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"Experimental Study on Bendable Concrete"

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Abstract - The objective of the study was to investigate the properties of flexible concrete mix design, aiming to develop a durable and flexible alternative to conventional concrete. Engineered Cementitious Concrete (ECC) was introduced to enhance the strain capability and flexibility of the concrete. The experimental approach involved replacing coarse aggregate with fine aggregate by volume. The flexural strength and strain capability of ECC were determined through a four-point test, showing its ability to withstand tensile strains of approximately 2.5% to 3% without failure, unlike traditional concrete which immediately fractures at 0.1% strain. The results demonstrated significantly improved flexural and compressive strength in bendable concrete specimens compared to normal concrete. This enhancement is attributed to the increased strain capability and flexibility of ECC. Flexible concrete offers advantages such as better energy absorption, resistance to cracking, improved durability, and reduced risk of structural failures. The utilization of flexible concrete mix design has the potential to revolutionize the construction industry by providing resilient and sustainable solutions. The findings contribute to the growing research on ECC and its application in structural and infrastructure projects, supporting the development of more flexible and durable concrete structures.

***Key Words*:**ECC, Bendable, Cement, fibres, Recron 3s.

1.INTRODUCTION

Concrete is brittle material when it is subjected to tensile loads cracks are easily observed. Bendable concrete is ductile in nature this concrete is also known as Engineered cementious composite (ECC). This was created by victor Li at the college of Michigan.
Bendable concrete is a ultra-ductile reinforced mixture is made to produce high ductility and more cracking control effect. In the present study the materials of cement, sand, fibers (Recron fibers), fly ash, water and water reducing agent is used to make bendable concrete mixture. The concrete specimens were casted and cured for 7days, 14 days, 28 days strength calculations. The slabs are casted for load deflection calculations. The main advantages of ECC are Increased tensile strength,Greater impact resistance of fiber reinforced concrete, Reduce permeability , Arrest drying shrinkage, Controls cracking and Increases flexibility.

2. MATERIALS AND MIX PROPORTION

2.1 Cement

Cement is the fine material which is generally used for binding in concrete mix. In the present study cement of OPC 53 grade was used. The cement of OPC 53 grade is shown in the below figure 1.

Fig 1. Cement

2.2 Fine aggregates

Fine aggregates are the particles which are passing through IS 4.75mm sieve. These are used to fill the air voids in concrete mixture the fine aggregates which are used in the present study are shown in below figure 2.

Fig. 2 Fine aggregate

2.3 Fibers (Recron fibers)

Fibers are generally used for making the high strength concrete. The fibers are mainly used to decrease the cracking effect of concrete. The recron 3S fiber which is used in this study is shown in below figure 3.

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Fig.3 Recron 3s

2.4 High range water reducing agent

High range water reducing admixture can reduce the water-cement ratio while maintaining slump, increase slump while maintaining a constant water-cement ratio, or reduce the cementitious materials content and water content while maintaining constant slump and strength. Slump loss characteristics of the concrete would determine whether the high range water reducer should be introduced at the plant, at the site, or both locations. Matching the chemical admixture to the cementitious materials, both in type and dosage rate is important. High range water reducing admixture is used to produce high strength concrete to reduce cross section of compression members in high rise building, improve durability of concrete in aggressive environments, and many more applications.

Fig. 4 HWRA

2.5 Mix proportion

In the current study, a concrete mixture of M25 Grade was used, and the mix proportion was determined based on the properties of the materials. The quantities of the materials used in the mixture are presented in Table 1.

Table -1: Mix proportion of concrete

Cement	Fine aggregate	Water cement ratio	HWRA	Recron fiber
462.222 Kg/m^3	1681 Kg/m^3	0.45	2%	1%, 2%, 3%

3. EXPERIMENTAL WORK

3.1 Mixing of concrete

In the study, different combinations of ingredients were used to create trial mixes for M40 grade concrete. These mixes were categorized as 0% RF, 1% RF, 2% RF, and 3% RF. For your initial selection, choose one of these mixtures. Based on the specific mix design, measure the required quantity of materials and combine them together to create the concrete mixture.

3.2 Workability of concrete

For four trial mixes the slump cone test values are studies to check the workability of concrete mix.

3.3 Casting of the specimens

The specimens of cubes, cylinder and prisms are used to check the strength. The slab plates were casted to check the ultimate load values for the trails.

Fig. 5 Casting

3.4 Curing of the test samples

The test samples are cured for 7days, 14 days and 28 days in curing tank to check the strength values for cubes and slabs.

3.5 Compressive strength

Compressive strength of concrete is measured for 0%RF, 1%RF, 2%RF and 3%RF. Initially select any mixture for M40 grade concrete at 7days, 14 days and 28 days curing for this study. The compressive strength is measured by using UTM machine.

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Fig.6 Compressive strength

3.6 Flexural strength

The flexural strength of concrete is measured for 0%RF, 1%RF, 2%RF and 3%RF Initially select any mixture for M40 grade concrete prism specimens which are cured at 7 days, 14 days and 28 days. This test is also measured for four trial mixes.

Fig. 7. Flexural strength

4. RESULTS AND ANALYSIS

4.1. Compressive strength

Compressive strength of concrete is measured for 0%RF, 1%RF, 2%RF and 3%RF. Initially select any mixture for M40 grade concrete at 7days, 14 days and 28 days curing for this study. The compressive strength is measured by using CTM machine.

Table 4.1.1: Compressive strength of cubes at 7 day

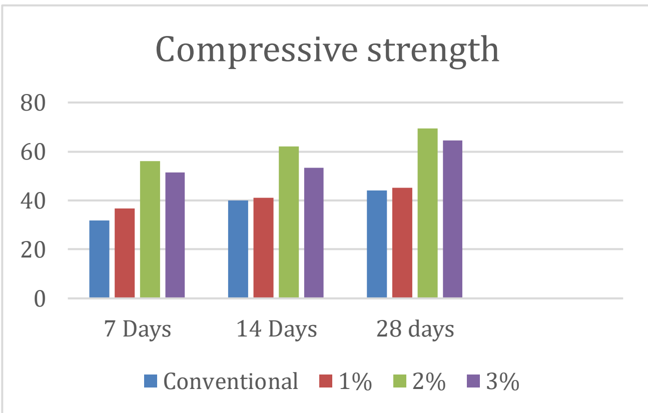
Sr. No.	Grade	Name	Proportion (%)	Load (kn)	Compressive strength (N/mm²)	Average strength (N/mm²)
1	M40	Normal Concrete	0	710	31.56	31.88
2	M40		0	721	32.08	
3	M40		0	720	32.02	
1	M40	Fibre Concrete	1	821	36.51	36.67
2	M40		1	835	37.12	
3	M40		1	819	36.40	
1	M40	Fibre Concrete	2	1261	56.05	55.99
2	M40		2	1260	56.03	
3	M40		2	1257	55.90	
1	M40		3	1152	51.23	
2	M40	Fibre	3	1155	51.37	51.42
3	M40	Concrete	3	1162	51.67	

Table 4.1.2: Compressive strength of cubes at 14 days

Sr. No.	Grade	Name	Proportion (%)	Load (kn)	Compressive strength (N/mm²)	Average strength (N/mm²)
1	M40	Normal Concrete	0	903	40.16	40.12
2	M40		0	905	40.23	
3	M40		0	899	39.98	
1	M40	Fibre Concrete	1	927	41.23	41.08
2	M40		1	920	40.89	
3	M40		1	925	41.12	
1	M40	Fibre Concrete	2	1397	62.12	62.1
2	M40		2	1400	62.23	
3	M40		2	1393	61.95	
1	M40	Fibre Concrete	3	1195	53.15	53.25
2	M40		3	1220	54.23	
3	M40		3	1196	53.16	

Table 4.1.3: Compressive strength of cubes at 28 days

Sr. No.	Grade	Name	Proportion (%)	Load (kn)	Compressive strength (N/mm²)	Average strength (N/mm²)
1	M40	Normal Concrete	0	991	44.05	44.05
2	M40		0	992	44.13	
3	M40		0	989	43.98	
1	M40	Fibre Concrete	1	1016	45.16	45.09
2	M40		1	1010	44.89	
3	M40		1	1017	45.23	
1	M40	Fibre Concrete	2	1555	69.13	69.50
2	M40		2	1577	70.13	
3	M40		2	1557	69.25	
1	M40	Fibre Concrete	3	1445	64.23	64.57
2	M40		3	1466	65.18	
3	M40		3	1447	64.32	



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4.2. Flexural strength

The flexural strength of concrete is measured for 0%RF, 1%RF, 2%RF and 3%RF Initially select any mixture for M40 grade concrete prism specimens which are cured at 7 days, 14 days and 28 days. This test is also measured for four trial mixes.

Table 4.2.1: Flexural strength of Slab at 7 days

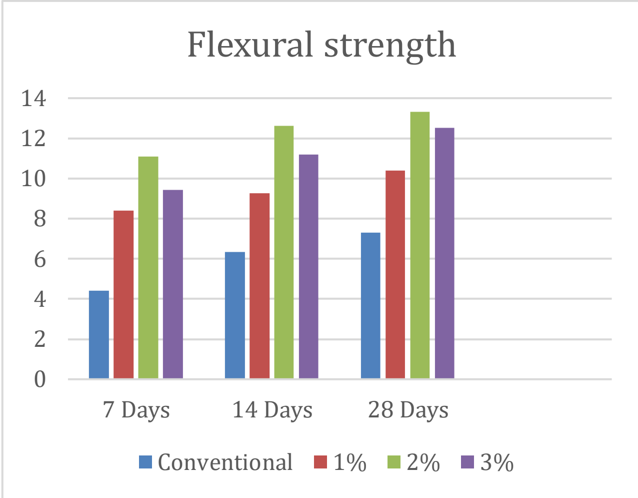
Sr. No.	Grade	Name	Proportion (%)	Load (kn)	Flexural strength (N/mm^2)	Average strength (N/mm^2)
1 2 3	M40 M40 M40	Normal Concrete	0 0 0	5.4 5.3 5	4.53 4.45 4.23	4.40
1 2 3	M40 M40 M40	Fibre Concrete	1 1 1	10 10 10.5	8.23 8.19 8.75	8.39
1 2 3	M40 M40 M40	Fibre Concrete	2 2 2	13.5 13.5 13	11.16 11.23 10.92	11.10
1 2 3	M40 M40 M40	Fibre Concrete	3 3 3	11.5 11.3 11	9.56 9.43 9.23	9.42

Table 4.2.2: Flexural strength of Slab at 14 days

Sr.No.	Grade	Name	Proportion (%)	Load (kn)	Flexural strength (N/mm^2)	Average strength (N/mm^2)
1 2 3	M40 M40 M40	Normal Concrete	0 0 0	8 8 7.2	6.45 6.56 5.98	6.33
1 2 3	M40 M40 M40	Fibre Concrete	1 1 1	11.2 11.2 10.8	9.41 9.38 8.98	9.25
1 2 3	M40 M40 M40	Fibre Concrete	2 2 2	14.5 15 16	12.12 12.63 13.12	12.62
1 2 3	M40 M40 M40	Fibre Concrete	3 3 3	13.5 14 13	11.19 11.52 10.89	11.20

Table 4.2.3: Flexural strength of Slab at 28 days

Sr.No.	Grade	Name	Proportion (%)	Load (kn)	Flexural strength (N/mm^2)	Average strength (N/mm^2)
1 2 3	M40 M40 M40	Normal Concrete	0 0 0	8.5 9 8.5	7.23 7.49 7.19	7.30
1 2 3	M40 M40 M40	Fibre Concrete	1 1 1	12.5 13 12	10.52 10.89 9.79	10.40
1 2 3	M40 M40 M40	Fibre Concrete	2 2 2	16.5 16 15.50	13.65 13.45 12.91	13.33
1 2 3	M40 M40 M40	Fibre Concrete	3 3 3	15 15 15	12.52 12.43 12.64	12.53



5. CONCLUSIONS

The Engineered Cementitious Concrete (ECC) was eventually developed comprising of Recron 3s fibre, HWRA from above data.

The Specimens casted have been tested on the Compression Testing Machine (CTM) and 4-point test for compression and flexure respectively and results are achieved accordingly.

The Experimental investigation shows that the flexural and compression strength of ECC is increased at 2% proportion. It also proves that bendable concrete obtains twice the strength when compared to normal concrete.

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