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STUDY ON CONSEQUENCE OF E-WASTE ON STRENGTH OF SELF-HEALING CONCRETE

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ABSTRACT

The two objectives are to increase concrete's qualities while lowering construction costs. Additionally, e-waste is a global issue that affects both wealthy and underdeveloped countries. The reason is that, except from a few conventional methods, there is no alternative way to dispose of electronic waste. E-waste is typically disposed of by incineration or landfill, but landfills require a large land area and can also seep pollutants into the groundwater. In contrast, burning produces air pollution. Therefore, incorporating E-Waste in concrete is a better concept than using these conventional techniques. Several researchers have studied the use of E-Waste in concrete. They conduct strength and durability tests on the E-Waste they use as coarse aggregate, fine aggregate, admixture, and other materials in their study. Research suggests that raw resources could be substituted by e-waste. In the current study, ABS plastic is used in various percentages to replace coarse aggregate, including 5%, 10%, 15%, and 20%. A concrete structure's lifespan is between 50 and 100 years. But ten years after completion, and occasionally much sooner, the structure begins to deteriorate. After a given number of years, the structure develops little cracks that might either be structural or superficial. Multiple studies have suggested bacterial self-healing concrete as a solution to this problem. Numerous works have studied the self-healing capabilities of concrete, thus in this paper we analyze the strength characteristics of self-healing bacterial concrete by mixing bacteria (Bacillus Subtilis) with calcium source.Calcium lactate was supplied as a calcium source at 5% and 10%, respectively, while Bacillus subtilis bacteria were added at 3% and 5%, respectively, in the study. Therefore, the study addresses the economic aspects of both building and upkeep. A comparison of earlier studies using ANN and MLR models in relation to e-plastic waste as coarse aggregate demonstrates that ANN model is significantly more accurate in predicting the strength of e-plastic waste concrete than MLR model.

Key Words: E-Waste ,Calcium Lactate, Bacillus Subtilis, e-plastic waste, Single, MLR model.

INTRODUCTION

Usually referred to as gravel and sand, coarse and fine aggregate are chemically inert materials that are joined together by cement and water to form concrete, a composite material. Nearly all civil engineering projects, including those involving railroads, airports, defense installations, etc., employ concrete. Clay was once utilized by people as a binding agent. Later, the Egyptians began mixing lime and gypsum. At that time, lime started to be regarded as the main building material. Portland cement was created in 1824 by "Joseph Aspdin" through the burning and grinding of clay and limestone.
Because they are inert materials and can react with other concrete constituents, aggregates must be carefully chosen. In aggregates, sizes smaller than 4.75mm are referred to as fine aggregates, whereas sizes greater than 4.75mm are referred to as coarse aggregate. More water is needed to fully hydrate concrete, therefore curing was taken into consideration at this point. Technically, the Calcium-Silicate-Hydrate gel, often known as C-S-H gel, is created following

This stage took around 6-7 hours to complete, and the pace of strength development is faster than it was in the first. In the third stage, which occurs towards the end and completes hydration, less heat is produced and the rate of strength development is slower.

India came in third with 3.2 million tonnes of E-Waste output, after the US and China.

According to that, India's production of e-waste surged by more than 43% between 2017–18 and 2019–20. E-waste surged by more over one million tonnes in three years, which is far greater than Supriyo's (2020) prediction of 0.7 million tonnes.

OBJECTIVE OF THEWORK

The goal of this study was to lessen the environmental contamination that is caused by plastics from e-waste, which is bad for both the environment and human health. In a similar manner, self-healing concrete, a new method, and waste materials were introduced in an effort to lower the cost of concrete building.
The study's aims are as follows:

- Examine the impact of partially substituting coarse aggregate with e-waste plastic on the strength of concrete.
- Test the impact of calcium lactate, a calcium supply for bacteria, on the

strength of concrete.

- Test the impact of bacteria (Bacillus Subtilis) and calcium lactate on the strength of concrete.
- To establish the ideal proportion of calcium lactate and bacteria in the concrete mix.
- Add E-Waste plastic and bacteria to the concrete mix together with the calcium source to see how that affects the concrete's strength.
- To assess the savings and costs of concrete construction.
- To do results analysis based on prior literature

Result:-

1. TestresultofCement

In the study OPC 43 grade is used for concrete mix design. Table 4.1 is showing theresults obtained by testing of cement. All the test results of cement were obtained asperspecified in**IS 8112-20**.

Table1Testresultof OPC43gradeCement

Test	Result
Specific Gravity	3.15
initial setting time	35 minutes
final setting time	363 minutes
7 days compressive strength	32.9
28 days compressive strength	45.32
Fineness	9%
Consistency	27%

2. TestresultofAggregate

TestofFineaggregateaswellasCoarseaggregateisdoneinthefollowingformats.Theresults of fineandcoarseaggregatearedonein the section 4.3.1and 4.3.2.

TestresultsofFineAggregates(Sand)-Table4.2and4.3isshowingthePropertiesof sand.Figure4.1 showsthegradingoffine aggregate.

Table2 Resultoffineaggregate

Test	Result
Specific gravity	2.62
fineness modulus	2.63
Loose density	1579 kg/m^3
compacted density	1590 kg/m^3
grading zone	2

Fromtheabovesieveanalysis,itisconfirmedthatthefineaggregatebelongsto**ZONE2**

Table3Grading offineaggregateas persieveanalysis

S. No.	Is Sieve	Weight Retained	Cumulative Weight Retained	Cumulative Percent Retained	Cumulative Percent Passing
1	10mm	0	0	0%	100%
2	4.75mm	26	26	5%	95%
3	2.36mm	53	79	16%	84%
4	1.18mm	79	158	32%	68%
5	600µ	53	211	42%	58%
6	300µ	158	369	74%	26%
7	150µ	105	474	95%	5%
8	PAN.	26	500		
	Total	500		263%	

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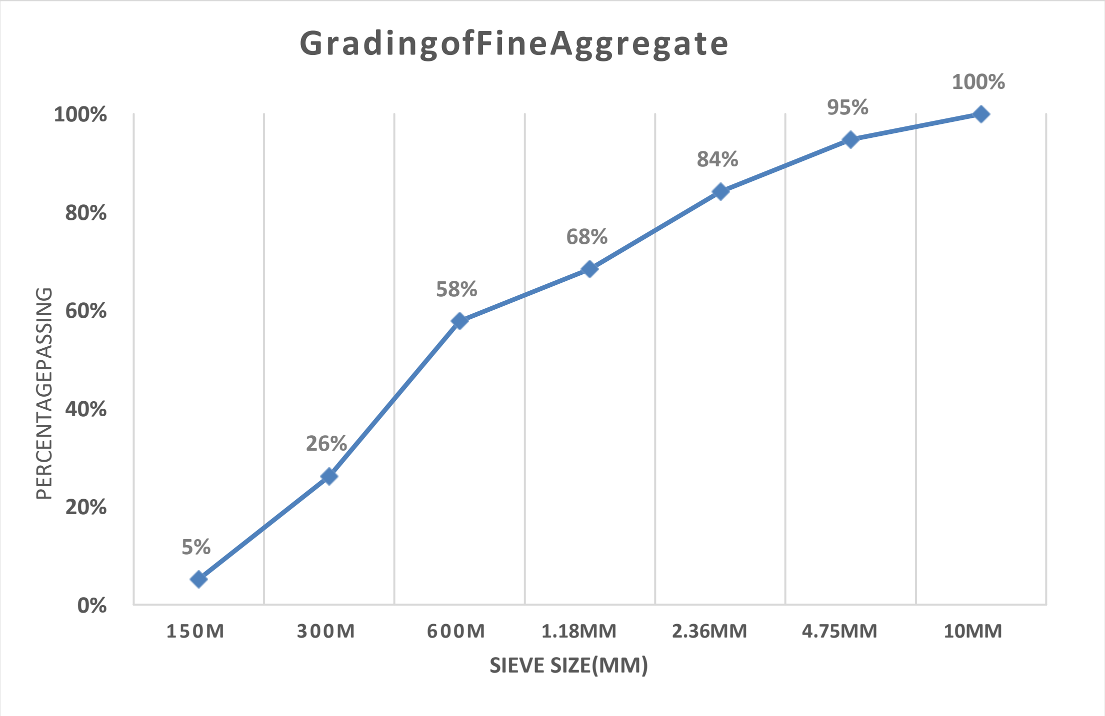

Fig.1Gradingoffineaggregate

TestresultsofCoarseAggregates-ResultsofTestofCoarseaggregatesisgivenin Table 4.4 to 4.8, Table 4.4 provides the properties of Aggregate used and Table 4.5toTable4.8givesthevariousgradingofcoarseaggregates.TheFigures4.2to4.5givesgradingof coarse aggregate.

Table4TestResultsof CoarseAggregate

Test	**Result**
SpecificGravity	2.91
Waterabsorption	0.61%
CrushingValue	21.90%
Impactvalue	10.02%
Abrasionvalue	20.20%
Density	1743.2Kg/m3

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Table5Gradingof 20mmAggregate

Sieve	Weight Retained(Gram)	%Retained	Cumulative %Retained	%Passing
40	0	0%	0%	100.00%
20	2610	26%	26%	73.90%
10	6980	70%	96%	4.10%
4.75	410	4%	100%	0.00%
Total	10000			

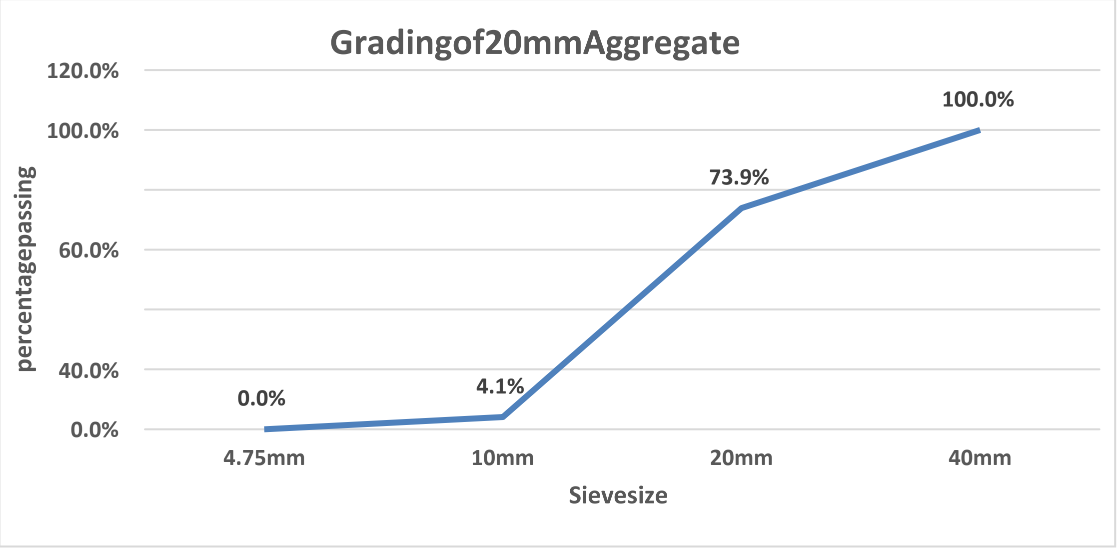

Fig. 2 Grading of 20mm

aggregateTable4.6Gradingof10mmAggregate

Sieve	Weight Retained(Gram)	%Retained	Cumulative %Retained	%Passing
20mm	0	0%	0%	100.00%
10mm	590	12%	12%	88.20%
4.75mm	4096	82%	94%	6.28%
2.36mm	145	3%	97%	3.38%
pan	169	3%	100%	0.00%
Total	5000			

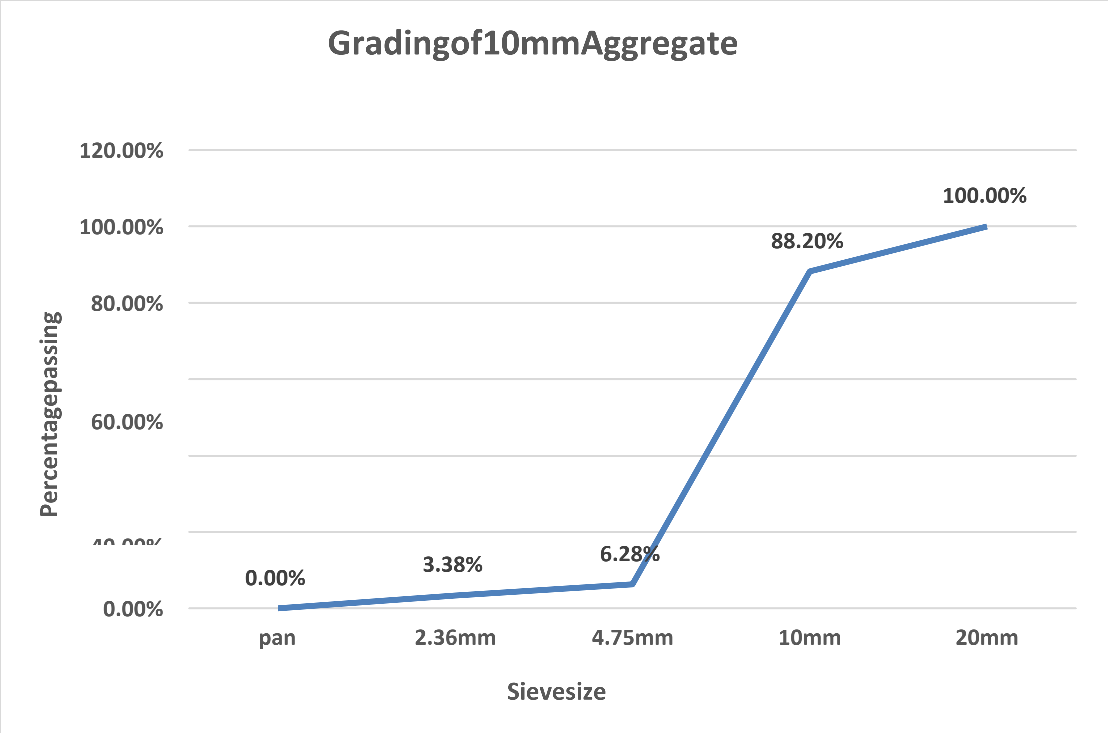

Fig.3Gradingof10mmaggregate

Table7Gradingof MixedAggregate

SieveSize	**AggregateSize**		**BlendedAggregate**	**DesiredProportion**
	20mm(50%)	**10mm(50%)**		
40mm	100.0%	100.00%	100.00%	100
20mm	73.9%	100.00%	86.95%	90 to 100
10mm	4.1%	88.20%	46.15%	25 to 55
4.75mm	0	6.28%	3.14%	0 to10

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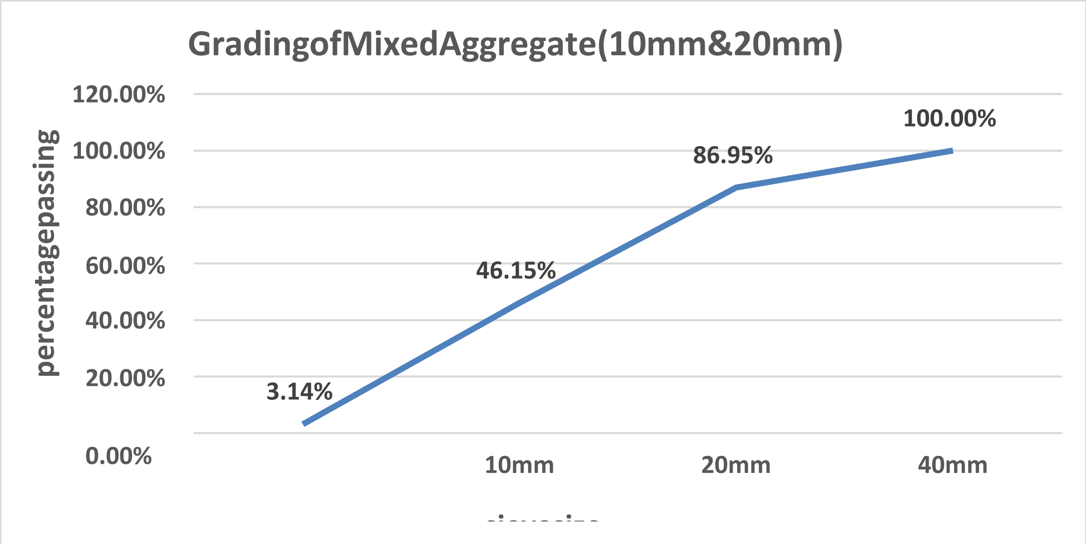

Fig.4GradingofMixedaggregate10mmand 20mm

Table8Grading of allin aggregate

SieveSize	Aggregate(66 %)	Sand(34%)	BlendedProportion	DesiredProportion
40mm	100.00%	100.00%	100.00%	100
20mm	86.95%	100.00%	91.39%	95 to 100
4.75mm	3%	94.80%	34.30%	30 to 50
600µ	0%	57.80%	19.65%	10 to 35
150µ	0%	5.20%	1.77%	0 to6

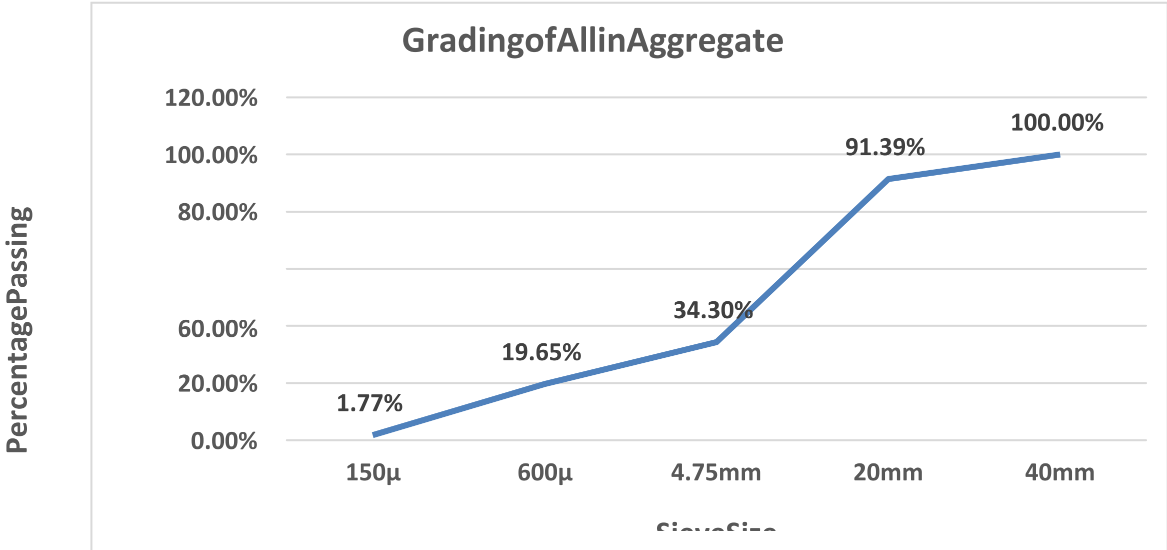

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Fig.5GradingofAllinAggregate

TestsonConcrete

Mainlytwotestsareconductedonconcrete.Firstworkabilitytestforfreshconcreteandstrengthtest for hardconcrete.

1. Concrete Workabilitytest
2. ConcreteCompressivestrengthtest
3. ConcreteSplitTensilestrengthtest

WorkabilityTest

Workability is how easily the fresh concrete can mixed, placed, and finished. TheWorkability of concrete is determined through slump cone test, as per **IS 1199**. Slumptest is conducted over fresh concrete. The slump mould has Top diameter of 100mmand Bottom of 200mm. height of mould is 300mm as per the **IS Code 1199**. Aftermixing of concrete that is filled in cone in three layers and each layer is compacted 25timesbythetampingrod.Lengthoftempingrodis600mmwithdiameterof16mm.Thevariousslump values areshown in Table4.9 for all typeof mixproportion.

Table9ValueofSlumpfordifferentconcretemixes

Mix	E-Waste(R)	Bacteria(B)	Calcium Lactate(L)	Slump(mm)
C	0%	0%	0%	78
R1	5%	0%	0%	80
R2	10%	0%	0%	83
R3	15%	0%	0%	85
R4	20%	0%	0%	88
B1	0%	3%	0%	81
B2	0%	5%	0%	88
L1	0%	0%	5%	76
L2	0%	0%	10%	72
L+B	0%	3%	5%	79
L+B+R	10%	3%	5%	84

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Results of Concrete Testing using E-Waste as a Partial Replacement of Coarse Aggregate

Compressive Strength test results by replacement of coarse aggregates by E-Waste isshown in the Table 4.10 and Fig 4.6 as well as the results of split tensile strength testareshown in Table 4.11and Fig. 4.7.

Table 10 Concrete Compressive Strength with E-Waste Used to Replace Coarse Aggregates

Mix	E-Waste(%)	Compressive Strength(MPa)	
		7 days	28 days
C	0%	28.41	41.19
R1	5%	28.83	41.78
R2	10%	29.41	42.96
R3	15%	28.38	40.3
R4	20%	27.82	39.17

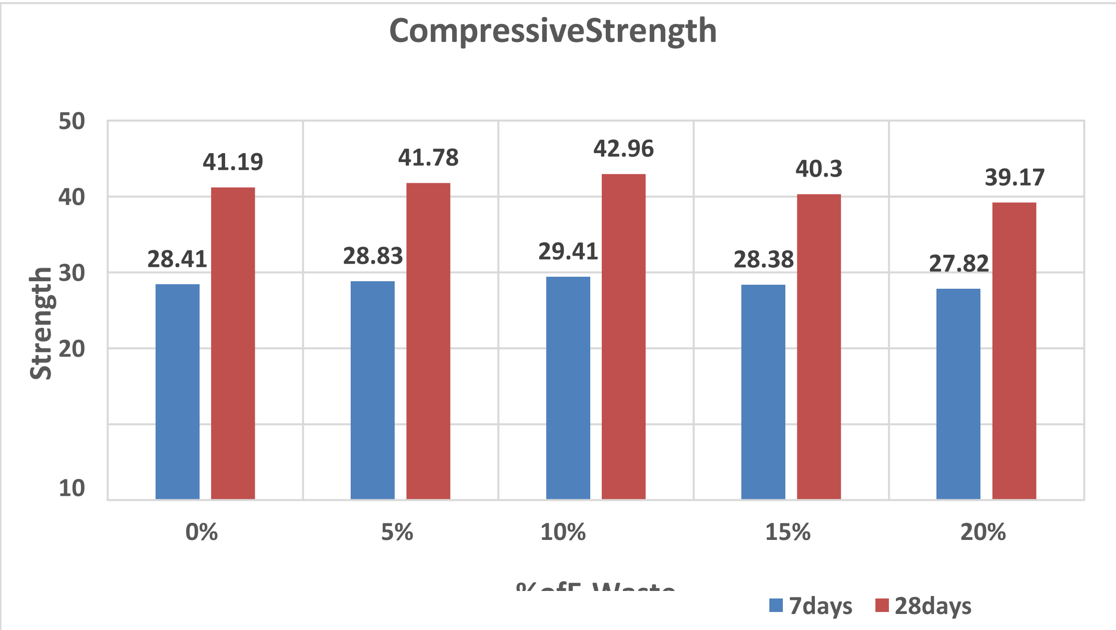

Fig.6Compressive strength over 7 and 28 days with varying E-Waste content

Table11Concrete's Split Tensile Strength When Coarse Aggregates Are Replaced With E-Waste

Mix	E-Waste(%)	Split Tensile Strength(MPa)	
		7 days	28 days
C	0%	3.77	4.29
R1	5%	3.89	4.38
R2	10%	3.96	4.44
R3	15%	3.89	4.38
R4	20%	3.71	4.24

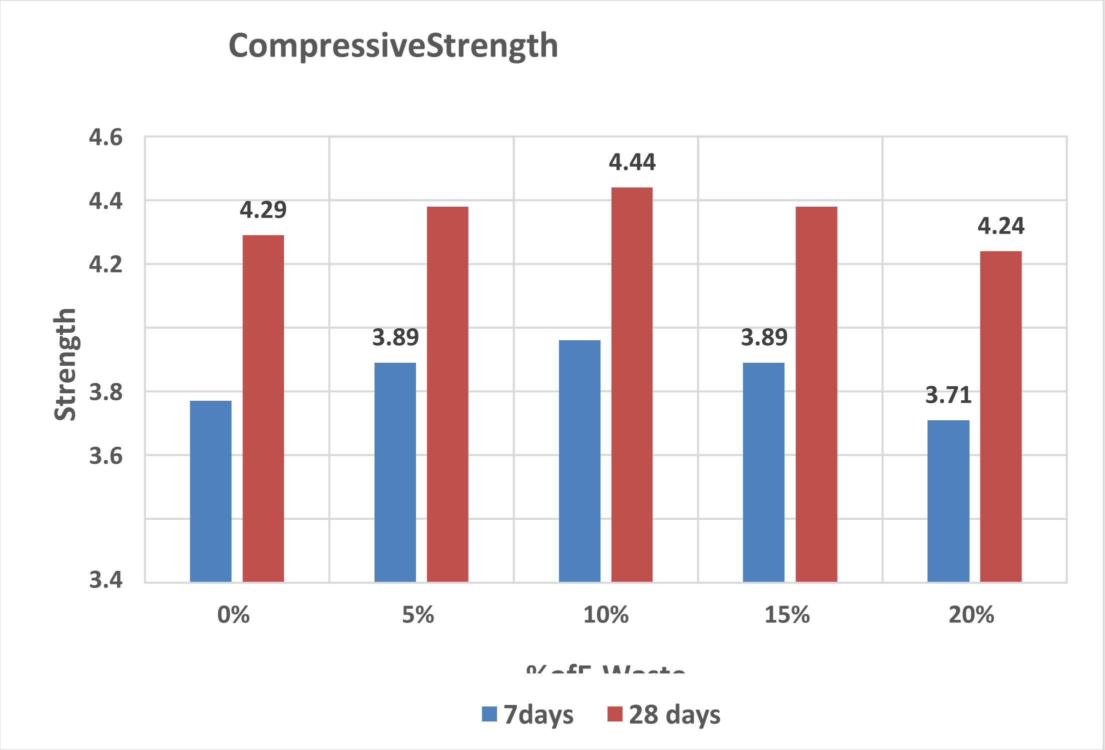

Fig. 7 Split tensile strength over 7 and 28 days with varying e-waste content

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TestResults ofConcretebyadditionofCalciumLactate

CompressiveStrengthtestresultsbyadditionofCalciumLactateisshownintheTable 4.12 andFig4.8aswellastheresultsofsplittensilestrengthtestareshowninTable 4.13 andFig.4.9.

Table 12 Results of Concrete's Compressive Strength Test after Calcium Lactate Addition

Mix	CalciumLactate(%)	Compressive Strength(MPa)	
		7 days	28 days
C	0%	28.41	41.19
L1	5%	28.34	40.36
L2	10%	21	30.48

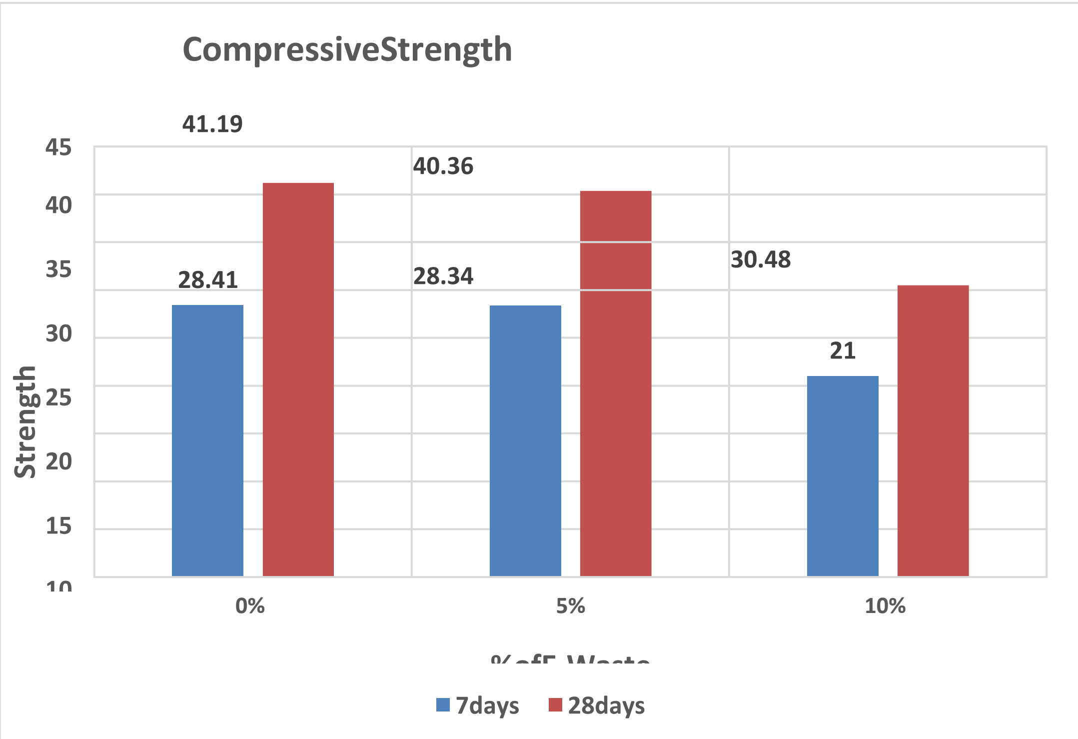

Fig.8Compressive strength over 7 and 28 days at various calcium lactate percentages

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Table 13 Concrete's split tensile strength after being strengthened with calcium lactate

Mix	CalciumLactate(%)	SplitTensileStrength(MPa)	
		7 days	28 days
C	0%	3.77	4.29
L1	5%	3.88	4.42
L2	10%	3.28	3.79

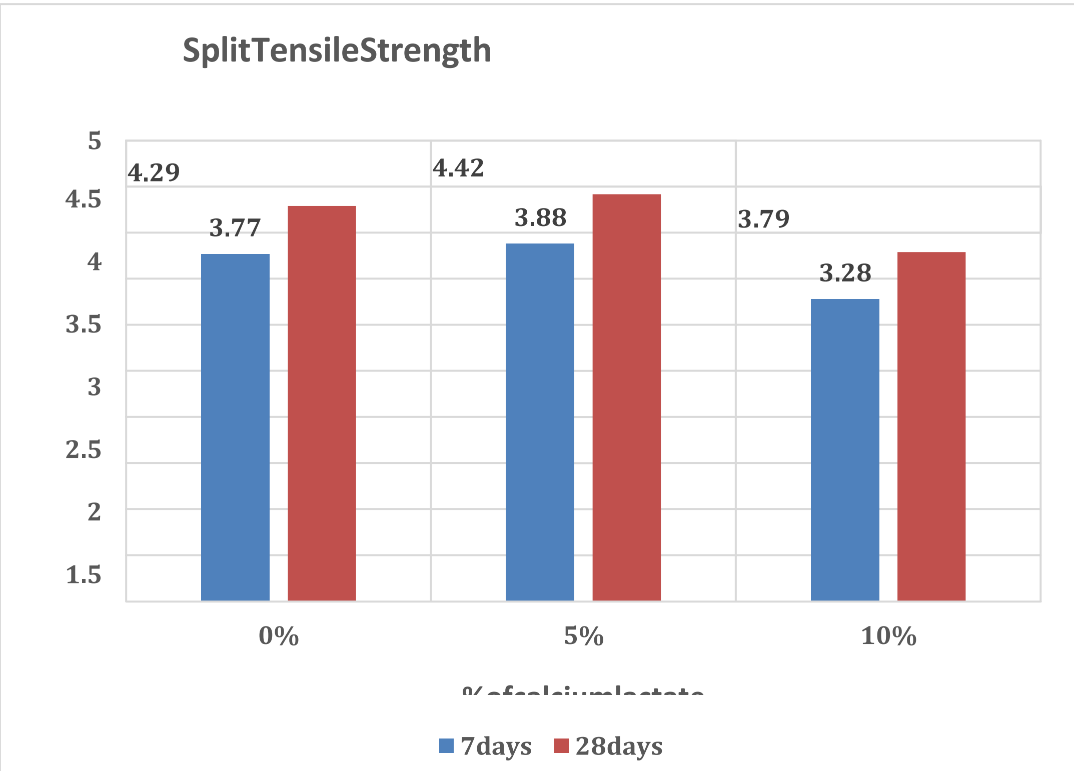

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Fig.9Compressive strength at different calcium lactate percentages after 7 and 28 days

TestResultsofConcretebyadditionofBacteria(BacillusSubtilis) Compressive Strength test results by addition of Bacteria (Bacillus Subtilis) is shownin the Table 4.14 and Fig 4.10 as well as the results of split tensile strength test areshownin Table 4.15 andFig. 4.11.

Table14Results of Concrete's Compressive Strength Test after Bacteria Addition

Mix	Bacteria(Bacillus Subtilis)(%)	Compressive Strength(MPa)	
		7 days	28 days
C	0%	28.41	41.19
B1	3%	31.17	43.91
B2	5%	26.73	37.48

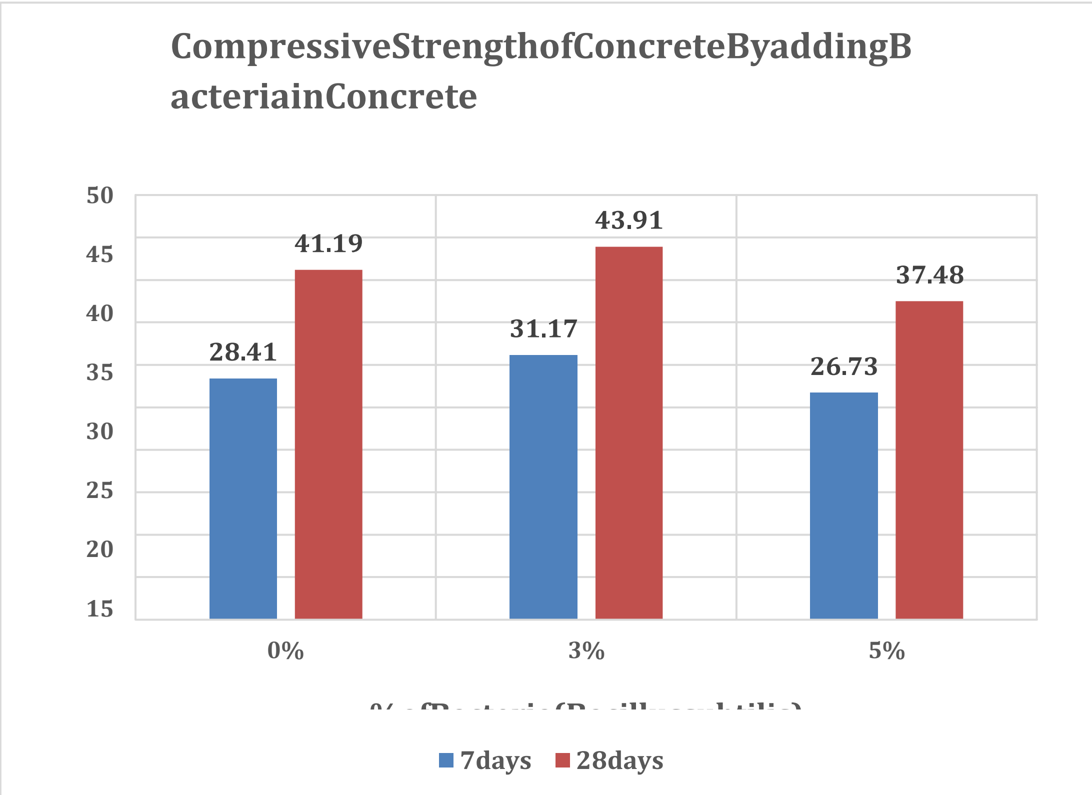

Fig.10Compressive strength at different percentages of bacteria (Bacillus Subtilis) for 7 and 28 days

Table15Concrete's split tensile strength test results when bacteria are added

Mix	**Bacteria(Bacillus Subtilis)(%)**	**SplitTensileStrength(MPa)**	
		7 days	**28 days**
C	0%	3.77	4.29
B1	3%	3.97	4.58
B2	5%	3.69	4.21

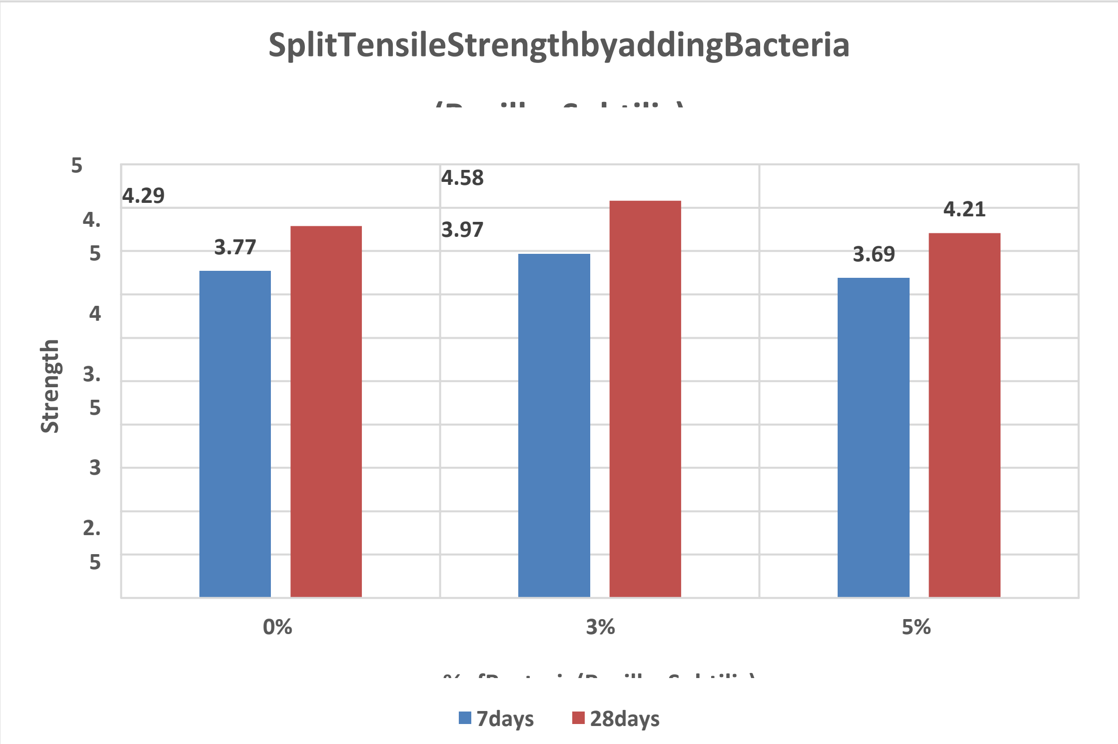

Fig.11Split tensile strength at 7 and 28 days with different bacterial concentrations (Bacillus Subtilis)

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Test Result of Concrete by combined Bacteria (Bacillus Subtilis)andCalciumLactate

TopreparetheconcretebycombiningBacteria(BacillusSubtilis)andCalciumLactatewetookthe optimumpercentagesoftheBacillusSubtilisandCalciumLactatefromtheprevious mixes prepared. Through them we got to know that 3% Bacteria gives themaximum strength and in the same way 5% Calcium Lactate gives the maximumstrength. So here a mix is prepared consists of 5% calcium Lactate and 3% Bacteria.The results are as follows. Compressive strength test results are shown in Table 4.16andFig4.12and splittensilestrengthtest isgivenin Table4.17 andFig. 4.13

Table 16 Results of Concrete's Compressive Strength Test after Adding Calcium Lactate and Bacteria

Mix	Calcium Lactate(%)	Bacteria(%)	Compressive Strength(MPa)	
			7 days	28 days
C	0%	0%	28.41	41.19
L1	5%	0%	28.34	40.36
B1	0%	3%	31.17	43.91
B+L	5%	3%	30.28	43.13

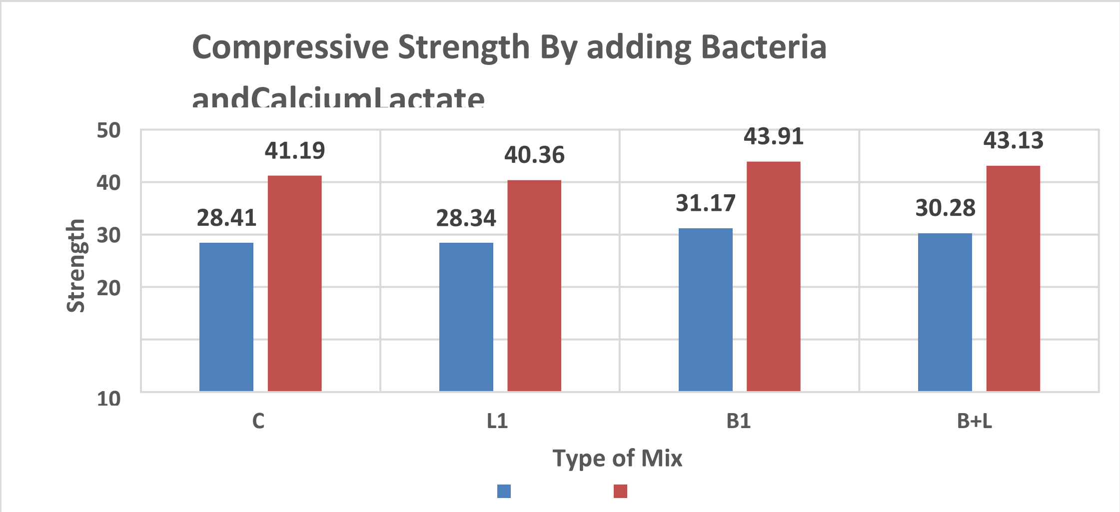

Fig. 12 7 Compressive Strength at days and 28 days with Bacteria and Calcium Lactate

Table 17 Concrete's split tensile strength after being strengthened with calcium lactate and bacteria

Mix	Calcium Lactate(%)	Bacteria(%)	SplitTensileStrength(MPa)	
			7 days	28 days
C	0%	0%	3.77	4.29
L1	5%	0%	3.88	4.42
B1	0%	3%	3.97	4.58
B+L	5%	3%	4.41	5.08

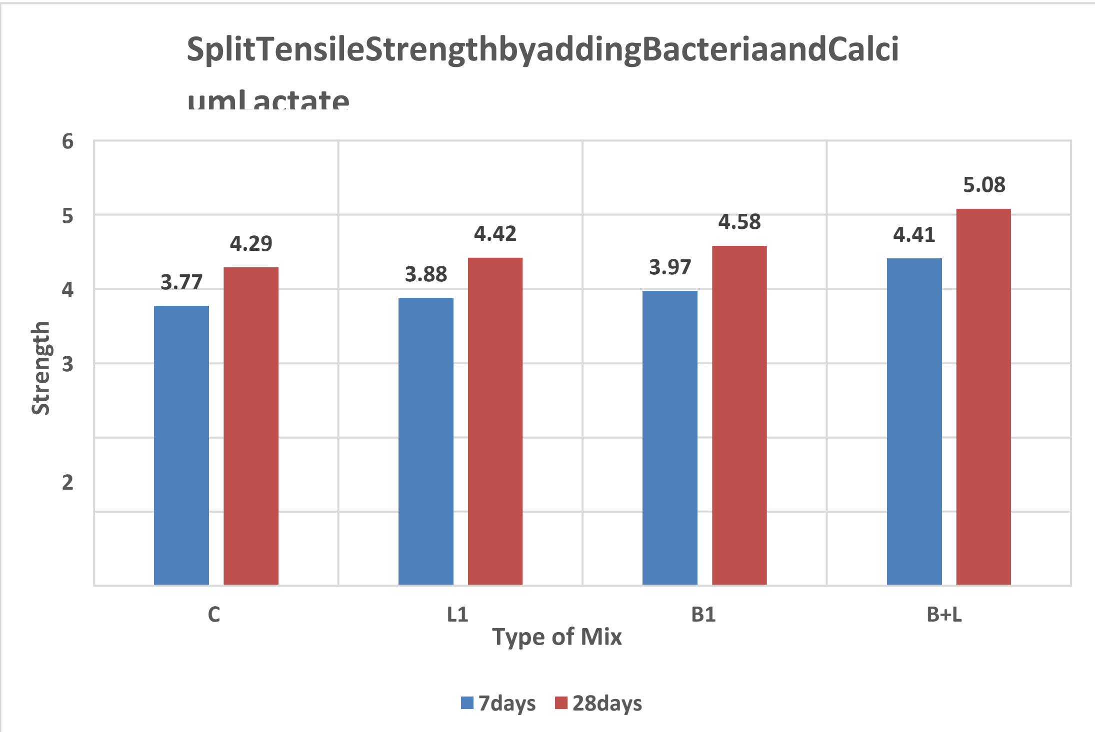

Fig. 13 Split tensile strength over 7 and 28 days when bacteria and calcium lactate are added

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Test Result of Concrete by combined Bacteria (Bacillus Subtilis),CalciumLactateandE-Waste

To prepare the concrete by adding Bacillus subtilis, Calcium Lactate and E-Waste weuse optimum of all these. Which is 3% for Bacteria (Bacillus Subtilis), 5% CalciumLactate, and 10% of E-Waste. The results are as follows. Compressive strength testresults are shown in Table 4.18 and Figure 4.14 and Split Tensile strength test resultsareshown in Table 4.19andFigure4.15.

Table 18 Concrete's compressive strength after being tested with calcium lactate, bacteria, and e-waste

Mix	Calcium Lactate(%)	Bacteria(%)	E-Waste(%)	Compressive Strength(MPa)	
				7 days	28 days
C	0%	0%	0%	28.41	41.19
L1	5%	0%	0%	31.17	43.91
B1	0%	3%	0%	28.34	40.36
B+L	5%	3%	0%	30.28	43.13
B+L+R	5%	3%	10%	31.93	44.87

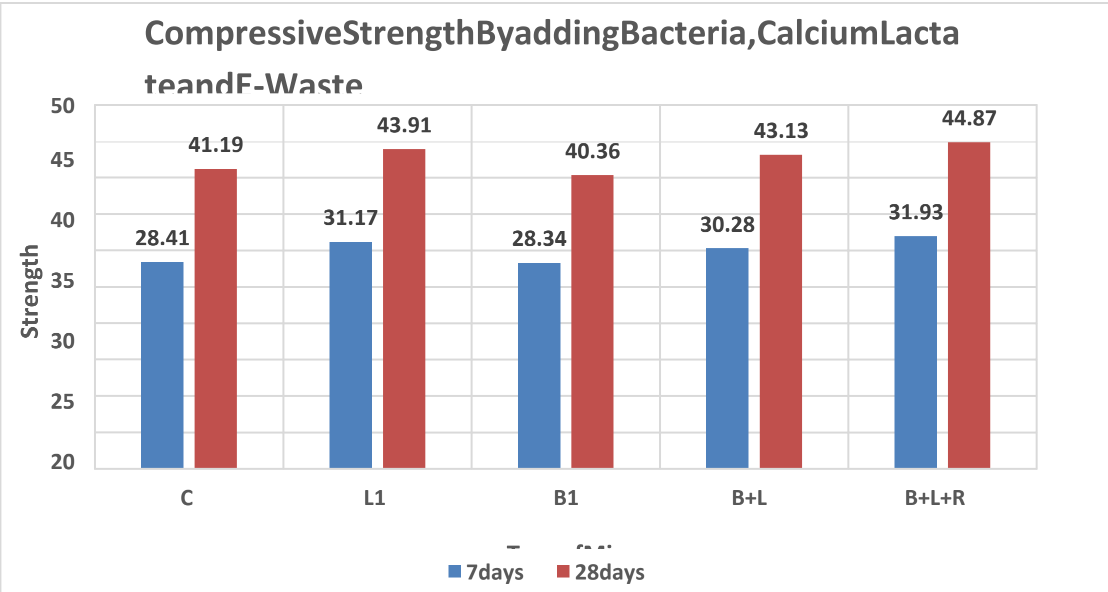

Fig.14Compressive strength for 7 and 28 days after introducing bacteria, calcium lactate, and e-waste

Table 19 Concrete's split tensile strength was tested with the addition of calcium lactate, bacteria, and e-waste.

Mix	Calcium Lactate(%)	Bacteria(%)	E-Waste(%)	Split Tensile Strength(MPa)	
				7 days	28 days
C	0%	0%	0%	3.77	4.29
L1	5%	0%	0%	3.97	4.58
B1	0%	3%	0%	3.88	4.42
B+L	5%	3%	0%	4.41	5.08
B+L+R	5%	3%	10%	4.52	5.16

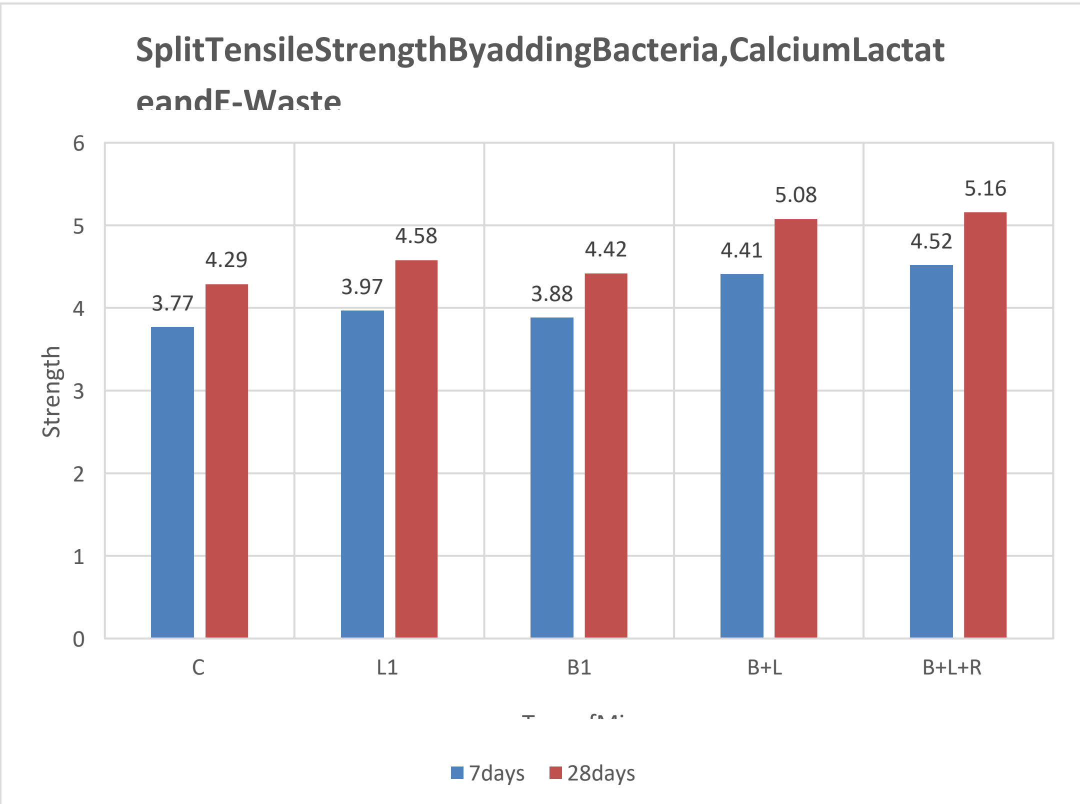

Fig. 15 Split tensile strength over 7 and 28 days when bacteria, calcium lactate, and e-waste are added

Conclusion-

The experimental study's results can be used to reach the following conclusions:

The study examined the effects of incorporating various additives into concrete and assessed their impact on compressive strength and split tensile strength. Coarse aggregates were replaced with E-plastic waste at different percentages.

The results showed that the maximum strength was observed when coarse aggregates were 10% replaced with E-plastic waste. Compared to ordinary concrete, this replacement led to a 4.30% increase in compressive strength and a 3.50% increase in split tensile strength.

However, it was noted that as the replacement percentage of coarse material with E-plastic waste increased beyond 10%, the strength started to decline.

Another aspect investigated was the addition of bacteria to concrete. When bacteria were added, the split tensile strength improved by 6.76% and the compressive strength increased by 6.6%. However, beyond a bacteria percentage of 5%, the strength began to decline.

Furthermore, the study looked into the effects of adding 5% calcium lactate to concrete. This resulted in a decrease of 2.02% in compressive strength but an increase of 3.03% in split tensile strength. However, when the percentage of calcium lactate was increased to 10%, both compressive and split tensile strengths declined.

Additionally, the combination of calcium lactate and bacteria in concrete showed positive results. Compressive strength and split tensile strength increased by 5% and 3%, respectively, resulting in increases of 4.71% and 18.41%, respectively.

Finally, the study examined the combined effects of E-plastic waste, bacteria, and calcium lactate in concrete. The addition of 10%, 3%, and 5% of E-Plastic, Bacteria, and Calcium Lactate, respectively, led to an 8.93% increase in compressive strength and a 20.28% increase in split tensile strength compared to ordinary concrete.

It is essential to note that these results provide valuable insights into the potential of these additives to enhance concrete strength, but further research is necessary to optimize their application in real-world construction scenarios.

The cost of construction was reduced by 3.44% by using E-Waste Plastic aggregates in place of coarse aggregate.

Cost research reveals that 10% of coarse aggregate can be replaced with e-waste to save $55,600 per km of road length.

Analysis reveals that the Multiple Linear Regression (MLR) model with R2=0.8948 predicts experimental compressive strength values less accurately than the Artificial Neural Network (ANN) with R2=0.9998.

It is possible to replace coarse aggregate with E-Plastic waste, bacteria, and calcium lactate when strength standards are taken into account. Consequently, it can be said that using E-Plastic Waste as coarse aggregate in concrete is a possibility.

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