

A Review on Fundamentals of Engineered Cementitious Composite (Bendable Concrete)

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Abstract- This paper provides an overview of the various properties of engineered cementitious composites (ECCs) that are used in a variety of structural applications. Different properties of engineered cementitious composites are investigated in this paper, including tensile, flexural, compressive, tensile strain capacity, shear strength, toughness, fibre matrix interaction, drying shrinkage, water permeability, sorptivity, cracking, impact and frost resistance, and beam-column connection behavior. According to the study, ECC has a much greater strain capacity than conventional concrete, as well as a higher energy absorption capacity, deflection capacity, and impact resistance, as well as a crack width of less than 100 μ m. The use of mineral admixtures improves tensile strain capacity with multiple fine cracks, while compressive strength and carbon dioxide emissions decrease, according to the findings of various studies. Fiber hybridization can increase ECC's strain hardening with various fine cracking, flexural and toughness properties, impact resistance, and crack width resistance.

Keywords- ECC properties, flyash, fibres, composites, superplasticisers.

I. INTRODUCTION

Concrete is becoming a necessary component of construction. Cement, coarse aggregates and fine aggregates, are used to make it. Concrete has a weak tension and a strong compression behavior. Steel bars and various types of fibres can be used to enhance concrete's tension behavior. Concrete is fragile by its very nature.

High-strength concrete has been used in the construction industry for many decades for a variety of applications. However, the majority of the materials used in high-strength concrete were nearly identical to those used in regular concrete. Several research studies have found that as concrete's compressive strength increases, so does its brittleness number. This high-strength concrete restriction is extremely dangerous for structural applications.

Use of such high ductile materials in seismic components can help structures respond more quickly to earthquakes. For various structural applications, high ductile performance cement based material is required from a seismic standpoint or to reduce the brittleness of concrete.

As a result, self-healing has become a major topic in civil engineering. Despite the fact that it has been observed in civil infrastructures for over a century, studies on it have only begun to appear in the last two decades. Quality, durability, and serviceability are lacking in civil infrastructures made of concrete-like materials, necessitating frequent inspection and repair. Self-healing

of damage (such as cracks) in concrete structures may lead to lower deterioration rates, fewer repairs, lower costs, and a longer overall service life. Furthermore, self-healing without human intervention allows self-repair in locations that are inaccessible due to structural constraints, such as large infrastructures.

The uniaxial tensile properties of ECC have always been emphasised in previous studies. ECC's long-term tensile properties were also given special consideration. As a result, the current review aims to summarize recent progress in these areas in order to provide some insights and recommendations for future research as well as to make ECC applications easier.

II. MATERIALS USED

The Ordinary Portland Cement, Mineral Admixtures like Fly ash, GGBS, Silica fume and sand, Super Plasticizers are used in this ECC mix proportion. Additionally the Fibres are used to provide Strength and increase self healing capacity of the Engineered Cementitious Composite. The super plasticizers are used to improve Workability of Engineered Cementitious Composites.

1. Fly Ash:

In ECC mostly Class F Fly ash is preferred because Class F fly ash comes from anthracite and bituminous coals, according to ASTM C 618. It contains more alumina and silica than Class C fly ash and has a higher LOI. Fly ash

from Class F has lower calcium content than fly ash from Class C.

2. GGBS:

Workability is important because it aids in placement and compaction. The temperature increase would be lower as a result of the lower heat of hydration, reducing the risk of thermal cracks in large areas of concrete. It has a high resistance to chloride attack, lowering the risk of concrete corrosion.

3. Silica Fume:

The production of silicon metal or ferrosilicon alloys produces silica fume as a byproduct. Concrete is one of the most advantageous applications for silica fume. It is a highly reactive pozzolan due to its chemistry and physical properties. Concrete containing silica fume can be extremely strong and long-lasting.

Super plasticizers:

Super plasticizers (SPs), also referred to as high-range water reducers, are additives used in the production of high-strength concrete. Plasticizers are chemical compounds that allow for the production of concrete with a water content of about 15% less. Water content can be reduced by up to 30% with super plasticizers.

Fibres:

The PVA fiber is also known as vinyl or vinylal. PVA fibers have high tenacity, high Young's modulus, low elongation, low creep, and excellent resistance to severe weather (UV) and chemicals (alkali, acid, oil, etc.). Polypropylene fiber, also known as polypropene or PP, is a synthetic fiber, transformed from 85% propylene, and used in a variety of applications.

Chemical resistance is a term that refers to a person's ability to withstand dimensional stability. Fiberglass fiber fabrics will not rot, mildew, or deteriorate. Good thermal properties. High tensile strength, high thermal endurance low moisture absorption electrical insulation product versatility.

III. MECHANICAL PROPERTIES OF ECC

1. Compressive Strength:

ECC has a compressive strength of 30 to 90 MPa. Due to the lack of coarse aggregates, it has a lower elastic modulus (around 20-25 GPA) than concrete. ECC has a slightly greater compressive strain capacity, about 0.45-0.65 percent.

2. Direct Tensile Strength:

Under standard curing conditions, the compressive strength of the UHP-ECC reached 150 MPa after 28 days, while the tensile strength and strain capacity of the UHP-ECC were 18 MPa and 8%, respectively.

3. Flexural Strength:

The strain-hardening properties of ECC may be evaluated indirectly using the four-point bending test. At failure, the midspan deflection was 20.5 mm. The first cracking strength and flexural strength were both 7.7 and 14.7 MPa, which were significantly greater than those of ordinary concrete.

4. Impact Strength:

At 28 days, the ECC composites had a strain capacity of 4.4 percent and an eventual strength of around 5 MPa. At 28 days, ECC's tensile stress-strain response is typical.

IV. PERFORMANCE OF ECC

The tensile performance of ECC with high-volume fly ash is significantly improved by a proper temperature treatment. After a temperature treatment of no more than 200°C, ECC effectively controls the crack width. The strain capacity of ECC with high-volume fly ash is improved by improving interface properties.

The high tensile ductility, which is hundreds of times that of concrete while keeping compressive strengths that are comparable to concrete or high strength concrete, is the most distinguishing feature. ECC exhibits metal-like behaviour without requiring high fibre content, defying conventional wisdom that high fibre volume fraction is required for high material performance.

ECC is readily adaptable to field construction project execution or precast plant structural element production because of its mild fibre content (2 percent or less by volume). ECC has shown versatility in processing pathways, including self-consolidating casting and spraying on-site, as well as off-site precasting and extrusion. ECC's high tensile ductility allows it to deform in a consistent manner, resulting in a load-sharing capability with steel reinforcement in structural members.

As a result, steel reinforcements in R/ECC members are used more effectively to improve structural performance. Concurrently, ECC's tight crack width protects steel reinforcement from corrosive processes, resulting in increased structural durability.

Given the material's recent growth, the long-term performance of ECC in full-scale structures has yet to be fully developed. However, limited data from at least two field demonstration experiments backs up the claim that ECC can withstand real-world conditions.

V. CONCLUSION

Permeation in the presence of hydraulic pressure, such as in liquid containers and reservoir dams, is a common occurrence. Diffusion in the presence of an ion

concentration gradient, such as on bridge decks, salt tanks, and maritime settings, and surface tension-induced capillary suction, which is particularly important in ECC when crack width becomes very tight. Even when strained in tension to several percent, cracked ECC had roughly the same water permeability as sound concrete ($k \approx 5 \times 10^{-11}$ m/s).

Both ECC and reinforced mortar specimens were pre-tensioned up to 1.5 percent deformation in this study, resulting in a wide range of crack widths and numbers of crack analysed the chloride diffusion coefficients for ECC. AASHTO T259-80 required that beam specimens be ponded in a saltwater solution of 3% NaCl. Because the actual transport process is likely more complex than diffusion in a homogeneous medium without cracks, these measured values should be referred to as "effective chloride diffusion coefficient. The volume percent of permeable pores is used to measure water absorption. When allowed to absorb water by capillary suction, the sorptivity test measured the increase in mass of pre-dried specimens over time.

Permeation under hydraulic gradients, diffusion under ion concentration gradients, and sorption and absorption under capillary suction all show a trend to improve over concrete, especially cracked concrete. Considering that reinforced concrete structures are intended to enable some tensile cracking, and that these cracks are often the source of corrosion due to increased water and corrosive transport, ECC has a significant potential to enhance the longevity of R/C structures by acting as a quality cover that greatly inhibits all transport mechanisms.

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REFERENCES

- [1] Ahmed, S. F. U. and H. Mihashi (2007). "A review on durability properties of strain hardening fibre reinforced cementitious composites (SHFRCC)." *Cement and Concrete Composites* 29(5): 365-376.
- [2] Ali, M. A. E. M. and M. L. Nehdi (2017). "Innovative crack-healing hybrid fiber reinforced engineered cementitious composite." *Construction and Building Materials* 150: 689-702.
- [3] Chen, Z., et al. (2014). "Latex-modified Engineered Cementitious Composites (L-ECC)." *Journal of advanced concrete technology* 12(12): 510-519.
- [4] Chen, Z., et al. (2013). "Quasi-static and dynamic compressive mechanical properties of engineered cementitious composite incorporating ground granulated blast furnace slag." *Materials & Design* 44: 500-508.
- [5] Deng, M. and S. Yang (2018). "Cyclic testing of unreinforced masonry walls retrofitted with engineered cementitious composites." *Construction and Building Materials* 177: 395-408.
- [6] Desai, D., et al. (2014). "Development of thermally adaptive Engineered Cementitious Composite for passive heat storage." *Construction and Building Materials* 67: 366-372.
- [7] Ding, Y., et al. (2018). "Basic mechanical properties of ultra-high ductility cementitious composites: From 40 MPa to 120 MPa." *Composite Structures* 185: 634-645.
- [8] Lepech, M. D. and V. C. Li (2009). "Water permeability of engineered cementitious composites." *Cement and Concrete Composites* 31(10): 744-753.
- [9] Li, V. C. (2003). "On engineered cementitious composites (ECC)." *Journal of advanced concrete technology* 1(3): 215-230.
- [10] Ma, H., et al. (2014). "Effect of self-healing on water permeability and mechanical property of Medium-Early-Strength Engineered Cementitious Composites." *Construction and Building Materials* 68: 92-101.
- [11] Maalej, M. and K. S. Leong (2005). "Engineered cementitious composites for effective FRP-strengthening of RC beams." *Composites Science and Technology* 65(7-8): 1120-1128.
- [12] Maalej, M., et al. (2010). "Engineered cementitious composites for effective strengthening of unreinforced masonry walls." *Engineering Structures* 32(8): 2432-2439.
- [13] Maalej, M., et al. (2012). "Review of potential structural applications of hybrid fiber Engineered Cementitious Composites." *Construction and Building Materials* 36: 216-227.
- [14] Meng, D., et al. (2017). "Mechanical behaviour of a polyvinyl alcohol fibre reinforced engineered cementitious composite (PVA-ECC) using local ingredients." *Construction and Building Materials* 141: 259-270.
- [15] Paegle, I. and G. Fischer (2016). "Phenomenological interpretation of the shear behavior of reinforced Engineered Cementitious Composite beams." *Cement and Concrete Composites* 73: 213-225.
- [16] Şahmaran, M., et al. (2009). "Internal curing of engineered cementitious composites for prevention of early age autogenous shrinkage cracking." *Cement and Concrete Research* 39(10): 893-901.
- [17] Şahmaran, M. and V.C. Li (2007). "De-icing salt scaling resistance of mechanically loaded engineered cementitious composites." *Cement and Concrete Research* 37(7): 1035-1046.

- [18] Şahmaran, M. and V. C. Li (2008). "Durability of mechanically loaded engineered cementitious composites under highly alkaline environments." *Cement and Concrete Composites* 30(2): 72-81.
- [19] Şahmaran, M., et al. (2012). "Frost resistance and microstructure of Engineered Cementitious Composites: Influence of fly ash and micro poly-vinyl-alcohol fiber." *Cement and Concrete Composites* 34(2): 156-165.