EXPERIMENTAL INVESTIGATION ON CHARACTERISTICS OF BENDABLE CONCRETE

Ashwini Salve[1], Dr S.G Makarande[2], Ms. Rutuja kakpure [3]

[1]mtech Student Struvtural Engineering Bapurao Deshmukh College Of Engineering
[2]Professor ,civil engineering department ,Bapurao Deshmukh College Of Engineering
[3]Assistant professor, civil engineering department ,Bapurao Deshmukh College Of Engineering

---***---

Abstract –
Engineered cementitious composites (ECC), often known as bendable concrete, are mortar-based composites that can be easily moulded and are reinforced with carefully chosen short random fibres. When stretched by an earthquake or by frequent abuse, traditional concrete fails catastrophically. At tensile loads of up to 5%, ECC is undamaged and safe to use. At 0.01% tensile strain, conventional concrete fractures and may not be able to support a load. In this study, poly vinyl alcohol fibre is utilised to minimise cement content and increase flexibility in order to meet future demand for concrete while also developing fibre materials. PVA fiber has an excellent affinity for water, a high aspect ratio, a high ultimate tensile strength, a moderately high modulus of elasticity, strong chemical compatibility with Portland cement, and no health risks. Super plasticizer is used to make concrete easier to work with. During the flexural strength test, the concrete's bendability properties are examined together with the cubes and slabs compressive and flexural strengths.

Keywords: ECC (Engineered Cementitious concrete) ,Polyvinyl alcohol (PVA)

1.INTRODUCTION

Conventional concretes are extremely brittle and inflexible with a strain capacity of only 0.1 percent, making them practically unbendable. This inflexibility is an important factor that leads to failure under load and has led to the creation of an elegant material, namely Bendable Concrete, sometimes referred to as Engineered Cementitious Composites, abbreviated as ECC. This material has a significantly increased degree of elasticity. Micromechanically engineered polymer fibre is used to reinforce a bending concrete**.**

The same fundamental components as conventional concrete are used to make ECC, but a high-range water reduction (HRWR) agent is also added to ensure optimal workability. However, ECCs do not employ coarse materials; as a result, mortar is used instead of concrete. The amount of powder in ECC is comparatively considerable. To boost the paste content, cementitious materials can be added, such as fly ash, silica fume, blast furnace slag, and silica fume. Additionally, ECC uses tiny amounts of short, discontinuous fibres—typically 2% by volume. ECC contains extremely fine silica sand and small polyvinyl alcohol fibres that are coated in a thin, slippery coating that is only a few nanometers thick. When the fibres are overloaded, this surface coating enables the fibres to start sliding, preventing fracture.

2.LITERATURE REVIEW

Kallepalli Bindu Madhavi, Mandala Venugopal ,V Rajesh , KuncheppuSuresh

performed the experiment using flexible concrete.They came to the following conclusions based on their research: bendable concrete is also referred to as engineered cementitious composite.This substance can exhibit significantly more flexibility.In this research, fresh and mechanical properties of various ECC mixtures are tested by adding additives like fly ash, and various experiments are carried out such flexure, deflection, and compressive strength. Concrete that can be bent is ductile in nature. Normal concrete breaks in a brittle way when subjected to flexure. Contrarily, extremely high curvature can be attained for ECC with progressively larger stresses, similar to a ductile metal plate yielding. Multiple microcracks with widths no greater than 60 m, or roughly half the diameter of a human hair, are used to create extensive elastic deformation in ECC. Although not the same as dislocation movement, this inelastic deformation is comparable to plastic yielding inductile metals, which causes the material to sustain widespread damage throughout the yield zone. Unlike ordinary concrete, which has a tensile strain capacity of just 0.01%, ECC has a range of 3-5%. In recent full-scale structural applications, structural designers discovered that ECC attractive's damage tolerance and intrinsic tight fracture width control were attractive. Similar to normal to high strength concrete, ECC has a similar compressive strength..ECC elongates without fracturing, due to the interaction between fibers, sand, and cement working in a matrix that binds everything togetherwithin the material. In addition to reinforcing the concrete with fibers that act asligaments to bond it more tightly. The design of the cement matrix with specialingredients to make it more compatible with the fiber sand to increase flexibility. Whereordinary concrete and fiber reinforced concrete are designed to resist cracking, ECC isdesigned to crack only in a carefully controlled manner. The cracks that appear inordinary concretes are griffith-type cracks; they increase in width as they grow longer.The cracks that are formed in ECC are steady state (or flat) cracks. The width of these cracks remains constant regardless of the length .In the present experimental work, the ECC is prepared by the low modulus polyester group fiber in it.

Sagar Gadhival, TN Patel and Dinesh Shah (2000)

ECC incorporates super fine silica sand and tiny Polyvinyl Alcohol-fibres covered with a very thin(nanometer thick), slick coating. This surface coating allows the fibre to begin slippingwhen they are over loaded so they are not fracturing

Victor C. Li (2007), "Engineered Cementitious Composites Material, Structural and Durability Performance".

It claims that when the specimen fails, a fracture plane forms, and that in order to overcome this, many microcracks must form in order to increase the composite's tensile ductility. In other words, where steel reinforcement is employed to manage width in concrete, such steel reinforcement can fully eradicate ECC. The micro crack opening increases from zero to around 60 micron between initial cracking strength (about 0.01%) and 1% strength. ECC has a compressive strength range of 30 to 90 MPa. Due to the lack of coarse aggregate, concrete typically has a lower elastic modulus (about 20–25 gpa) than concrete. ECC has a somewhat higher compressive strain capacity, ranging from 0.45% to 0.65%. Compared to ECC, regular concrete is brittle by nature and ECC is ductile in nature, due to this property; it has wide applications & wide future scope in various fields

Victor C. Li [2009] "Damage Tolerant ECC for Integrity of structures Under Extreme Loads", ASCE,

This research suggests that ECC can provide all the benefits of concrete or even more so than regular concrete. ECC is highly damage resistant under very high loading, including reverse cyclic loading, earth quake loads, and low velocity impact, according to experimental research. The micro crack opening rises from zero to around 60 m between the first cracking strain (about 0.01%) and the 1% strain. More numerous cracks develop with extra loading above 1%, but none open further than the steady state value of 60 m..

Jun Zhang et al (2013)

The fiber-reinforced engineered cementitious composite (LSECC) with low drying shrinkage characteristics has been published as a potential use for concrete pavements with the goal of removing joints that are typically utilised to account for temperature and shrinkage deformation. The tensile cracks could be localised within the LSECC strip instead of the neighbouring concrete slab in a composite slab made of both plain concrete and LSECC, steel barn at the LSECC concrete interface, and designed building techniques. The overall strain capacity and integrity of the composite slab can be greatly increased thanks to the strain-hardening and high strain capacity of the LSECC. The length ratio of the LSECC strip can be properly chosen to handle the temperature and shrinkage deformations can be accommodated by adequate selection on the length ratio of LSECC strip and concrete slab

Yu Zhu et al. (2014)

The ratio of water to binders (W/B) is maintained at 0.25 for a variety of binary and ternary system combinations. By adding fly ash and slag, it was seen that the ductility of ECC increased.

In 2015, Pan Z. et al.

In addition to taking into account evaluated unoiled polyvinyl alcohol fibres and hybrid PVA fibres in ECC, the combination percentage was rebuilt using amount analysis. Three standard mixtures have been used to preserve PVA-ECC's price and overall performance.

It is suggested that M7 has a low tensile strength whereas M17 and M21 have a high tensile strength.

Zhang Z. et al (2019)

According to this, ECC is impacted by the direct addition of vegetative Bacillush alodurans and its mutant cells. Once microorganisms were added, the mechanical performance of ECC, along with its compressive strength and tensile characteristics, was significantly altered. At the macroscale level, microorganism ECC increased the compressive strength and strength of bacteria-ECC in comparison to Control-ECC. The tensile strain capability of bacteria-ECCs, on the other hand, exhibits a reversible trend, but is nevertheless kept at a high level. Similar to the strength enhancement, the matrix fracture toughness was also amplified in bacteria-ECCs at the microscale level. Lower chemical bond and slip-hardening constant were discovered for the matrix/fiber interface attributes linked to fibre bridging performance by bacteria-ECCs.

P. Krithika and A. Richard (2019)

Used PP and PVA fibres with varying amounts of microbe in the water content to grow the self-healing ability of ECC. It showed that PVA fibres perform better overall than PP fibres and that self-healing occurs under different conditions.

Ramin Andalib et al, (2016) discussed portrays five distinctive cell groupings of Bacillus megaterium (10x105 to 50x105cfu/ml) were acquainted in underlying cement to accomplish the ideal convergence of microbes. A significant increase in the strength was obtained in the case of 30x105 cfu/ml at different ages. The strength of the highest grade of bacterial concrete had improved (24%) as compared to the lowest grade (12.8%) due to the calcification mechanism.

3.AIM AND OBJECTIVE

- **AIM :** The aim of the study is to evaluate the performance and suitability of poly vinyl alcohol fibers to make bendable concrete

- **OBJECTIVE:**

1. The main objective of this work is to find out the strength of bendable concrete
2. Find out its structural behavior.
3. To find out its flexural behavior.
4. To compare the strength of bendable concrete with conventional concrete

4.METHODOLOGY

The materials used for making bendable concrete are the following:

1. cement
2. Fine aggregate
3. Poly Vinyl Alchohol(PVA)
4. Potable water
5. super plasticizer

Property	**Result**
Type	OPC
Specific gravity	3.15
consistency	28%
fineness	4.16

Table 1; properties of cement

s.noC	**property**	**result**
1	shape	round
2	Fineness of sand	3.12
3	Specific gravity	2.84
4	Water absorbtion	0.8 %
5	Zone as per IS standard	II

TABLE 2: PROPERTIES OF FINE AGGREGATE

TABLE 3:PROPERTIES OF PVA

s.No	Parameters	Result
1	Diameter	40 um
2	length	12mm
3	density	1500kg/m3
4	Specific gravity	1.3
5	Tensile strength	1600 mpa
6	Elongation	6
7	Youngs modulus	40 Gpa
8	color	white

5.MIX DESIGN

Micromechanics design is the foundation of the mix design for ECC Concrete. The application of the micromechanics concept occurs at the constituent level of the material, where there is an obvious mechanical interaction between the fibre, mortar matrix, and fiber-matrix contact. The average fibre has a diameter of tens of microns, is millimetres long, and may have a nanometer-scale surface coating. The PVA fibres utilised by various studies range in length from 8 mm to 12 mm. The PVA fibre has a 40pm diameter. The ratio of the different ingredients in the concrete is determined by the optimal mix percentage described in the ECC literature.

Workability is a crucial concrete attribute that will influence the velocity of placement and the level of compaction, according to Ravindrarajah (1999).

Different trials were taken to achive the workability and following mix proportion was taken .

MIX DESIGN

Cement:	689.88kg
Sand	1379.75kg
water	241.46kg
fibers	1% ,1.5%
Super plasticizer	600 ml/ bag
W/C	0.35

TABLE 4 :MIX DESIGN

6.TEST RESULTS

CONCRETE	PVA	COMPRESSIVE STRENGTH
ECC CONCRETE	1%	18.12 N/mm2
ECC CONCRETE	1.5%	24.59 N/mm2
NORMAL CONCRETE	0%	19.1 N/mm2

TABLE 5: COMPRESSIVE STRENGTH 14 DAYS

CONCRETE	PVA	COMPRESSIVE STRENGTH
ECC CONCRETE	1%	27.52N/mm2
ECC CONCRETE	1.5%	28.9 N/mm2
NORMAL CONCRETE	0%	26.67 N/mm2

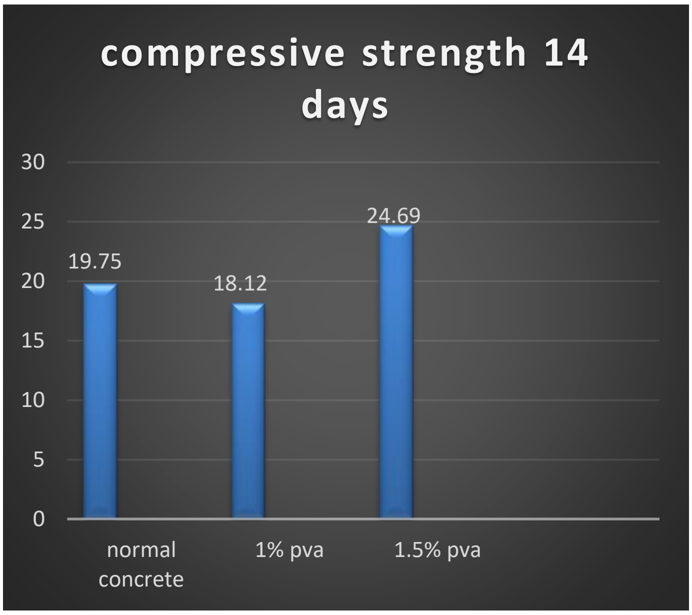
TABLE 6: COMPRESSIVE STRENGTH 28DAYS

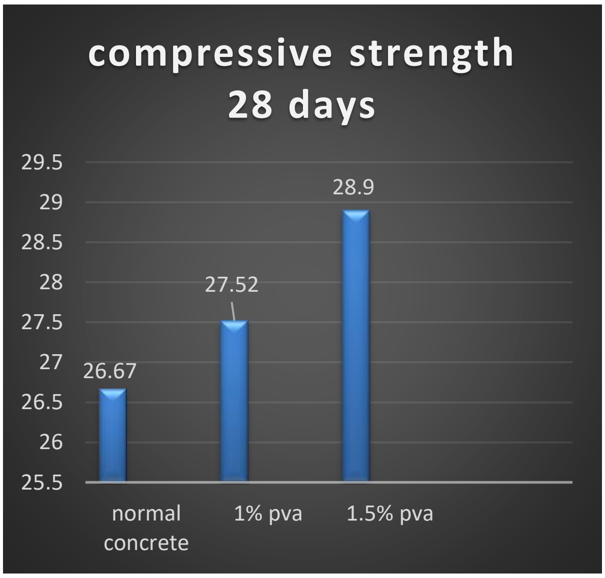
CONCRETE	PVA	FLEXURAL STRENGTH
ECC CONCRETE	1%	7.61N/mm2
ECC CONCRETE	1.5%	8.74N/mm2
NORMAL CONCRETE	0%	5.08N/mm2

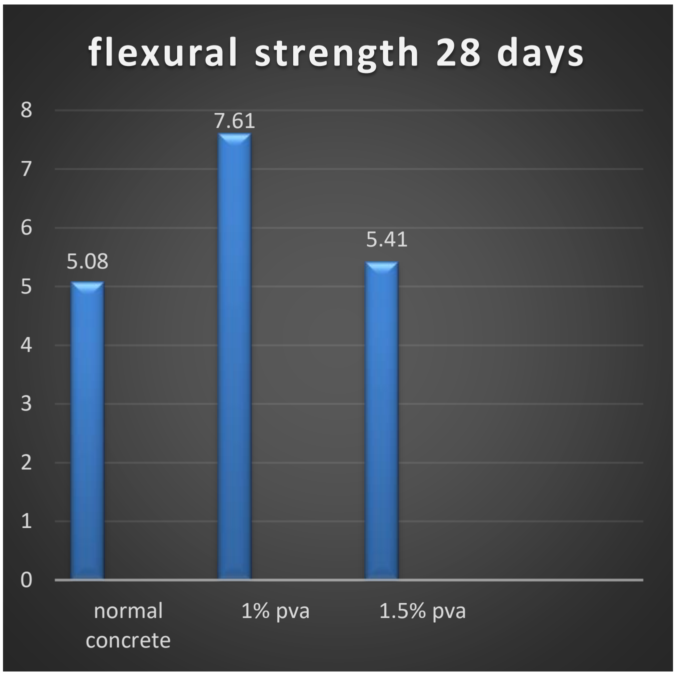
TABLE 7: FLEXURAL STRENGTH 14 DAYS

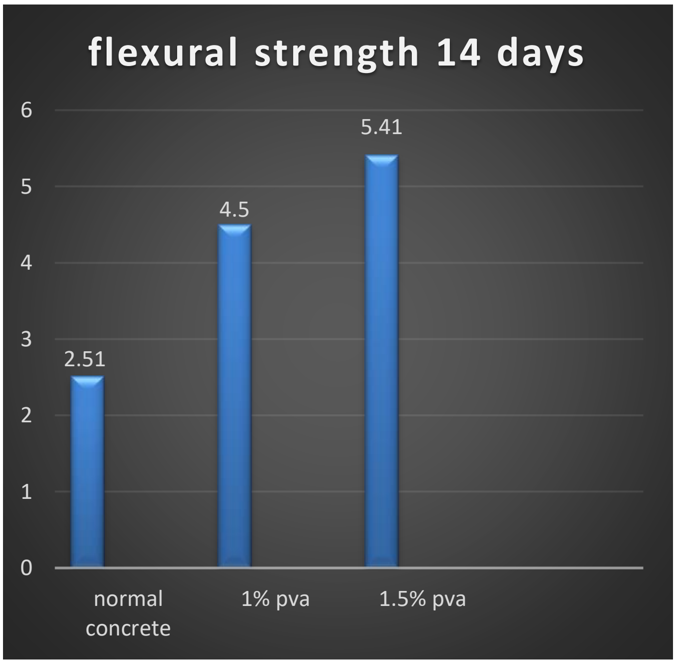
CONCRETE	PVA	FLEXURAL STRENGTH
ECC CONCRETE	1%	4.5N/mm2
ECC CONCRETE	1.5%	5.41N/mm2
NORMAL CONCRETE	0%	2.51N/mm2

TABLE 8: FLEXURAL STRENGTH 28 DAYS









7.CONCLUSION

- It is seen from test results that the significant properties of ECC concrete are ductility, durability, compressive strength.
- The compressive strength of normal concrete is slightly less than bendable concrete but the flexural strength of normal concrete is less by good amount than bendable concrete.
- The strength of concrete for 1.5% is more than 1% and normal concrete. So for this paper the ideal combination is of 1.5% pva
- In this paper the compression and flexural strength of bendable concrete is done the values are compared with conventional cubes
- On comparing the 7 days and 28 days test, better results was obtained in the 28 days strength.
- Therefore it is proved that the bendable concrete is more strength than the conventional concrete and it is more flexible so that is resist cracks and acts as more efficiency in seismic region

8. ACKNOWLEDGEMENT

It is really a matter of great pleasure to acknowledge the valuable guidance, enormous assistance, and excellent cooperation extended to us valuable every corner, in processing smoothly throughout the project seminar entitled

I take this opportunity to express my deep sense of gratitude and wholehearted thanks to my guide **Dr S.G MAKARANDE** Professor in Civil Engineering Department and my co guide **Ms. R.K KAKPURE** Assiatant professor for their invaluable guidance. It wouldn't have been possible for us to carry out this work to this extent without him.

I wish to thank, **Mr. R. S. KEDAR,** Associate Professor, H.O.D. of Civil Engineering Department & **Dr. G. V. THAKRE** Principal of BDCE, Sewagram and special thanks to who helped me a lot of during preparation of this project seminar.

Last but not least I wish to all teaching and non-teaching staff and all my friends and my family who directly or indirectly help us in our work.

REFERENCES

1. Sagar Gadhiya. (2015) "bendable concrete a review "(ISSN 2319 – 6009 www.ijscer.com Vol. 4, No. 1, February 2015 © 2015 IJSCER.
2. Victor C Li (2007)" "Engineered Cementitious Composites Material, Structural and Durability Performance",research gate publication
3. Victor C. Li [2009] "Damage Tolerant ECC for Integrity of structures Under Extreme Loads", ASCE.
4. Jun Zhang et al (2013) "The fibre reinforced engineered cementitious composite with characteristic of low drying shrinkage (LSECC0"
5. Richard and P. Krithika 2019," An Experimental Investigation Of Self-Healing Property On Ecc With Pp And Pva Fibers Using Bacteria Under Different Exposure" International Journal of Innovative Technology and Exploring Engineering (IJITEE),8:1886-1891.
6. En-hua Yang et.al (2009), "Rheological Control in production of Engineered Cementitious Composites.", ACI Materials Journal/ July-August 2009, pp357-366
7. Dr. A. W. Dhawale and Mrs. V. P. Joshi., "Engineered Cementitious Composites for Structural Applications." International journal of application or innovation in Engineering and Management., Volume 2, Issue 4, April 2013., pp 198-205
8. Michael D. Lepech, Victor C. Li, Richard E. Robertson, and Gregory A.Keoleian(2008)Design of Green Engineered Cementitious Composites for Improved Sustainability. ACI Materials Journal Title no.105-M64
9. Munshi GalibMuktadir, M I Fahim Alam, Asifur Rahman, Mohammad Robiul Haque (2020)Comparison of Compressive Strength and Flexural Capacity between Engineered CementitiousComposites (Bendable Concrete) and Conventional Concrete used in Bangladesh. Journal ofmaterials and engineering structures 7 (2020) 73–82)