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INVESTIGATION OF BACTERIAL MORTAR FOR SUSTAINABLE STRUCTURAL REPAIR APPLICATIONS

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Abstract:
The study addresses the substantial influence of cracking on the strength and durability of concrete structures by investigating the efficacy of bacterial-based self-healing technology for fixing fractured concrete. Conventional repair techniques frequently fail to offer long-term fixes. The experiment used conventional mortar, bacterial mortar containing calcium lactate and Bacillus bacteria, and a hybrid approach to repair M30 grade concrete that had been cast with controlled cracks. The results showed that bacterial mortar functioned far better than conventional methods, regaining 90.9% of its strength as opposed to 80.8% for conventional specimens. With a reduction in breadth of almost 82% compared to 38% for conventional repairs, the bacterial mortar showed improved crack healing. It also showed reduced water absorption (2.35% vs. 4.47%), sorptivity, and chloride permeability. Bacterial repairs have exceptionally low chloride permeability (1180 Coulombs) according to the Rapid Chloride Penetration Test, compared to conventional mortar's 3120 Coulombs. Additionally, bacterial repairs demonstrated improved durability, withstanding 36 impact blows and reaching a 4.5 MPa bond strength. A balance between acute restoration and long-term healing was provided by the hybrid approach. This work presents bacterial mortar as a practical, effective, and long-lasting repair material for contemporary infrastructure rehabilitation, greatly improving strength recovery and impermeability while addressing durability through efficient fracture sealing.

Keywords:
Bacterial mortar, Crack repair, Self-healing concrete, MICP, Strength recovery, Durability.

1.Intoduction

The most common building material is concrete, which is well-known for its durability, flexibility, and compressive strength. It is essential to infrastructure, including pavements, buildings, and bridges. However, because to shrinkage, thermal strains, excessive load, fatigue, chemical attacks, and environmental exposure, it has intrinsic tension flaws that cause cracking. In addition to being unsightly, these fractures allow dangerous materials to enter, hastening the corrosion of reinforcements and reducing the lifespan of the structure [1-4].
To restore structural integrity, conventional repair techniques such as cement-based mortars, epoxy resins, and polymer-modified alternatives have been extensively employed. These techniques are expensive, labor-intensive, and require constant upkeep even though they are somewhat effective. Additionally, they neglect to fix microcracks, which results in ongoing deterioration. Self-healing concrete offers a ground-breaking, eco-friendly way to overcome the drawbacks of traditional repairs [5-7]. Among these, the capacity of bacterial-based healing materials to self-heal cracks through biological processes has attracted attention. Concrete structures can be made more durable and long-lasting by using bacterial mortar, which is a mixture of cement, certain bacteria, and nutrient sources [10].

Concrete cracking can happen at any stage, from construction to long-term use, and is mostly caused by plastic and drying shrinkage, temperature variations, structural overload, and environmental effects. Steel corrosion is accelerated by these fissures because they weaken the barriers against moisture and chloride. Crack assessments concentrate on the size and distribution of cracks, which have serious repercussions if ignored. Even though they work well, standard repair methods including surface sealing, epoxy injection, and polymer-modified mortars have drawbacks such high maintenance costs, compatibility problems, and a lack of self-healing. While cement mortars are more affordable, they may not last as long because of shrinkage and permeability issues, while epoxy restorations are more costly and less environmentally friendly.

On the other hand, bacterial mortar offers a self-sustaining method of crack healing. Concrete cracks and voids are naturally sealed by microbiologically induced calcite precipitation (MICP), which is facilitated by the bioactive component. When latent bacterial spores come into contact with moisture, they begin to metabolize nutrients and produce calcium carbonate, which builds up in cracks and improves the durability and integrity of the concrete. Autogenous healing, which entails continuous hydration and carbonation, is responsible for the self-healing concrete's capacity to fix cracks on its own. This healing is restricted to fractures less than 0.2 mm, according to early research, most notably by Edvardsen (1999) [8]. According to Li et al. (2012), engineered self-healing systems are crucial for addressing broader cracks. Van Tittelboom and De Belie (2013) determined that bacterial-based solutions are extremely effective and sustainable among diverse therapeutic techniques [6]. Since Ramachandran et al. (2001) first showed that microorganisms may precipitate calcium carbonate in concrete, research has focused on finding appropriate bacterial species for concrete rehabilitation [11]. Certain bacteria, such as Bacillus subtilis and Bacillus sphaericus, flourish in the alkaline environment of concrete, while Bacillus megaterium has demonstrated potent crack-repairing ability (Jonkers et al. 2010) [22].

Crack healing in bacterial mortar is mainly caused by MICP. According to De Muynck et al. (2008), this process creates calcium carbonate crystals by mixing carbonate ions from bacterial metabolism with calcium ions [9]. These precipitates improve microstructure and durability by filling up pores and cracks (Achal et al., 2011; Wang et al., 2014) [13]. According to several studies, calcium carbonate precipitation can effectively seal cracks in bacterial cement up to 0.5 mm (Wang et al., 2012) [26], increase compressive strength by 10–20% (Ghosh et al., 2009) [19], and improve bacterial resistance to water and chloride permeability (Jonkers and Schlangen, 2007) [20].

According to research, bacterial mortar can restore up to 80–90% of the initial flexural strength in cracked specimens while also dramatically reducing water permeability (Vijay et al., 2017) [25]. In comparison to conventional repairs, hybrid systems that incorporate bacterial mortar with conventional repair mortars have shown improved durability and decreased crack recurrence (Wang and De Belie, 2016; Xu and Yao, 2014).

There are still issues, though, like dependence on moisture (De Muynck et al., 2010) and reduced early-age strength with increased bacterial doses (Jonkers, 2011). The lack of consistent mixing techniques and long-term performance data in previous studies calls for additional research. There are gaps in the literature about the use of bacterial mortar to repair damaged structures, inadequate comparison with conventional techniques, and ambiguous deployment protocols.

In conclusion, more study is required to enable the practical deployment of bacterial agents in the construction industry, even though they exhibit promise for improving the durability and repair capabilities of concrete.

Investigating several facets of bacterial mortar in concrete repair is the goal of this study. The main goals are to determine how well bacterial mortar fixes broken concrete members; investigate how bacterial mortar interacts with conventional repair mortar; assess how well restored specimens recover compressive, split tensile, and flexural strength; and investigate whether bacterial mortar can reduce crack width and repair cracks. To assess the durability performance of the repair materials, the study will also include tests such sorptivity, water absorption, and the RCPT. Additionally, the concrete specimens impact resistance and bond strength will be evaluated. Additionally, the study looks into the sustainable and ecologically friendly uses of bacterial mortar in concrete structure repairs while analyzing hybrid repair systems that combine conventional and bacterial mortars.

2. Materials & Methods

This section describes the supplies and techniques for employing bacterial mortar and hybrid methods to fix broken concrete. It places a strong emphasis on following Indian standards to ensure consistent results. The study compares the utilization of bacteria-driven self-healing processes in repair materials with conventional concrete. Control samples are made, cracks are created, repair mortars are applied, and mechanical and durability qualities are assessed under controlled circumstances.

2.1 Cement
Ordinary Portland Cement (OPC) with a grade of 53, which complies with IS 12269, was used in the experimental program to cast concrete and make conventional and bacterial repair mortars. OPC was maintained in sealed containers to minimize moisture absorption and was selected since it is widely used in construction. Testing verified that the cement satisfied IS 4031 requirements for specific gravity of 3.15, standard consistency of 30%, initial setting time of 60 minutes, ultimate setting time of 360 minutes, and fineness of 8%.
2.2 Fine aggregates
In order to achieve the best packing density and workability, naturally existing river sand that matched IS 383's Zone II grading was used as fine aggregate. It had a specific gravity of 2.62 and had been purified of impurities.
2.3 Coarse aggregates
According to IS 383, coarse aggregate was made up of crushed angular material with a maximum size of 20 mm, a specific gravity of 2.65, and a water absorption rate of 1%.
2.4 Water
For mixing and curing, portable tap water that complied with IS 456 was utilized.
2.5 Bacteria Utilized
The Bacillus genus, more especially Bacillus subtilis or Bacillus pasteurii, which can flourish in the alkaline conditions of concrete, was the bacterial agent used. Through MICP, this bacterium can create calcium carbonate ($CaCO_3$), which improves durability and allows for crack closure.
The nutrient medium, calcium lactate, was essential for promoting bacterial activity. Its non-toxicity, effectiveness, and suitability for concrete led to its selection.
Two types of mortar were developed: bacterial mortar, which incorporated a bacterial solution as a partial mixing water replacement to impart self-healing capabilities, and standard repair mortar, which used OPC and fine aggregate in a 1:3 ratio with a water-cement ratio of 0.40.

Table 1 Typical Bacterial Mortar Composition

Component	Proportion
Cement	1 part
Fine aggregate	3 parts
Bacterial solution	Partial replacement of mixing water
Nutrient medium	0.5–1% of cement weight

In order to address both immediate strength and long-term self-healing capabilities, a hybrid repair mortar was also created, integrating the best qualities of both conventional and bacterial mortars, offering improved performance and durability over single techniques.
2.6 Concrete specimens casting & curing process
All specimens in the recorded study were cast using grade M30 concrete, and the mix design adhered to IS 10262 to guarantee the desired mean strength, workability, and durability. Strength and exposure factors led to the selection of a water-to-cement ratio of 0.45. According to Table 3.6, the precise proportions of the concrete mix were 380 kg of cement, 650 kg of fine aggregate, 1200 kg of coarse material, and 171 kg of water.
The purpose of the specimen preparation was to assess the durability and mechanical properties of both restored and fractured concrete elements. To evaluate compressive, tensile, and flexural characteristics, a variety of standard specimen types were cast. As shown in Table 3.7, the chosen sizes are consistent with Indian Standards. These specimens were subjected to the following tests:

- To evaluate strength recovery following repair, perform a compressive strength test on cubes of 150 mm by 150 mm.
- To examine tensile strength behavior, do the Split Tensile Strength Test on cylinders measuring 150 mm by 300 mm.
- Flexural strength test on prism beams (100 mm x 100 mm x 500 mm) with an emphasis on crack resistance and bending strength.
- Water Absorption Test on cubes (150 mm x 150 mm) to evaluate durability and permeability.

- Capillary water absorption characteristics are assessed using the Sorptivity Test on cylinders.
- To assess the resistance to chloride ion penetration, disc specimens of 100 mm in diameter by 50 mm in thickness are subjected to the Rapid Chloride Penetration assess (RCPT).
- Bond Strength Test on cubes (150 mm x 150 mm) to gauge how well repair mortar and parent concrete bond.
- To investigate toughness and energy absorption capacity, disc specimens of 150 mm in diameter and 50 mm in thickness were subjected to an impact resistance test.

According to Table 3.8, specimens were divided into four different types:
An uncracked and unrepaired reference is represented by the CTRL (Control Specimen). Conventional cement-based mortar was used to fix the cracked specimen.
Bacterial Repair, or BAC, involves applying nutrient-rich bacterial cement to a cracked specimen.HYB (Hybrid Repair): This method uses a combination of bacterial and conventional repair processes to fix a cracked specimen.

Figure 1 Casting of specimens

Table 3.9 provides additional information about the material composition of each type of specimen, showing differences in the percentages of cement, fine aggregate, water, bacteria, and nutrients. For instance, the HYB (Hybrid Repair) contains lesser percentages of these additives, allowing for a balance between traditional and cutting-edge repair methods, while the BAC (Bacterial Repair) uses 1-2% bacteria and 0.5-1% nutrients in a repair mortar with partial substitution.

Table 2 Material Composition (%) for Each Specimen Type

Specimen Type	**Bacteria (%)**	**Nutrient (%)**	**Description**
CTRL (Control)	0	0	Conventional concrete without cracks or repair
CON (Conventional Repair)	0	0	Cement-based repair mortar without bacteria
BAC (Bacterial Repair)	1–2%	0.5–1%	Repair mortar with bacterial solution and nutrient
HYB (Hybrid Repair)	0.5–1%	0.25–0.5%	Combination of conventional and bacterial mortar

2.7 Test programs

The water absorption test, sorptivity test, rapid chloride penetration test (RCPT), bond strength test, and impact resistance test are the main tests used to assess the permeability characteristics and durability of repaired concrete specimens.

2.7.1 Water Absorption Test

This test gauges the durability of concrete by measuring how much water it absorbs. After 24 hours of drying at 105 ± 5°C, 150 mm cube specimens were immersed in clean water for an additional 24 hours. The formula
Water Absorption (%) = (W2 - W1) / W1 × 100,
where W1 is the dry weight and W2 is the wet weight, was used to determine the percentage of water absorption. Because calcium carbonate precipitation sealed microcracks, specimens treated with bacterial mortar exhibited reduced water absorption, increasing their impermeability.

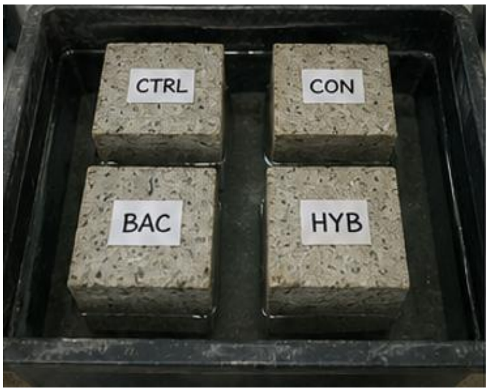

Figure 2 Cube Specimens immersed in water

2.7.2 Sorptivity Test

The rate of capillary water absorption is measured using the Sorptivity Test. A shallow water level was used to submerge cylindrical specimens that had been dried to a consistent weight and sealed on all but one round face. At predetermined intervals, mass increase was measured. Bacterial mortar-repaired specimens had lower sorptivity values, which indicate fewer capillary pores and increased durability.

Figure 3 Sorptivity test

2.7.3 Rapid Chloride Penetration Test (RCPT)

RCPT assesses how resistant concrete is to the penetration of chloride ions, which can lead to corrosion of reinforcement. The specimens were examined for six hours at a voltage of 60V with sodium hydroxide on one side and sodium chloride on the other. Because of their narrowed pore channels, specimens treated with bacterial mortar showed noticeably less chloride penetration, and lower charge passing values indicate greater durability.

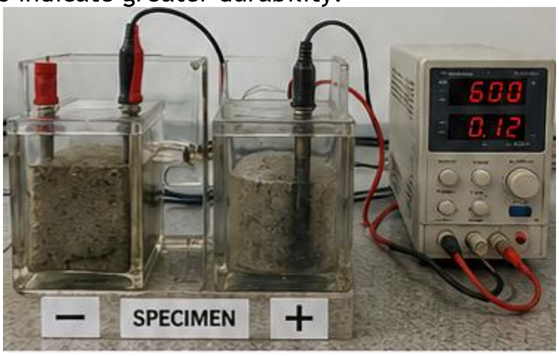

Figure 4 RCPT test

2.7.4 Bond Strength Test

The Bond Strength Test evaluates how well repair mortar adheres to concrete. Various mortars were used to fix cracked concrete cubes, and compressive force was used until the cubes failed. The failure load was divided by the bonded area to determine the bond strength. Because calcium carbonate precipitation increased interfacial bonding and reduced weak zones, bacterial mortar demonstrated improved bonding.

Figure 5 Bond Strength Testing

2.7.5 Impact Resistance Test

This test assesses how resilient concrete is against abrupt loads. A hammer dropped from a predetermined height was used to strike disc specimens, and the number of strikes required before failure was recorded. Better toughness was indicated by higher counts. Because internal calcite deposition sealed fissures, specimens restored with bacterial mortar successfully absorbed energy and demonstrated superior impact resistance compared to conventional mortars.

Figure 6 Impact Resistance Testing

4. Results and Discussion

4.1 Compressive strength test

The experimental results comparing conventional repair mortar, bacterial mortar, and hybrid repair solutions for cracked concrete members are presented in this chapter with a focus on crack healing, durability, and strength recovery. As a baseline, the control specimen's average compressive strength was 32.8 MPa. The strength recovery of repaired specimens varied; conventional repairs only reached 80.8% recovery, whereas bacterial mortar showed a recovery of 90.9%, which was attributable to calcium carbonate precipitation.

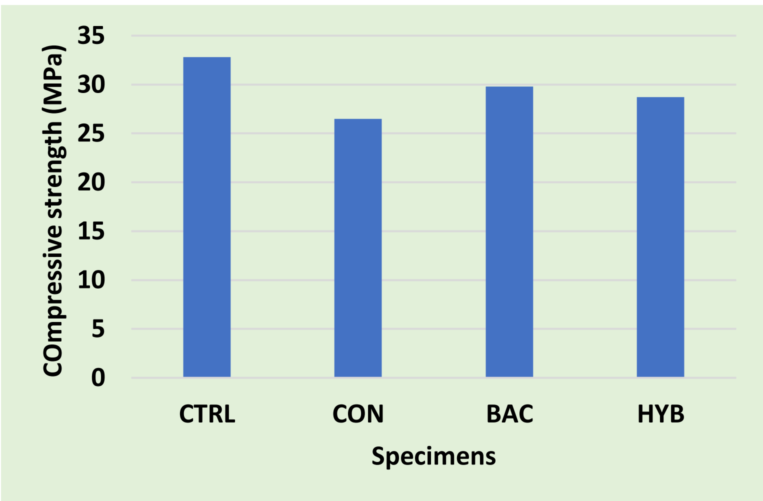

Figure 7 Compressive strength results

4.2 Split tensile strength test

Conventional specimens attained 74.2% of control strength in split tensile strength, while bacterial repairs restored approximately 90.3% because of improved bonding from calcium carbonate. The recovery rate from hybrid repairs was 83.9%. Conventional repairs only achieved 76.1% of control in flexural strength testing, whereas bacterial mortar recovered 91.3%, demonstrating its efficacy in controlling tensile stresses.

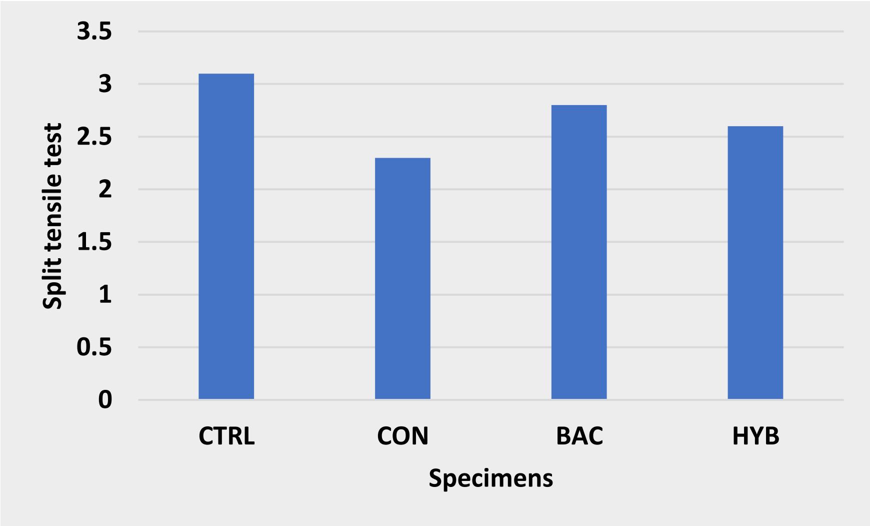

Figure 8 Split tensile strength results

4.3 Water absorption test

Evaluations of crack width revealed an 83% decrease with bacterial mortar as opposed to 38% with traditional techniques. This type of treatment showed improved durability in addition to successfully sealing cracks. According to water absorption studies, bacterial repairs improved impermeability by absorbing only 2.35% of water, which is significantly less than the 4.47% of conventional repairs.

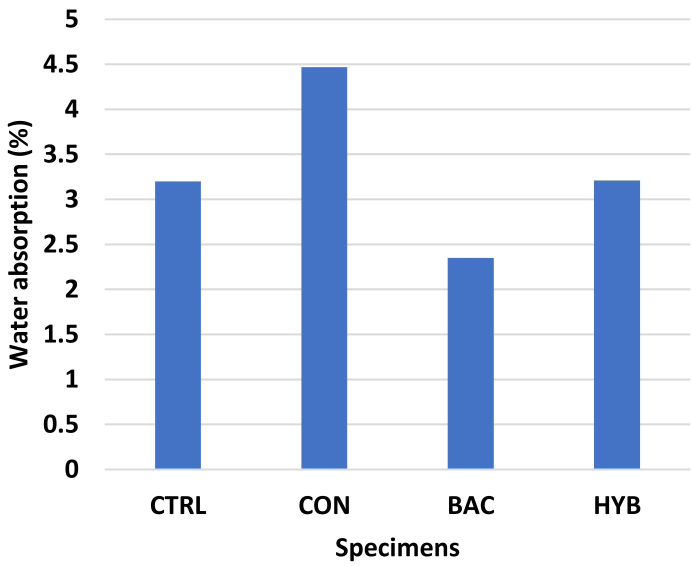

Figure 9 Water absorption test results

4.4 Flexural strength test

In flexural strength testing, control beams showed an average strength of 4.6 MPa. Conventionally repaired beams achieved only 76% of this strength, indicating poor tensile resistance. On the other hand, because calcium carbonate crystals effectively sealed cracks, beams treated using bacterial mortar had a 91% recovery rate. Due to decreased bacterial activity, a hybrid repair system produced an 85% recovery, which was better than conventional techniques but still less successful than bacterial repair. These findings imply that the performance of repaired flexural parts is much improved by bacterial mortar, especially in terms of tensile resistance and fracture control.

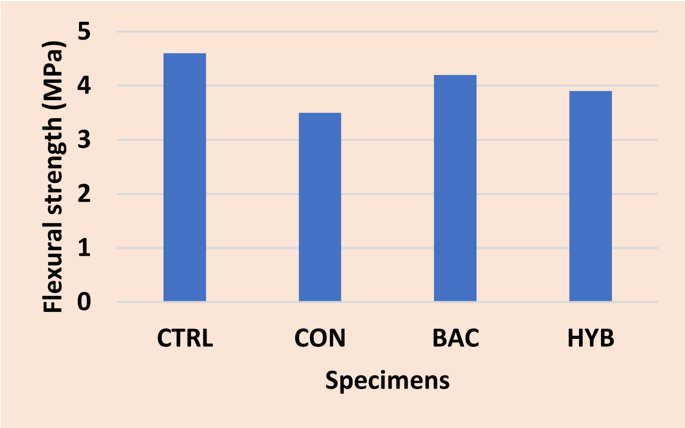

Figure 10 Flexural strength test results

4.5 Sorptivity test

According to sorptivity tests, conventional repairs had the highest results, suggesting poor moisture resistance, while bacterial mortar had the lowest capillary absorption due to decreased pore connection. The superiority of bacterial mortar was further validated by the RCPT, which revealed the lowest charge passing (1180 Coulombs) compared to 3120 Coulombs for traditional repairs.

Table 3 Sorptivity Test Results

Specimen Type	Initial Sorptivity (mm/min½)	Secondary Sorptivity (mm/min½)
CTRL	0.085	0.045
CON	0.132	0.071
BAC	0.061	0.031
HYB	0.078	0.040

4.6 Bond strength test

The advantages of calcium carbonate deposition at the interface were demonstrated by bond strength tests, which showed that bacterial mortar produced a bond strength of 4.5 MPa, exceeding the 3.2 MPa of traditional repairs. Bacterial mortar had the highest level of durability in impact resistance testing, while traditional repairs performed poorly. Combining the benefits of both repair techniques, the hybrid system also worked effectively.

Overall, the results show that bacterial mortar greatly improves the longevity, durability, and structural integrity of treated concrete, making it a very successful substitute for conventional repair techniques.

Table 4 Bond Strength Test Results

Specimen Type	Bond Strength (MPa)
CON	3.2
BAC	4.5
HYB	4.1

4.7 Impact Resistance Test

Through impact resistance testing, the study assessed the toughness and energy absorption of rehabilitated concrete specimens subjected to sudden loading. Due to their brittle character, which resulted in early crack propagation and decreased energy absorption, typical repair mortar specimens had the lowest impact resistance. The strongest impact resistance, on the other hand, was shown by specimens repaired using bacterial mortar. This is because calcite precipitation improves internal bonding and reduces crack propagation, which increases impact energy absorption and toughness. Furthermore, a hybrid repair approach improved structural performance by combining the advantages of bacterial healing with conventional repair techniques, producing impact resistance equivalent to control specimens. In general, under dynamic loading circumstances, bacterial mortar greatly improves the toughness, crack resistance, and energy absorption capacity of restored concrete.

Table 5 Impact Resistance Test Results

Specimen Type	Number of Blows to First Crack	Number of Blows to Failure
CTRL	18	32
CON	12	21
BAC	20	36
HYB	17	30

4.8 Rapid Chloride Penetration Test

The RCPT was used in the study to assess the resistance of repaired concrete to chloride ion intrusion. The findings showed that lower charge passing values were correlated with increased durability against reinforcement corrosion. Because of its open microcracks and porous zones, conventional repair mortar exhibited the greatest charge passing value of 3120 Coulombs, indicating considerable chloride permeability. The specimens that were repaired using bacterial mortar, on the other hand, had the lowest value of 1180 Coulombs, indicating exceptionally low chloride permeability since the chloride pathways were well blocked and the matrix density was increased by the precipitation of bacterial calcite. With a charge passing value of 1645 Coulombs, the hybrid repair system, which benefits from mechanical bonding and bacterial healing, also showed significant gains. Overall, the results highlight bacterial mortar's higher resistance to chloride intrusion.

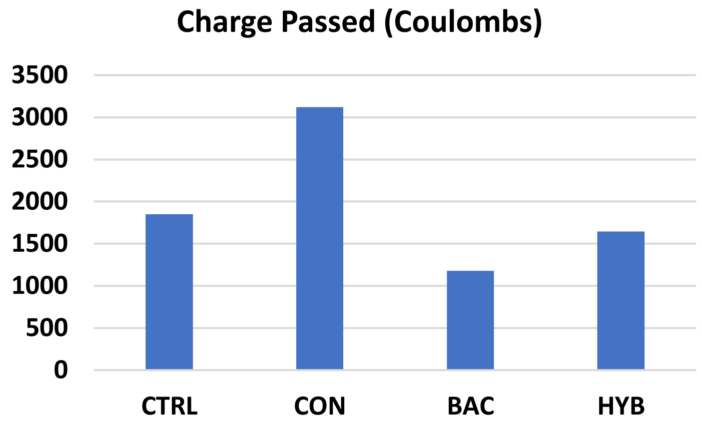

Figure 11 RCPT results

5. Conclusions

The results of an experimental investigation comparing conventional repair mortar, bacterial mortar, and hybrid repair systems for fixing fractured concrete components are covered in this chapter. The study's main objectives were to assess the repaired specimens' durability, mechanical strength recovery, and crack healing effectiveness. Important outcomes consist of:

- Bacterial mortar outperformed conventional mortar in terms of compressive strength, reaching 29.8 MPa (about 90.9% recovery) as opposed to 26.5 MPa (80.8% recovery).
- Better bonding and crack resistance were demonstrated by the split tensile strength of bacterially repaired specimens, which was 2.8 MPa as opposed to 2.3 MPa for traditional mortar. Furthermore, bacterial mortar had a flexural strength of 4.2 MPa, which was greater than conventional mortar's 3.5 MPa.
- Conventional mortar only achieved about 38% reduction in crack width, whereas bacterial mortar achieved over 80%.
- The water absorption rate decreased from 4.47% for standard mortar to 2.35% for specimens treated with bacteria, indicating improved impermeability and decreased pore connectivity.
- Bacterial repairs had substantially lower sorptivity values (0.061 mm/min½) than conventional repairs (0.132 mm/min½), suggesting superior resistance to capillary water flow.
- The RCPT revealed significant variations in permeability: bacterial repairs produced 1180 Coulombs, indicating lower chloride permeability, while conventional repairs produced 3120 Coulombs.
- Bacterially repaired specimens had a bond strength of 4.5 MPa, which was higher than traditional mortar's 3.2 MPa.
- According to impact resistance tests, specimens repaired using bacterial mortar could sustain 36 blows, while those fixed with conventional mortar could only take 21.
- When compared to conventional mortar, the hybrid repair system also demonstrated good performance, with moderate gains in strength recovery, durability, and crack healing.

The study emphasizes the effectiveness of bacterial mortar, which successfully fills gaps and improves durability by using bacterial activity to precipitate calcium carbonate. This capacity for self-healing encourages longer-lasting infrastructure, lowering the frequency of maintenance and boosting concrete constructions sustainability. In the end, bacterial mortar turns out to be a durable, environmentally beneficial, and promising substance for upcoming structural restoration and sustainable building uses.

References:

1. ACI Committee 224. (2001). *Control of cracking in concrete structures* (ACI 224R-01). American Concrete Institute, Farmington Hills, MI.
2. ACI Committee 546. (2014). *Concrete repair guide* (ACI 546R-14). American Concrete Institute, Farmington Hills, MI.
3. Mehta, P. K., & Monteiro, P. J. M. (2014). *Concrete: Microstructure, properties, and materials* (4th ed.). McGraw-Hill Education.
4. Neville, A. M. (2011). *Properties of concrete* (5th ed.). Pearson Education Limited.
5. Emmons, P. H., & Vaysburd, A. M. (1996). Performance criteria for concrete repair materials. *Concrete International, 18*(3), 56-60.
6. Van Tittelboom, K., & De Belie, N. (2013). Self-healing in cementitious materials—A review. *Materials, 6*(6), 2182-2217.
https://doi.org/10.3390/ma6062182
7. Jonkers, H. M. (2011). Bacteria-based self-healing concrete. *Heron, 56*(1/2), 1-12.
8. Edvardsen, C. (1999). Water permeability and autogenous healing of cracks in concrete. *ACI Materials Journal, 96*(4), 448-454.
9. De Muynck, W., De Belie, N., & Verstraete, W. (2008). Microbial carbonate precipitation in construction materials: A review. *Ecological Engineering, 36*(2), 118-136.
10. Li, V. C., Herbert, E., & Yang, E. H. (2012). Self-healing concrete materials. *ACI Materials Journal, 109*(1), 51-58.
11. Ramachandran, S. K., Ramakrishnan, V., & Bang, S. S. (2001). Remediation of concrete using microorganisms. *ACI Materials Journal, 98*(1), 3-9.
12. De Belie, N., Wang, J., & Bundur, Z. (2018). Bacteria-based self-healing and repair of concrete structures. *Journal of Advanced Concrete Technology, 16*(10), 1-17.
13. Achal, V., Mukherjee, A., & Reddy, M. S. (2011). Microbial concrete: Way to enhance the durability of building structures. *Journal of Materials in Civil Engineering, 23*(6), 730-734. https://doi.org/10.1061/(ASCE)MT.1943-5533.0000159
14. Algaifi, H. A., Bakar, S. A., Sam, A. R. M., & Abubakar, M. (2020). Bio-based repair materials for concrete structures: A review. *Construction and Building Materials, 256,* 119470. https://doi.org/10.1016/j.conbuildmat.2020.119470
15. Chahal, N., Siddique, R., & Rajor, A. (2012). Influence of bacteria on the compressive strength, water absorption and rapid chloride permeability of concrete. *Construction and Building Materials, 28*(1), 351-356. https://doi.org/10.1016/j.conbuildmat.2011.08.042
16. De Belie, N., Wang, J., Bundur, Z. B., & Paine, K. (2018). Bacteria-based repair and self-healing of concrete. *Journal of Advanced Concrete Technology, 16*(10), 1-17.
17. De Muynck, W., Cox, K., De Belie, N., & Verstraete, W. (2010). Bacterial carbonate precipitation as an alternative surface treatment for concrete. *Construction and Building Materials, 24*(9), 1776-1781.
18. Ghosh, P., Mandal, S., Chattopadhyay, B. D., & Pal, S. (2005). Use of microorganism to improve the strength of cement mortar. *Cement and Concrete Research, 35*(10), 1980-1983.
19. Ghosh, P., Mandal, S., & Pal, S. (2009). Enhancement of durability of cement mortar using bacteria. *Cement and Concrete Composites, 31*(6), 406-410.
20. Jonkers, H. M., & Schlangen, E. (2007). Crack repair by concrete-immobilized bacteria. *Proceedings of the First International Conference on Self-Healing Materials*, Noordwijk, Netherlands.
21. Jonkers, H. M., Thijssen, A., Muyzer, G., Copuroglu, O., & Schlangen, E. (2010). Application of bacteria as self-healing agent for the development of sustainable concrete. *Ecological Engineering, 36*(2), 230-235.
22. Jonkers, H. M. (2011). Bacteria-based self-healing concrete. *Heron, 56*(1/2), 1-12.
23. Li, V. C., Herbert, E., & Yang, E. H. (2012). Self-healing concrete materials. *ACI Materials Journal, 109*(1), 51-58.
24. Luo, M., Qian, C., & Li, R. (2015). Factors affecting crack repairing capacity of bacteria-based self-healing concrete. *Construction and Building Materials, 87*, 1-7.
25. Vijay, K., Murmu, M., & Deo, S. V. (2017). Bacteria based self-healing concrete—A review. *Construction and Building Materials, 152*, 1008-1014.
26. Wang, J., Van Tittelboom, K., De Belie, N., & Verstraete, W. (2012). Use of silica gel or polyurethane immobilized bacteria for self-healing concrete. *Construction and Building Materials, 26*(1), 532-540.
27. Wang, J., & De Belie, N. (2016). Application of bacteria-based materials in concrete repair. *Advanced Materials Research, 1135*, 56-63.

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