IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Experimental Investigation on Bacterial Concrete with M Sand

[1]J. Sree Naga Chaitanya, [2]Dr.K.Chandramouli, [3]Dr.N.Pannirselvam, [4]Dr.D.Vijaya Kumar,[5]T.Rajesh

[1]Assistant Professor, [2]Professor & HOD, [3]Associate Professor, [4]Principal , [5]UG Student.

[1,2,5]Department of Civil Engineering, NRI Institute of Technology, Visadala (V),Medikonduru (M), Guntur, Andhra Pradesh,India.

[3]Department of Civil Engineering, SRMIST, Kattankulathur, Chennai, TN, India.

[4]Department of Civil Engineering, kodada institute of technology and sciences for women, Telangana, India.

Abstract: Concrete is used worldwide and hence the usage of its constituents plays 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 MSand 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 MSand showed better performance towards strength for M20 and M40 grade of concrete at 28, 56 and 90 days with UPV also.

Key words: Bacterial Concrete; coarse aggregate; compressive strength; fine aggregate; flexural strength; MSand.

1. INTRODUCTION

Concrete is recognized to have a variety of downsides, despite its structural versatility. It is fragile under tension, has low ductility, and is crack-prone. Microbial mineral precipitation caused by the metabolic activities of beneficial bacteria in concrete has recently been discovered to reconcile concrete. The history of microbiology bacteria are microscopic single-celled prokaryotic creatures. Bacteria occur in a variety of forms and sizes.

2. BACTERIAL CONCRETE

Microbiologically induced calcite precipitation (MICP) is a field of research in bio mineralization. Calcite precipitation can be caused by Bacillus subtilis JC3, a common soil bacterium. In simulated cracks and surface fissures in granites, as well as sand consolidation, $CaCO_3$ showed promise as a microbial sealant. The MICP is a technique that belongs to the field of bio mineralization. When precipitated calcite clings to the concrete surface, it produces scales due to its coarse crystalline structure. 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. 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.

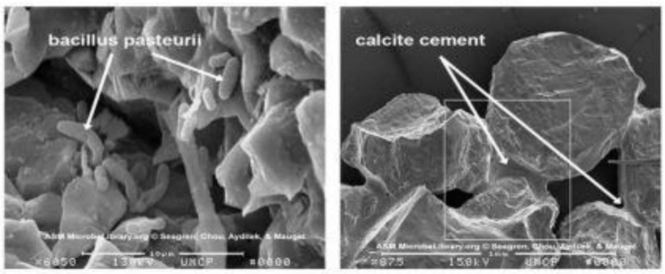

Figure 1: Magnified image of B.Pasteurii

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

4.1 Cement: Locally available cement utilized for evaluating the physical properties in table 1.

Table 1. Properties of cement

Description	Test Result
Grade used	53
Fineness of the cement	6%
Consistency	28%
Initial setting time	25min
Final setting time	460+
Specific gravity	3.14

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

4.3 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.

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

Table 2. Properties of fine and coarse aggregate

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.65	2.70
Loose density, kg/m^3	1439	1439
Rodded, kg/m^3	1622	1610

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

4.6 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 JC3 Bacillus subtilis pure culture was isolated from a JNTUH soil sample and is kept on nutrient agar slants at all times. On nutrient agar plates, it develops irregular dry white colonies. A single colony of the culture is injected into 25 mL of nutrient broth in a 100 mL conical flask as needed, and the growth conditions are maintained at 37°C using a 125 rpm orbital shaker (Fig. 2).

Figure 2: B.Subtilis incubation

7. 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). 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 combined and added to the cement sand mix to make cement sand paste. All of the specimens are cured with water.

7.1 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 3. Ingredients 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.

8. RESULTS AND DISCUSSION

8.1 Compressive strength

The cube specimens were cast, cured and are tested. Table 5 to 10 represents the compressive strength of concrete.

Figure 3. Testing of cube specimen

Table 5. Compressive strength of BS for M20

Bacillus subtilis	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0	28.85	31.19	33.56
104 Cells/ml	32.88	35.70	38.29
105 Cells/ml	33.77	36.94	39.51
106 Cells/ml	30.22	32.90	35.31

Table 6. Compressive strength of M-Sand for M20

M-Sand	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0%	28.85	31.19	33.56
10%	30.37	32.87	35.24
20%	32.84	35.67	38.24
30%	34.98	38.05	40.88
40%	33.87	36.88	39.62

Table 7. Compressive strength of optimum replacements for BS & M-Sand for M20

Combined replacements	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0%	28.85	31.19	33.56
105 Cells/ml BS+30%MS	37.43	40.78	43.78

Table 8. Compressive of strength of BS for m-40

Bacillus subtilis	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0	51.05	55.52	59.58
104 Cells/ml	58.22	63.07	68.01
105 Cells/ml	60.24	65.39	70.45
106 Cells/ml	53.88	58.11	63.01

Table 9. Compressive of strength of M-Sand for m-40

M-Sand	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0%	51.05	55.52	59.58
10%	54.54	59.07	63.72
20%	58.48	63.53	68.37
30%	62.91	67.94	73.51
40%	60.96	66.30	71.29

Table 10. Optimum compressive of strength of M-Sand & BS for m-40

Combined replacements	Compressive strength, N/mm^2		
	28 days	56 days	90 days
0%	51.05	55.52	59.58
105 Cells/ml BS+30%MS	67.51	73.92	79.82

8.2 Split tensile strength

The split tensile strength test has been conducted on concrete with different sizes of coarse aggregate and curing carried out. Table 11 to 16 represents the split tensile strength of concrete.

Table 11. Split tensile strength of BS for M20

Bacillus subtilis	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0	2.80	3.02	3.25
104 Cells/ml	3.17	3.43	3.69
105 Cells/ml	3.33	3.62	3.89
106 Cells/ml	**2.90**	**3.15**	**3.38**

Table: 12 Split tensile strength of M- Sand for M20

M-Sand	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0%	2.80	3.02	3.25
10%	3.00	3.17	3.49
20%	3.23	3.51	3.77
30%	3.67	4.01	4.29
40%	3.37	3.67	3.93

Table 13. Split tensile strength Optimum replacement of BS & M-Sand for M20

Combined replacements	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0%	2.80	3.02	3.25
105 Cells/ml BS+30%MS	3.93	4.28	4.59

Table 14. Split tensile strength of BS for M40

Bacillus subtilis	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0	5.04	5.46	5.86
104 Cells/ml	5.76	6.26	6.73
105 Cells/ml	6.32	6.88	7.34
106 Cells/ml	5.17	5.62	6.04

Table 15. Split tensile strength of M-Sand for M40

M-Sand	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0%	5.04	5.46	5.86
10%	5.39	5.85	6.29
20%	5.79	6.27	6.72
30%	6.60	7.16	7.71
40%	4.24	4.62	4.95

Table 16. Split tensile strength optimum replacement for BS & M-Sand for m-40

Combined replacements	Split tensile strength, N/mm^2		
	28 days	56 days	90 days
0%	5.04	5.46	5.86
105 Cells/ml BS+30%MS	7.23	7.83	8.49

8.3 Ultrasonic pulse velocity

The non-destructive testing for the specimens at 28 days and the destructive test was conducted on the same sample presented in table 17.

Table 17. Ultrasonic pulse velocity

Grade of concrete	UPV(m/s)
M20 (NC)	4370
M20 (BS-10%)	4637
M20 (M- SAND-30%)	4766
M20 M- SAND-30%+BS-10%	4894
M40 (NC)	4450
M40 (BS-10%)	4648
M40 (M- SAND-30%)	4794
M40 M- SAND-30%+BS-10%	4941

9. 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 for the compressive strength at 105 Cells/ml of Bacillus subtilis and 30% M-sand at 28, 56 and 90 days are 37.43, 40.78 and 43.78 N/mm^2
5. The optimum combined replacements are noted for the split tensile strength 105 Cells/ml of Bacillus subtilis and 30% M-sand at 28, 56 and 90 days are 3.93, 4.28and 4.59 N/mm^2
6. The compressive strength bacillus subtils and M-sand shown satisfactory results at both M-20 and M-40 Grades of concrete.
7. Optimum Replacements shown 12% improvements for M-20 Grade of concrete
8. For M-40 Grade concrete the optimum values shown greater performance at 30% of Msand and 105 Cells/ml of BS is 32.25 %.
9. The optimum combined replacements are noted for the UPV at 105 Cells/mlof Bacillus subtilis and 30% M-sand at 28 days are 4894 N/mm^2 for M20 grade of concrete.
10. The optimum combined replacements are noted for the UPV at 105 Cells/mlof Bacillus subtilis and 30% M-sand at 28 days are 4941 N/mm^2 for M40 grade of concrete.

REFERENCES

1. Achal, V. Mukherjee, A. Basu, P. C. Reddy, M. S. Lactose liquor as an alternative nutrient source for microbial concrete production by sporosarcina Pasteurii, Journal of industrial Microbiology and biotechnology, 36, (2009), 433-438.
2. Altamashuddinkhan Nadimalla , Siti Aliyyah Masjuki. The impact of manufactured sand (m-sand) as partially and fully replacement of fine aggregate in concrete, ASTESJ, 1(5), (2020), 302-306.
3. Baek, K. H. Yoon, B. D. Kim, B. H. Cho, D. H. Lee, I. S. Oh, H. M. Monitoring of microbial diversity and activity during bioremediation of crude oil contaminated soil with different treatments, Journal of Microbiology Biotechnology, 17, (2007), 67–73.
4. Bains, A. Dhami, N. Mukherjee, A. Reddy, M. Influence of exopolymeric materials on bacterially induced mineralization of carbonates, Appl. Biochem. Biotechnol, 175, (2015) 3531–3541.
5. Bastian, F. Alabouvette, C. Saiz-Jimenez, C. Bacteria and free-living amoeba in the Lascaux Cave. Res. Microbiol. 160, (2009), 38–40.
6. Bharanedharan, G. Logesh, S. Studies on self-healing sustainable concrete using bacterial carbonate precipitate, IJAER, 24(13), (2018), 16719-16728.
7. Dhiraj ahiwale. Rushikesh Khartode. Determination of bacterial concrete strength using bacillus subtilis and light weight expandable clay aggregate, AJAS, 2(5), (2021), 25-29.
8. Ercole, C. Cacchio, P. Botta, A. Centi, V. Lepidi, A. Bacterially induced mineralization of calcium carbonate: the role of exopolysaccharides and capsular polysaccharides. Micros. Microanal. 13, (2007), 42–50.
9. El zbieta Stanaszek-Toma. Bacterial concrete as a sustainable building material, MDPI, 6(12), (2020), 1-13.
10. Gandhimathi .A, and Vigneswari. N. Experimental study on self –healing concrete, ETER, 32(1), (2012), 17-28.
11. Jian,C., Ivanov, V. Biocement- A new sustainable and energy saving material for construction and waste treatment, Civil Engineering Research, 7, (2009), 53-54.
12. Kalyana Chakravarthy, P. R. Kalaiselvam. A. Replacement of river sand by m-sand, JAT, 2(11), (2019), 5-12.
13. Jayaraman. A, and Saravanan.M ,Comparative study on m-sand concrete and (nano-silica with m-sand concrete), IJSTER, 3(3).(2014), 444-448.
14. Lagazo, Magil A. Noriesta. Exploratory research using bacteria (bacillus subtilis) as a self-healing concrete: a basis for strengthening infrastructure in the Philippine setting, IJRTE, 1(4), (2019), 125-129.
15. MuraliKrishnan, S. Felix Kala, T. Properties of concrete using manufactured sand as fine aggregate, IJCR, 3(11), (2018), 94-100.
16. Muhd Afiq Hizami Abdullah, and Nurul Ain Harmiza Abdullah. Development and performance of bacterial self-healing concrete - A Review, IOP, 6(6), (2003), 1-10.
17. NavneetChahal, RafatSiddique, Anita Rojar, Influence of bacteria on the compressive strength, Water absorption and rapid chloride permeability of fly ash concrete. Construction and Building Materials, 28, (2012), 351-356.
18. Padmanaban.R, andAshik Ahamed. S. Use of m-sand in concrete manufacturing, mix design & quality expectations from the user industry, IJERD, 7(16), (2020),18-23.

19. RADHAKRISHNA. PRAVEEN KUMAR, K. CHARACTERISTICS OF CEMENT MORTAR WITH M-SAND AS REPLACEMENT OF FINE AGGREGATES, IJCR, 11(5), (2018), 25412-25419.
20. SAGURA .R , JAGADEESAN .R. EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF M-SAND CONCRETE BY DIFFERENT CURING METHODS, JMCE, 23(20), (2011), 19-25.
21. SeshagiriRao, M. V. Srinivasa Reddy, V. Hafsa, M. Veena, P. Anusha, P. Bioengineered Concrete- A Sustainable Self- Healing Construction Material, Research Journal of Engineering Sciences, 2(6), (2013).
22. Shubham Ajay Puranik, and Siddharth Jain. Bacterial concrete- a sustainable solution for concrete maintenance, IJITEE, 11(8), (2019), 227-232.
23. VarenyamAchal, Abhijit Mukherjee, ShwetaGoyal, and Sudhakarareddy M. Corrosion prevention of reinforced concrete with microbial calcite precipitation, Materials Journal, 109(2), (2012), 157-164.
24. SRI BHAVANA.R, AND POLU RAJU. P. EXPERIMENTAL STUDY ON BACTERIAL CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY FLY ASH, IJCIET, 4(8), (2017), 201-209.
25. SACHIN KUMARS, AND ROSHAN S KOTIAN. M-SAND, AN ALTERNATIVE TO THE RIVER SAND IN CONSTRUCTION TECHNOLOGY, IJSER, 4(9), (2018), 98-102.