# EFFECT OF FLY ASH ON THEPROPERTIES OF HYBRID FIBRE REINFORCED SINTERED FLY ASH AGGREGATE CONCRETE

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## ABSTRACT

*The main objective of this experimental program is to study the effect of fly ash on the properties of hybrid fibre reinforced sintered fly ash aggregate concrete. 30% cement is replaced by fly ash and the natural aggregates are replaced by sintered fly ash aggregates in different percentages such as 0%, 25%, 50%, 75% & 100%. Steel and polypropylene hybrid fibre combination is used in the experimentation. Fibres are added at (0.5% + 0.5%) by volume fraction.*

**Keyword: -** *Fly ash, Steel fibre, Polypropylene fibre, Sintered fly ash aggregates, Hybrid fibre.*

## 1. INTRODUCTION

Concrete is fundamental construction material utilized everywhere throughout the world, because of its structural stability, strength and high moulding ability. Many types of buildings with different technologies are being built all over the world, but construction using concrete is always the common factor. In all these constructions usage of cement is unavoidable as it is the soul of the concrete. But we all know that the cement manufacture contributes greenhouse gases by producing carbon dioxide. To minimize the greenhouse gasses and burden of pollutants on environment, Fly ash is generated in thermal power plant can be used as partial replacement of cement.

### 1.1 Fly ash

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. Fly ash is the most widely used pozzolanic material all over the world. In the recent time, the importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high strength and high performance concrete. Extensive research has been done all over the world on the benefits that could be accrued in the utilization of fly ash as a supplementary cementitious material.

### 1.2 Sintered fly ash aggregates

Fly ash is finely divided residue, comprising of spherical glassy particles, resulting from the combustion of powdered coal. By heat treatment these small particles can be made to combine, thus forming porous pellets or nodules which have considerable strength. The fly ash is mixed with limited amount of water and is first made into pellets and then sintered at a temperature of 1000° to 1200°C. Sintered fly ash aggregates are one of the most important types of structural light-weight aggregate used in modern days.

### 1.3 Hybrid fibre reinforced concrete

A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that derives benefits from each of the individual's fibres and exhibits a synergetic response. Addition of short discontinuous fibres plays an important role in the improvement of mechanical properties of concrete. It increases elastic modulus, decreases brittleness controls cracks initiation and its subsequent growth and propagation.

## 2. MTERIALS USED

The various materials used are as follows:-

- **Cement**

  In this investigation Shakti 53S grade cement manufactured by Cement Corporation of India is used. The characteristics of cement values are given in table 1.

**Table -2.1**: Characteristics of cement

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Grade of Cement | 53-S |
| 2 | Specific gravity | 3.19 |
| 3 | Minimum specific surface area | 225 cm²/gm |
| 4 | Initial setting time minutes | 38 minutes |
| 5 | Final setting time | 2hr 32minutes |

- **Fly ash**

  In this investigation fly ash is brought from Raichur thermal power plant, Karnataka, India.The physical characteristics of fly ash are given in table 2.2.

**Table -2.2:** Physical characteristics of fly ash

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Specific gravity | 2.2 |
| 2 | Passing sieve size | 45 micron |
| 3 | Colour | Grey |

- **Sand**

  Natural sand confirming to IS 383-1970 of Zone-II is used and it is collected from river Thungbadra, Karnataka, India. The characteristics of sand used are given in table 2.3.

**Table -2.3**: Characteristics of Sand

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Particle shape, size | Round 4.75mm down |
| 2 | Specific gravity | 2.7 |
| 3 | Water absorption | 1.0% |

- **Natural aggregate (NA)**

Aggregates were collected from aggregate crusher unit at Swarna RMC plant Chalamatti, Hubbli, Karnataka, India. The characteristics of natural aggregate are given in table 2.4.

**Table -2.4**: Characteristics of natural aggregate

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Size of aggregate | 20mm and down size |
| 2 | Specific gravity | 2.67 |
| 3 | Water absorption | 0.5% |

- **Sintered fly ash aggregate (SFA)**

Sintered fly ash aggregates were taken from Swarna RMC plant Chalamatti, Hubbli, Karnataka, India. The characteristics of sintered fly ash aggregate are given in table 2.5.

**Table -2.5**: Characteristics of sintered fly ash aggregates

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Specific gravity | 1.78 |
| 2 | Size of aggregate | 8-12mm |
| 3 | Water absorption | 15.8% |
| 4 | Fineness modulus | 6.24 |
| 5 | Bulk porosity | 35-40% |
| 6 | Bulk density | 800kg/m$^3$ |

- **Steel fibre**

In this project work steel fibres was brought from STEWOLS INDIA (P) LTD Nagpur Industrial Estate Kamptee Road Uppalwadi, Nagpur, Maharastra, India. The characteristics of steel fibre are given in table 2.6.

**Table -2.6**: Characteristics of steel fibre

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Length | 60mm |
| 2 | Density | 7850kg/m$^3$ |
| 3 | Tensile strength | 8500kg/m$^2$ |
| 4 | Specific gravity | 7.85 |
| 5 | Average thickness | 0.75mm |
| 6 | Type of steel fibre | crimped steel fibre |
| 7 | Aspect ratio | 80 |

- **Polypropylene fibre**

  In this project Recron 3s fibre CT-2424 is used and it is developed after extensive research at Reliance Technology Centre. Recron 3s fibres CT-2424 are brought from Aahana Enterprises, Chamarajpet, Bengaluru, Karnataka, India. The characteristics of polypropylene fibre are given in table 2.7.

**Table -2.7**: Characteristics of Polypropylene fibre

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Material | Polypropylene triangular fibre |
| 2 | Type | CT 2424 |
| 3 | Cut length | 12mm |
| 4 | Tensile strength | $600kg/cm^2$ |
| 5 | Filament diameter | 25 Microns |

- **Super plasticizer**

  In this experimental work Auracast270M super plasticizer is used. It is manufactured by Fosroc Company, Bengaluru, Karnataka, India. The characteristics of Auracast270M are given in table 2.8.

**Table -2.8** Characteristics of Auracast270M

| SL. No. | Characteristics | Values |
|---|---|---|
| 1 | Colour | Light brown |
| 2 | Plasticizer | 1.069 |
| 3 | Specific gravity | High performance |
| 4 | Chemical admixture | Setting time retarder |

## 3. MIX PROPORTION

The M-55 concrete mix design was done in accordance with IS 10262-2009. The mix proportion obtained is as shown in table 3.1.

**Table -3.1**: M55 mix proportion

| Water | Cement | Fly ash | Fine aggregate | Coarse aggregate | Super plasticizer |
|---|---|---|---|---|---|
| **177.3** $Ltr/m^3$ | **323.40** $kg/m^3$ | **138.60** $kg/m^3$ | **701.39** $kg/m^3$ | **1057.9** $kg/m^3$ | **1.616** $kg/m^3$ |
| **w/c 0.382** | **1** | | **1.51** | **2.28** | **0.005** |

## 4. EXPERIMENTAL RESULTS

### 4.1 Workability test results

The table 4.1 gives workability test results. Variation in workability results are represented graphically as shown in figure 1,2, 3.

**Table -4.1:** Workability test results

| % replacement of natural aggregates by sintered fly ash aggregates | Slump (mm) | Compaction factor | Vee-bee degree (sec) |
|---|---|---|---|
| 0% | 14 | 0.752 | 32 |
| 25% | 9 | 0.730 | 35 |
| 50% | 5 | 0.724 | 37 |
| 75% | 2 | 0.716 | 42 |
| 100% | 0 | 0.699 | 45 |

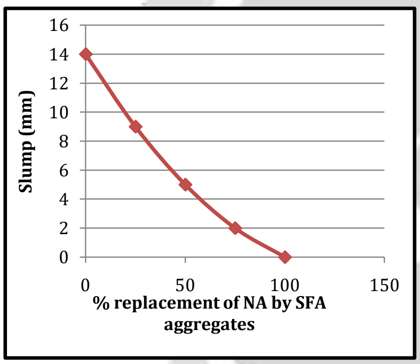


**Figure -1**: Graphical representation of slump

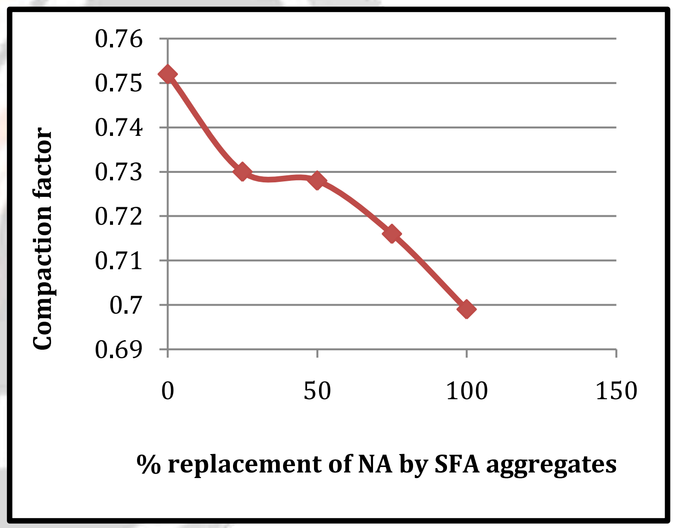


**Figure -2**: Graphical representation of compaction factor

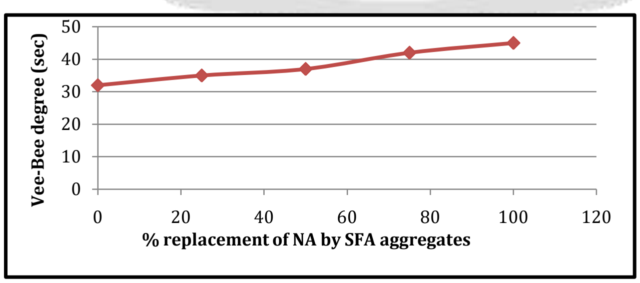


**Figure -3**: Graphical representation of vee-be degree

## 4.2 Strength results

### 4.2.1 Compressive strength test results

The results and graphical representation of compressive strength are shown in table 4.2 and figure 4 respectively.

**Table -4.2:** Results of compressive strength

| % replacement of natural aggregates by sintered fly ash aggregates | Compressive strength in (MPa) | % increase or decrease compressive strength w.r.t reference mix |
|---|---|---|
| 0 (Ref. mix) | 57.19 | 0.00 |
| 25 | 43.26 | -24.35 |
| 50 | 38.81 | -32.12 |
| 75 | 36.00 | -37.05 |
| 100 | 28.00 | -51.04 |

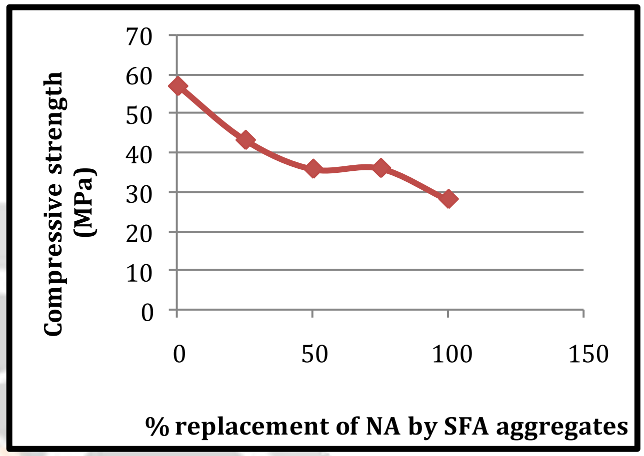


**Figure -4**: Graphical representation of compressive strength

### 4.2.2 Flexural strength test results

The results and graphical representation of flexural strength are shown in table 4.3 and figure 5 respectively.

**Table -4.3:** Results of flexural strength

| % replacement of natural aggregates by sintered fly ash aggregates | Flexural strength (MPa) | % increase or decrease in flexural strength w.r.t reference mix |
|---|---|---|
| 0 (Ref. mix) | 10.13 | 0.00 |
| 25 | 9.07 | -10.53 |
| 50 | 8.27 | -18.42 |
| 75 | 7.60 | -25.00 |
| 100 | 6.27 | -38.16 |

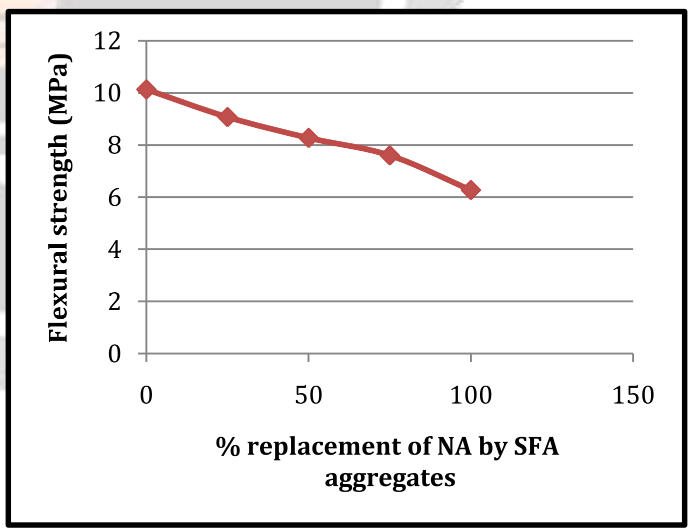


**Figure -5**: Graphical representation of flexural strength

### 4.2.3 Impact strength test results

The results and graphical representation of impact strength are shown in table 4.4 and figure 6 respectively.

**Table -4.4:** Results of impact strength

| % replacement of natural aggregates by sintered fly ash aggregates | Impact Strength for first crack (N-m) | Impact Strength for final crack (N-m) | % decrease in final impact strength w.r.t reference mix |
|---|---|---|---|
| 0 (Ref. mix) | 8984.63 | 9298.13 | 0.00 |
| 25 | 8129.63 | 8414.63 | -9.50 |
| 50 | 6975.38 | 7502.63 | -19.31 |
| 75 | 5130.00 | 5415.00 | -41.76 |
| 100 | 1810.00 | 2059.13 | -77.85 |

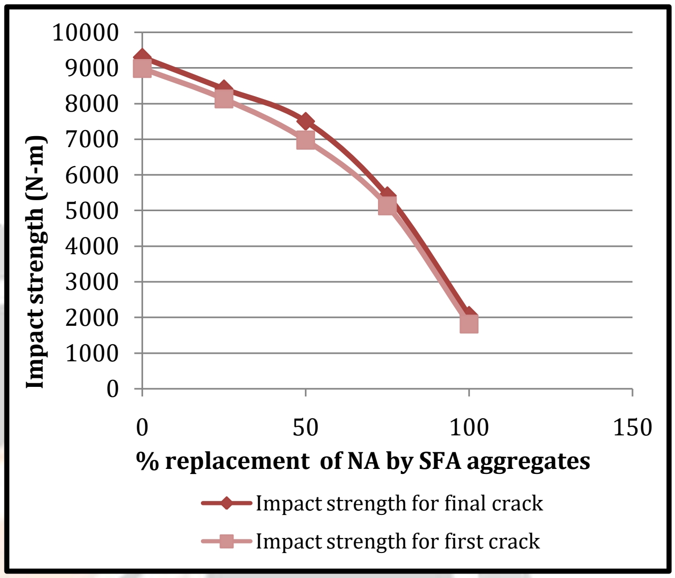


**Figure -6**: Graphical representation of impact strength

### 4.2.4 Sorptivity test results

The results and graphical representation of sorptivity are shown in table 4.5 and figure 7 respectively.

**Table -4.5:** Results of soroptivity test

| % replacement of natural aggregates by sintered fly ash aggregates | Sorptivity (mm/sec0.5) | % increase or decrease in sorptivity w.r.t reference mix |
|---|---|---|
| 0 (Ref. mix) | 3.01 | 0.000 |
| 25% | 3.43 | 13.824 |
| 50% | 3.66 | 21.576 |
| 75% | 3.68 | 22.222 |
| 100% | 3.83 | 25.969 |

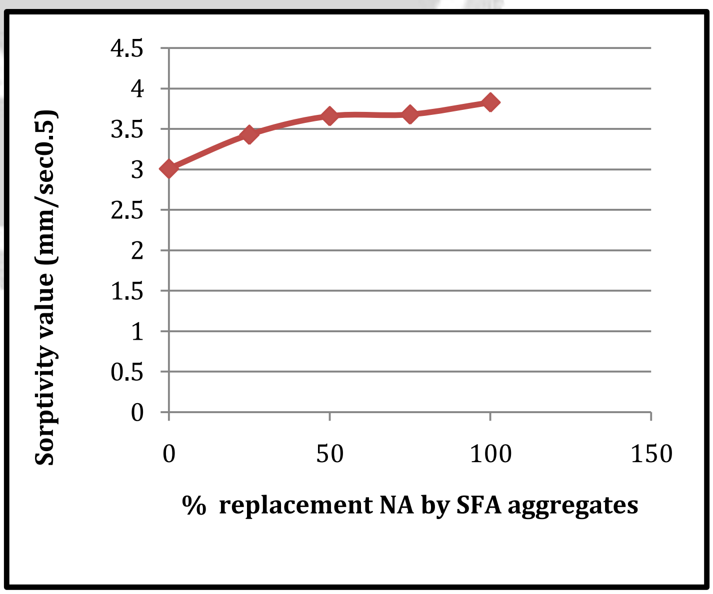


**Figure -7**: Graphical representation of sorptivity values

### 4.2.5 Rapid chloride penetration test

The results and graphical representation of RCPT values in coulombs are shown in table 4.6 and figure 8 respectively.

**Table -4.6:** Results of RCPT

| % replacement of natural aggregates by sintered fly ash aggregates | RCPT value (Coulombs) | % increase or decrease in RCPT value w.r.t reference mix |
|---|---|---|
| 0 (Ref. mix) | 1528.83 | 0.00 |
| 25 | 1935.99 | 21.03 |
| 50 | 2903.22 | 47.34 |
| 75 | 4179.6 | 63.42 |
| 100 | 4647.96 | 67.10 |

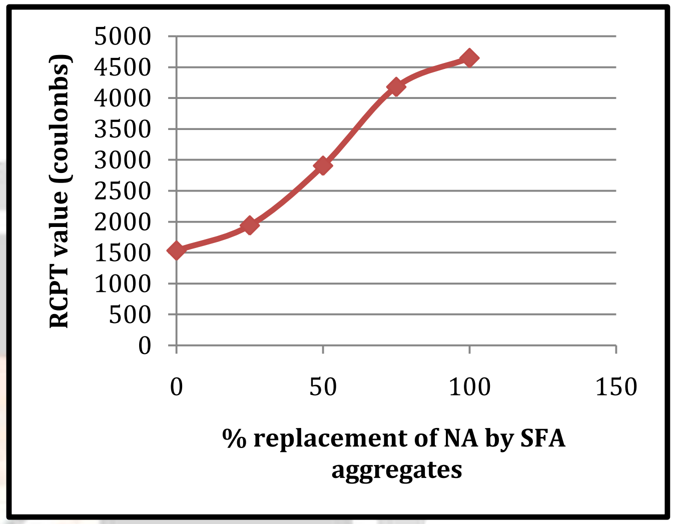


**Figure -8**: Graphical representation of RCPT values

### 4.2.6 Sleeper static bending strength test

The results and graphical representation of sleeper static bending strength are shown in table 4.7 and figure 4.9 respectively.

**Table -4.7:** Results of static bending strength

| % replacement of natural aggregates by sintered fly ash aggregates | Flexural strength (MPa) | | | % decrease in flexural strength w.r.t reference mix | | |
|---|---|---|---|---|---|---|
| | Centre | R1 | R2 | Centre | R1 | R2 |
| 0 (Ref. mix) | 16.94 | 45.6 | 45.5 | 0.00 | 0.00 | 0.00 |
| 25 | 16.00 | 45.0 | 44.7 | -5.59 | -1.3 | -1.7 |
| 50 | 15.14 | 44.0 | 44.4 | -10.66 | -3.4 | -2.4 |
| 75 | 14.24 | 43.4 | 42.7 | -15.96 | -4.7 | -6.0 |
| 100 | 13.20 | 40.5 | 40.3 | -22.08 | -11 | -11 |

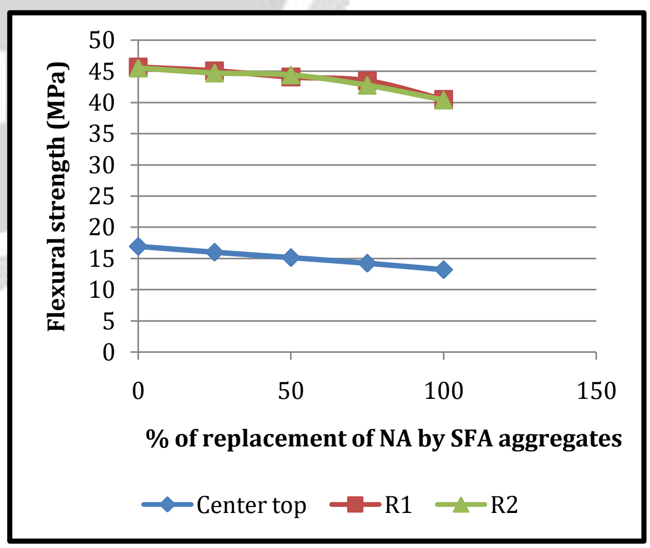


**Figure -9**: Graphical representation of flexural strength

### 4.2.7 Energy absorption test

The results and graphical representation of energy absorption capacity are shown in table 4.7 and figure 10 respectively.

**Table -4.7:** Results of energy absorption test

| % replacement of natural aggregates by sintered fly ash aggregates | Energy absorption capacity (kN-mm) | Ductility factor | % increase or decrease in energy absorption capacity w.r.t reference mix |
|---|---|---|---|
| 0 (Ref. mix) | 160.00 | 3.00 | 0.00 |
| 25 | 148.00 | 2.60 | -7.50 |
| 50 | 128.00 | 2.30 | -20.00 |
| 75 | 118.75 | 2.20 | -25.00 |
| 100 | 105.00 | 2.00 | -34.40 |

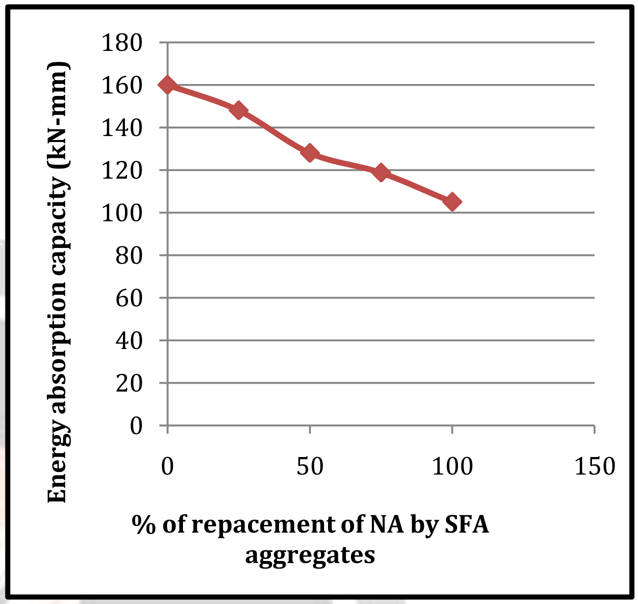


**Figure -10**: Graphical representation of energy absorption

## 5. CONCLUSIONS

- Workability of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by fly ash go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.
- Compressive strength, flexural strength and impact strength of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by fly ash go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.
- Sorptivity of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by fly ash go on increasing as percentage replacement of natural aggregates by sintered fly aggregates increase.
- Chloride resistance of hybrid fibre reinforced sintered fly ash aggregate concrete produced by replacing 30% cement by fly ash go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates increase.
- Flexural strength of railway sleepers produced by hybrid fibre reinforced sintered fly ash aggregate concrete by replacing 30% cement by fly ash go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates go on increasing.
- Energy absorption capacity and ductility factor for railway sleepers produced by hybrid fibre reinforced sintered fly ash aggregate concrete by replacing 30% cement by fly ash go on decreasing as the percentage replacement of natural aggregates by sintered fly ash aggregates go on increasing.
- Finally it can be concluded that hybrid fibre reinforced sintered fly ash aggregate concrete with 30% replacement of cement by fly ash and 25% replacement of natural aggregates by sintered fly ash aggregates may be used to produce quality railway sleepers.

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