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Durability Study on Bacterial Concrete by Using Calcium Lactate and Bacillus Subtilis Bacteria

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Abstract : **Self-healing concrete is a type of concrete that has the ability to repair cracks and damage on its own over time. This is achieved through the use of encapsulated healing agents such as bacteria or microcapsules that are integrated into the concrete mix. When cracks form, the healing agents are exposed and activated, leading to the formation of calcium carbonate and the closing of the crack. This technology has the potential to significantly extend the lifespan of concrete structures and reduce maintenance costs.**

Keywords: Compressive strength, Bio concrete, Bacillus Subtilis, Acid Attack, Chloride Attack, Sulphate Attack, Water Absorption.

1. INTRODUCTION

1.1 GENERAL

Concrete is a commonly used building material due to its strength, durability, and affordability. However, it is not immune to cracking and damage over time, which can lead to structural weakness and the need for costly repairs.

Self-healing concrete offers a promising solution to this problem by incorporating healing agents within the concrete mixture.

2. MATERIAL PROPERTIES

2.1 MATERIALS USED

- Cement (OPC 53)
- Fine Aggregate
- Coarse Aggregate
- Water
- Bacillus subtilis (Self healing Bacteria)
- Calcium lactate (Nutrition)

3. MIX DESIGN

Grade	Cement Kg/m³	Fine aggregate Kg/m³	Coarse aggregate Kg/m³	Water Content Lit/m³
M30	413	589	1202	186

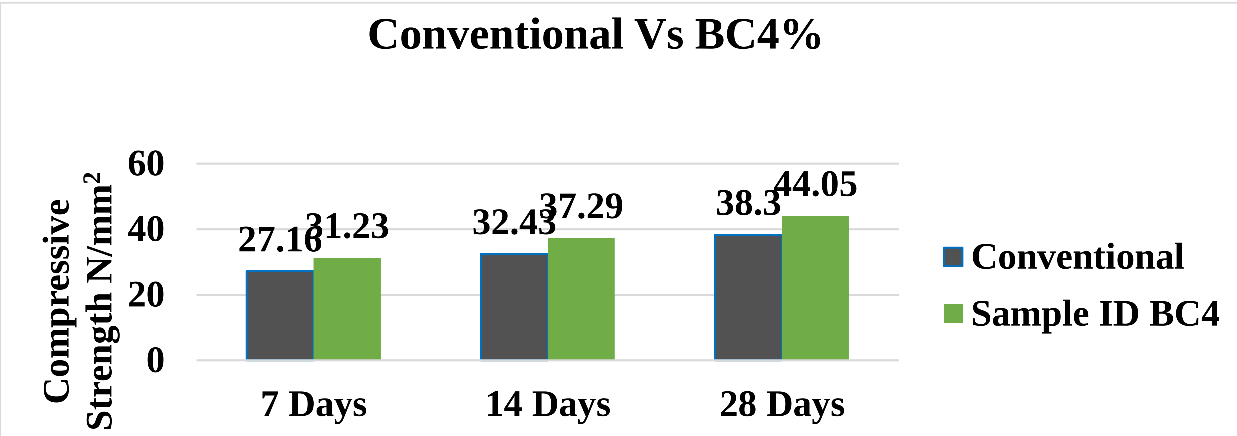
- Mix Ratio
- 1 : 1.42 : 2.9
- w/c = 0.45

4. Compressive strength of conventional concrete cube

Curing period	Samples	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
28 days	1 2 3	38.2 38.1 38.6	38.3

5. Compressive strength of bacterial concrete cube

Curing period	Samples ID	Compressive Strength (N/mm^2)
28 days	BC4	44.05



6. DURABILITY STUDY

Durability testing of concrete is a critical aspect of ensuring the long-term performance and service life of concrete structures. Durability tests are conducted to assess how well concrete can resist various deteriorating factors and environmental conditions over time.

- Acid Resistance Test - ASTM C1898-20
- Chloride Attack Test- ASTM C 1218/C1218M-99
- Sulphate Attack test -ASTM C267
- Water Absorption Test - ASTM C642-06
- Sorptivity Test - ASTM C1585-13

6.1. Hydrochloric Acid Attack test

6.1.1. Compressive strength on conventional by acid test

DURATION	SPECIMEN NO	CONTROL COMPRESSIVE STRENGTH (Mpa)					
		INITIAL N/mm^2	FINAL N/mm^2	DECREASE IN STRENGTH (%)	DECREASE IN STRENGTH Avg (%)	RESIDUAL STRENGTH (%)	RESIDUAL STRENGTH Avg (%)
15 DAYS	1	37.9	34.11	10	10.2	90	89.8
	2	37.9	33.958	10.4		89.6	
30 DAYS	1	37.9	33.542	11.5	11.7	88.5	88.3
	2	37.9	33.39	11.9		88.1	

6.1.2 compressive strength on BC4% by acid test

DURATION	SPECIMEN NO	BC 4% COMPRESSIVE STRENGTH (Mpa)					
		Initial N/Mm^2	Final N/Mm^2	Decrease In Strength (%)	Decrease In Strength Avg(%)	Residual Strength (%)	Residual Strength Avg (%)
15 DAYS	1	44.8	40.499	9.6	9.81	90.4	90.2
	2	44.8	40.311	10.02		89.98	
30 DAYS	1	44.8	40.051	10.6	10.82	89.4	89.2

	2	44.8	39.854	11.04		88.96	

6.2. Sulphate attack test

A sulfate attack test on concrete is conducted to assess the resistance of concrete to the deteriorating effects of sulfate-containing compounds in the environment. Sulfate attack can cause expansion, cracking, and overall damage to concrete structures.

6.2.1 Weight gain on conventional concrete by sulphate attack test

DURATION	SPECIMEN NO	CONVENTIONAL			
		Dry weight (kg)	Final weight (kg)	Increase in weight (%)	Increase in weight Avg (%)
15 Days	1	2.72	2.78	2.21	2.42
	2	2.67	2.74	2.63	
30 Days	1	2.78	2.85	2.52	2.695
	2	2.79	2.87	2.87	

6.2.2 Weight gain on BC4% concrete by sulphate attack test

DURATION	SPECIMEN NO	BC 4%			
		Dry weight (kg)	Final weight (kg)	Increase in weight (%)	Increase in weight Avg (%)
15 Days	1	2.61	2.67	2.3	1.93
	2	2.57	2.61	1.56	
30 Days	1	2.68	2.75	2.62	2.055
	2	2.69	2.73	1.49	

6.2.3 Compressive strength on conventional by sulphate attack test

DURATION	SPECIMEN NO	CONTROL					
		COMPRESSIVE STRENGTH (Mpa)					
		Initial (N/Mm^2)	Final (N/Mm2)	Decrease In Strength (%)	Avg (%)	Residual Strength (N/Mm^2)	Avg (%)
15 DAYS	1	38.1	33.871	11.1	11	88.9	89
	2	38.1	33.947	10.9		89.1	
30 DAYS	1	38.1	33.338	12.5	12.7	87.5	87.3
	2	38.1	33.185	12.9		87.1	

6.2.4 Compressive strength on BC4% by sulphate attack test

DURATION	SPECIMEN NO	BC 4%					
		COMPRESSIVE STRENGTH (Mpa)					
		INITIAL (kg)	FINAL (kg)	DECREASE IN STRENGTH (%)	Avg (%)	RESIDUAL STRENGTH (%)	Avg (%)
15 DAYS	1	43.9	39.378	10.3	10.6	89.7	89.4
	2	43.9	39.115	10.9		89.1	
30 DAYS	1	43.9	38.764	11.7	11.95	88.3	88.05
	2	43.9	38.544	12.2		87.8	

6.3 chloride attack test

6.3.1 Weight gain on conventional concrete by chloride attack test

DURATION	SPECIMEN NO	CONVENTIONAL			
		Dry weight (kg)	Final weight (kg)	Increase in weight (%)	Avg (%)
15 Days	1	2.658	2.688	1.13	2.19
	2	2.618	2.703	3.25	
30 Days	1	2.658	2.678	0.76	2.55

6.3.2 Weight gain on BC4% concrete by chloride attack test

DURATION	SPECIMEN NO	BC 4%			
		Dry weight (Kg)	Final weight (Kg)	Increase in weight (%)	Avg (%)
15 Days	1	2.56	2.63	2.74	2.2
	2	2.654	2.69	1.36	
30 Days	1	2.65	2.71	2.27	2.4
	2	2.485	2.55	2.62	
	2	2.49	2.551	2.45	

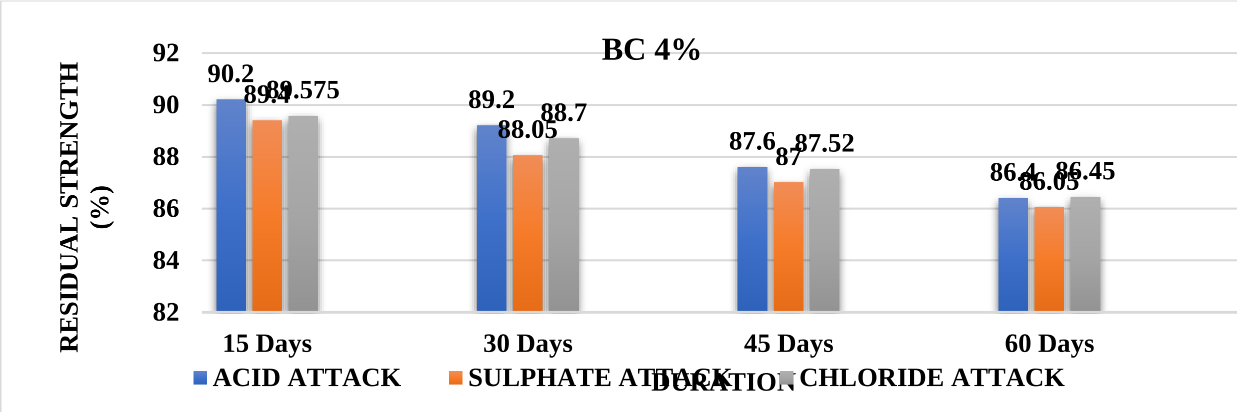
6.3.3 Compressive strength on conventional by chloride attack test

DURATION	SPECIMEN NO	CONTROL					
		COMPRESSIVE STRENGTH (Mpa)					
		INITIAL N/mm^2	FINAL N/mm^2	DECREASE IN STRENGTH (%)	Avg (%)	RESIDUAL STRENGTH (%)	Avg (%)
15 DAYS	1	38.5	34.34	10.8	10.9	89.2	89.1
	2	38.5	25	11		89	
30 DAYS	1	38.5	22	11.4	11.6	88.6	88.4
	2	38.5	22.5	11.8		88.2	
	2	38.5	20	14.2		85.8	

6.3.4 Compressive strength on BC4% by chloride attack test

DURATION	SPECIMEN NO	BC 4%					
		COMPRESSIVE STRENGTH (Mpa)					
		INITIAL N/mm^2	FINAL N/mm^2	DECREASE IN STRENGTH (%)	Avg (%)	RESIDUAL STRENGTH (%)	Avg (%)
15 DAYS	1	44.1	39.668	10.05	10.42	89.95	89.5
	2	44.1	29.5	10.8		89.2	
30 DAYS	1	44.1	27	11.04	11.3	88.96	88.7
	2	44.1	24.5	11.56		88.44	
	2	44.1	23	13.89		86.11	

6.3.5 Comparison of Compressive strength on BC4% concrete

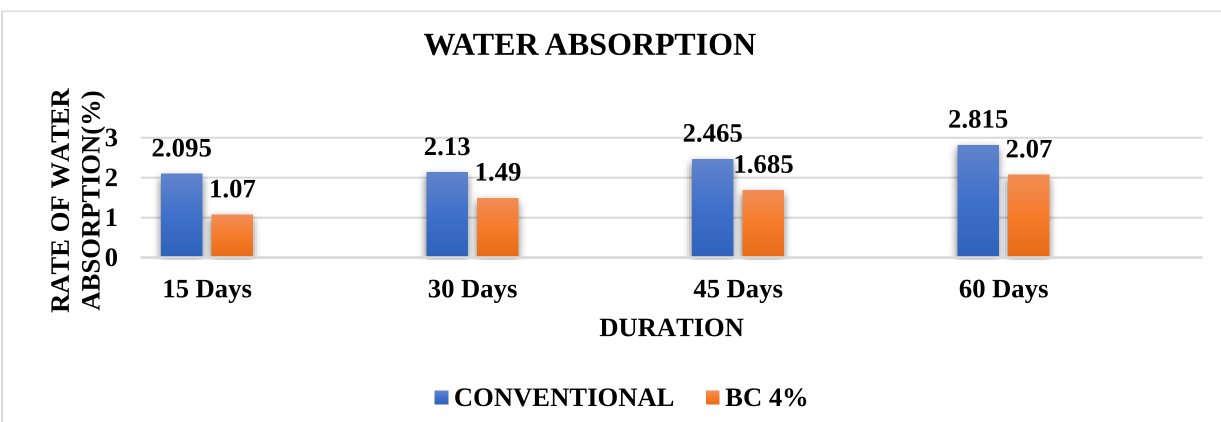


6.4. Water absorption test on conventional

DURATION	SPECIMEN NO	CONVENTIONAL			
		Dry weight (kg)	Final weight (kg)	Water absorption (%)	Avg (%)
15 Days	1	2.624	2.68	2.14	2.095
	2	2.636	2.69	2.05	
30 Days	1	2.586	2.64	2.09	2.13
	2	2.682	2.74	2.17	
	2	2.642	2.71	2.58	

6.4.1 Water absorption test on BC4%

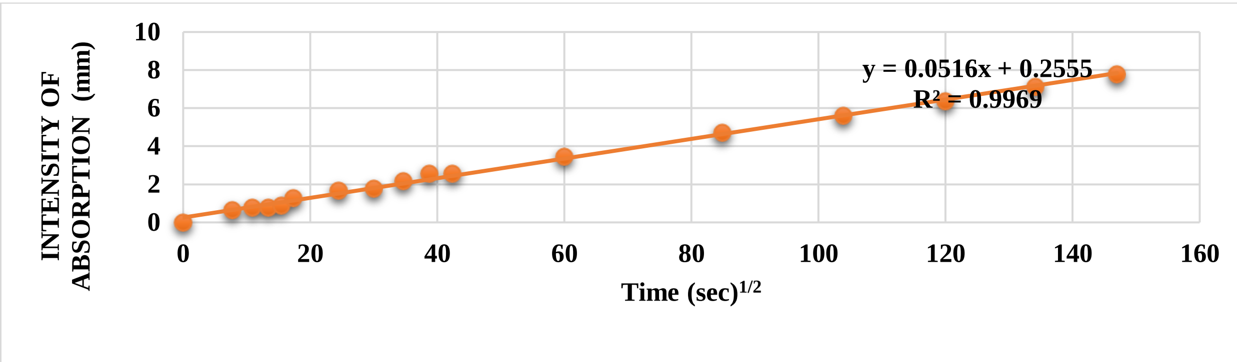
DURATION	SPECIMEN NO	BC 4%			
		Dry weight (kg)	Final weight (kg)	Water absorption (%)	Avg (%)
15 Days	1	2.53	2.56	1.19	1.07
	2	2.538	2.562	0.95	
30 Days	1	2.53	2.57	1.59	1.49
	2	2.53	2.565	1.39	
	2	2.582	2.636	2.1	



6.5. Sorpitivity

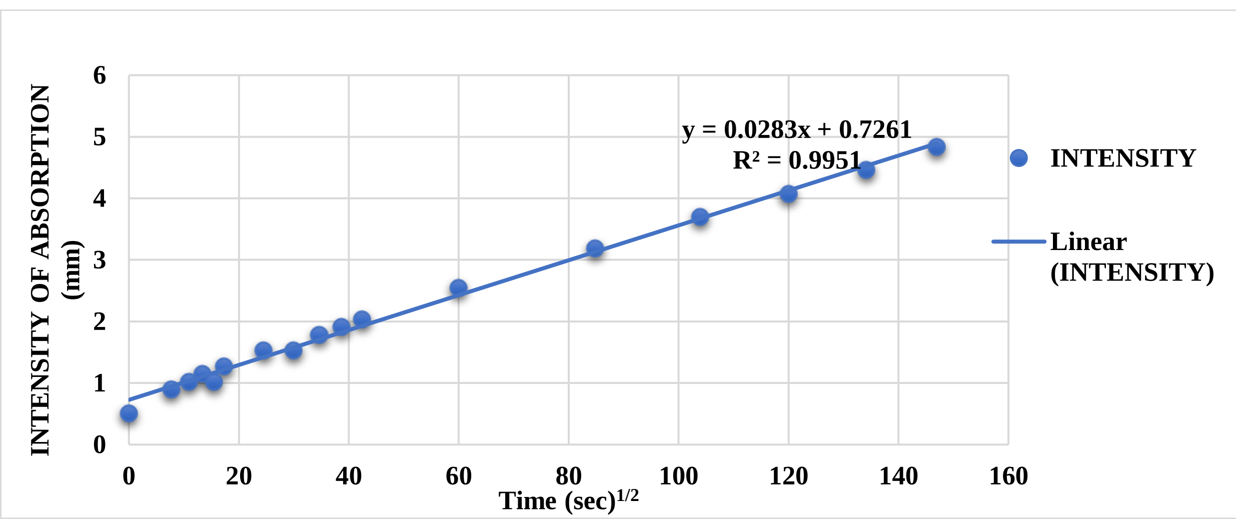
6.5.1 Sorpitivity test on conventional concrete

TIME (Sec)	√ TIME √s	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	CHANGE IN WEIGHT (g)	INTENSITY I=Δm / (A x ρ)
0	0	1015	1015	0	0
60	7.745967	1015	1010	5	0.637
120	10.95445	1015	1009	6	0.764
180	13.41641	1015	1009	6	0.764
240	15.49193	1015	1008	7	0.891

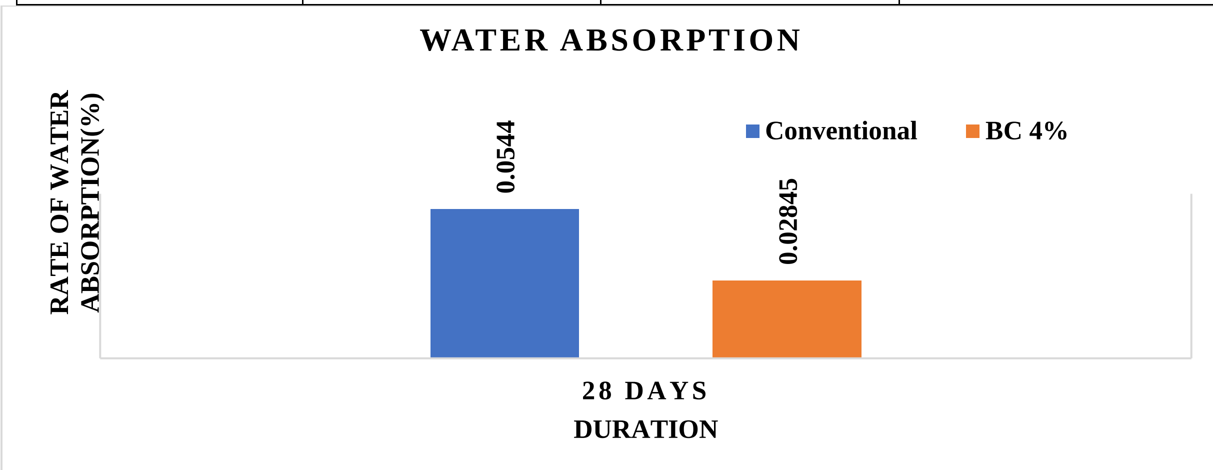


6.5.2 Sorpitivity test on BC4%

TIME (Sec)	√ TIME √s	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	CHANGE IN WEIGHT (g)	INTENSITY mm I=Δm / (A x ρ)
0	0	1010	1006	4	0.509301
60	7.745967	1010	1003	7	0.891277
120	10.95445	1010	1002	8	1.018602
180	13.41641	1010	1001	9	1.145928
240	15.49193	1010	1002	8	1.018602



Mix	Specimen 1	Specimen 2	Average (mm/sec)
Conventional	0.0596	0.0492	0.0544
BC 4%	0.0283	0.0286	0.02845



7. FLEXURAL BEHAVIOUR OF RCC BEAM

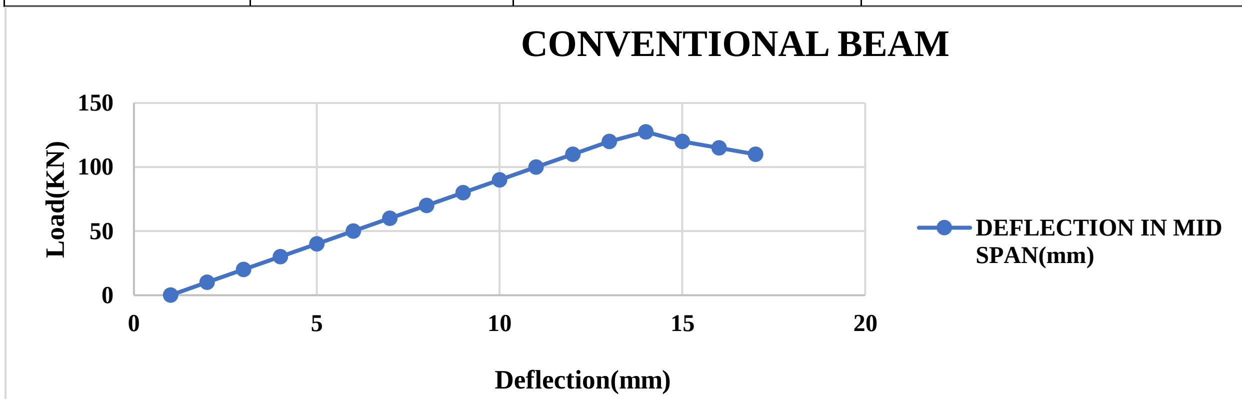
The flexural behavior of reinforced concrete was determined according to IS 516:1959. In the present investigation, studies have been carried out on the flexural behavior of properties such as load and deflection are determined by conducting suitable laboratory tests on concrete beam in its hardened stage.

The concrete beam mould of length 1000 mm, with a cross-section of 150mm x 150mm were used. The beam mould were cleaned thoroughly using a waste cloth and proper oiled along its face. 2 numbers10mm diameter bars and 2 numbers of 12mm diameter bars are provided at top and bottom of the beam and 2 legged stirrups of 8mm diameter at 150mm c/c spacing are provided. The concrete material was mixed in a mixture machine and concrete are then filled in mould and compacted using needle vibrator. The beams were cured for 28 days.

7.1 CASTING OF BEAM

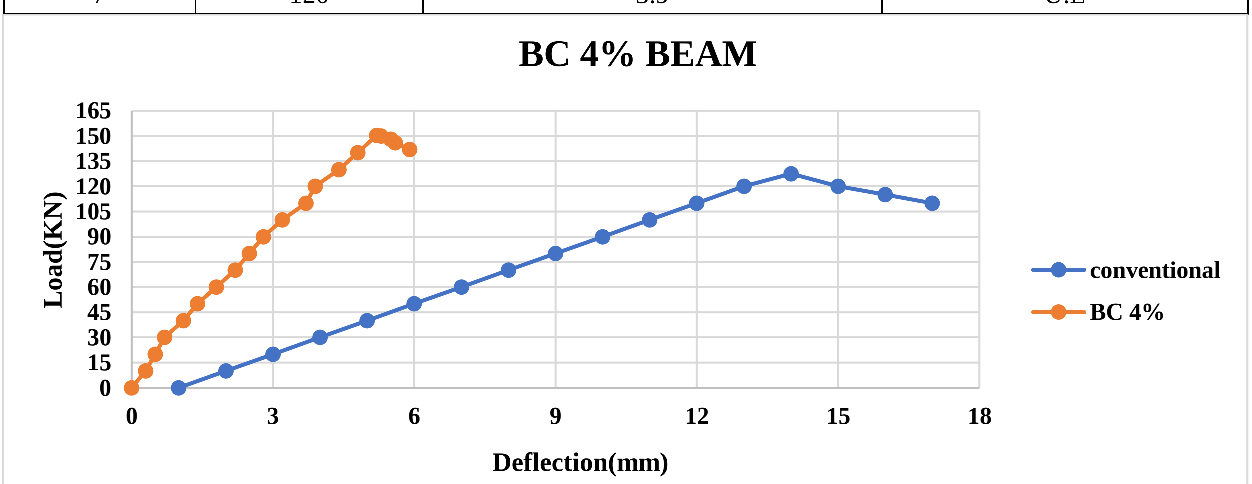
7.3.1 Flexural behaviour test results on conventional reinforced concerte beam

S.NO	LOAD (KN)	DEFLECTION IN MID SPAN (mm)	REMARKS
1	0	0	
2	20	0.7	
3	40	1.4	First crack
4	60	2.3	
5	80	2.3	
6	100	4.4	
7	120	5.4	
8	127.5	5.6	U.L



7.3.1 Flexural behaviour test results on conventional reinforced concerte beam

S.NO	LOAD (KN)	DEFLECTION IN MID SPAN (mm)	REMARKS
1	0	0	
2	20	0.5	
3	40	1.1	
4	60	1.8	First crack
5	80	2.5	
6	100	3.2	
7	120	3.9	U.L



CONCLUSION

- The Acid attack test has a weight gain of BC4% which is 0.25% less than the conventional mix.
- The Acid attack test has a residual compressive test of BC4% which is 0.7% higher than the conventional mix.
- The Sulphate attack test has a Weight gain of BC4% which is 0.465% less than the conventional mix.
- The Sulphate attack test has a residual compressive test of BC4% which is 1.2% higher than the conventional mix.
- The chloride attack test has a weight gain of BC4% which is 0.455% less than the conventional mix.
- The chloride attack test has a residual compressive test of BC4% which is 0.45% higher than the conventional mix.
- In Sorpitivity test the rate of absorption for BC4% is 25% less than the conventional mix.
- The ultimate load for BC4% is 18% higher than the conventional mix.