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Experimental Investigation on Flexural Behaviour of ECC-RCC Composite Beam

Fathumathul Anasi K[1], Sankaranarayanan. K. M[2]
[1]*M.Tech. Student, Structural Engineering, SIMAT, KTU, Kerala, India*
[2]*Assisitant Professor, Dept. Of Civil Engineering, SIMAT, KTU, Kerala, India*

Abstract: ***Engineered Cementitious Composite (ECC) is a newly developed composite material with high ductility, tensile strength, durability and crack control. In this experimental work, ECC is used as a bottom cover to beam to reduce rebar corrosion. This introduction to beam resulted in a composite beam and there are many ways in which bonding can be provided between ECC and concrete. This paper investigates the flexural behaviour of composite beam under different bonding condition. The result shows that unbound composite beam with propping have more flexural strength than any of the other beam type.***
Keywords: Engineered cementitious composite, Durability, Tensile strength, Bond strength, Compressive strength, Compression testing machine, Universal testing machine.

I. INTRODUCTION

For years, we have been using cementitious materials for infrastructure construction. But due to the deterioration of these structures, researches are widely carried out to enhance the properties of cementitious material, especially toughness in shear and tension is increased by adding fibers to cementitious materials. Thus this new innovative idea led to the development of Engineered Cementitious Composite (ECC). Here the fiber added is limited to 2% content by volume. ECC is more durable, sustainable, ductile, tensile and crack control material composite. The main component of ECC is cement and this has led to the increase in cost of production, so cement is replaced by supplementary materials up to a limit.

Most of the structures when subjected to adverse environment resulted in structural failure. This failure is mainly due to rebar corrosion due to entry of corrosive agents through cracks in structure. This project mainly aims to provide a more tensile and flexible layer as rebar cover to reduce the crack formation. Such a layer chosen is made of ECC and here it is provided as bottom reinforcement cover of beam. So the beam is made up of RCC and a bottom layer of ECC and it is called composite beam.

In this investigation, the flexural behaviour of composite beam with different bonding condition is studied. In the normal composite beam, it is seen that ECC layer is fully bonded to concrete and hence they would both deform together. Large cracks in concrete resulted in localised cracking in ECC layer and thus it creates a path for entry of corrosive agents. Inorder to equally distribute the load of concrete to the ECC layer, unbound composite beam is proposed. And also to reduce the effect of providing an external bonding, we provided props which connect ECC and concrete layer. This paper investigates the flexural behaviour of composite beams with different bonding condition.

II. MATERIALS

The materials used in this experimental work includes cement, fly ash, M-Sand, Coarse aggregate, PVA fiber, superplasticizer, reinforcing bar, two side hooked end bar, wire mesh, plastic sheet.

A. Cement

The cement used in this work is OPC 53 grade cement.



Fig. 1 OPC Cement

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B. Fly ash

Class C fly ash is used in production of ECC. It is used as replacement of cement from 33% -70%.



Fig. 2 Class C Fly ash

C. M-sand

M-sand is used for both concrete and ECC. It is used as fine aggregate.



Fig .3 M-Sand

D. Coarse Aggregate

Crushed granite rock is used as coarse aggregate. The maximum size of aggregate used is 20 mm.



Fig.4 Coarse Aggregate

E. PVA Fiber

ECC consists of fiber and here we use polyvinyl alcohol fiber.



Fig.5 PVA fiber

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F. Superplasticizer

Superplasticizer is used to reduce the amount of water in the mix. ECC utilises superplasticizer because it has low water-binder ratio. Here we used polycarboxylate ether as superplasticizer.



Fig.6 HI- PCE HR50

G. Reinforcing Bars

Here reinforcing bars are used in beam. In this work, we used Fe 500 grade, 4mm rebars.



Fig.7 Rebar

H. C Shaped Hooked end bar

We made C shaped hooked ended bar by bending rebar. It is used in propping for bonding in composite beam.

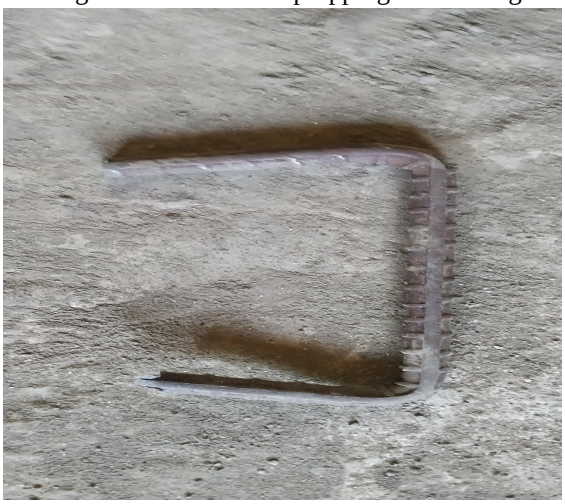


Fig.8 C shaped hooked end bar

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I. Wire Mesh

We used half inch square wire mesh to increase the tensile strength of beams.

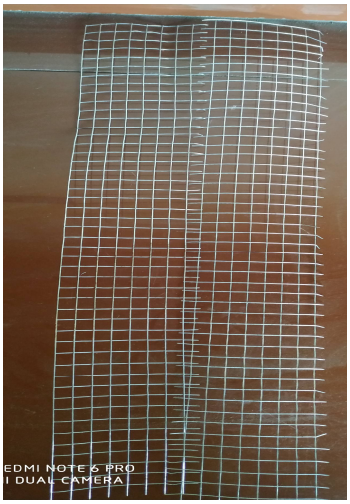


Fig.9 Wire mesh

J. Plastic Sheet

A plastic sheet locally available in the market is used for unbound composite beams.



Fig.10 Plastic sheet

K. Water

Water used in this work is clean and devoid of chemicals and organic matter.

III.EXPERIMENTAL WORKS

Experimental work includes conducting preliminary test on materials, mix design, mixing and casting specimens, curing and testing. M25 mix was designed using IS 456:2000 and IS 10262:2009. The designed M25 mix ratio was 1:1.7:3. (Cement: fine aggregate: coarse aggregate). The water-cement ratio is 0.5. From previous studies and test results, ECC mix chosen was 1:1:1 (cement: sand: fly ash). PVA fiber constituted to 2% by volume of mix. The water-binder ratio used was 0.36. Cement and fly ash together constituted binder volume. Superplasticizer dosage used is 0.2L/100 Kg of binder.

Cubes and cylinders of both M25 and ECC were casted, cured and tested to obtain compressive strength and split tensile strength of both mixes. Cubes had a standard dimension of 150x150x150 mm and cylinder had a height of 300 mm and diameter 150 mm. Cubes and cylinders were tested in Compression Testing Machine (CTM). Tensile bond strength is also conducted on cubes. It is conducted on M25 normal cube, ECC cube, and also in composite cube which is made of half M25 and half ECC layer. Tensile Bond strength is tested in similar way as split tensile strength test.

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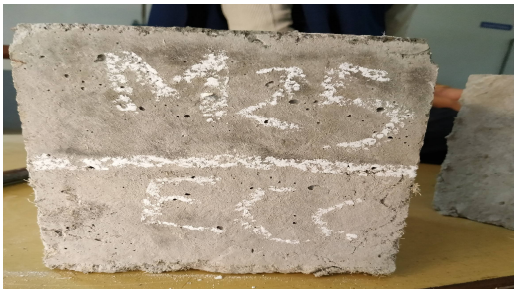


Fig. 11 Composite cube



Fig.12 Split Tensile Test on cylinders



Fig.13 Compression test on cube

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Fig.14 Tensile bond strength on cube

TABLE I
Test Results Of Specimens

Mix Designation	Test Conducted (after 28 days of curing)	Result (N/mm^2)
M 25	Compression test	32.88
	Split Tensile Strength	3.68
	Tensile Bond Strength	4.24
ECC	Compression test	25.55
	Split Tensile Strength	5.94
	Tensile Bond strength	3.96
M25 + ECC	Tensile Bond Strength	3.39

This M25 and ECC mixes are used for casting beams. Beams are singly reinforced with 2 number of Fe 500 grade rebars. A cover of 25mm is provided at the bottom. In composite beam, the bottom ECC layer is 30 mm. In some beams mesh is provided 15mm from the bottom (tension zone of beam). The beams had a standard dimension of 700x150x150 mm. Beams were tested under universal testing machine (UTM) and two-point loading method was used.

IV. CASTING PROCESS OF BEAMS

There are totally 10 type of beams in which 6 of them are composite beams. Casting of composite beam follows similar procedure. Here M25 is in compression zone while ECC is in tension zone. But inorder to overcome the difficulties, M25 layer is casted first and then left for hardening (24 hours) and above it ECC layer is placed. In case of propping , M25 is propped by embedding one end of hooked end bar at M25 and the other end extends outwards and hooked bar is fully covered with M25 mix in a tubular form. After hardening ECC layer is placed above them. While testing the beam under UTM, the beam is placed in such a way that ECC layer is at the bottom. The detail casting process of each beam is given below.

A. Type I : M25 Reinforced Beam

Here beam is casted by pouring the M25 mix into the mould and 2 rebars are placed at bottom with a cover of 25 mm.

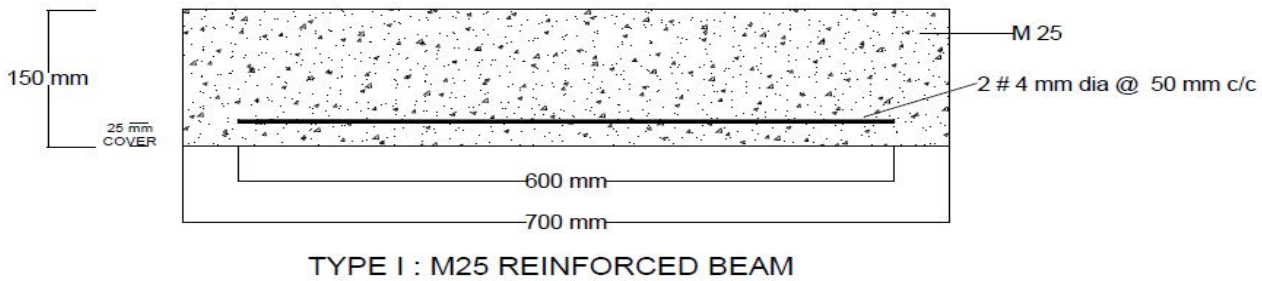
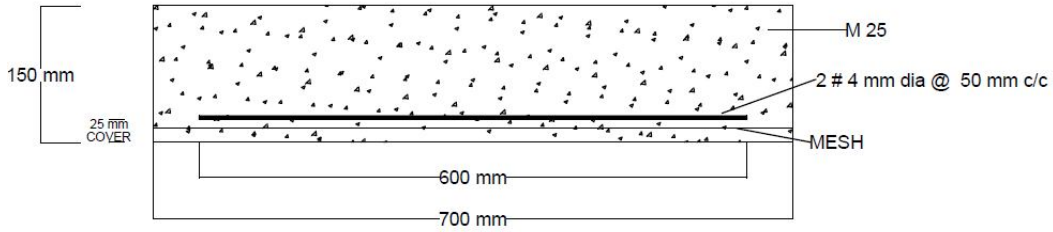


Fig.15 Type I Beam

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B. Type II : M25 Reinforced Beam with Mesh

Here additional to the above process a wire mesh is provided at 15 mm above the bottom.

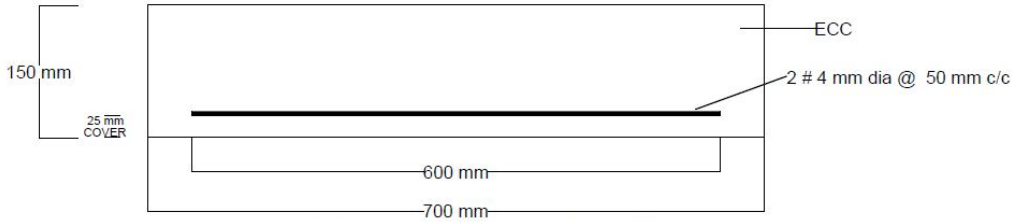


TYPE II : M25 REINFORCED BEAM WITH MESH

Fig.16 Type II Beam

C. Type III : ECC Reinforced Beam

The beam is made of ECC mix and also reinforced by providing 2 bars at bottom.

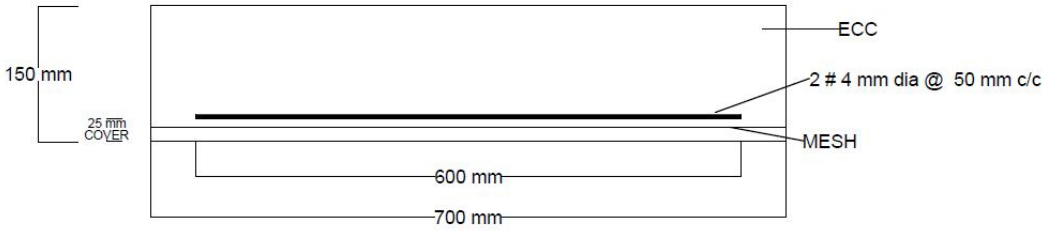


TYPE III : ECC REINFORCED BEAM

Fig.17 Type III Beam

D. Type IV : ECC Reinforced Beam with Mesh

The ECC beam is provided with a mesh at the bottom.

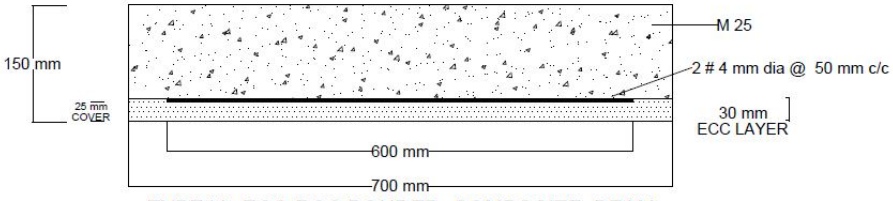


TYPE IV : ECC REINFORCED BEAM WITH MESH

Fig.18 Type IV Beam

E. Type V: ECC-RCC Bonded Composite Beam

Here M25 layer is casted first (top surface is roughened) and allowed it to harden for 24 hours and above it reinforcing bars and ECC layer is placed.



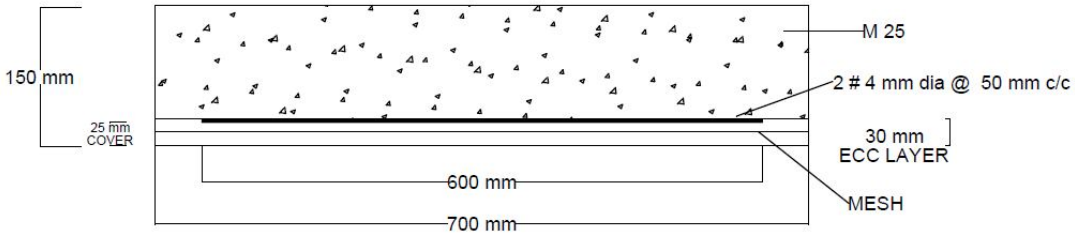
TYPE V : ECC-RCC BONDED COMPOSITE BEAM

Fig.19 Type V Beam

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F. Type VI : ECC-RCC Bonded Composite Beam with Mesh

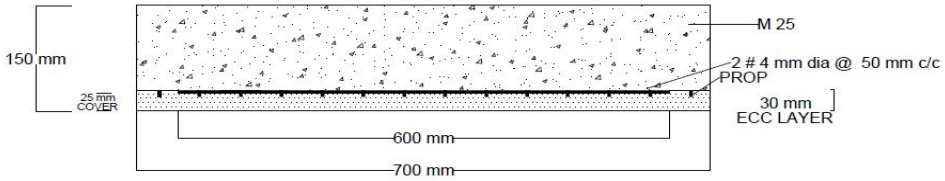
Additionally to the above beam a mesh is also provided at middle of ECC layer.



TYPE VI : ECC-RCC BONDED COMPOSITE BEAM WITH MESH

Fig.20 Type VI Beam

G. Type VII: ECC-RCC Bonded + Propped Composite Beam



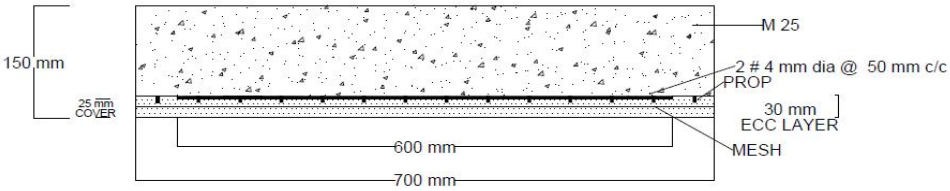
TYPE VII : ECC-RCC BONDED + PROPPED COMPOSITE BEAM

Fig.21 Type VII Beam

In this type of composite beam a propping is provided to M25 layer by embedding C shaped hooked end bars into it and also covering the outward extended portion with M25 in a tubular shape. After letting the M25 layer harden for 24 hours, reinforcing bars and ECC layer is placed above it.

H. Type VIII: ECC-RCC Bonded + Propped Composite Beam with Mesh

Additional to the above mentioned beam casting procedure, a wire mesh is provided at the middle of ECC layer.

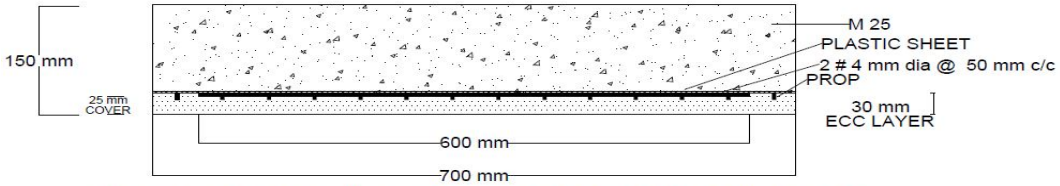


TYPE VIII : ECC-RCC BONDED + PROPPED COMPOSITE BEAM WITH MESH

Fig.22 Type VIII Beam

I. Type IX : ECC-RCC Unbound + Propped Composite beam

Here for unbounding M25 and ECC layer, a plastic sheet is provided at the bonding region. Like the above beam a propping is provided at the M25 layer and it extend outwards. After the M25 layer is hardened, plastic sheet is placed above it and holes are made in plastic sheet for allowing the prop to pass through it. Then ECC layer and rebars are placed above it.



TYPE IX : ECC-RCC UNBOUND + PROPPED COMPOSITE BEAM

Fig.23 Type IX Beam

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J. Type X : ECC-RCC Unbound + Propped Composite beam with Mesh

Additionally to the above casting procedure, a mesh is placed at the middle of ECC layer.

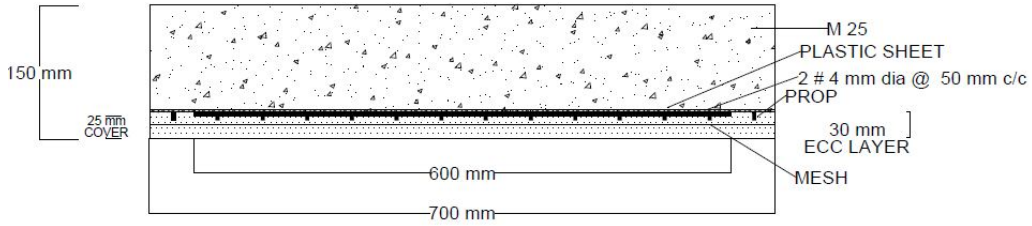


Fig.24 Type X Beam



Fig.25 Roughened top surface of M25





Fig.26 Props on M25 layer



Fig.27 placing plastic sheet for unbound composite beam

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Fig.28 Placing rebars for reinforcement



Fig.29 placing mesh

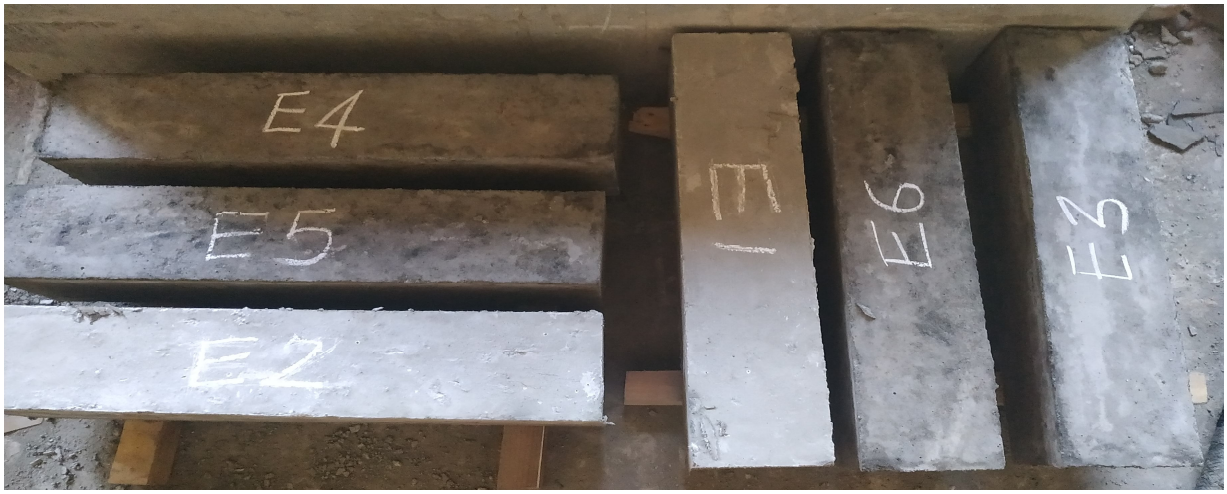


Fig.30 Casted beams

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V. RESULTS AND DISCUSSION

All the above mentioned beams were tested in UTM machine under two-point loading method to calculate flexural strength.



Fig.31 Two point load flexural strength testing method

The test result is tabulated below:

TABLE 2
TEST ON BEAMS

Designation	Specimen	Average Flexural Strength (after 28 days of curing) N/mm^2
E1	Type I	9.50
E2	Type II	9.68
E3	Type III	10.05
E4	Type IV	10.54
E5	Type V	11.20
E6	Type VI	12.10
E7	Type VII	12.73
E8	Type VIII	13.10
E9	Type IX	13.94
E10	Type X	14.22

The lowest flexural strength is shown by M25 beam while the higher value is for ECC-RCC unbound + propped beam with mesh. It is seen that when mesh is provided at the tension zone, flexural strength is increased. Propping also result increased flexural strength.

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VI. CONCLUSION

Composite beams are made of different materials and here it is made of RCC and ECC. This experimental investigation gave an insight to the flexural behaviour of composite beam under different bonding condition. The following conclusions are made:

A. All beams showed higher flexural strength than M25 reinforced beam
B. Providing wire mesh at tension zone increased the flexural strength
C. Propping increased the flexural strength of beam
D. Unbounded composite beams showed greater flexural strength

Composite beam can be used in places where high flexural strength is a concern. Composite beam reduce the cost of production when compared with ECC beam. Since the ECC layer is more tensile than the M25 layer, it reduces the crack formation at bottom and inhibits the rebar corrosion.

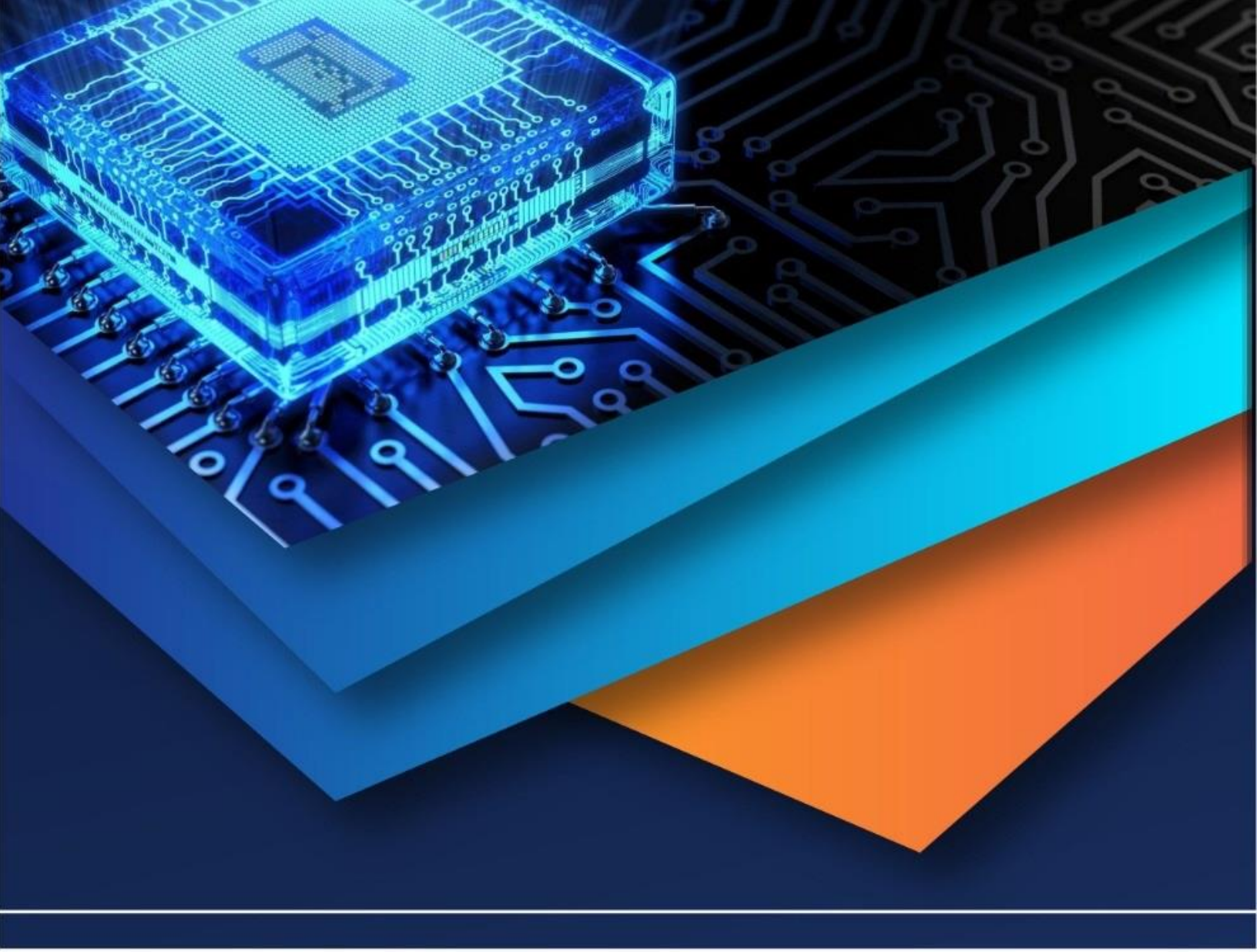
VII. ACKNOWLEDGMENT

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REFERENCES

[1] Ammapalayam Ramasamy Krishnaraja and Shanmughasundaram Kandasamy, “Flexural Performance of Hybrid Engineered Cementitious Composite Layered Reinforced Concrete Beams”, Periodica Polytechnica, Civil Engineering, 62(4), pp. 921–929, 2018.
[2] K.L. Vinoth Kumar and G.Karthikeyan, “Experimental Study on Flexural Response of Engineered Cementitious Composite (ECC) Strengthened Reinforced Concrete Beams”, International Journal of Civil Engineering and Technology, 8(8), 2017, pp 313–323.
[3] Parul Khaped, Prof. Jignesh Solanki and Prof. M A Jamnu, “Experimental Study on Strength of Engineered Cementitious Composite Prepared By Using Alccofine and Fly Ash”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 6 ,Issue X, Oct 2018.
[4] Piotr Dybeł and Daniel Wałach, “Evaluation of the Development of Bond Strength between Two Concrete Layers”, IOP Conf. Series, Materials Science and Engineering, 245, 2017.
[5] S.Ooviya, S.Vaishalani, D.Nethra and S.Karuppasamy, “Experimental Study on Flexible Concrete”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 6, Issue IV, April 2018.
[6] Wenjie Ge, Ashraf F. Ashour, Weigang Lu and Dafu Cao, “Flexural Performance of Steel Reinforced ECC-Concrete Composite Beams Subjected to Freeze–Thaw Cycles” , International Journal of Concrete Structures and Materials, Ge et al. Int J Concr Struct Mater (2020) , 14:11.
[7] Yanhua Guan, Huaqiang Yuan, Zhi Ge , Yongjie Huang, Shuai Li, and Renjuan Sun, “Flexural Properties of ECC-Concrete Composite Beam”, Hindawi, Advances in Civil Engineering, Volume 2018, Article ID 3138759, 7 pages.
[8] Yousaf Ali and Sajjad Wali Khan, “Experimental Study on the Flexural Behavior of Composite Rc Beams Having an Engineered Cementitious Composite Layer at the Bottom”, International Journal of Advances in Mechanical and Civil Engineering, Volume-4, Issue-4, Aug.-2017.

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