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# INVESTIGATION ON FLEXURAL BEHAVIOUR OF ALKALI RESISTANT GLASS FIBER (ARGF) REINFORCED CONCRETE BEAM

***A.R.Sree Shyam[1], M. Subha Sri[1], Dr.R.Manju[2]***

PG Student[1], Professor[2,]
Department of Civil Engineering, Kumaraguru College of Technology,
Coimbatore– 641 049, Tamil Nadu, India
Corresponding author E-mail ID: *subashri911@gmail.com*.

ABSTRACT:

In the present scenario, natural fibres including jute, coir, and sisal fibres are often employed as natural reinforcing materials to enhance the mechanical qualities of concrete and mortar. It involves the preparation of NFRC specimens with varying fibre types, lengths, and dosages, followed by comprehensive testing to evaluate their compressive strength, tensile strength, flexural strength, and durability characteristics. The addition of these fibres can enhance the mechanical properties of concrete, including tensile strength, ductility, and crack resistance. This paper goes into detail regarding textile-reinforced concrete's characteristics. The use of these fibres will aid in reducing steel bar-related corrosion. Regarding mechanical performance, environmental impact, and sustainability, natural fibre-reinforced concrete (NFRC) has become a popular substitute for traditional concrete that is both sustainable and environmentally friendly. An overview of the main conclusions and revelations from the most current research on non-fungible reinforced concrete (NFRC) beams is given in this abstract, with particular attention to the material's mechanical characteristics, benefits for the environment, and potential uses. Research has thoroughly examined the mechanical qualities of non-fibrous reinforced concrete (NFRC) beams, including elements like durability, toughness, flexural strength, and bond properties. The experimental results are then compared to analytical results (ANSYS software)

Keywords: Natural Fibres Reinforced Concrete, Sustainability, Mechanical Properties, Durability, Flexural behaviour, ANSYS software

## INTRODUCTION:

Alkali Resistant Glass-fiber reinforced concrete (ARGFRC) is a composite material comprising a cementitious matrix containing smaller coarse aggregates, fine aggregates, rebars, cement, water, and admixtures, with dispersed alkali resistant glass fibers. ARGFRC has several advantageous traits, including lightweight, durability, aesthetic appeal, and high strength. Glass fiber reinforced composite materials entail high-strength glass fibers embedded within a cementitious matrix. In this composition, both fibers and matrix maintain their distinct physical and chemical properties, yet together they yield a blend of characteristics unattainable by either component alone. Generally, fibers serve as the primary load-bearing elements, while the surrounding matrix secures them in their intended positions and orientation, acting as a medium for load transfer between them and safeguarding them from environmental degradation.

## AGRF:

Glass fibers have high tensile strength when compared to organic fibers. Glass fibers have major drawback as it gets degraded due to the formation of Portlandite ($Ca(OH)2$). Portlandite is produced during the hydration and curing stage of concrete. The portlandite forms crystals on top of the glass fibers which decreases the flexibility affecting the tensile strength of the glass fibers. During hydration the lime keeps the pH of the cement about 12.6 which is strong alkali condition for the glass fibers to survive, causing reduction in weight, shrinkage in size and decrease in diameter.

## OBJECTIVES

- To determine the physical properties of aggregates.
- To prepare the appropriate mix proportion for the concrete reinforced with alkali resistant glass fiber contents with varying percentages of 0.5%,0.1%,0.15%,2%,2.5% and 3% each by weight of the cement.
- To determine the mechanical properties of concrete.
- To compare the results between the combinations and decide the optimum percentage of ARGF to be used in concrete.

- To cast beams with various percentage of ARGF and compare its flexural behaviour.
- Analysis of concrete beams using Ansys software and compare the results with the experimental results.

## METHODOLOGY:

- Papers related to replacement of aggregates and effects of Alkali resistant glass fibers in concrete were collected and literature review was carried out.
- The required materials like cement, fine aggregates, coarse aggregates, fly ash, Alkali resistant glass fibers and Superplasticizer (Conplast SP430) were collected
- The basic tests of aggregates were conducted and Mix design for ARGF concrete is calculated as per IS 10262:2019.
- Fresh concrete tests were done and the readings were noted.
- Conventional concrete specimens were casted and tested for 7th day and 14th day strength.
- Specimens with different dosages of ARGF (0.5%,1%,1.5%,2%,2.5%,3%) were casted and tested for 7th and 14th day strength.
- Optimum fiber dosage which gave better results is obtained.
- Conventional concrete beam and ARGF reinforced concrete beams (0.5%,1%,1.5%,2%,2.5%,3%) are casted.
- The beams are compared for their flexural behaviour.
- Analytical study of conventional beam and beam with optimum percentage of ARGF is done using Ansys software.

## BASIC AGGREGATES TESTING:

### *SPECIFIC GRAVITY TEST*

| Aggregates | W1 | W2 | W3 | W4 |
|---|---|---|---|---|
| M- Sand | 0.6 | 1.582 | 2.081 | 1.506 |
| Coarse aggregates | 0.6 | 1.683 | 2.195 | 1.506 |

SIEVE ANALYSIS For M-sand

| Sieve size | Weight retained (Kg) | % weight retained | Cumulative % weight retained | Cumulative passing % |
|---|---|---|---|---|
| 4.75 mm | 0.004 | 0.4 | 0.4 | 99.4 |
| 2.36 mm | 0.052 | 5.2 | 5.6 | 94.4 |
| 1.18 mm | 0.211 | 21.1 | 26.7 | 73.6 |
| 600 μ | 0.233 | 23.3 | 50 | 50 |
| 300 μ | 0.294 | 29.4 | 79.4 | 20.8 |
| 150 μ | 0.155 | 15.5 | 94.9 | 5.2 |
| Pan | 0.051 | 5.1 | 100 | 0 |

**SIEVE ANALYSIS For COARSE AGGREGATES**

| Sieve size | Weight retained (Kg) | Percentage of weight retained | Cumulative percentage of weight retained |
|---|---|---|---|
| 40 mm | 0 | 0 | 0 |
| 20 mm | 1.782 | 35.64 | 35.64 |
| 10 mm | 3.110 | 62.2 | 97.84 |
| 4.75 mm | 0.106 | 2.12 | 99.96 |
| 2.36 mm | - | - | 99.96 |
| 1.18 mm | - | - | 99.96 |
| 600 µ | - | - | 99.96 |
| 300 µ | - | - | 99.96 |
| 150 µ | - | - | 99.96 |

***MIX RATIO:***

| CEMENT | FINE AGGREGATE | COARSE AGGREGATE | W/C RATIO |
|---|---|---|---|
| 1 | 1.8 | 3.46 | 0.40 |

***MIX ID:***

| MIX NO. | MIX ID | ARGF% IN CEMENT | ARGF QUANTITY (Kg/m$^3$) |
|---|---|---|---|
| M1 | CCS | 0 | 0 |
| M2 | AGF0.5 | 0.5 | 1.85 |
| M3 | AGF1 | 1 | 3.7 |
| M4 | AGF1.5 | 1.5 | 5.55 |
| M5 | AGF2 | 2 | 7.4 |
| M6 | AGF2.5 | 2.5 | 9.25 |
| M7 | AGF3 | 3 | 11.1 |

## HARDENED CONCRETE TEST

***COMPRESSIVE STRENGTH TEST***

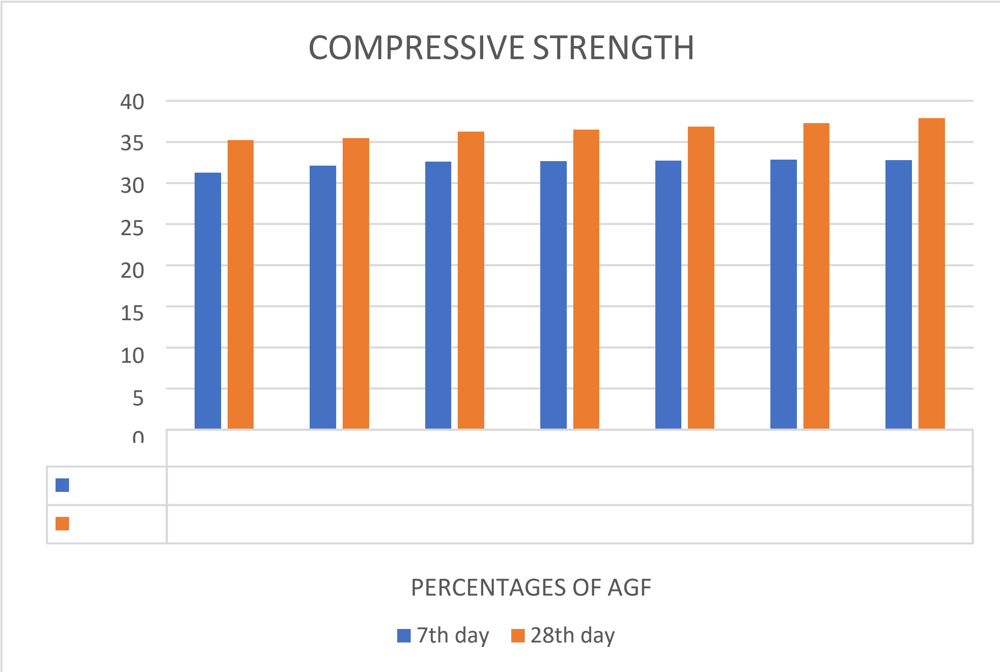
**7th day compressive strength result**

| SL. NO. | MIX ID | SPECIMEN | WEIGHT (KG) | DENSITY (KG/M3) | LOAD (KN) | COMPRESSIVE STRENGTH (N/MM2) | AVERAGE COMPRESSIVE STRENGTH (N/MM2) | PERCENTAGE OF VARIATION |
|---|---|---|---|---|---|---|---|---|
| 1 | CCS | 1 | 8.45 | 2503.7 | 704 | 31.2 | 31.2 | _ |
| | | 2 | 8.8 | 2607.4 | 694 | 30.8 | | |
| | | 3 | 9.05 | 2681.5 | 710 | 31.6 | | |
| 2 | AGF0.5 | 1 | 8.85 | 2622 | 526.6 | 33.4 | 32.1 | 2.88 |
| | | 2 | 9.06 | 2684.4 | 591 | 29.3 | | |
| | | 3 | 9 | 2666.7 | 603.3 | 31.4 | | |
| 3 | AGF1 | 1 | 8.68 | 2572 | 732.1 | 32.5 | 32.56 | 7.56 |
| | | 2 | 9.2 | 2726 | 772.7 | 32.3 | | |
| | | 3 | 8.73 | 2586.7 | 756.2 | 33.9 | | |
| 4 | AGF1.5 | 1 | 8.95 | 2652 | 769.5 | 33.7 | 32.66 | 8.2 |
| | | 2 | 9.2 | 2726 | 745 | 32.9 | | |
| | | 3 | 8.77 | 2598.5 | 773 | 32.7 | | |
| 5 | AGF2 | 1 | 8.55 | 2742 | 756.6 | 31.4 | 32.71 | 2.88 |
| | | 2 | 9.26 | 2623.4 | 791.9 | 32.3 | | |
| | | 3 | 8.64 | 2678.7 | 713.3 | 33.4 | | |
| 6 | AGF2.5 | 1 | 8.25 | 2472 | 772.1 | 32.5 | 32.84 | 7.56 |
| | | 2 | 8.65 | 2626.2 | 742.7 | 33.5 | | |
| | | 3 | 9.16 | 2626.7 | 736.2 | 32.4 | | |
| 7 | AGF3 | 1 | 8.95 | 2672.6 | 789.5 | 31.7 | 32.75 | 8.2 |
| | | 2 | 8.66 | 2761.3 | 765.9 | 32.9 | | |
| | | 3 | 9.32 | 2578.5 | 783.5 | 32.5 | | |

**28th day compressive strength result**

| SL. NO. | MIX ID | SPECIMEN | WEIGHT (KG) | DENSITY (KG/M`3) | LOAD (KN) | COMPRESSIVE STRENGTH (N/MM2) | AVERAGE COMPRESSIVE STRENGTH (N/MM2) | PERCENTAGE OF VARIATION |
|---|---|---|---|---|---|---|---|---|
| 1 | CCS | 1 | 8.7 | 2401.3 | 785 | 35.8 | 35.23 | _ |
| | | 2 | 9.1 | 2453.4 | 826.7 | 34.7 | | |
| | | 3 | 8.3 | 2373.6 | 815 | 35.2 | | |
| 2 | AGF(0.5) | 1 | 8.9 | 2300 | 820.4 | 35.9 | 35.40 | 0.47 |
| | | 2 | 9.3 | 2425.1 | 816.9 | 34.6 | | |
| | | 3 | 8.6 | 2411.3 | 826.3 | 35.7 | | |
| 3 | AGF(1) | 1 | 9.2 | 2451.5 | 821.3 | 36.6 | 36.24 | 2.36 |
| | | 2 | 8.8 | 2374.1 | 835.5 | 35.33 | | |
| | | 3 | 9.5 | 2341.6 | 829.6 | 36.78 | | |
| 4 | AGF(1.5) | 1 | 8.5 | 2426.3 | 831.5 | 36.57 | 36.46 | 0.62 |
| | | 2 | 8.2 | 2409.5 | 834.7 | 35.99 | | |
| | | 3 | 9 | 2350.3 | 827.5 | 36.82 | | |
| 5 | AGF(2) | 1 | 8.4 | 2408.6 | 829.4 | 36.74 | 36.87 | 1.13 |
| | | 2 | 9.4 | 2451.3 | 834.5 | 36.23 | | |
| | | 3 | 8.3 | 2374.6 | 831.9 | 37.65 | | |
| 6 | AGF(2.5) | 1 | 8.5 | 2415.3 | 833.6 | 37.62 | 37.25 | 1.03 |
| | | 2 | 8.6 | 2442.5 | 827.5 | 36.58 | | |
| | | 3 | 9.3 | 2460.3 | 839.4 | 37.56 | | |
| 7 | AGF(3) | 1 | 9.4 | 2462.3 | 823.4 | 37.5 | 37.88 | 1.68 |
| | | 2 | 8.2 | 2401.2 | 833.8 | 38.25 | | |
| | | 3 | 8.4 | 2408.6 | 832.7 | 37.89 | | |

**average compressive strength on 7th and 28th day**




## SPLIT TENSILE STRENGTH TEST

**7th day split tensile strength**

| SL. NO. | MIX ID | SPECIMEN | WEIGHT (KG) | DENSITY (KG/M`3) | LOAD (KN) | PEAK STRESS (N/MM2) | SPLIT TENSILE STRENGTH (N/MM2) | AVERAGE SPLIT TENSILE STRENGTH (N/MM2) | PERCENTAGE OF VARIATION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CCS | 1 | 13.85 | 2614 | 132.5 | 5.7 | 2.01 | 2.04 | _ |
| | | 2 | 14 | 2642 | 117.3 | 5.1 | 1.98 | | |
| | | 3 | 13.65 | 2570.4 | 120.2 | 5.3 | 2.14 | | |
| 2 | AGF(0.5) | 1 | 14.05 | 2651.6 | 119.2 | 5.2 | 1.98 | 2.11 | 3.26 |
| | | 2 | 13.85 | 2614 | 134.6 | 5.9 | 2.3 | | |
| | | 3 | 13.96 | 2634.6 | 140.3 | 6.03 | 2.05 | | |
| 3 | AGF(1) | 1 | 13.65 | 2576 | 179.5 | 7.9 | 2.53 | 2.36 | 12.01 |
| | | 2 | 13.8 | 2610.3 | 147.2 | 6.5 | 2.08 | | |
| | | 3 | 14.03 | 2651.4 | 175.7 | 7.8 | 2.48 | | |
| 4 | AGF(1.5) | 1 | 13.95 | 2634.9 | 169.3 | 7.1 | 2.28 | 2.44 | 3.39 |
| | | 2 | 13.78 | 2631.2 | 173.2 | 7.6 | 2.49 | | |
| | | 3 | 14.13 | 2647 | 176.3 | 7.9 | 2.56 | | |
| 5 | AGF(2) | 1 | 13.05 | 2615.2 | 135 | 5.6 | 2.44 | 2.51 | 2.59 |
| | | 2 | 14.25 | 2651.2 | 125.8 | 6.3 | 2.57 | | |
| | | 3 | 13.76 | 2622 | 136.5 | 5.8 | 2.51 | | |
| 6 | AGF(2.5) | 1 | 13.98 | 2656.9 | 137.9 | 7.2 | 2.61 | 2.61 | 4.26 |
| | | 2 | 14.7 | 2651 | 141.2 | 6.5 | 2.54 | | |
| | | 3 | 14.03 | 2648.4 | 145.7 | 7.5 | 2.69 | | |
| 7 | AGF(3) | 1 | 13.95 | 2637 | 136.5 | 6.9 | 2.47 | 2.44 | -6.51 |
| | | 2 | 14.38 | 2659.3 | 143.8 | 7.6 | 2.41 | | |
| | | 3 | 13.43 | 2634 | 139.6 | 7.6 | 2.45 | | |

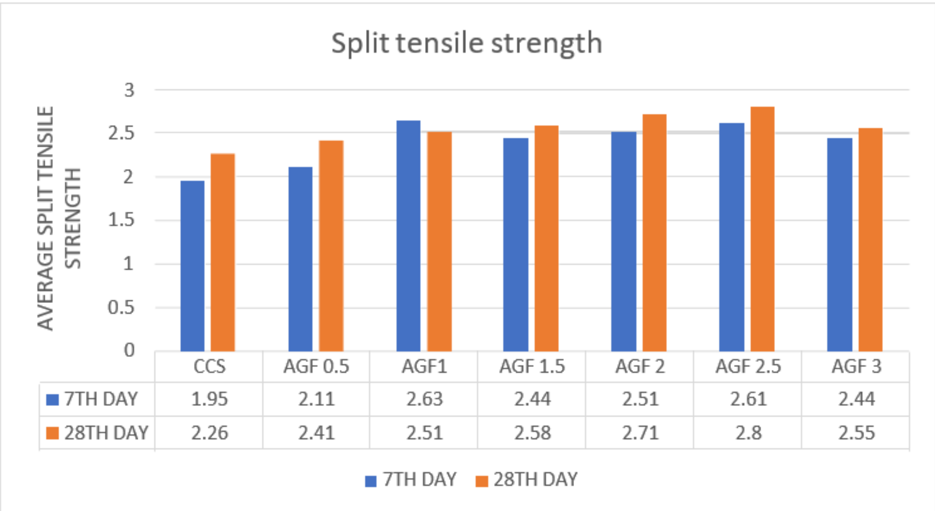
**28th day split tensile strength result**

| SL. NO. | MIX ID | SPECIMEN | WEIGHT (KG) | DENSITY (KG/M`3) | LOAD (KN) | PEAK STRESS (N/MM2) | SPLIT TENSILE STRENGTH (N/MM2) | AVERAGE SPLIT TENSILE STRENGTH (N/MM2) | PERCENTAGE OF VARIATION |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CCS | 1 | 13.65 | 2614 | 150.2 | 6.6 | 2.56 | 2.56 | _ |
| | | 2 | 14.03 | 2642 | 151.1 | 8 | 2.36 | | |
| | | 3 | 13.95 | 2570.4 | 182.1 | 8.1 | 2.77 | | |
| 2 | AGF(0.5) | 1 | 12.96 | 2651.6 | 148.3 | 6.5 | 2.85 | 2.70 | 5.33 |
| | | 2 | 13.5 | 2614 | 156.23 | 7.9 | 2.42 | | |
| | | 3 | 13.09 | 2634.6 | 173 | 8.4 | 2.83 | | |
| 3 | AGF(1) | 1 | 12.83 | 2576 | 165 | 7.6 | 2.77 | 2.79 | 3.46 |
| | | 2 | 13.74 | 2610.3 | 159.8 | 7.9 | 2.75 | | |
| | | 3 | 13.56 | 2651.4 | 161.9 | 8.1 | 2.86 | | |
| 4 | AGF(1.5) | 1 | 14.3 | 2634.9 | 165 | 7.5 | 2.76 | 2.84 | 1.79 |
| | | 2 | 13.69 | 2631.2 | 148 | 7.2 | 2.83 | | |
| | | 3 | 13.98 | 2647 | 167.6 | 8.2 | 2.94 | | |
| 5 | AGF(2) | 1 | 13.76 | 2615.2 | 158.3 | 7.5 | 2.86 | 2.92 | 2.81 |
| | | 2 | 14.1 | 2651.2 | 171.3 | 7.9 | 2.95 | | |
| | | 3 | 13.25 | 2622 | 163.3 | 8.3 | 2.96 | | |
| 6 | AGF(2.5) | 1 | 13.66 | 2656.9 | 176 | 8.4 | 2.99 | 2.95 | 0.80 |
| | | 2 | 13.54 | 2651 | 165.8 | 7.9 | 2.94 | | |
| | | 3 | 13.73 | 2648.4 | 174.9 | 8.1 | 2.91 | | |
| 7 | AGF(3) | 1 | 14.06 | 2637 | 169 | 7.9 | 2.67 | 2.69 | -8.60 |
| | | 2 | 13.77 | 2659.3 | 161.3 | 7.4 | 2.66 | | |
| | | 3 | 13.45 | 2634 | 159.6 | 7.2 | 2.75 | | |

Average split tensile strength

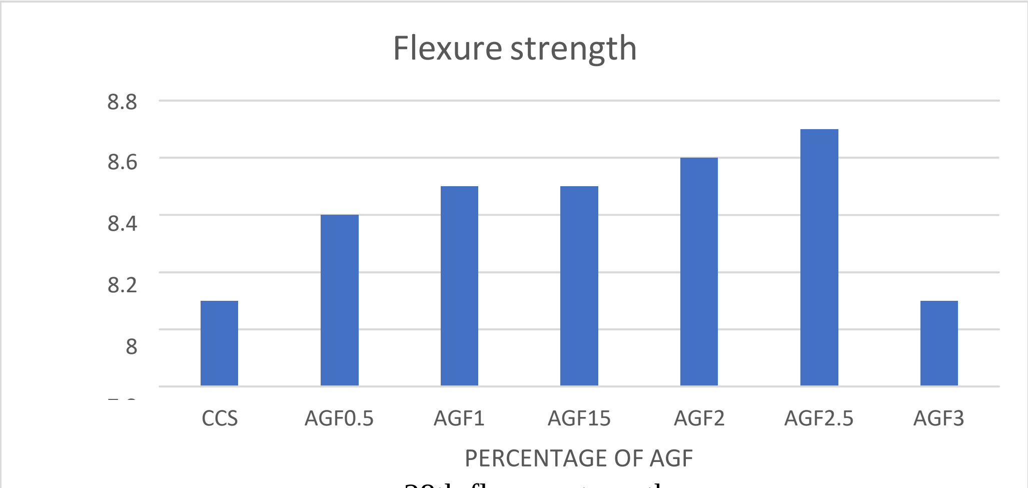
**FLEXURAL STRENGTH TEST:**

**28th day flexural strength result**




| SL. NO. | MIX ID | SPECIMEN | WEIGHT (KG) | DENSITY (KG/M`3) | LOAD (KN) | FLEXURAL STRENGTH (N/MM2) | PERCENTAGE OF VARIATION |
|---|---|---|---|---|---|---|---|
| 1 | CCS | 1 | 12.6 | 2412.4 | 17.5 | 8.24 | |

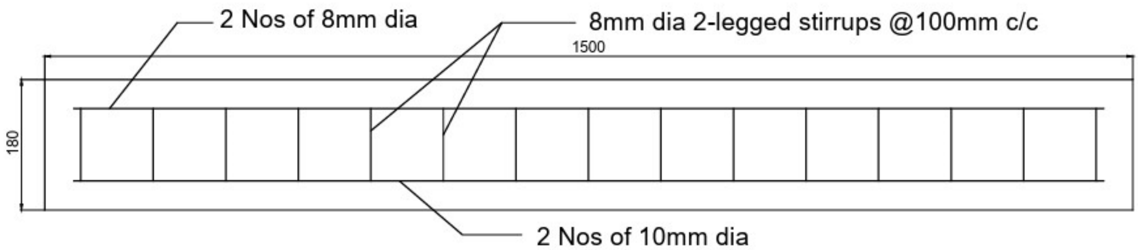
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | AGF(0.5) | 1 | 127 | 2410.8 | 18.5 | 8.42 | 2.18 |
| 3 | AGF(1) | 1 | 12.2 | 2418.7 | 16.5 | 8.56 | 1.66 |
| 4 | AGF(1.5) | 1 | 12.3 | 2400.5 | 16.5 | 8.76 | 2.34 |
| 5 | AGF(2) | 1 | 127 | 2410.8 | 15.5 | 8.79 | 0.34 |
| 6 | AGF(2.5) | 1 | 12.2 | 2418.7 | 16.5 | 8.9 | 1.25 |
| 7 | AGF(3) | 1 | 12.3 | 2400.5 | 16.5 | 8.56 | -3.82 |

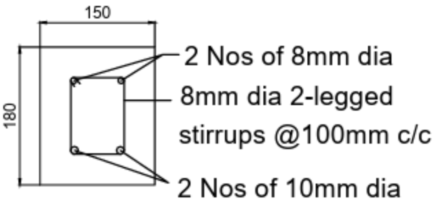



28th flexure strength

## DESIGN OF BEAM:

- Grade of Concrete : M30
- Grade of steel : Fe 500
- Length of Beam : 1500 mm
- Effective span : 1300 mm
- Breadth of beam : 150 mm
- Depth of Beam : 180 mm
- Loading Method : Two point Load (Equal Distance (L/3))
- End condition : Simply Supported Beam






## EXPERIMENTAL INVESTIGATION:

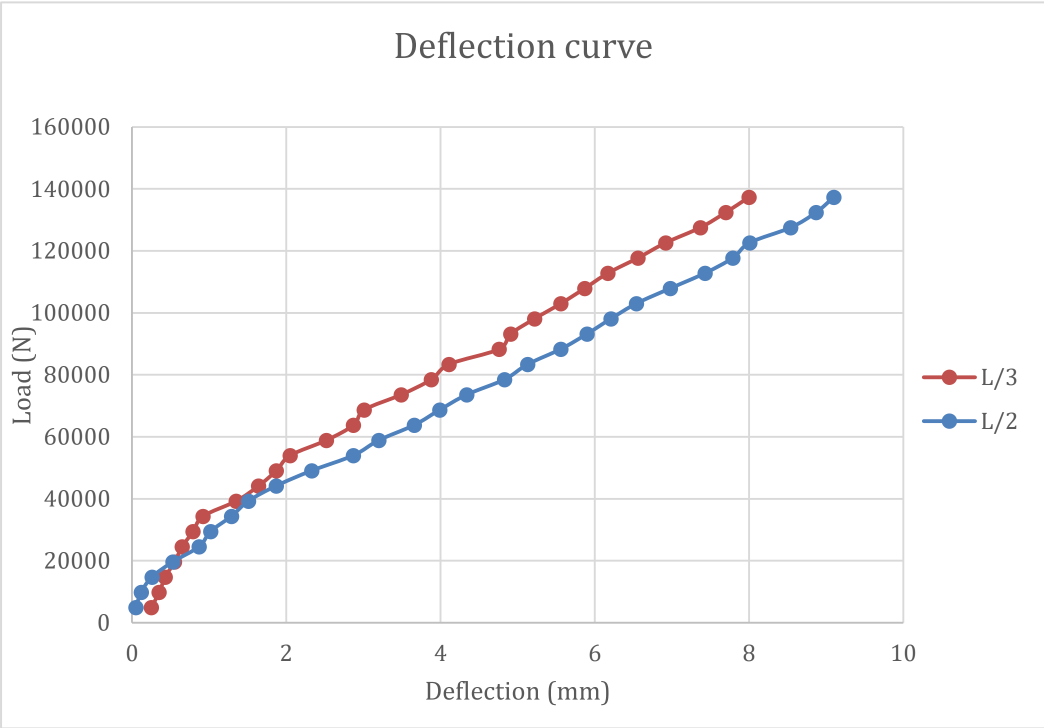
## Flexure test of beam

### *FLEXURAL STRENGTH TEST RESULTS*

Flexural strength test of CCS beam

**Test result for conventional beam (CCS)**

| CCS | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2 | L/3 |
| | | DEFLECTION (mm) | DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.16 | 0.02 |
| 1 | 9.81 | 0.35 | 0.12 |
| 1.5 | 14.71 | 0.48 | 0.24 |
| 2 | 19.61 | 0.69 | 0.31 |
| 2.5 | 24.52 | 1.05 | 0.54 |
| 3 | 29.42 | 1.26 | 0.65 |
| 3.5 | 34.32 | 1.36 | 0.86 |
| 4 | 39.23 | 1.8 | 1.05 |
| 4.5 | 44.13 | 2.06 | 1.24 |
| 5 | 49.03 | 2.5 | 1.68 |
| 5.5 | 53.94 | 2.94 | 1.99 |
| 6 | 58.84 | 3.16 | 2.03 |
| 6.5 | 63.74 | 3.44 | 2.14 |
| 7 | 68.65 | 3.87 | 2.56 |
| 7.5 | 73.55 | 4.12 | 2.86 |
| 8 | 78.45 | 4.65 | 3.1 |
| 8.5 | 83.36 | 5.11 | 3.22 |
| 9 | 88.26 | 5.62 | 3.48 |
| 9.5 | 93.16 | 5.96 | 3.89 |
| 10 | 98.07 | 6.25 | 4.05 |
| 10.5 | 102.97 | 6.69 | 4.26 |
| 11 | 107.87 | 7.2 | 4.48 |
| 11.5 | 112.78 | 7.82 | 5.1 |
| 12 | 117.68 | 8.35 | 5.38 |
| 12.5 | 122.58 | 8.94 | 5.87 |
| 13 | 127.49 | 9.28 | 6.23 |
| 13.5 | 132.39 | 9.75 | 6.54 |
| 14 | 137.29 | 10.56 | 7.19 |
| 14.5 | 142.20 | 11.14 | 7.57 |
| 15 | 147.10 | 11.9 | 7.98 |
| 15.5 | 152.00 | 12.6 | 8.36 |
| 16 | 156.91 | 13.06 | 8.75 |
| 16.5 | 161.81 | 13.65 | 9.1 |
| 17 | 166.71 | 14.02 | 10.55 |
| 17.5 | 171.62 | 14.48 | 10.89 |




**Load deflection graph for CCS beam**

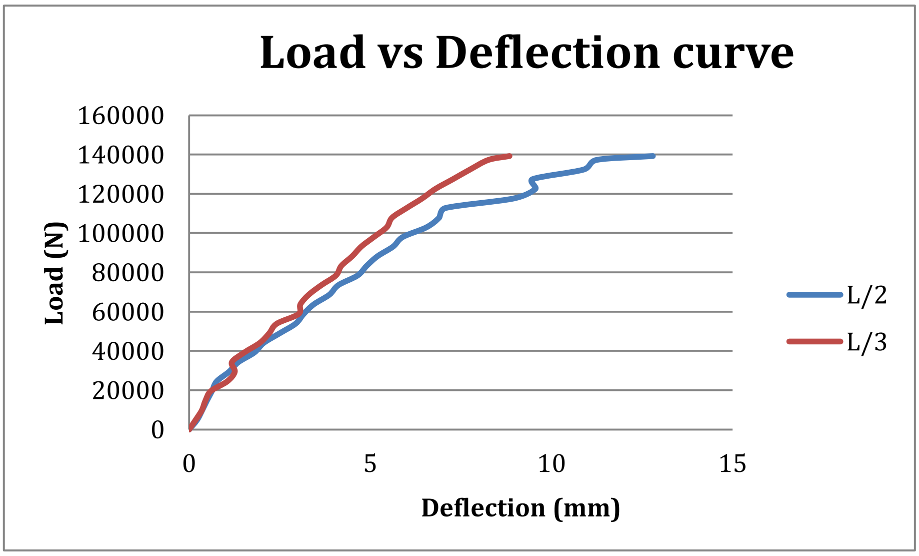
**Test result of CCS beam**

| Parameters | Values |
|---|---|
| Initial Load | 49.03325 KN |
| Initial deflection | 0.05 mm |
| First crack load | 3.4328 KN |
| Deflection at First crack load | 2.11 mm |
| Yield load | 53.936 KN |
| Deflection at yield load | 2.94 mm |
| Ultimate load | 171.638 KN |
| Ultimate deflection | 14.48 mm |

**Test result of AGF 0.5**

| AGF 0.5 | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2<br>DEFLECTION (mm) | L/3<br>DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.22 | 0.18 |

| | | | |
|---|---|---|---|
| 1 | 9.81 | 0.36 | 0.23 |
| 1.5 | 14.71 | 0.49 | 0.29 |
| 2 | 19.61 | 0.63 | 0.35 |
| 2.5 | 24.52 | 0.76 | 0.374 |
| 3 | 29.42 | 1.1 | 0.45 |
| 3.5 | 34.32 | 1.23 | 0.49 |
| 4 | 39.23 | 1.55 | 0.59 |
| 4.5 | 44.13 | 1.93 | 0.76 |
| 5 | 49.03 | 2.13 | 1.06 |
| 5.5 | 53.94 | 2.36 | 1.47 |
| 6 | 58.84 | 2.53 | 1.82 |
| 6.5 | 63.74 | 2.85 | 2.1 |
| 7 | 68.65 | 3.14 | 2.44 |
| 7.5 | 73.55 | 3.43 | 2.64 |
| 8 | 78.45 | 4.58 | 2.87 |
| 8.5 | 83.36 | 4.9 | 3.08 |
| 9 | 88.26 | 5.2 | 3.34 |
| 9.5 | 93.16 | 5.63 | 3.56 |
| 10 | 98.07 | 5.9 | 3.91 |
| 10.5 | 102.97 | 6.55 | 4.12 |
| 11 | 107.87 | 6.9 | 4.65 |
| 11.5 | 112.78 | 7.07 | 4.72 |
| 12 | 117.68 | 8.96 | 4.95 |
| 12.5 | 122.58 | 9.56 | 5.13 |
| 13 | 127.49 | 9.48 | 5.46 |
| 13.5 | 132.39 | 10.89 | 5.92 |
| 14 | 137.29 | 11.25 | 6.84 |
| 14.5 | 142.20 | 12.8 | 7.76 |



**Load deflection graph for AGF 0.5 beam**

**Test result of AGF 0.5 beam**

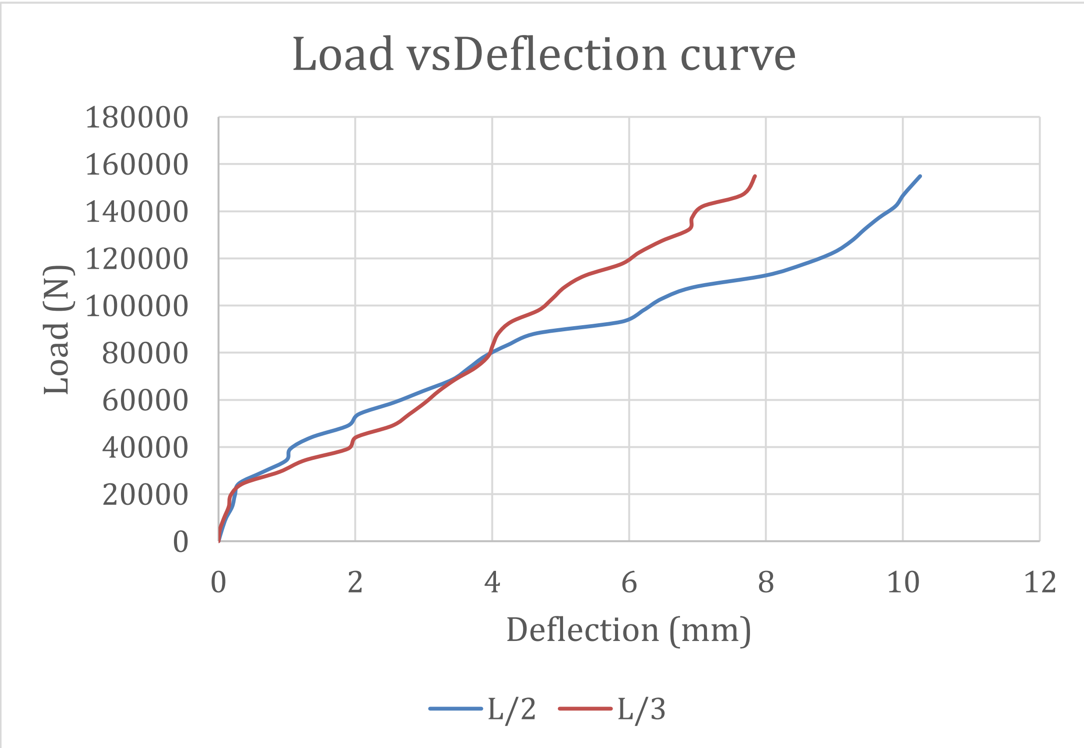
| Parameters | Values |
|---|---|
| Initial Load | 4903.325 N (0.5 tonnes) |
| First crack load | 39226.60 (4 tonnes) |
| Deflection at First crack load | 1.55 mm |
| Yield load | 63743.2 N (6.5 tonnes) |
| Deflection at yield load | 2.85 mm |
| Ultimate load | 142196.43 N (14.5 tonnes) |
| Ultimate deflection | 12.81 mm |

**Flexural strength test of AGF 1**

**Test result of AGF 1**

| AGF 1 | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2 | L/3 |
| | | DEFLECTION (mm) | DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.22 | 0.18 |
| 1 | 9.81 | 0.36 | 0.23 |
| 1.5 | 14.71 | 0.49 | 0.29 |
| 2 | 19.61 | 0.63 | 0.35 |
| 2.5 | 24.52 | 0.76 | 0.374 |
| 3 | 29.42 | 1.1 | 0.45 |
| 3.5 | 34.32 | 1.23 | 0.49 |
| 4 | 39.23 | 1.55 | 0.59 |
| 4.5 | 44.13 | 1.93 | 0.76 |
| 5 | 49.03 | 2.13 | 1.06 |
| 5.5 | 53.94 | 2.36 | 1.47 |
| 6 | 58.84 | 2.53 | 1.82 |
| 6.5 | 63.74 | 2.85 | 2.1 |
| 7 | 68.65 | 3.14 | 2.44 |
| 7.5 | 73.55 | 3.43 | 2.64 |

| | | | |
|---|---|---|---|
| 8 | 78.45 | 4.58 | 2.87 |
| 8.5 | 83.36 | 4.9 | 3.08 |
| 9 | 88.26 | 5.2 | 3.34 |
| 9.5 | 93.16 | 5.63 | 3.56 |
| 10 | 98.07 | 5.9 | 3.91 |
| 10.5 | 102.97 | 6.55 | 4.12 |
| 11 | 107.87 | 6.9 | 4.65 |
| 11.5 | 112.78 | 7.07 | 4.72 |
| 12 | 117.68 | 8.96 | 4.95 |
| 12.5 | 122.58 | 9.56 | 5.13 |
| 13 | 127.49 | 9.48 | 5.46 |
| 13.5 | 132.39 | 10.89 | 5.92 |
| 14 | 137.29 | 11.25 | 6.84 |




Load deflection graph for AGF 1 beam

**Test result of AGF 1 beam**

| Parameters | Values |
|---|---|
| Initial Load | 4.903325 KN |
| First crack load | 39.22660N |

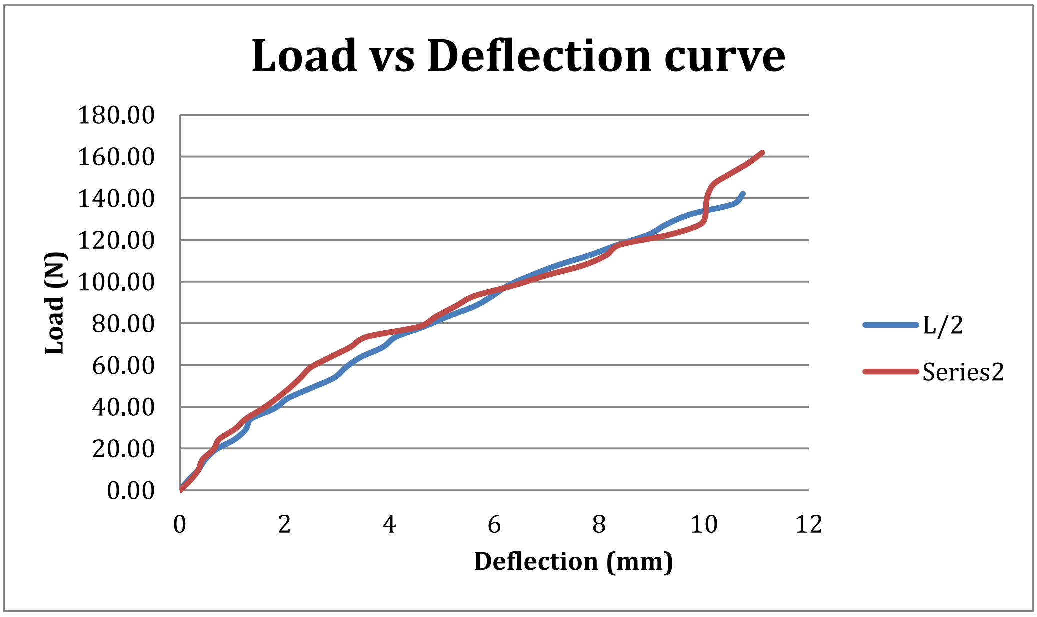
| | |
|---|---|
| Deflection at First crack load | 1.55 mm |
| Yield load | 49.03325 N |
| Deflection at yield load | 0.62 mm |
| Ultimate load | 137.2938 KN |
| Ultimate deflection | 11.25 mm |

Flexural strength test of AGF 1.5

**Test result of AGF 1.5**

| AGF 1.5 | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2 | L/3 |
| | | DEFLECTION (mm) | DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.16 | 0.05 |
| 1 | 9.81 | 0.35 | 0.11 |
| 1.5 | 14.71 | 0.48 | 0.26 |
| 2 | 19.61 | 0.68 | 0.29 |
| 2.5 | 24.52 | 1.12 | 0.79 |
| 3 | 29.42 | 1.25 | 1.1 |
| 3.5 | 34.32 | 1.36 | 1.15 |
| 4 | 39.23 | 1.75 | 1.66 |
| 4.5 | 44.13 | 2.11 | 1.78 |
| 5 | 49.03 | 2.25 | 1.97 |
| 5.5 | 53.94 | 3.11 | 2.32 |
| 6 | 58.84 | 3.36 | 2.68 |
| 6.5 | 63.74 | 3.44 | 2.98 |
| 7 | 68.65 | 3.87 | 3.05 |
| 7.5 | 73.55 | 4.18 | 3.34 |
| 8 | 78.45 | 4.29 | 3.68 |
| 8.5 | 83.36 | 4.88 | 3.99 |
| 9 | 88.26 | 5.36 | 4.08 |
| 9.5 | 93.16 | 5.89 | 4.33 |
| 10 | 98.07 | 6.21 | 4.59 |
| 10.5 | 102.97 | 6.48 | 4.85 |
| 11 | 107.87 | 6.95 | 5.08 |
| 11.5 | 112.78 | 7.05 | 5.11 |
| 12 | 117.68 | 7.45 | 5.19 |
| 12.5 | 122.58 | 7.87 | 5.36 |

| | | | |
|---|---|---|---|
| 13 | 127.49 | 8.46 | 5.75 |
| 13.5 | 132.39 | 8.74 | 5.89 |
| 14 | 137.29 | 9.26 | 6.05 |
| 14.5 | 142.20 | 9.68 | 6.55 |
| 15 | 147.10 | 10.45 | 7.05 |
| 15.5 | 152.00 | 10.88 | 8.22 |
| 16 | 156.91 | 11.42 | 8.56 |
| 16.5 | 161.81 | 11.85 | 8.99 |




**Load deflection graph for AGF 1.5 beam**

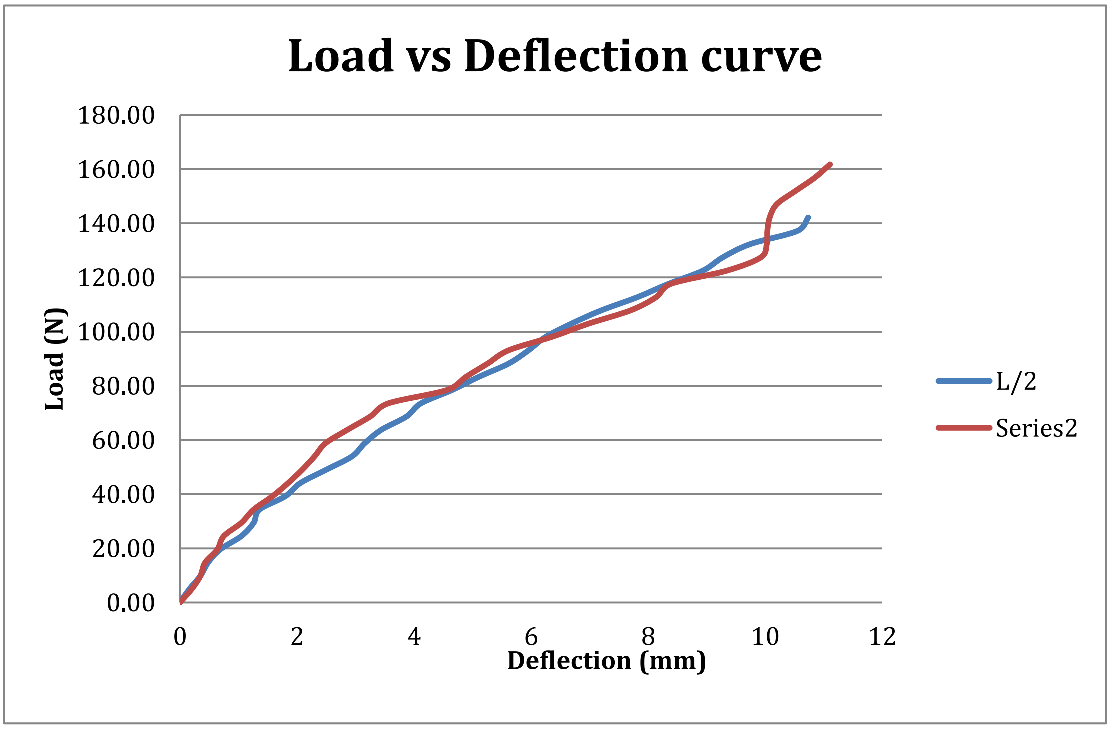
**Test result of AGF 1.5 beam**

| Parameters | Values |
|---|---|
| Initial Load | 4.903325 KN |
| First crack load | 44.12993KN |
| Deflection at First crack load | 2.11 mm |
| Yield load | 58.83990 KN |
| Deflection at yield load | 3.36 mm |
| Ultimate load | 160.40973 KN |
| Ultimate deflection | 11.8 mm |

**Flexural strength test of AGF 2**

**Test result of AGF 2**

| AGF 2 | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2 | L/3 |
| | | DEFLECTION (mm) | DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.2 | 0.2 |
| 1 | 9.81 | 0.33 | 0.35 |
| 1.5 | 14.71 | 0.56 | 0.43 |
| 2 | 19.61 | 0.65 | 0.64 |
| 2.5 | 24.52 | 0.78 | 0.75 |
| 3 | 29.42 | 0.89 | 1.05 |
| 3.5 | 34.32 | 1.02 | 1.26 |
| 4 | 39.23 | 1.46 | 1.58 |
| 4.5 | 44.13 | 1.85 | 1.85 |
| 5 | 49.03 | 2.15 | 2.09 |
| 5.5 | 53.94 | 2.59 | 2.3 |
| 6 | 58.84 | 2.9 | 2.49 |
| 6.5 | 63.74 | 3.22 | 2.86 |
| 7 | 68.65 | 3.68 | 3.25 |
| 7.5 | 73.55 | 4.35 | 3.56 |
| 8 | 78.45 | 4.8 | 4.56 |
| 8.5 | 83.36 | 5.6 | 4.89 |
| 9 | 88.26 | 6.11 | 5.26 |
| 9.5 | 93.16 | 6.4 | 5.62 |
| 10 | 98.07 | 6.8 | 5.96 |
| 10.5 | 102.97 | 7.65 | 6.35 |
| 11 | 107.87 | 7.82 | 6.98 |
| 11.5 | 112.78 | 8.22 | 7.7 |
| 12 | 117.68 | 8.65 | 8.14 |
| 12.5 | 122.58 | 9.05 | 8.39 |
| 13 | 127.49 | 9.96 | 9.35 |
| 13.5 | 132.39 | 10.35 | 9.93 |
| 14 | 137.29 | 11.24 | 10.33 |
| 14.5 | 142.20 | 11.89 | 10.54 |
| 15 | 147.10 | 12.59 | 10.88 |
| 15.5 | 152.00 | 13.45 | 11.2 |
| 16 | 156.91 | 13.96 | 11.52 |
| 16.5 | 161.81 | 14.05 | 11.8 |




**Load deflection graph for AGF 2 beam**

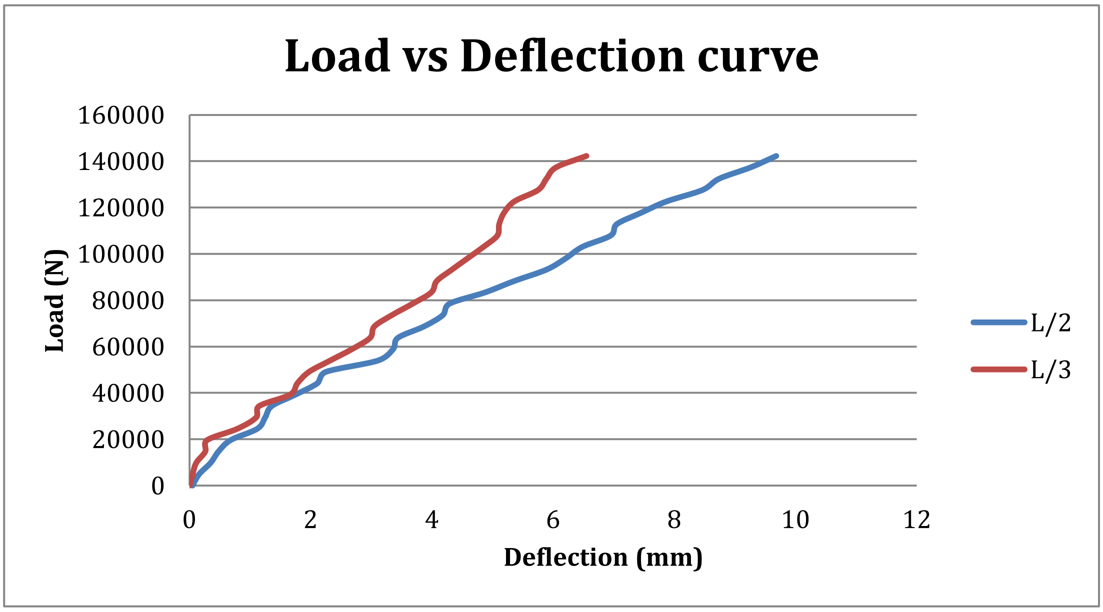
**Test result of AGF 2 beam**

| Parameters | Values |
|---|---|
| Initial Load | 4.903325 KN |
| First crack load | 49.03325 KN |
| Deflection at First crack load | 2.15 mm |
| Yield load | 44.12993 KN |
| Deflection at yield load | 1.87 mm |
| Ultimate load | 161.80973 KN |
| Ultimate deflection | 6.1 mm |

**Flexural strength test of AGF 2.5**

| AGF 2.5 | | | |
|---|---|---|---|
| LOAD (TONNE) | LOAD (kN) | L/2 | L/3 |
| | | DEFLECTION (mm) | DEFLECTION (mm) |
| 0 | 0.00 | 0 | 0 |
| 0.5 | 4.90 | 0.16 | 0.2 |

| | | | |
|---|---|---|---|
| 1 | 9.81 | 0.35 | 0.35 |
| 1.5 | 14.71 | 0.48 | 0.43 |
| 2 | 19.61 | 0.69 | 0.64 |
| 2.5 | 24.52 | 1.05 | 0.75 |
| 3 | 29.42 | 1.26 | 1.05 |
| 3.5 | 34.32 | 1.36 | 1.26 |
| 4 | 39.23 | 1.8 | 1.58 |
| 4.5 | 44.13 | 2.06 | 1.85 |
| 5 | 49.03 | 2.5 | 2.09 |
| 5.5 | 53.94 | 2.94 | 2.3 |
| 6 | 58.84 | 3.16 | 2.49 |
| 6.5 | 63.74 | 3.44 | 2.86 |
| 7 | 68.65 | 3.87 | 3.25 |
| 7.5 | 73.55 | 4.12 | 3.56 |
| 8 | 78.45 | 4.65 | 4.56 |
| 8.5 | 83.36 | 5.11 | 4.89 |
| 9 | 88.26 | 5.62 | 5.26 |
| 9.5 | 93.16 | 5.96 | 5.62 |
| 10 | 98.07 | 6.25 | 6.35 |
| 10.5 | 102.97 | 6.69 | 6.98 |
| 11 | 107.87 | 7.2 | 7.7 |
| 11.5 | 112.78 | 7.82 | 8.14 |
| 12 | 117.68 | 8.35 | 8.39 |
| 12.5 | 122.58 | 8.94 | 9.35 |
| 13 | 127.49 | 9.28 | 9.93 |
| 13.5 | 132.39 | 9.75 | 10.03 |
| 14 | 137.29 | 10.56 | 10.04 |
| 14.5 | 142.20 | 10.74 | 10.08 |
| 15 | 147.10 | 10.9 | 10.2 |
| 15.5 | 152.00 | 11.2 | 10.52 |
| 16 | 156.91 | 11.66 | 10.85 |
| 16.5 | 161.81 | 11.95 | 11.11 |
| 17 | 166.71 | 12.02 | 11.41 |
| 17.5 | 171.62 | 13.48 | 11.71 |
| 18 | 176.52 | 13.93 | 12.02 |
| 18.5 | 181.42 | 14.29 | 12.62 |
| 19 | 186.33 | 14.55 | 13.05 |



**Load deflection graph for AGF 2 beam**

**Test result of AGF 2 beam**

| Parameters | Values |
|---|---|
| Initial Load | 4.903325 KN |
| First crack load | 63.74323 kN |
| Deflection at First crack load | 2.15 mm |
| Yield load | 83.35653 KN |
| Deflection at yield load | 5.11 mm |
| Ultimate load | 186.3235 KN |
| Ultimate deflection | 14.1 mm |

**Flexural strength test result**

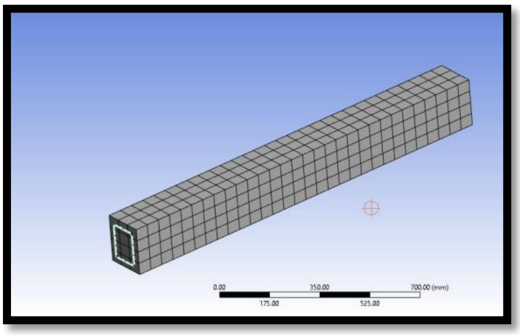
**flexure strength test results**

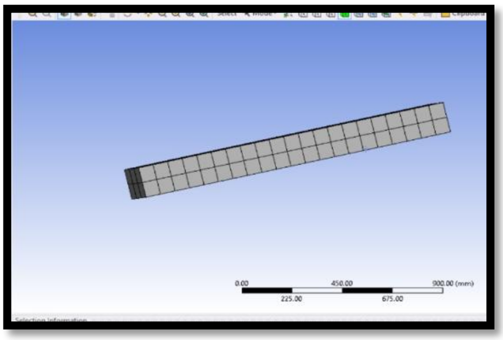
| PARAMETERS | CCS | AGF 0.5 | AGF 1 | AGF 1.5 | AGF 2 | AGF 2.5 |
|---|---|---|---|---|---|---|
| Initial Load | 49.025 KN | 49.325 KN | 4.9025 KN | 49.025 KN | 4.9325 KN | 4.925KN |
| First crack load | 343.28 KN | 39.60 KN | 39.60KN | 44.93KN | 49.25 KN | 63.23 KN |
| Deflection at Firstcrack load | 2.11 mm | 1.55 mm | 1.55 mm | 2.11 mm | 2.15 mm | 2.15 mm |
| Yield load | 53.58 KN | 63.2 KN | 49.25 KN | 58.90 KN | 44.93 KN | 833 KN |
| Deflection at yield load | 2.94 mm | 2.85 mm | 0.62 mm | 3.36 mm | 1.87 mm | 5.11 mm |
| Ultimate load | 171.38 KN | 142.43 KN | 137.8 KN | 160.73 KN | 161.73 KN | 186.35 KN |
| Ultimate deflection | 14.48 mm | 12.81 mm | 11.25 mm | 11.8 mm | 6.1 mm | 10.5 mm |

## ANALYTICAL INVESTIGATION:

***MESHING***

**Meshing view of the specimen**





MATERIAL PROPERTIES

**Material properties of the CCS specimen**

a Sources

Outline of Schematic K2: Engineering Data

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Contents of Engineering Data | | | Source | Description |
| 2 | Material | | | | |
| 3 | Concrete MW | | | F:\ansys beam\ | |

Properties of Outline Row 3: Concrete MW

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Property | Value | Unit | | |
| 2 | Material Field Variables | Table | | | |
| 3 | Isotropic Elasticity | | | | |
| 4 | Derive from | Young's Modulus and Po... | | | |
| 5 | Young's Modulus | 28360 | MPa | | |
| 6 | Poisson's Ratio | 0.15 | | | |
| 7 | Bulk Modulus | 1.3505E+10 | Pa | | |
| 8 | Shear Modulus | 1.233E+10 | Pa | | |
| 9 | Menetrey-Willam | | | | |
| 10 | Menetrey-Willam Base | | | | |
| 11 | Uniaxial Compressive Strength | 30 | MPa | | |
| 12 | Uniaxial Tensile Strength | 8.5 | MPa | | |
| 13 | Biaxial Compressive Strength | 35 | MPa | | |
| 14 | Dilatancy Angle | 30 | degree | | |
| 15 | Softening | | | | |
| 16 | Active Table | Exponential | | | |
| 17 | Plastic Strain at Uniaxial Compressive Strength | 0.001 | | | |
| 18 | Plastic Strain at Transition from Power Law to Exponential Softening | 0.002 | | | |
| 19 | Relative Stress at Start of Nonlinear Hardening | 0.33 | | | |
| 20 | Residual Relative Stress at Transition from Power Law to Exponential Softening | 0.85 | | | |
| 21 | Residual Compressive Relative Stress | 0.2 | | | |
| 22 | Mode 1 Area Specific Fracture Energy | 116 | N m^-1 | | |
| 23 | Residual Tensile Relative Stress | 0.1 | | | |

a Sources

Outline of Schematic K2: Engineering Data

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Contents of Engineering Data | | | Source | Description |
| 2 | Material | | | | |
| 3 | Concrete MW | | | F:\ansys beam\ | |

Properties of Outline Row 3: Concrete MW

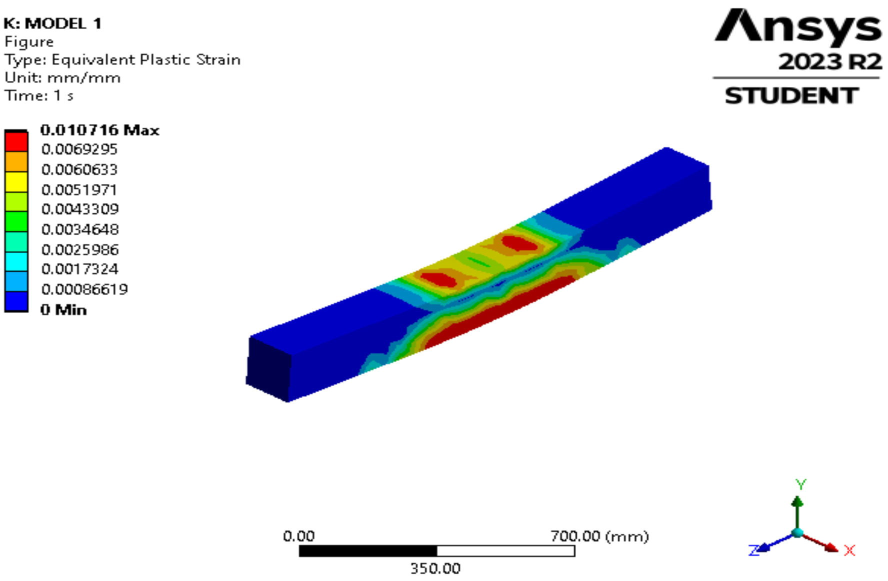
| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Property | Value | Unit | | |
| 2 | Material Field Variables | Table | | | |
| 3 | Isotropic Elasticity | | | | |
| 4 | Derive from | Young's Modulus and Po... | | | |
| 5 | Young's Modulus | 28360 | MPa | | |
| 6 | Poisson's Ratio | 0.15 | | | |
| 7 | Bulk Modulus | 1.3505E+10 | Pa | | |
| 8 | Shear Modulus | 1.233E+10 | Pa | | |
| 9 | Menetrey-Willam | | | | |
| 10 | Menetrey-Willam Base | | | | |
| 11 | Uniaxial Compressive Strength | 30 | MPa | | |
| 12 | Uniaxial Tensile Strength | 8.5 | MPa | | |
| 13 | Biaxial Compressive Strength | 35 | MPa | | |
| 14 | Dilatancy Angle | 30 | degree | | |
| 15 | Softening | | | | |
| 16 | Active Table | Exponential | | | |
| 17 | Plastic Strain at Uniaxial Compressive Strength | 0.001 | | | |
| 18 | Plastic Strain at Transition from Power Law to Exponential Softening | 0.002 | | | |
| 19 | Relative Stress at Start of Nonlinear Hardening | 0.33 | | | |
| 20 | Residual Relative Stress at Transition from Power Law to Exponential Softening | 0.85 | | | |
| 21 | Residual Compressive Relative Stress | 0.2 | | | |
| 22 | Mode 1 Area Specific Fracture Energy | 116 | N m^-1 | | |
| 23 | Residual Tensile Relative Stress | 0.1 | | | |

| PARAMETERS | VALUE |
|---|---|
| LENGTH | 1500 mm |
| BREADTH | 150 mm |
| WIDTH | 180 mm |
| BOTTOM REINFORCEMENT | 10 mm dia. |
| TOP REINFORCEMENT | 8 mm dia. |
| STIRRUPS | 8 mm dia. |
| STIRRUPS SPACING | 100 mm |
| AGRF % | 0 |

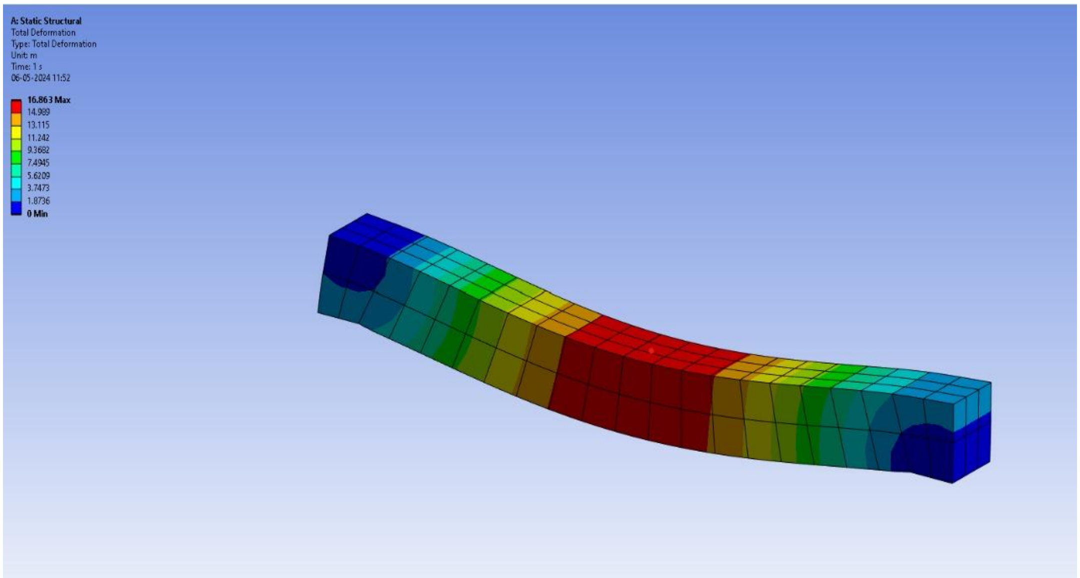
Beam dimensions

***EQUIVALENT PLASTIC STRAIN***

**Model of equivalent plastic strain**

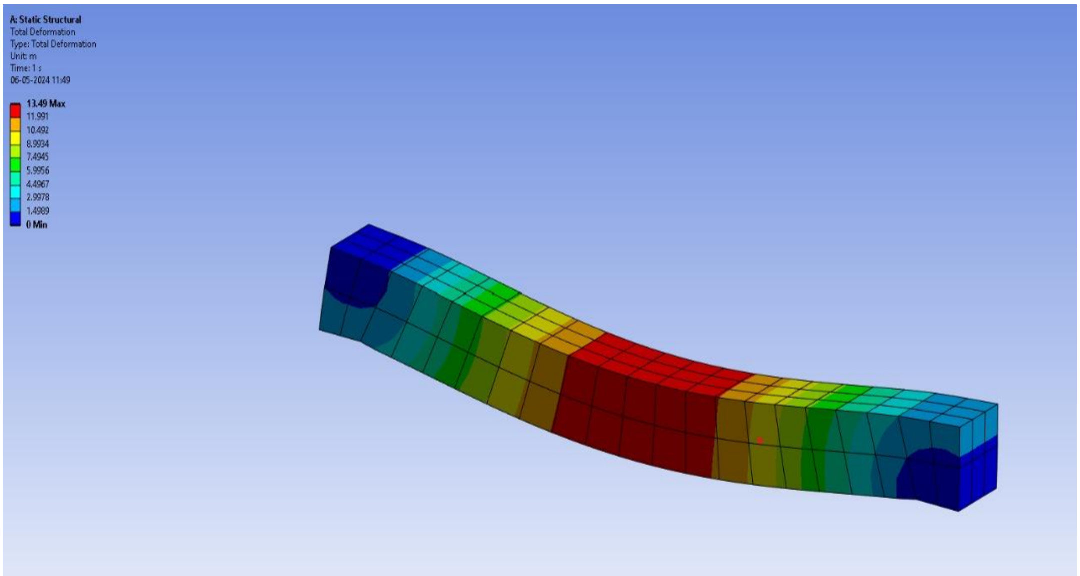



***TOTAL DEFORMATION***




**Deflection in CCS beam**

**Deflection in AGF 2.5 beam**




## CONCLUSION:

In conclusion, the experimental study on AR-glass fibre reinforced concrete (ARGFRC) has provided valuable insights into the strength and durability properties of concrete mixes incorporating glass fibres. The findings underscore the potential of glass fibres as effective reinforcements, contributing to the improvement of concrete performance in both mechanical strength and durability aspects. The compressive strength results indicated that the inclusion of AR-glass fibres influenced the overall strength of the concrete, with variations observed based on the type and percentage of fibres added. The flexural strength exhibited improvements, highlighting the ability of AR- glass fibres to enhance the tensile and flexural properties of the concrete matrix. This suggests that ARGFRC has promising applications in structural elements subjected to bending stresses.

The flexural strength test proves that ARGF shows more load carrying capacity with less deflection when compared with conventional beam. This shows that ARGF has high tensile strength, durable and can take load without breaking.

This result emphasizes how natural fibre reinforcement can improve the mechanical qualities of concrete constructions. Through the simulation of beam behaviour under various loading circumstances, the ANSYS analytical research further validated these conclusions. The accuracy of the analytical model in forecasting the structural response of ARGF and conventional beams was validated by the near alignment of the ANSYS results with the experimental data. Lower stress and more uniform stress transfer were shown by the ANSYS stress distribution analysis. he testing findings comparing the mechanical behaviour of fresh and hardened concrete demonstrated how the curing and hydration processes affect the material. When compared to traditional concrete, ARGF outperformed it in both fresh and hardened states, exhibiting greater modulus of elasticity, flexural strength, and compressive strength. This demonstrates how natural fibre reinforcement can improve concrete's overall durability.

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