully, SSA used as organic fertilizer, landfill, backfill of trenches and used for manufacturing of bricks etc. In this investigation, SSA is brought from faecal sludge treatment plant (FSTP) located in ammavaripet village, Warangal urban Telangana state.

Fibres used in concrete are mainly categorized into natural and artificial fibres. The sources of natural fibres are vegetables, animal and mineral sources. On the other hand, artificial fibres are produced from synthetic materials, steel and natural polymers [5]. Fibres exist in various forms such as Cocos Nucifera (coconut) fibre, Musa acuminate (banana) fibre, Musa sapientum which is commonly known as banana is a herbaceous plant of the family Musaceae. The plant is produced from its fruits and mainly cultivated for the production of fiber. The Musa sapientum can grow up to a height of about 2-8m and the length of leaves are of about 3.5m. In our country, we are producing 70 million of metric of banana every year. The availability of banana fibres is large in amount [4]. The banana fiber used in the textile industry. Some amount of fiber has remained as waste, which can’t be used in textiles. In this investigation, fiber is brought from Women Technology Park located in SR Engineering College, Warangal urban Telangana state.

So, in this experimental investigation authors have used these two materials to find the optimum percentage that can be replaced in concrete [1]. In this research septage ash is put back by 10%, 20%, 30%, and 40% instead of cement without and with banana fiber added 1% of the weight of cement. Compressive, tensile along with flexural strength test is conducted [5] for 7 days and 28 days and results are compared to finding the optimum percentage of septage ash with mineral admixture as banana fiber that can be replaced instead of cement.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Cement. OPC (ordinary Portland cement) of 53 grade was used for the investigation. All the test on cement are conducted as per IS 1489-1(1991). Cement was taken Same band and source Cement throughout the research work and stored in moisture free place.

2.1.2. Fine aggregate. In this investigation locally available sand passing through 4.75mm sieve is used as fine aggregate. Specific gravity and fineness modulus of used fine aggregate is 2.65 (range of specific gravity should be between 2.65 to 2.75) and 2.46 respectively.

2.1.3. Coarse aggregates. Coarse aggregate was collected from a local quarry and it was tested in the laboratory. The specific gravity of coarse aggregate is found as 2.75 (range of specific gravity should be between 2.70 to 3.00).

2.1.4. Septage ash. SSA is tested in the laboratory, ph vale is 10.27, Electric Conductivity 4.66, Total dissolved Solids 2.66. In this investigation, SSA is brought from faecal sludge treatment plant (FSTP) located in ammavaripet village, Warangal urban Telangana state. It was added as 10, 20, 30, and 40% replacement of cement.

2.1.5. Banana fiber. The banana fiber was cut into 2.5 mm length pieces and 1% of the weight of cement, fiber is added into concrete during mixing. For this investigation, fiber is brought from Women Technology Park located in SR Engineering College, Warangal urban Telangana state.
2.2 Methods

2.2.1. Compressive strength test. The compression test is one of the important and common tests conducted for different kind of materials. Compression strength is the resistance offered by the material due to the compression load on it. This test down mainly to concrete because it should with stand loads as per designed amount. By the experimental investigation, it is clear that the strength of concrete is increased with increase in age of concrete. This experiment is down as per IS 516:1959. Size of the specimen 150×150×150mm

\[
\text{Compression strength} = \frac{\text{load}}{\text{area}}
\]

2.2.2. Split tensile strength. Concrete is strong in compression and weak in tension, so the concrete will fail in tension as compared with Compression. This test is conducted as per IS 5816 – 1970. Size of the specimen is 150mm length and 100mm diameter. Specimen placed horizontal along the length and load is applied in vertical direction. Below mentioned Formula is used to calculate the tensile strength.

\[
\text{Split tensile strength} = \frac{2P}{\pi LD}
\]

Where
\[P = \text{load}, \ D = \text{diameter of specimen (100mm)}, \ L = \text{length of specimen (150mm)}\]

2.2.3. Flexural strength. Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. Beams of 10×10×50cm are cast and tested under single point load for 7,28 days.

\[
\text{Flexural strength} = \frac{3PL}{2BD}
\]

Where
\[P = \text{load}, \ L = \text{length of specimen}, \ B = \text{breadth of specimen}, \ D = \text{depth of specimen}\]

3. METHODOLOGY

Cement, fine aggregate and coarse aggregate are tested and concrete is prepared with mix proportion of 1:1.5:3 (i.e M20). In this mix proportion, three different types of concretes are prepared i.e control concrete, fiber reinforced concrete and fiber reinforced concrete with partial replacement of septage as 10, 20, 30, 40% in place of cement, additional to theses paver blocks are cast. Then all the specimens are put in a curing tank and tested for 7 and 28 days. Compression strength test, tensile strength, and flexural strength test are conducted and results are compared.

4. RESULTS AND DISCUSSION

| Type of concrete | without fiber 7 days(N/mm²) | without fiber 28 days(N/mm²) | with fiber 7 days(N/mm²) | with fiber 28 days(N/mm²) |
|-----------------|-----------------------------|-----------------------------|--------------------------|--------------------------|
| C,C             | 14.70                       | 25.53                       | 14.90                    | 26.35                    |
| 10% SSA         | 14.36                       | 25.82                       | 14.45                    | 27.86                    |
| 20% SSA         | 13.48                       | 24.12                       | 13.95                    | 27.29                    |
| 30% SSA         | 12.20                       | 23.49                       | 11.89                    | 24.45                    |
| 40% SSA         | 9.92                        | 22.76                       | 10.20                    | 22.46                    |
From the above (Table 1) compressive strength of concrete, it is clear that target mean strength i.e. 20\(N/mm^2\) is obtained from C.C to 40% SSA and C.C+ fiber to 40% SSA + Fiber. As the SSA content up to 20% compressive strength increasing (Figure 1).

**Figure 1.** Graphical representation of compressive strength of concrete

| Type of concrete | without fiber 7 days\((N/mm^2)\) | without fiber 28 days\((N/mm^2)\) | with fiber 7 days\((N/mm^2)\) | with fiber 28 days\((N/mm^2)\) |
|------------------|-----------------------------------|-----------------------------------|-------------------------------|-------------------------------|
| C.C              | 1.52                              | 2.97                              | 1.63                          | 3.28                          |
| 10% SSA          | 1.62                              | 3.20                              | 1.73                          | 3.87                          |
| 20% SSA          | 1.60                              | 2.90                              | 1.70                          | 3.54                          |
| 30% SSA          | 1.35                              | 2.67                              | 1.55                          | 3.12                          |
| 40% SSA          | 1.12                              | 2.24                              | 1.27                          | 2.98                          |

From the above (Table 2) split tensile strength of concrete, it is clear that minimum tensile strength i.e. 2N/mm² (generally tensile strength will be 7-10% of compressive strength of concrete) is obtained from C.C to 40% SSA and C.C+ fiber to 40% SSA + Fiber. Comparing the above results 10% SSA and 10% SSA + fiber both are having the highest values (Figure 2).
Figure 2. Graphical representation of split tensile strength of concrete

Table 3. Flexural strength of concrete

| Type of concrete | without fiber 7 days(N/mm²) | without fiber 28 days(N/mm²) | with fiber 7 days(N/mm²) | with fiber 28 days(N/mm²) |
|------------------|----------------------------|-----------------------------|-------------------------|--------------------------|
| C.C              | 2.30                       | 3.20                        | 2.48                    | 3.60                     |
| 10% SSA          | 2.56                       | 3.12                        | 2.86                    | 3.76                     |
| 20% SSA          | 2.39                       | 3.00                        | 2.64                    | 3.75                     |
| 30% SSA          | 1.96                       | 2.92                        | 2.54                    | 3.40                     |
| 40% SSA          | 1.44                       | 2.56                        | 1.68                    | 2.80                     |

From the above (Table 3) flexural strength of concrete, it is clear that minimum flexural strength i.e. 2.4N/mm² (generally flexural strength will be 10-15% of compressive strength of concrete) is obtained from C.C to 40% SSA and C.C+ fiber to 40% SSA + Fiber. Comparing the above results C.C+ SSA to C.C+20% SSA and C.C + fiber to C.C+20% SSA are having the highest values (Figure 3).
5. CONCLUSION

1. From the above results, it is very clear that SSA+FIBER concrete gained more strength compared with SSA concrete.
2. Compressive strength value satisfying up to 20% SSA+FIBER concrete.
3. Tensile strength values of 10% SSA+FIBER concrete are high compared to SSA concrete.
4. Flexural strength values of SSA+FIBER concrete are increased compared with SSA concrete. 20% SSA+FIBER have the highest value compared to other values.
5. From the overall observation it is clear that, max 10% to 20% of septage ash can be replaced with 1% of banana fiber.

6. SCOPE

- In the future experimental investigations different percentages of banana fiber can be added and 56 days strength can also be checked.
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