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An Experimental Study on Mechanical Properties of Bendable Concrete by using Fly Ash and Recron 3S Fibers

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***Abstract*— Removing the fragile concept of concrete has opened up a whole new realm of possibilities for improving the future of civil infrastructure in terms of strength, durability, safety, and longevity.**

Because of its long life and the materials' planned versatility, Engineered Cement Composites (ECC) are expected to cost less in the long run. Additionally, its exhibition is primarily made up of little strands. Except for the coarse aggregate, the ingredients in flexible cement are the same as those in regular solid cement. It seems to be regular concrete, but ECC concrete allows the unusually covered organisation of fibres to move within the concrete under excessive force, preventing the stiffness that causes weakness and breaking.

Crucial to ECC's design is the use of tiny strands that function as tendons, reinforcing the solid and making it more securely bind.

Using various percentages of Recron fibres and the ideal proportion for partial cement substitution with fly ash, an experiment was conducted for M25 concrete. The percentages of fly ash and Recron fibre used to substitute cement were 10%, 20%, and 30%, respectively. Cubes, cylinders, and beams made of conventional concrete with a water-cement ratio of 0.45 were cast and subjected to testing for 7 and 28 days, respectively. Extensive discussion of the findings follows.

By substituting 30% fly ash and 1.5% Recron fibre for the cement in regular concrete, the latter achieved 15.15% higher compressive strength, 50% higher tensile split strength, and 20.63% higher flexural strength. When compared to the standard concrete plate specimen, the deflection value is much higher when 30% fly ash and 1.5% Recron fibre are used in lieu of cement.

The ideal cement substitute for a pliable concrete plate was determined to be 30% fly ash and 1.5% recron fibre. The great flexural strength of the plate (700×150×30) & (700×150×45) mm is evident when compared to a standard plate.

***Keywords*— ECC, Bendable Concrete, Recron fiber.**

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I. INTRODUCTION

Concrete, when exposed to tensile stresses, readily displays fractures since it is an extremely brittle material. Concrete that can be bent is ductile. One name for this kind of concrete is ECC, or engineered cementious composite. Victor Li of the University of Michigan was the first to create it (Qian S Z, 2010).

Concrete that can be bent is ductile. Regular concrete cracks in a brittle manner when subjected to flexure. Conversely, ECC may achieve a very high degree of curvature under progressively larger loads, much like a ductile metal plate that yields under stress.

The widest microcracks in ECC, which are regulated to be less than 60 µm in width (about half the diameter of a human hair), allow for significant inelastic deformation. While dislocation movement is distinct from this inelastic deformation, the material experiences dispersed damage across the yield zone, much like plastic yielding in ductile metals (Li, 2012). In contrast to regular concrete, which has a tensile strain capacity of just 0.01%, ECC has the potential to reach 3-5%. In recent full-scale structural applications, structural designers have been drawn to ECC due to its inherent tight fracture width control and damage tolerance. Similar to regular to high-strength concrete, ECC has a compressive strength. Because of its ductile nature, ECC has many potential uses and will continue to expand into many new areas, in contrast to the brittle nature of regular concrete (Yu Zhu, 2012).

The interaction between the fibres, sand, and cement in the matrix that holds the material together ensures that ECC does not fracture as it elongates. In addition to using fibres, which act as ligaments and bond the concrete more firmly, engineers may make the cement matrix more flexible and compatible with the fibres by designing it with certain elements. According to Jun Zhang (2013), ECC is designed to fracture only in a regulated way, in contrast to regular and fiber-reinforced concrete, which are engineered to resist cracking. Common concretes often have griffith-type cracks, which enlarge with length. Flat, steady-state cracks are what you'll find in ECC. According to Mustafa Sahmaran (2013), the diameter of these fissures remains constant regardless of their length.

Because of its very low strain capacity of only 0.1% and extreme rigidity, regular concrete is practically unworkable. Bendable concrete, also known as Engineered Cementations Composites, is a remarkable new material whose inflexibility is a key cause of its failure under stress. To that end, ECC exhibits more ductile behaviour (Yu Zhu Z. Z., 2013).

At the moment, we're working on a way to make regular concrete more ductile by replacing some of the cement with fly ash and some of the coarse aggregate with natural and synthetic fibres like jute and nylon. This work presents the results of an experimental study on bending concrete using additives and fibres. The findings highlight the need to develop a new class of FRCs that can be produced using normal equipment while still having the strain-hardening feature.

Furthermore, ECC does not use coarse particles, therefore the material is mortar instead of concrete (Erdem, 2014). There is a significant amount of powder in ECC. You may boost the paste content by adding components like fly ash, silica fume, blast furnace slag and cement. Furthermore, ECC makes use of minute quantities of short, discontinuous fibers—typically 2% by volume.

A. How ECC reacts when subjected to flexural stress

If you look at the picture up there, you can see how ECC behaved under flexural strain; the beam bent without breaking. In 2014, Bensaid Boulekbache To distribute the imposed load, the various ECC components worked together.

Because of its reduced weight and fifty times more flexibility compared to traditional concrete, ECC has the potential to alter design choices for skyscrapers. Additionally, ECC is the best option for seismic zone core components due to its ideal energy-absorbing properties.

II. MATERIALS AND MIX PROPORTION

The following is a list of the elements that go into making ECC: cement, sand, fibres (Recron fibres), fly ash, water, and super plasticiser (Conplast SP 430).

A. Cement

A frequent binder in concrete mixes is cement, a powdered substance. This experiment made use of an OPC cement with a grade of 53. Below is a figure displaying the 53-grade OPC cement.

Figure 1: OPC 53 Grade cement

B. Fine aggregates

The material that is able to pass through an IS 4.75mm sieve is referred to as fine aggregate. To make concrete, they are utilised to fill the spaces where air has been removed. Figure 2 below shows the fine aggregates used in this work.

Figure 2: Fine aggregates

C. Fibers (Recron fibers)

To make high-strength concrete, fibre is the main ingredient. The primary use of the fibres is to lessen the likelihood of cracking in concrete. In figure 3 we can see the recron 3S fibre that was used for this experiment..

Figure 3: Recron fibers

D. Fly ash

Coal combustion produces fly ash as a waste product. This substance is very fine. Because of its similarity to cement in terms of its physical and chemical characteristics, fly ash is sometimes used in concrete mixes. In this study, figure 4 shows that Class F fly ash was used to create the concrete (Soutsos M T, 2012).

Figure 4: Class F fly ash

E. Super plasticizer

This material makes use of the Conplast SP 430 super plasticiser. The primary function of the SP430 super plasticiser is to reduce the amount of water in the mixture while simultaneously increasing its strength. In Figure 5, we can see the conplast SP430.

Figure 5: Conplast SP 430

F. Mix proportion

How many of each material are used in the process is known as the mix percentage. Table 1 below shows the amounts of materials used to formulate the concrete mixture used in this research, which is of M25 Grade. The mix percentage was determined based on the attributes of the ingredients.

TABLE I: MIX PROPORTION OF CONCRETE

Binder	Cement	Fly ash	Fine aggregate	Recron fibers	Super plasticizer	Water
425.73	298.01	127.71	1582.42	0%, 0.5%, 1%, and 1.5%	2.98	192.58

III. RESULTS AND ANALYSIS

A. Slump cone test

Slump cone diminishes when rcarbon fibre structure level increases from 0% to 1.5% and fly ash level increases from 0% to 30%, as shown in the table below.

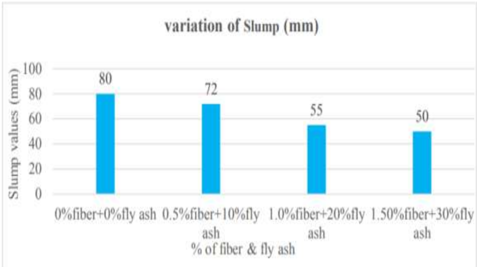

Figure 6. Graph 1: Comparison of slump cone test

B. Compressive strength

According to the graph below, the compressive strength achieved its maximum at 1.5% fibre and 30% fly ash, and its minimum at 0.5% fibre and 10% fly ash for both the 7-day and 28-day tests (Alberti M G, 2014).

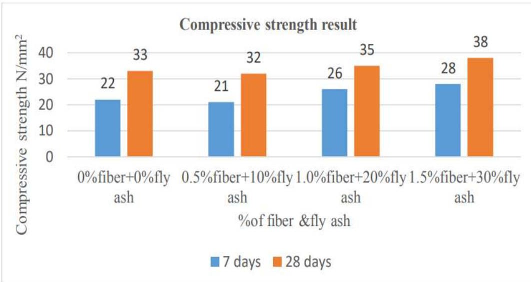

Figure 7. Graph 2: Comparison of Compressive strength

C. Split tensile strength

In both the 7-day and 28-day tests, the split tensile strength was found to be best at 1.5% fibre and 30% fly ash, and lowest at 0.5% filaments and 10% fly ash. These results are shown in the following chart.

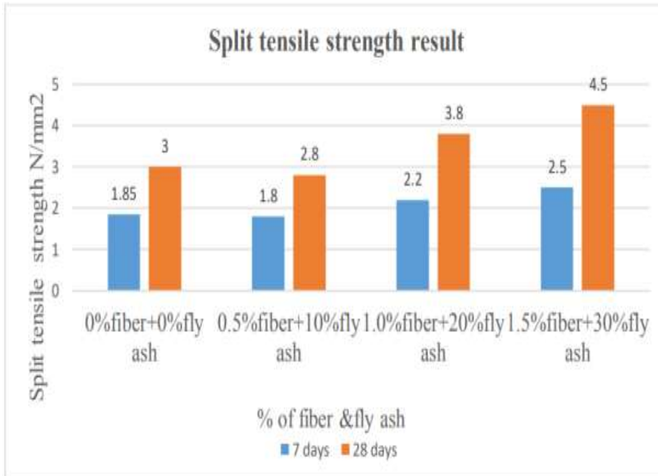

Figure 8. Graph 3: Comparison of split tensile strength

D. Flexural strength

In both the 7-day and 28-day tests, the graph below shows that the flexural strength was best for the combination comprising 1.5% fibre and 30% fly ash, while it was lowest for the sample having 0% fibre and 0% fly ash.

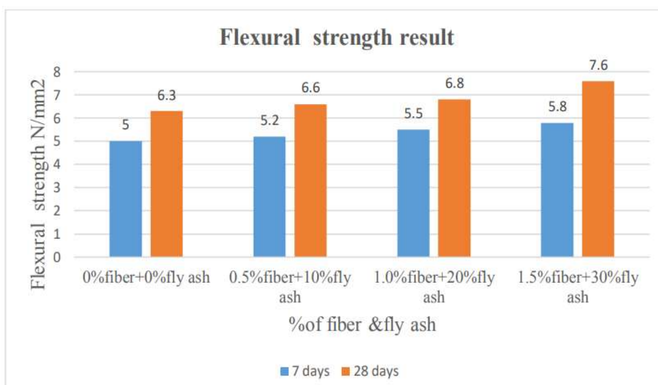

Figure 9. Graph 4: Comparison of flexural strength

E. Ultimate load VS deflection

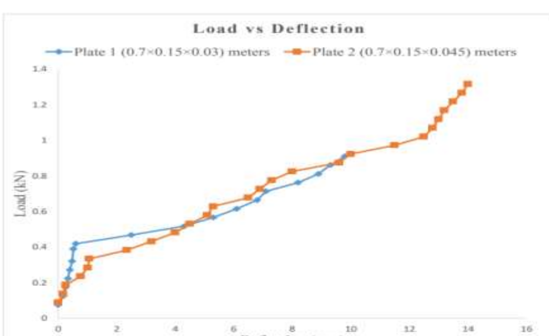

Figure 10. Graph 5: Normal Mix

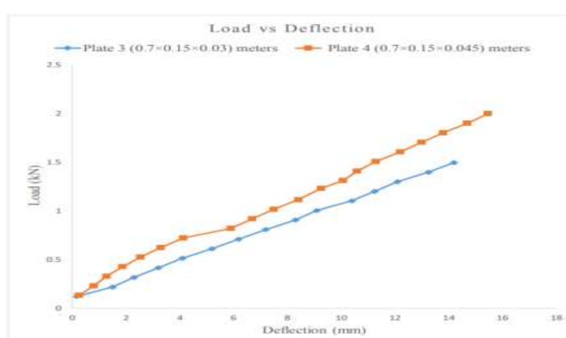

Figure 11. Graph 6: 0.5%RF+10%FA

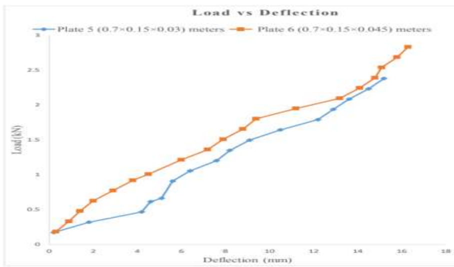

Figure 12. Graph 7: 1.0%RF+30%FA

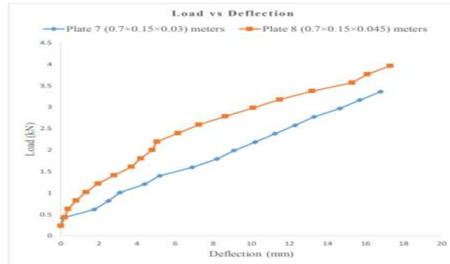

Figure 13. Graph 8: 1.5%RF+30%FA

IV. Conclusion and Future Scope

We have successfully completed an exploratory study on concrete advancements using incremental modification in the fractional amounts of fly ash as a partial replacement for concrete and varying proportions of Recron fibre. In the previous chapter, we discussed and presented the findings. Following the first experimental investigations on M25 grade, the following conclusions were drawn:

- The mix's workability is improved compared to controlled concrete when 0.5%, 1.5%, and 20% Recron fibre replace 10, 20, and 30% fly ash, respectively.
- As compared to the controlled concrete, the compressive strength is 15.15% higher when using 30% fly ash and 1.5% fibre.
- We observed a tensile strength improvement of 50.50% compared to the controlled concrete when using 30% fly ash and 1.5% fibre.
- The flexural strength, as compared to the controlled concrete, rose by 20.63% at 30% fly ash and 1.5% fibre.
- The maximum deflection for typical concrete plates with dimensions 700×150×30 mm and 700×150×45 mm was 9.80 mm and 14.00 mm, respectively, with a force of 0.9091 and 1.315 kN.
- At a load of 3.358 kN for the 700×150×30 mm plate and 3.959 kN for the 700×150×45 mm plate, the maximum deflection for bendable concrete was 16.80 mm and 17.30 mm, respectively.
- Therefore, it was clear from the test results that 30% fly ash and 1.5% fibre provided the largest strength increase compared to other contributions.

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