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# A STUDY ON ECO-FRIENDLY ULTRA HIGH PERFOMANCE FIBRE REINFORCED CONCRETE USING AGRO AND INDUSTRIAL WASTES

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## ABSTRACT

*Today world need a concrete which gives more strength with less cross section which to lead development of Ultra High Performance Fiber Reinforced Concrete, which made easier for building complex structures like harbor slabs, runways of airport, bridges. On one hand production of Cement leads to the 5% of the world's greenhouse gases, on other hand 300 million tons of bagasse waste leads to land degradation but bagasse ash can act as the supplementary cement material as partial replacement. Also silica fume and sand are being costlier and uneconomical. There is conscience for the need for alternatives such as industrial wastes.*

*A study on eco-friendly Ultra High Performance Fiber Reinforced Concrete using bagasse ash as partial replacement for cement and Thermal Cutting slag as replacements for silica fume and Oxygen Furnace slag such as Fine Steel Slag as replacement M.sand respectively. To understand and study the behavior of this concrete as individual replacements and combination of the high strength giving replacements in individuals it workability and durability tests like flowability, compressive strength, tensile strength and flexural strength.*

***Keywords-* Bagasse Ash, Steel slag, Thermal Cutting Wastes/ slag, UHPFRC.**

## I.INTRODUCTION

Concrete is the one of the most used material in the world of construction, as years passed the requirement for better concrete in various aspects increased like strength, workability etc. To meet requirement of modern construction a new form of concrete is developed called Ultra high performance concrete. It is purely new class of concrete and has good mechanical properties, durability and long-term stability compared to high performance concrete (HPC). Ultra-high performance concrete is made by using very fine aggregates, low water cement ratio and high range water reducing agents to make the concrete flowable. Ultra High Performance Fiber-Reinforced Concrete (UHPFRC) is material with a cement matrix and they contain steel fibers, in order to achieve ductile behavior in tension and overcome if possible the use of passive reinforcement.

UHSFRC is also known as reactive powder concrete (RPC) which exhibits excellent durability and mechanical properties. This is one of the latest and emerging topics in the concrete technology. Structural elements cast with UHPC can carry larger loads and exhibit energy absorption capacity with smaller sections.

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The high compressive strength, higher tensile strength along with almost negligible water and chloride permeability therefore better durability of this new concrete material makes it UHSFRC. The basic principle in UHSFRC is to make the cement matrix as dense as possible, by reducing the micro cracks and capillary pores in the concrete and also to make a dense transition zone between cement matrix and aggregates. Concrete (UHSFRC) using materials that are available locally are always economical since the patented products are very expensive and the materials such as silica sand and quartz powder are not readily available. The use of UHPC in the construction of shear keys can be a good solution for achieving long lasting bridge systems.

## II. EXPERIMENTAL PROGRAM

### 1.1 MATERIALS

**Materials for required for UHPFRC**

A. Cement- Ordinary Portland Cement 53 grade are used in this project.
B. Fine Aggregate- M.sand
C. Coarse Aggregate- Crushed Jelly Stone
D. Quartz Powder
E. Silica Fume
F. Steel Fibers
G. Super Plasticizers
H. Water

**Materials used for replacement**

A. Bagasse Ash- Used as replacement for Cement 5%, 10% and 15% by weight.

**Table No. 2.1: Properties of Bagasse Ash**

| Characteristics | Value |
|---|---|
| Color | Grey |
| Specific Gravity | 2.2 |

**Figure 2.1: Bagasse Ash**

B. Fine Steel Slag- Used as replacement for M.sand 50%, 75% and 100%by weight.

**Table No. 2.2: Properties of Fine Steel Slag**

| Characteristics | Value |
|---|---|
| Shape | Granular |
| Specific Gravity | 3.2 |
| Bulk Density | 3.63 |
| Impact Value | 6.15% |

**Figure 2.2: Steel Slag**

C. Thermal Cutting Waste/ Slag- Used as replacement for Silica Fume 50%, 75% and 100%by weight.

Table No. 2.3**: Properties of Thermal Cutting Waste/Slag**

| Characteristics | Value |
|---|---|
| Color | Black |
| Specific Gravity | 2.92 |

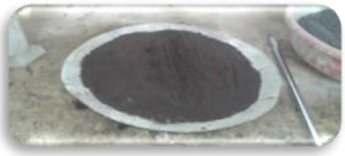

**Figure 2.3: Thermal Cutting Waste/ Slag**

### 1.2 Mix Proportion

The mix proportion for design that has been adopted from **SAHIL THESIS**

**Table No. 2.4: MIX PROPORTION FOR UHPFRC**

| Materials | Proportion |
|---|---|
| Ordinary Portland Cement (53 Grade) | 1 |
| M.sand | 0.61 |
| Quartz Powder | 0.25 |
| Silica Fume | 0.25 |
| Coarse Aggregate | 1.23 |
| Super Plasticizer | 0.0108 |
| Steel Fiber | 0.25 |
| Water | 0.26 |

**TABLE 2.5: MIX PROPORTION OF VARIOUS TRAIL MIXES**

| S.no | Details of Trail Mix | Naming |
|---|---|---|
| 1 | Reference Mix / Control Mix | R |
| 2 | Replacement Of Cement by Using Bagasse Ash 5%byWeight Of cement | $T_{B1}$ |
| 3 | Replacement Of Cement by Using Bagasse Ash 10%byWeight Of cement | $T_{B2}$ |
| 4 | Replacement Of Cement by Using Bagasse Ash 15%byWeight Of cement | $T_{B3}$ |
| 5 | Replacement Of Silica Fume by Using Thermal Cutting Slag 50%byWeight Of Silica Fume | $T_{T1}$ |
| 6 | Replacement Of Silica Fume by Using Thermal Cutting Slag 75%byWeight Of Silica Fume | $T_{T2}$ |
| 7 | Replacement Of Silica Fume by Using Thermal Cutting Slag 100%byWeight Of Silica Fume | $T_{T3}$ |
| 8 | Replacement Of M.sand by Using Fine Steel Slag 50%byWeight Of M.sand | $T_{S1}$ |
| 9 | Replacement Of M.sand by Using Fine Steel Slag 75%byWeight Of Silica Fume | $T_{S2}$ |
| 10 | Replacement Of M.sand by Using Fine Steel Slag 100%byWeight Of Silica Fume | $T_{S3}$ |
| 11 | Replacement of 10% Cement by Bagasse ash and 50% of Silica Fume by Thermal Cutting slag | $C_T$ |
| 12 | Replacement of 10% Cement by Bagasse ash and 50% of Fine Steel Slag | $C_S$ |

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### 1.3 TESTS ON FRESH CONCRETE

#### 1.3.1. Flowability

Fresh Concrete is poured through inverted cone of the slump on a plane surface and measure the diameter of the flow.

### 1.4 TESTS ON HARDEND CONCRETE

#### 1.4.1. Compression Test

Concrete Cubes of 150mm * 150mm * 150mm dimension are to be casted and cured for 7days and 28days in water and to be tested under in compression machine.

#### 1.4.2. Split Tensile Test

Cylindrical mould of 150mm diameter and length of 300mm to be casted and cured for 7 days and 28 days and tested in compression machine.

The magnitude of tensile stress (T) acting uniformly to the line of action of applied loading is given by formula:-

$T = 2 P/\pi DL$

Where,

T= split tensile strength (in MPa)

P = Applied load

D = Dia. of concrete cylinder sample (in mm)

L = length of concrete cylinder sample (in mm)

#### 1.4.3. Flexural Test

Beam moulds of the dimension 100mm * 100mm * 500mm to be casted and cured for 28 days and tested in UTM machine.

$$\text{Flexural Strength [Fb]} = PL/BD^2$$

Where,

P = Applied load

L = length of concrete beam sample (in mm)

B=breadth of concrete beam sample (in mm)

D=depth of concrete beam sample (in mm)

## II. RESULTS AND DISCUSSION

### 3.1. Flowability Tests

TABLE 3.1: Flowability Test Results

| Serial Number | Trial Mix | Flowability in mm |
|---|---|---|
| 1 | R | 180 |
| 2 | $T_{B1}$ | 185 |
| 3 | $T_{B2}$ | 187 |

| | | |
|---|---|---|
| 4 | $T_{B3}$ | 190 |
| 5 | $T_{T1}$ | 140 |
| 6 | $T_{T2}$ | 150 |
| 7 | $T_{T3}$ | 150 |
| 8 | $T_{S1}$ | 185 |
| 9 | $T_{S2}$ | 190 |
| 10 | $T_{S3}$ | 200 |
| 11 | $C_T$ | 160 |
| 12 | $C_S$ | 170 |

- The Trail Mix-$T_{B1}$ (5% replacement by weight of cement by bagasse ash ),$T_{B2}$ (10% replacement by weight of cement by bagasse ash) and $T_{B3}$ (15% replacement by weight of cement by bagasse ash) give comparative higher flowability of 185 mm, 187 mm and 190mm than the reference mix.
- Also increase in the percentage of the of bagasse ash increase the flowability of concrete but less than the trial mix of replacing of M.sand by steel slag.
- The Trail Mix-$T_{S1}$ (50% replacement by weight of M.sand by steel slag ),$T_{S2}$ (75%replacement by weight of M.sand by steel slag) and $T_{B3}$ (100% replacement by weight of M.sand by steel slag) give comparative higher flowability of 185 mm, 190 mm and 200mm than the reference mix give a good flowability.

### 3.2. Compression Test

The compression test conducted on the various trail mix samples on 7 Days and 28 Days. The sample R obtained values of 56.90 MPa for 7days and 85.83Mpa. The increase in the strength of the concrete is 66% in reference mix cube.

The comparisons of compressive strength of the trail mix sample with the references mix are as follows:

1. The sample$T_{S1}$ (50% replacement of M.sand by steel slag) as achieved 95%of the strength of the reference mix.
2. Sample $T_{T1}$ (50% replacement of silica fume by thermal cutting slag) as achieved 90% of strength of reference mix.

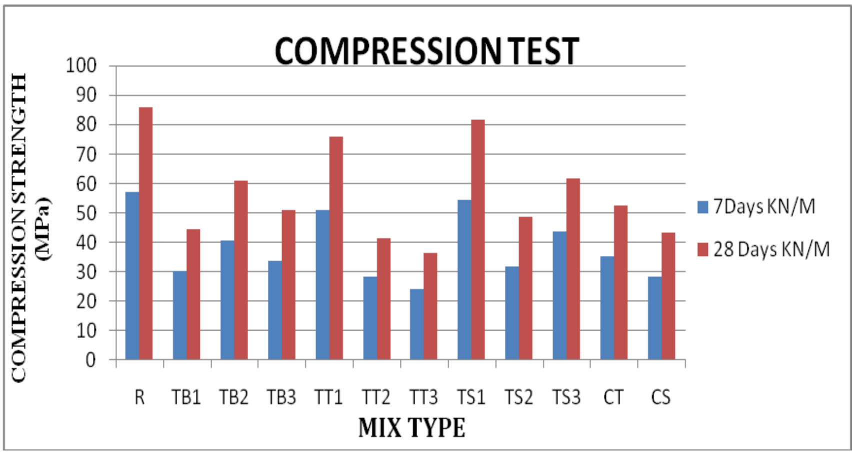


**Figure 3.1: Comparison Graph of Various Trail Mix for Compression strength**

**Figure 3.2: Performing Compression Tests**

### 3.3. Split Tensile Test

From obtained compression test values we take 6 trail mix samples which provide greater strength as compared to their individual values.

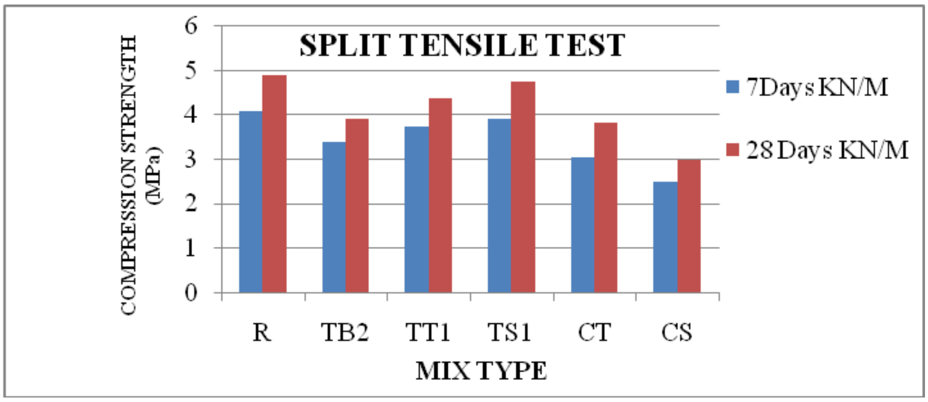


**Figure 3.3: Comparison Graph of Various Trail Mix for Split Tensile Test**

The comparisons of compressive strength of the trail mix sample with the references mix are as follows:

1. The sample$T_{S1}$ (50% replacement of M.sand by steel slag) as achieved 97.3% of the strength of the reference mix.
2. Sample $T_{T1}$ (50% replacement of silica fume by thermal cutting slag) as achieved 90 % of strength of reference mix.
3. The sample $T_{B2}$ (10% replacement of cement by bagasse ash) as achieved 80% of strength of reference mix.
4. The combination trial mix $C_S$, and $C_T$ have achieved 79% and 61% of the strength of the reference mix.

### 3.3.Flextural Strength

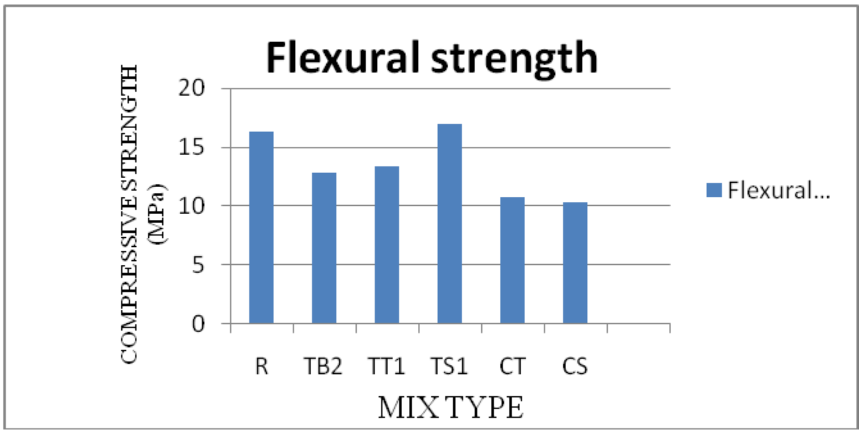


**Figure 3.4: Comparison Graph of Various Trail Mix for Flexural Strength Test**

The comparisons of compressive strength of the trail mix sample with the references mix are as follows:

1. The sample$T_{S1}$ (50% replacement of M.sand by steel slag) as achieved greater than of the strength of the reference mix.
2. Sample $T_{T1}$ (50% replacement of silica fume by thermal cutting slag) as achieved 82 % of strength of reference mix.
3. The sample $T_{B2}$ (10% replacement of cement by bagasse ash) as achieved 78.4% of strength of reference mix.
4. The combination trial mix $C_S$, and $C_T$ have achieved 66% and 63% of the strength of the reference mix.

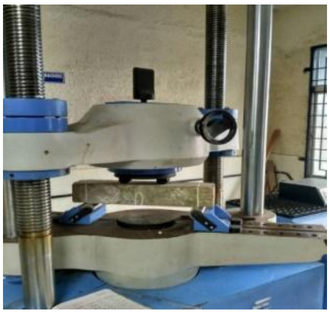

**Figure 3.5: Performing Flexural Strength Test**

## IV. CONCLUSION

**Table No. 4.1: Comparison Table Selected Trail Mixes**

| TRAIL MIX | R | $T_{B2}$ | $T_{SI}$ | $T_{T1}$ | $C_S$ | $C_T$ |
|---|---|---|---|---|---|---|
| FLOWABILITY (MM) | 180 | 187 | 185 | 140 | 170 | 160 |
| COMPRESSIVE STRENGTH (MPa) | 85.83 | 60.93 | 81.64 | 75.73 | 52.33 | 43.44 |
| SPLIT TENSILE STRENGTH (MPa) | 4.89 | 3.92 | 4.76 | 4.38 | 3.84 | 3 |
| FLEXURAL STRENGTH (MPa) | 16.32 | 12.8 | 17.25 | 13.35 | 10.775 | 10.3 |

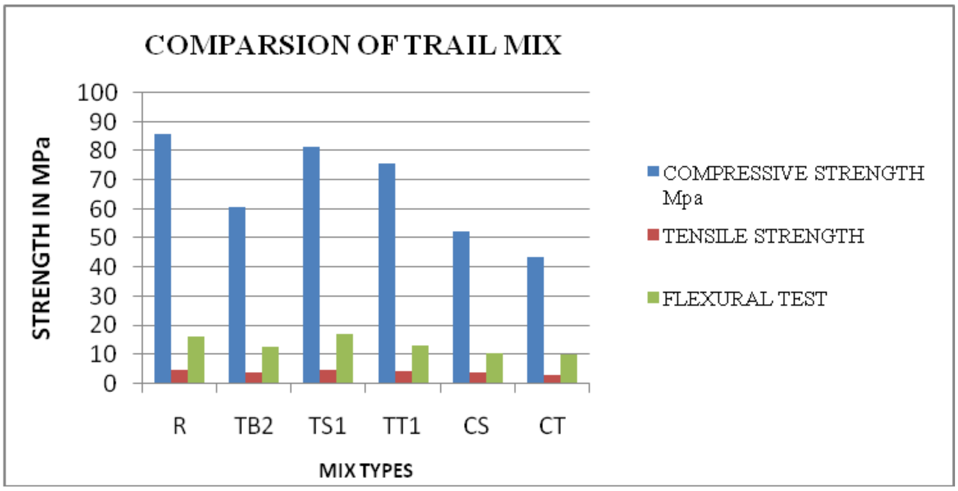


**Figure 4.1: Comparison Graph of the Selected Trail Mixes**

The overall conclusions of by the outcomes of project works are as follows:

1) The use of UHPFRC leads to building of complex structures like runway, Harbor slab in marine conditions and complex bridge structures with reduced cross section and with greater strength.
2) The steel slag as a replacement of fine aggregate provide good flowability, Compressive strength (81.64 MPa), split tensile (4.76 MPa) and also greater flexural strength (17.25) compared to the reference mix.
3) Partial replacement of silica fume also gives near 90% compressive(75.73 MPa), split tensile (4.38 MPa) and flexural strength (13.35 MPa) but it is poor in flowability.
4) Bagasse ash a supplementary cementitious material provides good flowability and 70% of compressive (60.93 MPa) and tensile strength (3.92 MPa).

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## REFERENCES

[1] Teichmann, T. and Schmidt, M., "Mix Design and Durability of Ultra High Performance Concrete(UHPC)," *Proceedings of the 4th International Ph.D. Symposium in Civil Engineering*, Munich, 2002, pp. 341–347.

[2] "Ultra-High Performance Concrete: A State Of the Art for Bridge Community", by U.S Department of Transportation, Federal Highways Administration, June 2013.

[3] "Experimental Investigation on the behavior of Ultra-High Strength Concrete with Agro Waste", By Dr. Arunachalam, Radha Srinivas and A. Rajasekar, IJERT, Vol. 4 Issue 04, April-2015.

[4] "Development Of Ultra-High Performance Concrete Using Silica Fume, Nano Silica and Slag." By Sahil Saini, A Thesis, July 2014.

[5] "The application of mine tailings to develop low cost UHPC", By Sukhoon, Million Tafesse and Hyeong-Ki Kim, 2016.

[6] "Mechanical Properties Of Ultra High Strength Fiber Reinforced Concrete", By Hafeez Mohammed, May 2015.

[7] "The UHPFRC revolution in structural design and construction", By Jacques Resplendino and Francois Toutlemonde, ICJ Vol. 88 Number 4 Page No. 72, April 2014.

[8] "UHPC in the U.S. highway Infrastructure: Experience and outlook", By Benjamin A. Graybeal, ICJ Vol. 88 Number 4 Page No. 84, April 2014.

[9] "A Comparative Study On Effect Of Basic Oxygen Furnace Slag and Iron Cutting Waste On Strength Properties of Concrete", By Sachin Sharma, Sandeep Singla", IJERT Vol. 04 Issue 03, March 2015.