An Experimental study on durability properties of bacterial concrete with nano silica.

Kodavati Divya Bharathi[1], Dhondy Rupesh Kumar[2],

[1]Research scholar, Civil Engineering Department, University college of Engineering, Osmania University, Hyderabad, Telangana.
[2]Professor, Civil Engineering Department, University college of Engineering, Osmania University, Hyderabad, Telangana.

---***---

ABSTRACT:

Rapid chloride penetration is a major issue in concrete structures, leading to corrosion and potential structural damage. Bacterial concrete has emerged as a promising solution, with bacteria added to the concrete mix producing calcium carbonate that can fill cracks and crevices to inhibit chloride penetration. However, the effectiveness of bacterial concrete can be further improved with the addition of nano silica. This abstract focuses on a study that examines the effect of nano silica on the rapid chloride penetration of bacterial concrete. The study compares the performance of bacterial concrete with and without the addition of nanosilica, analyzing the reduction in chloride penetration rate. The results show that the addition of nanosilica to bacterial concrete further reduces the rate of chloride penetration, making it a more effective solution for preventing corrosion in concrete structures. The findings have significant implications for the construction industry, as the use of bacterial concrete with nanosilica can improve the durability and sustainability of concrete structures, extending their service life. Test on Mechanical properties have perfomed with 10^5 cells/ml with nano silica (0%,0.5%,1%,1.5%,2%) on different grades of concrete(M20,M30,M40,M50),at 1.5% of nano silica with bacteria has achived higher strength, further durability studies is proceeded.

Keywords: Bacterial concrete ,bacillus subtilis, nanosilica, Rapid chloride penetration test.

INTRODUCTION:

Bacterial concrete is a new and innovative technology that utilizes bacteria to improve the strength and durability of concrete. In recent years, the addition of nanoparticles to concrete has gained significant attention due to their ability to enhance its mechanical and durability properties. One such nanoparticle is Nanosilica, which has been shown to improve the resistance of concrete to chloride penetration, a critical factor in concrete durability. The rapid chloride permeability test (RCPT) is a widely accepted method for assessing the chloride resistance of concrete. The test measures the ability of chloride ions to penetrate through the concrete under an electrical gradient. The lower the chloride penetration, the more resistant the concrete is to chloride-induced corrosion. The addition of Nanosilica to bacterial concrete has shown promising results in improving its resistance to chloride penetration. The nanoparticles fill the pores and micro-cracks in the concrete, reducing its permeability to chloride ions. The use of bacterial concrete also promotes the precipitation of calcium carbonate, which further reduces the permeability of the concrete. This combination of bacterial concrete and Nanosilica has the potential to significantly improve the durability of concrete structures, particularly in harsh environments. This introduction of new technology will help to promote sustainable infrastructure development and contribute to the reduction of carbon footprint.

Experimental Programme:

The experimental programme was designed to compare the durability properties i.e., rapid chloride penetration test of concentional concrete and bacterial concrete with nanosilica dosage (0%,0.5%,1%,1.5,2%).

MATERIALS USED:

Cement:

Cement is used as a binding material material , In the experiment, regular Portland cement of grade 53, which is readily available in local markets, is employed. The cement was tested for a number of qualities in accordance with IS:4031-1988, and it was discovered to be in compliance with a number of IS:12269- 1987 criteria, having a specific gravity of 3.12.

Coarse Aggregate:

As coarse aggregate, 20 mm nominal size crushed granite angular aggregate with a specific gravity of 2.68 is sourced locally.

Fine Aggregate:

Naturally available river sand with a specific gravity of 2.60, zone II that complies with IS-383.

Water:

Fresh potable water that complies with IS: 456 - 2000 is used for mixing and curing.

Nanosilica:

The interfacial transition zone of aggregates and the binding paste matrix grow denser and less plentiful when nano silica is used to adsorb Ca(OH)2 crystals. The matrix of the binding paste thickens, improving the long-term strength and toughness of the concrete. The nano silica particles act as a nucleus to firmly bond with the C-S-H gel particles and cover the voids in the C-S-H gel structure. Nanoscale Silica serves as both a filler to improve the microstructure of mortar and cement and a catalyst for pozzolanic processes. The specific gravity of the utilised nano silica is 1.22. Although though cementitious materials are extremely important in the construction industry, their complexity must not be overlooked.

Table :1. Shows detailed description of physical properties of Nanosilica.

S. No	Characteristics	Values obtained
1	Parameter	Cem Syn XTX
2	Active nano content	30%to 32%
3	pH (20 ^{0}C)	9-10
4	Specific gravity	1.20-1.22
5	Particle size	5-40nm

Bacteria:

Bacillus subtilis, a laboratory-cultured bacterium, is used. The sample of "*Bacillus subtilis*," a soil bacterium, was cultured by providing the mi-crobes with the right food, they evolved to meet theneeds of research at Professor Jayashankar Telangana State Agricultural University.

Culture of Bacteria:

The pure culture was continuously maintained on nutritional agar slants. On nutrient agar, it grows in uneven, dry, white colonies. Whenever necessary, Asingle colony of the culture is injected into 25 cc of nutrient broth in a conical flask measuring 100 ml, with the growth conditions kept at 37 °C and the flask being shaken at a speed of 125 rpm. Peptone (5g/l), sodium chloride (5 g/l), and yeast extract (3 g/

l) are the three components of the medium that mustbe present for the growth of the culture.

Maintenance of stock culture:

On nutritional agar slants, stock cultures of *Bacillussubtilis* were kept alive. With an inoculating loop, the culture was streaked on 37°C agar slants, and the slants were then incubated at 37°C. Slant cultures were stored under refrigeration (4 °C) for a future usage after two to three days of growth. Every 90 days, subculturing was done. On nutrient agar plates, streaking was used to screen for contamination from other microorganisms.

Rapid Chloride penetration test:

To measure the electrical conductivity of the M20, M30, M40 and M50 grade control and bacterial concrete with nano silica (0%,0.5%,1%,1.5%,2%) specimens at the age of 28 days curing, the RCPT test was carried out in accordance with ASTM C1202-12. It shows how difficult it is for chloride ions to penetrate. As illustrated in Figure.1, the test entails measuring the amount of electrical charge that passes through slices of cylindrical specimens that are 50 mm thick and 100 mm in diameter over the course of six hours. Figure 1, displays the test setup for RCPT with the required settings and the RCPT specimens.

Figure 1: **Rapid Chloride Penetration Test set up**

Two reservoirs make up the RCPT device. To make the test setup leak-proof, the specimen was attached between two reservoirs using an epoxy bonding agent. Three percent sodium chloride solution was placed in one reservoir, which was connected to the negative terminal of the DC source, and three N sodium hydroxide solution was placed in the reservoir that was attached to the positive terminal of the DC source. Two stainless steel electrodes (meshes) were used to provide a DC of 60 V across the specimen, and the current across the specimen was measured every 30 minutes for six hours. Using the trapezoidal rule from ASTM C1202-12, the total charge passed during this time was computed in terms of coulombs.

Where Q is the charge passed (in Coulombs), = the current (in amps) immediately following the application of voltage, and = the current (in amps) t minutes later. An increase in the quantity of electric charge that passed the test indicates that the concrete is more permeable to chloride ions. Based on the ASTM C1202-12 limits, the concrete's quality (degree of chloride ion penetrability) can be determined.

Table:.2. Rapid chloride penetration test ASTM C1202-12 limitations

Charge passed (Coulombs)	Chloride ion penetrability
> 4000	High
2000 - 4000	Moderate
1000 – 2000	Low
100 - 1000	Very Low
< 100	Negligible

Results and Discussion:

The Table:3 shows the rapid chloride penetration test results of control concrete, nanosilica based concrete without bacteria and bacterial concrete with nano silica, as 0% represents the control concrete and the graph is plotted in fig.2.

Table:3. Rapid chloride penetration test results.

S.NO	% of nano silica	Grade of concrete	Charge Passed (coulombs) Without	Chloride permeability as per	Charge Passed (coulombs) With bacteria	Chloride permeability as per ASTMC
1	0	M20	3515	Moderate	3200	Moderate
2	0.5		3420	Moderate	3000	Moderate
3	1		3350	Moderate	2750	Moderate
4	1.5		3200	Moderate	2550	Moderate
5	2		3160	Moderate	2250	Moderate
6	0	M30	2900	Moderate	2600	Moderate
7	0.5		2700	Moderate	2400	Moderate
8	1		2050	Moderate	1925	Low
9	1.5		1925	Low	1750	Low
10	2		1850	low	1650	low
11	0	M40	2500	Moderate	2200	Moderate
12	0.5		2250	Moderate	1900	Low
13	1		2100	Moderate	1700	Low

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 10 | Oct 2023 www.irjet.net p-ISSN: 2395-0072

14	1.5		1950	Low	1650	Low
15	2		1850	Low	1500	Low
16	0	**M50**	2200	Moderate	2000	Moderate
17	0.5		2050	Moderate	1800	Low
18	1		1975	Low	1600	Low
19	1.5		1800	Low	1200	Low
20	2		1675	Low	900	Very Low

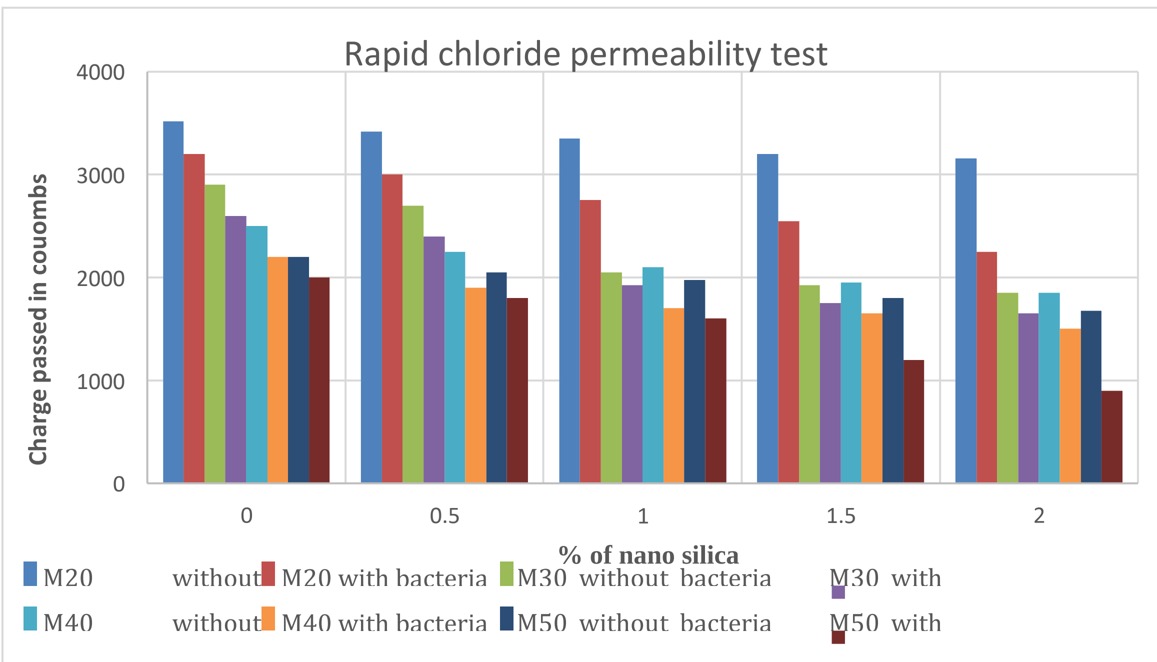

Figure:2. Rapid chloride penetration test results of with and without bacteria M20-M50 Concrete Mixes at 28 days

Conclusions:

1) As concrete strength (i.e grade) increases it becomes more denser and contains lesser pores leading to more impermeability.

2) Nano silica with its nano particles fills most of the pores available in concrete and so concrete becomes more impermeable with presence of nano silica.

3) As the percentage of nano silica is increased impermeability gets increased gradually.

4) Due to the presence of bacteria in concrete contributes towards filling the gaps and micro pores in concrete,hence bacterial concrete shows more impermeability than concrete withoutbacteria.

5) On the basis of experimental study conducted on the bacterial concrete,it is concluded that M20, M30, M40, M50 grade of concrete with Nano silica having bacteria has shown least permeability compared to control concrete and without bacteria with nanosilica.

6) From the experimental study conducted on the bacterial concrete, it is concluded that M20 to M50 grade of concrete with 1.5% and 2% of Nano silica having bacteria has shown least permeability.

References:

1. Aggarwal Paratibha, Rahul Pratap Singh and Yogesh Aggarwal 2015, 'Use of nano -silica in cement-based materials---A Review', Cogent Engineering, vol. 2, no. 1, pp.1078018.

2. S. Mondal and A. D. Ghosh, "Investigation into the optimal bacterial concentration for compressive strength enhancement of microbial concrete," Constr. Build. Mater., vol. 183, pp. 202-214,2018.

3. Bang SS, Ramakrishnan, V and Ramesh KP 2005, 'Improvement of concrete durability by bacterial mineral precipitation', Proceedings of the 11th international conference on fracture, Turin, Italy, vol. 1, pp. 2095-2100.

4. Ghosh, S, Chattopadhyay, BD and Mandai, S 2008, 'Use of hot spring bacteria for remediation of cracks and increment of durability of structures', Indian Concrete Journal, vol. 82, no. 9, pp. 11-16.

5. Sunil Pratap Reddy, S, Sehagiri Rao, MV, Apama, P and Sasikala, C 2010, 'Performance of standard grade bacterial Bacillus Subtilis concrete', Asian Journal of Civil Engineering Building and Housing, vol. 2, no. 1, pp. 43-55.

6. F. Hasan-Nattaj, M. Nematzadeh, The effect of forta-ferro and steel fibers on mechanical properties of high-strength concrete with and without silica fume and nano-silica, Constr. Build. Mater. 137 (2017) 557–572, https://doi.org/10.1016/j.conbuildmat.2017.01.078.

7. Balam, N.H.; Mostofinejad, D.; Eftekhar, M. Effects of bacterial remediation on compressive strength, water absorption, and chloride permeability of lightweight aggregate concrete. Constr. Build. Mater. 2017, 145, 107–116.