A Partial Replacement of Natural Sand by M Sand in Bacterial Concrete

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***Abstract* - Concrete is used worldwide and hence the usages of its constituents play a major role in determining its health. The vast majority of it contains fine aggregate. River sand, which is readily available, is commonly used as a fine total in many countries. The increased demand for concrete has led this common sand asset to deteriorate. On the one hand, the abundant consumption of river sand has had incredibly clear natural impacts. Essentially, the amount of M Sand added by weight was 10, 20, 30 and 40% of the fine total substitution in concrete, respectively. By adding bacterial into the concrete performed well in durability and 30% of M Sand showed better performance towards strength for M20 and M40 grade of concrete.**

***Index Terms* - Bacterial Concrete, coarse aggregate, compressive strength, fine aggregate, M Sand.**

1.INTRODUCTION

Concrete is recognised to have a variety of downsides, despite its structural versatility. It is fragile under tension, has low ductility, and is crack-prone. Based on continuing research conducted around the world, various adjustments have been made from time to time to alleviate the inadequacies of cement concrete. Microbial mineral precipitation caused by the metabolic activities of beneficial bacteria in concrete has recently been discovered to reconcile concrete.

Microbiology's history bacteria are single-celled prokaryotic organisms that are tiny in size. Bacteria occur in a variety of forms and sizes.

2. BACTERIAL CONCRETE

Microbiologically induced calcite precipitation (MICP) is a science that falls under the topic of bio mineralization. Bacillus subtilis JC3, a common soil bacterium, can cause calcite precipitation. $CaCO_3$ showed potential as a microbial sealer in simulated fractures and surface fissures in granites, as well as sand consolidation. The MICP is a technology that falls within the bio mineralization domain of science. The precipitated calcite has a coarse crystalline structure that forms scales when it adheres to the concrete surface. It is very insoluble in water, as well as having the ability to continually expand upon itself. It prevents hazardous substances (chlorides, sulphates, and carbon dioxide) from penetrating the concrete, reducing the negative impact they have. Because of its ability to continuously precipitate calcite, bacterial concrete is referred to as a "Smart Biomaterial" for repairing concrete. B. Pasteurii grows best at a pH of around 9. Concrete's alkaline environment, with a pH of around 12, is a significant obstacle to bacterial growth. Figure 1 shows a magnified view showing rod-shaped imprints scattered around the calcite crystals, which are compatible with the size of B. Pasteurii.

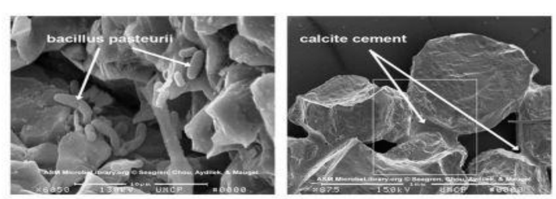

Figure 1: Magnified image of B.Pasteurii

3. OBJECTIVE OF THE PRESENT INVESTIGATION

1. Bacterial Growth
2. To optimize the percentage of MSand.
3. To investigate concrete's compressive and split tensile strengths.
4. To investigate concrete's stress-stain behaviour.
5. The purpose of this phase is to investigate the strength of cement mortar.

4. MATERIALS USED

Cement: Locally available cement utilized for evaluating the physical properties as shown in table 1.Fineness of cement is 6%.

Table: 1 Properties of cement

S.No.	Description	Test Result
1	Grade used	53
2	Fineness of the cement	6%
3	Consistency	28%
4	Initial setting time	25min
5	Final setting time	460+
6	Specific gravity	3.14

Fine aggregate: Locally available river sand utilised and it belongs to Zone II.

M Sand: M Sand obtained from locally available quarry and confirms to Zone II. 10, 20, 30 and 40% of M sand replaced with river sand and determined the optimum percentage.

Coarse aggregate: The aggregate used was locally accessible and had a nominal size of 20mmand table 2 represents the properties of fine and coarse aggregate.

Table: 2Properties of fine and coarse aggregate

S.No	Property	Fine aggregate	Coarse aggregate
1	Specific gravity	2.65	2.70
2	Loose density	1439 Kg/m3	1439 Kg/m3
3	Rodded	1622 Kg/m3	1610 Kg/m3

Water: Fresh potable water is utilised for mixing and curing.

Bacteria:Bacillus subtilis JC3 is a laboratory-grown bacterium.

5. MIX DESIGN

IS: 10262-2019 is used to calculate the mix proportions for 1: 2.43: 3.48: 0.55 for M20 and 1: 1.76: 2.71: 0.45 for M40 grade of concrete.

6. GROWTH OF BACTERIA

The pure culture of JC3 Bacillus subtilis was isolated from a JNTUH soil sample and is maintained on nutrient agar slants at all times. It forms uneven dry white colonies on nutrient agar plates. Whenever needed, a single colony of the culture is inoculated into 25 mL of nutrient broth in a 100 mL conical flask, and the growth conditions are preserved at 37℃ with a 125 rpm orbital shaker (Fig. 2).

Figure 2: B.Subtilis incubation

Specimen preparation

IS: 4031(Part 6)-2000 is used to cast standard cubes measuring 70.7mm x 70.7mm x 70.7mm. The cement-to-sand ratio is 1:3. (by weight). To manufacture cement sand paste, the needed amount of microorganisms and media (104 cells/ml of mixing water, 105 cells/ml of mixing water, 106 cells/ml of mixing water, 107 cells/ml of mixing water) are mixed and added to the cement sand mix. Water is used to cure all of the specimens.

Ingredients of M20 and M40 grade concrete

Mix proportions for M20 and M40 grade concrete were arrived at for the different replacement levels of natural sand with manufactured sand as ten increments. This meant considering the specific gravity and fineness modulus values of each replacement level of manufactured sand. In the process, the mixes were named as A, B, C, D, E, F, G, H, I, J and K for 0 to 100% respectively. Mix proportions of M 20 and M 40 grade concrete are given in Table 3 and 4.

Table: 3Ingredients of M20 grade concrete

D	CEMENT	FA	CA	WATER	A/C RATIO	FA : CA	FA : CA
A	372	550.56	1242.48	197.16	4.82	30 :70	1:2.26
B	372	550.56	1253.64	197.16	4.85	30 :70	1:2.28
C	372	550.56	1223.88	197.16	4.77	31 :69	1:2.23
D	372	587.76	1197.84	193.44	4.80	33:67	1:2.04
E	372	587.76	1197.84	189.72	4.80	33:67	1:2.04
F	372	591.48	1197.84	189.72	4.81	33:67	1:2.03
G	372	617.52	1197.84	186.00	4.88	34 :66	1:1.94
H	372	617.52	1197.84	186.00	4.88	34 :66	1:1.94
I	372	613.80	1197.84	182.28	4.87	34 :66	1:1.94
J	372	602.64	1197.84	182.28	4.84	33:67	1:1.99
K	372	595.20	1223.88	182.28	4.88	33:67	1:2.00

Table: 4 Ingredients of M40 grade concrete

D	CEMENT	FA	CA	WATER	A/C RATIO	FA : CA	FA : CA
A	404.35	529.38	1247.81	197.39	4.40	30:70	1:2.36
B	404.35	526.66	1247.80	196.03	4.39	30:70	1:2.37
C	404.35	539.17	1220.88	193.13	4.35	31:69	1:2.26
D	404.35	565.67	1193.76	191.72	4.35	32:68	1:2.11
E	404.35	566.57	1193.77	191.23	4.35	32:68	1:2.11
F	404.35	570.31	1193.78	189.74	4.36	32:68	1: 2.09
G	404.35	595.13	1193.78	187.34	4.42	33:67	1:2.01
H	404.35	593.22	1193.78	186.51	4.42	33:67	1:2.01
I	404.35	594.11	1193.78	183.87	4.42	33:67	1:2.01
J	404.35	592.74	1193.78	181.80	4.38	33:67	1:2.06
K	404.35	578.90	1193.78	178.52	4.42	33:67	1:2.01

It is found that the particle sizes of manufactured sand for the proportions A to H lie within the lower and upper limits. But the proportions I, J and K (80, 90 and 100% manufactured sand) exceed the upper limit. This represents that the finer fractions below 300 microns are higher in these proportions, which may affect the workability and the strength of the concrete.

According to this study, the gradation of manufactured sand, the increased amount of aggregate/cement ratio and the decreased amount of water cement ratio may limit the workability of concrete while increasing its strength. The inclusion of large amounts of particles in produced sand in proportions of 80, 90 and 100 percent may diminish the strength of the concrete.

7. RESULTS AND DISCUSSION

Compressive Strength

The cube specimens of size 150 mm x 150 mm x 150 mm are tested and the results are furnished. Table 5 to 10 represents the compressive strength of concrete.

Table: 5Compressive strength of BS at 7 &28 days

S.No.	BACILLUS SUBTILIS	Compressive strength, N/mm^2	
		M20	
		7 days	28 days
1	0	19.97	28.85
2	104 Cells/ml	22.98	32.88
3	105 Cells/ml	24.04	33.77
4	106 Cells/ml	21.13	30.22

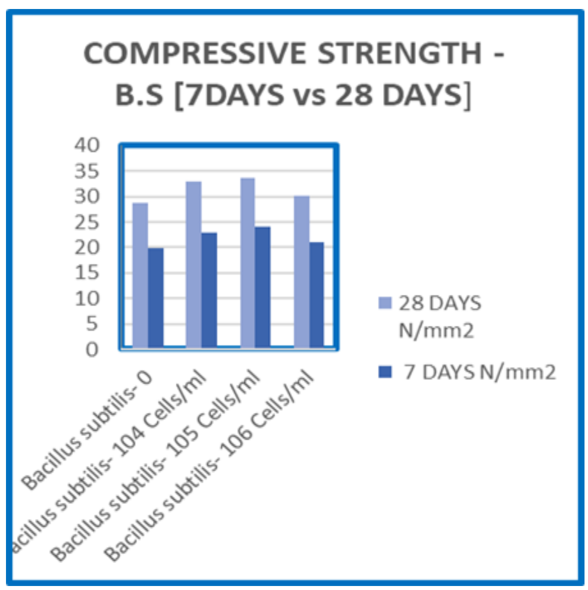

Figure 4: Compressive strength Graph of BS at 7 &28 days

Table: 6 compressive strength of M-SAND at 7 & 28 days

1	0%	19.97	28.85
2	10%	21.01	30.37
3	20%	22.95	32.84
4	30%	23.64	34.98
5	40%	23.20	33.87

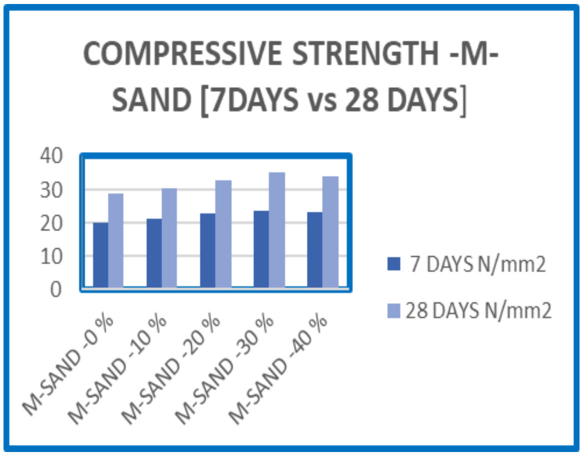

Figure 5: Compressive strength Graph of M-SAND at 7 &28 days

Table: 7Compressive strength of optimum Replacements for BS & M SAND

S.NO	COMBINED REPLACEMENTS	7 DAYS N/mm^2	28 DAYS N/mm^2
1	0%	35.35	51.05
2	105 Cells/ml	47.18	67.51

Table: 8 Compressive of strength of BS for m-40 at 7 & 28 days

S.NO	BACILLUS	7	28
1	0	35.35	51.05
2	104 Cells/ml	40.66	58.22
3	105 Cells/ml	42.46	60.24
4	106 Cells/ml	37.71	53.88

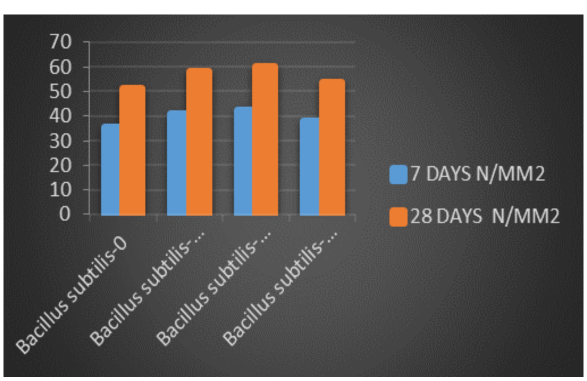

Figure 6: COMPRESSIVE STRENGTH Graph of BS at 7 &28 days

Table: 9Compressive of strength of M-SAND for m-40 at 7 & 28 days

S.NO	M-	7 DAYSN/mm^2	28
1	0%	35.35	51.05
2	10%	37.74	54.54
3	20%	41.17	58.48
4	30%	43.97	62.91
5	40%	42.12	60.96

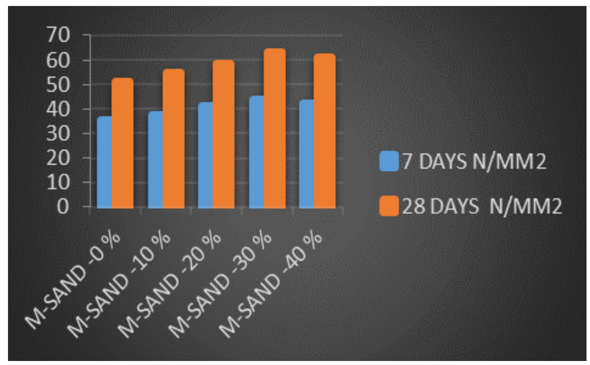

Figure 7: COMPRESSIVE STRENGTH Graph of M-SAND at 7 &28 days

S.NO	COMBINED	7	28
1	0%	19.97	28.85
2	105 Cells/ml	26.16	37.43

Table: 10Optimum compressive of strength of M-SAND & BS for m-40 at 7 & 28 days

8. CONCLUSIONS

1. Durability of concrete is increased due to usage of bacteria in concrete and eco- friendly.
2. Enhancement of compressive strength is observed.
3. In bacterial concrete interconnectivity of pores is disturbed.
4. The optimum combined replacements are noted at 105 Cells/mlof Bacillus subtilis and 30% M-sand at 7 and 28 days are 26.16 and 37.43 N/mm^2
5. The compressive strength bacillus subtils and M-sand shown satisfactory results at both M-20 and M-40 Grades of concrete
6. Optimum Replacements shown 12 % improvements for M-20 Grade of concrete

7. For M-40 Grade concrete the optimum values shown greater performance at 30 % of Msandand105 Cells/ml of BS is 11.05 %

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