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Strength Properties of a Self-Healing Concrete with GGBS and Sugarcane Bagasse Ash

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Abstract:- Concrete is the most popular construction material since it can sustain contraction, but because of its low tensile strength, cracks are inescapably going to appear and reduce a structure's strength and life span. The arrangement of cracks is still a veritably prevalent concrete phenomena construction; it causes the rebar to be affected when it comes into touch with water, CO2, and other chemicals. This causes water and various sorts of chemicals to enter the concrete through the cracks and reduce its durability and strength. Regular conservation and a unique form of treatment that will be truly expansive are required for fixing the fractures that have appeared in the concrete. In order to overcome this obstacle, a self-healing technology is applied to the concrete. This process uses calcium carbonate charges to pack the concrete's pores and microcracks, which helps to cure the fissures. In addition, access to high-rise buildings, basements, underwater structures, etc., is difficult, and the risk of accidents is high, making it physically impossible to go for maintenance. In such cases, self-healing concrete is very useful. According to the literature, bacteria can be used to increase the durability and strength of concrete, and the encapsulated method will produce superior outcomes than the direct application method. Industrial and agricultural wastes are both growing quickly today. Agricultural wastes and industrial wastes can be used in the building sector because of the high demand for natural resources brought on by increased urbanization and the difficulty in disposing of these wastes in industrialized nations. The earth must be sustainable so that the resources we currently use are available to both current and future generations. On the other hand, modernization and progress shouldn't have a negative impact on the environment. One such issue is cement production, which negatively impacts the environment on a daily basis due to the significant carbon dioxide emissions and other dangerous gas emissions. In order to reduce the need for cement, which will benefit the environment, this research explains how an industrial waste material like GGBS and an agricultural waste material like Sugarcane Bagasse Ash (SCBA). In the M30 mix, the cement is replaced with GGBS and SCBA contains bacillus subtilis bacteria. The GGBS was utilized in the ratios of 20% and 40%, the SCBA in the ratio of 10% by weight of cement, and the bacillus subtilis in the ratio of 10% by weight of cement. In comparison to the conventional concrete, the outcomes of this study are significantly better.

***Keywords*:-** *Self-Healing; Self-Healing Concrete; Bacteria; Bacterial concrete; GGBS; SCBA*

I. INTRODUCTION

Concrete was extensively utilized as structural material throughout the twentieth and twenty-first centuries. One of the most often utilized building materials is concrete. They fast development of ready-mixed concrete is crucial for technological advancement and general excellence enhancement in concrete, it isn't without its challenges. Cracks are necessary in concrete because it's strong in compression but weak in tension and its lifespan may be abbreviated once cracks start to appear. Cracking is one of the substantive causes of structure damage and degradation reported by builders, designers, and clients, as shown in Fig. 1 [2]. It's also one of the suggestive reasons for concrete decline and reduction in durability, and there are several different approaches for fixing cracks, but they are veritably both time- and money-consuming. Self-healing concrete is a subsequent technology is self-repairing the cracks. When the concrete is mixed, bacteria with a calcium nutrient font are added, and calcium carbonate is stormed by bacteria when concrete cracks appear, sealing the cracks. The bacterial concrete will be stronger than regular concrete because the biotechnological method grounded in calcite precipitation can be used to boost the strength and life of structural concrete.

One estimate places the annual greenhouse gas emissions from the manufacturing of cement at 1.35 billion metric tonnes, and the cement industry is also responsible for 18% of all industrial greenhouse gas emissions. When cement is produced, carbon dioxide (CO2) is released primarily from three sources. For each tonne of clinker produced, approximately 325 kg of CO_2 are released solely from the fuel consumed in the furnace, 525 kg are released during the de-carbonation of limestone, and 50 kg are released from the use of electrical energy. For every tonne of cement produced, approximately 1.5 tonnes of raw materials and 80 electric power units are needed. Carbon dioxide gas emissions are decreased by adding more cementation material. In addition to agricultural waste including sugarcane bagasse ash, rice husk ash, olive oil ash, and palm oil fuel ash, industrial trash includes silica fume, ground

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granulated blast furnace slag (GGBS), and fly ash in massive numbers. These industrial and agricultural waste items should never be dumped in open areas because they contaminate the air and water. When employed as pozzolanic substances in high-performance concrete, this waste product can improve the concrete's strength and durability. According to Figure 2, India produces the second-largest amount of sugarcane. They residue left behind from sugarcane juice extraction is known as sugarcane bagasse (SCB). The controlled burning of sugarcane bagasse yields sugarcane bagasse ash (SCBA). Due to direct disposal on open fields, one tonne of sugarcane produces 280 kg of bagasse waste, which also causes environmental annoyance and develops garbage piles nearby [53]. India produced 118.20 million metric tonnes (MT) of steel between January and December of 2021, ranking second in the world, an increase of 17.9% over the same time last year. Slag from blast furnaces is a byproduct of the global iron and steel industry. It is a form of industrial waste that is generated during the production of iron and steel. For every metric tonne of crude steel produced, approximately 300 kg of waste slag is created. According to reports, producing 1000 Kg of cement would require around 1500 Kg of mineral extraction, 5000 MJ of energy, and 950 Kg of CO_2 equivalent. The production of one tonne of GGBS, a by-product of the iron industry, is said to produce just around 70 Kg of CO_2 equivalent and use only about 1300 MJ of energy [41].

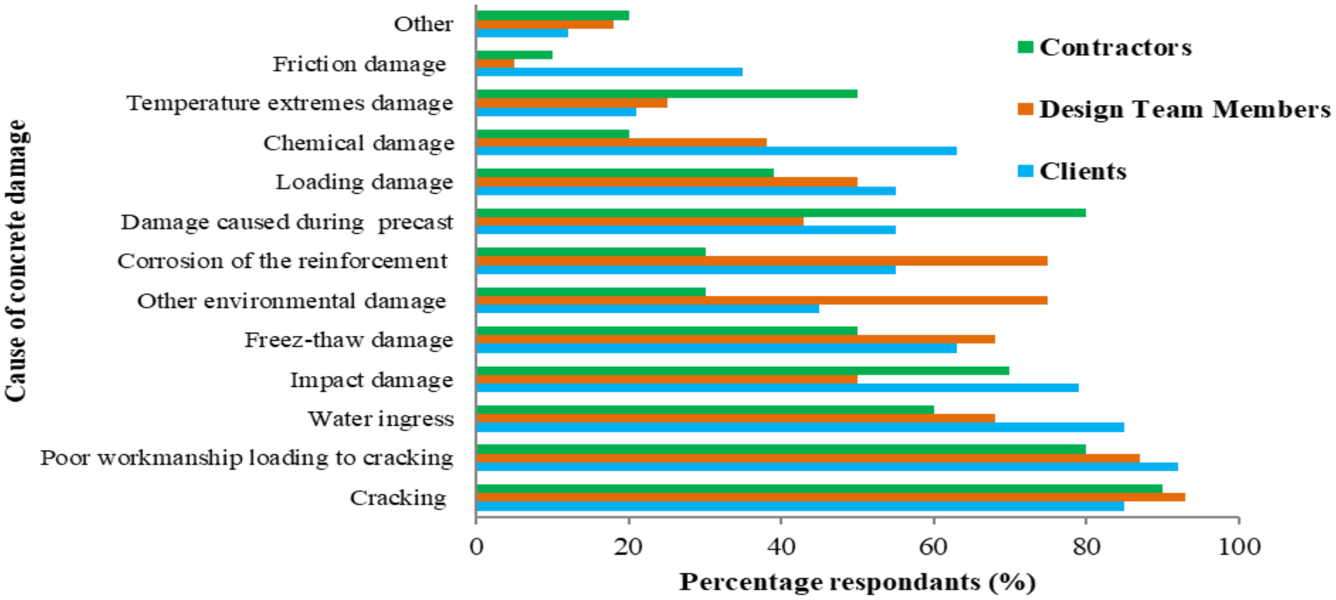

Fig 1 Main Causes of Deterioration and Damage to Concrete Structures [2].

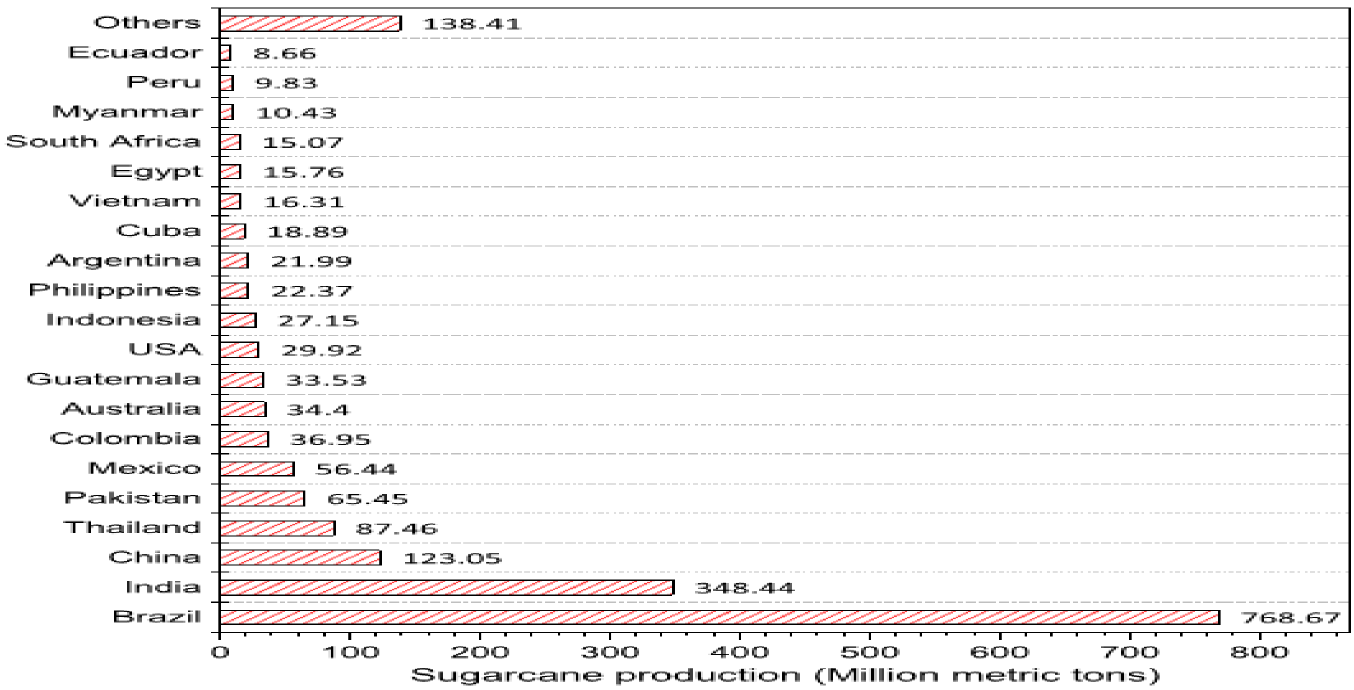

Fig 2 Annual Global Production of Sugarcane [53]

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Researchers elaborated on a technique called "self-healing" to prevent concrete edifices from deteriorating in response to the increasing number of cracks in these structures. The popularity of this approach is substantiated by the rising number of papers published each time, as in Fig. Although the idea of concrete self-healing with no assistance from humans (without adding any material or additive to entrapments, side cracks, or fractures) was initially observed in 1836 [4], researchers have been exploring new ways to functionalize this process over the past several decades [5]. Because it is impractical to regularly examine, form, and maintain large structures due to the high cost and labour requirements, The best method for preventing cracking in concrete structures is self-healing [6]. Given the aforementioned conditions, Self-healing or spontaneous repair is a useful to repair damaging cracks without the need for fresh labour or financial resources. Some of the main advantages of concrete that can heal on its own are shown in Fig. Self-healing mechanisms are being incorporated in a wide range with structures, showing in fig. 5.

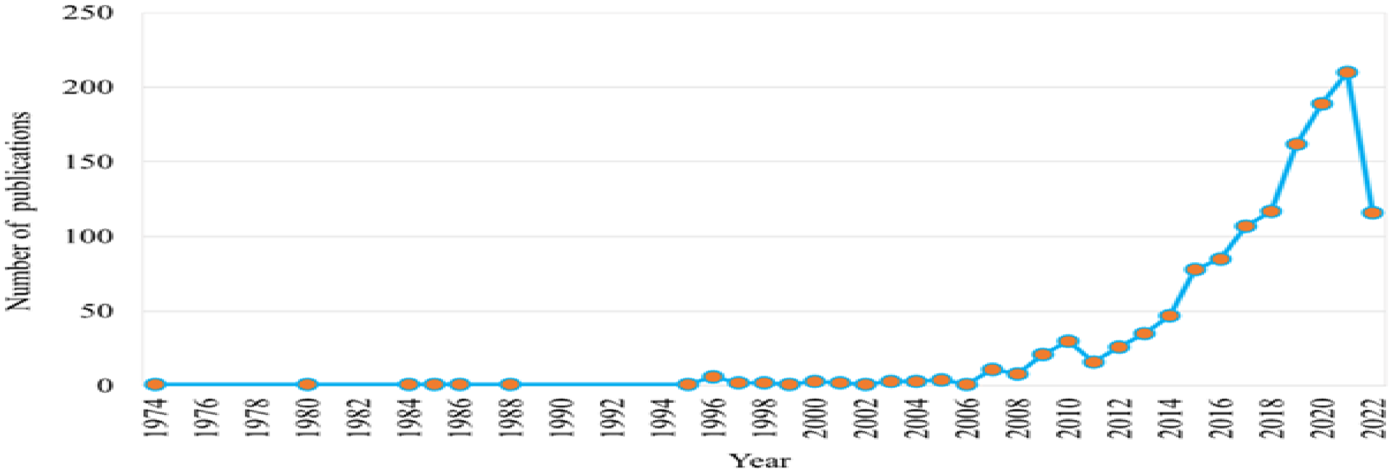

Fig 3 No. of Publications Regarding Self-Healing Concrete 1974–2022 [3]

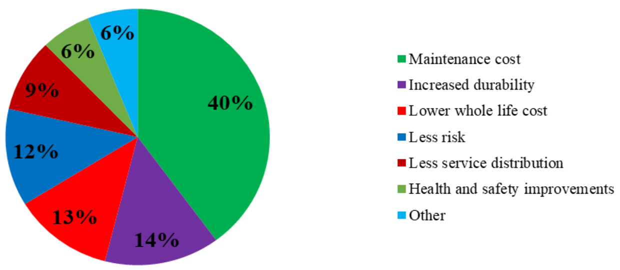

Fig 4 Problems Maintenance of Structures Causes [1].

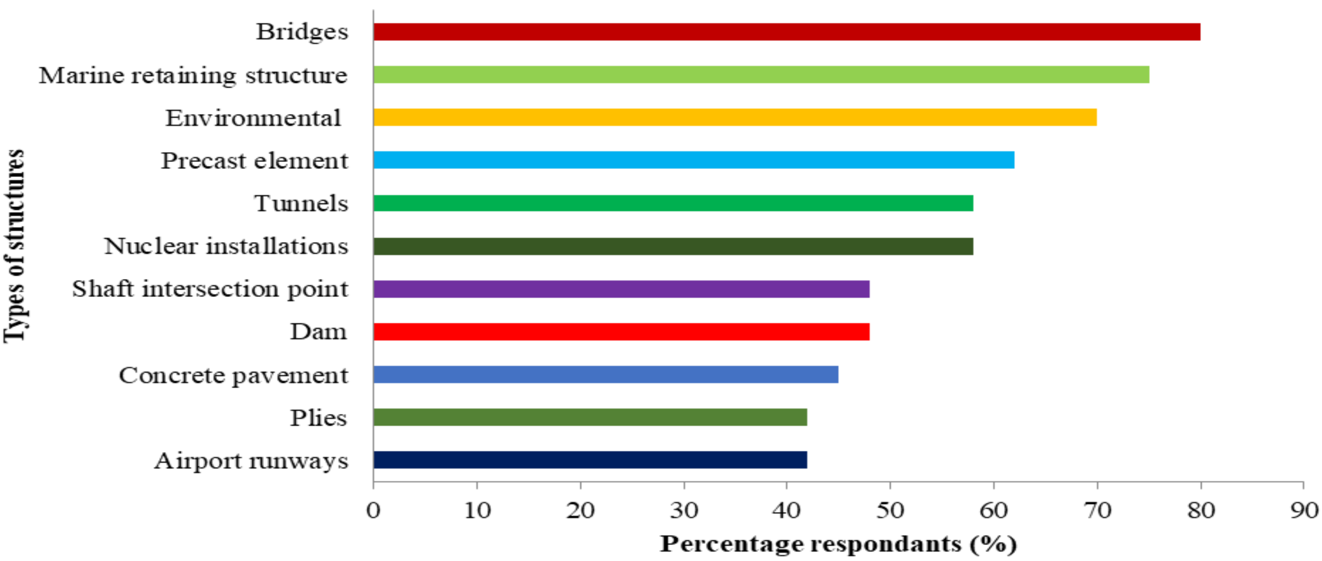

Fig 5 Application of Self-Healing in Different Civil Engineering Structures [2]

II. SELF-HEALING TECHNIQUES

A few self-healing techniques that have been found and described in many studies (as shown in Fig. 6) are described below.

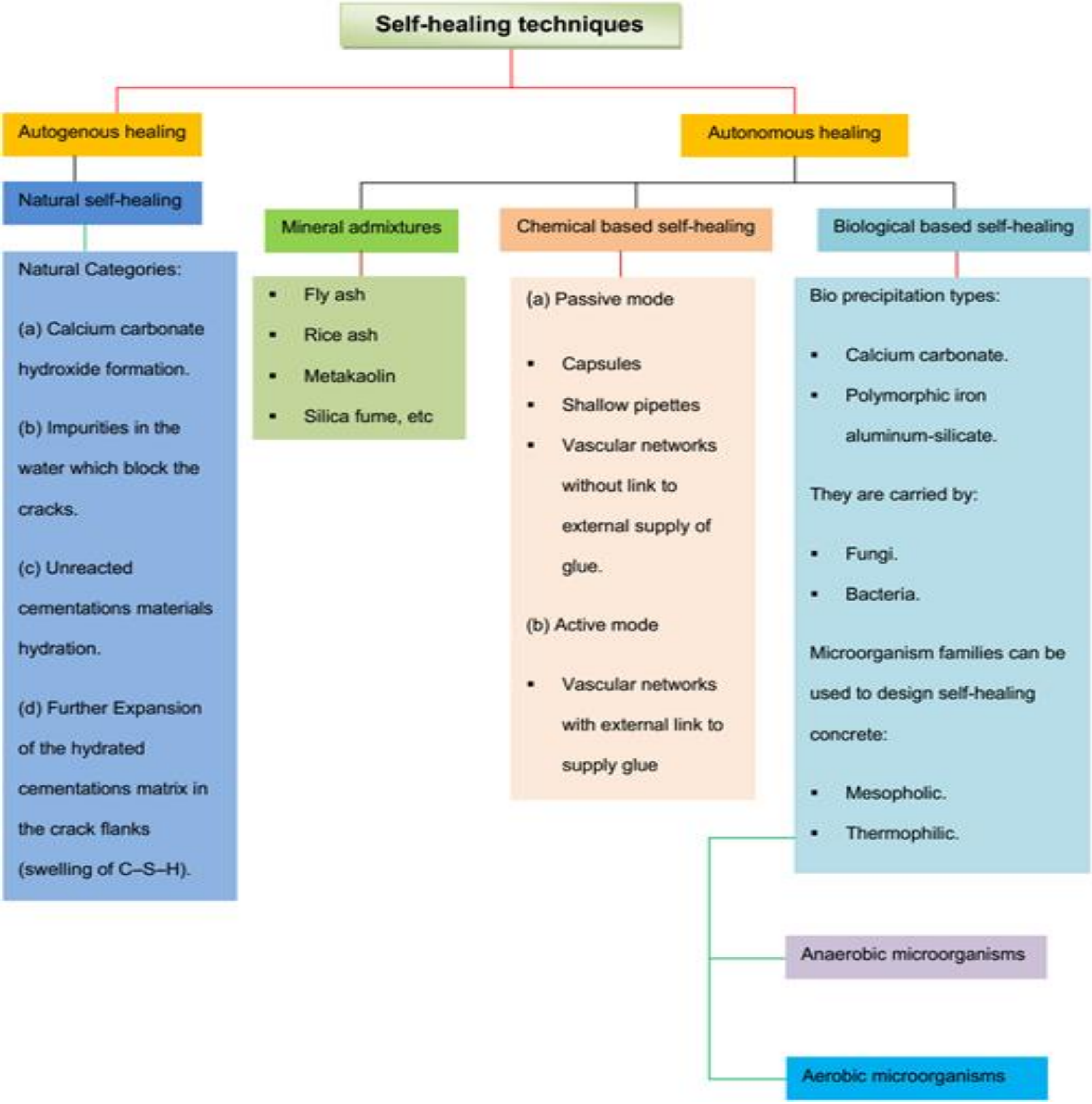

Fig 6 Hierarchical view of self-healing techniques

➢ *Autogenous /Natural Self-healing*

Autogenous healing, which does not necessitate the input of whatever specific agent to the matrix, is caused by the hydration of unhydrated cement material particles or the precipitation of calcium carbonate ($CaCO_3$). Additional cementation ingredients, like GGBS, fly ash, and silica fume, should be added in order to promote autogenous healing. By utilizing this material delayed hydration, autogenous healing could be enhanced. They phenomenon is crack healing, known as "autogenous healing," is based on the natural occurrence of chemical reactions and the interaction of water. Because it facilitates autogenous healing, crack width narrowing is likewise classified as autogenous healing. Conventional or traditional concrete contains about 20–30% unhydrated cement, which causes cracking when it reacts with water. These reactions restore the process of hydration and deliver to hydration products that gaps are fill. The innate process of self-healing is referred to as "autogenous healing" [19]. Autogenous healing could occur the as follows [8, 20], as shown in Figs. 7a and 7b:

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- Formation of $CaCO_3$ or $Ca(OH)_2$ to seal cracks.
- Hydration of unhydrated particles of cement
- Blocking of cracks by the presence of impurities in water
- Expansion/swelling of calcium-silicate hydrate (CSH) gel

Always advertised proceedings could also be conducted concurrently; some advertised proceedings can only partially fill in the cracks. The presence of $CaCO_3$ and $Ca(OH)_2$, that could take on the form of, is the most effective natural healing mechanism.

- $H_2O + CO_2 \Leftrightarrow H_2CO_3$ (1)
- $H_2CO_3 \Leftrightarrow H^+ + HCO_3^-$ (2)
- $HCO_3^- \Leftrightarrow 2H^+ + CO_3^{2-}$ (3)
- $Ca^{2+} + CO_3^{2-} \Leftrightarrow CaCO_3$ (4)
- $Ca^{2+} + HCO_3^- \Leftrightarrow CaCO_3 + H^+$ (5)

Numerous studies conducted too learn more about the effectiveness of self-healing and the variables influencing it [8]. There have demonstrated the small-sized cracks respond well to autogenous healing methods, and occasionally larger fractures (greater than 200 m) as well as cracks longer than 300 m can also be repaired in the presence of water.

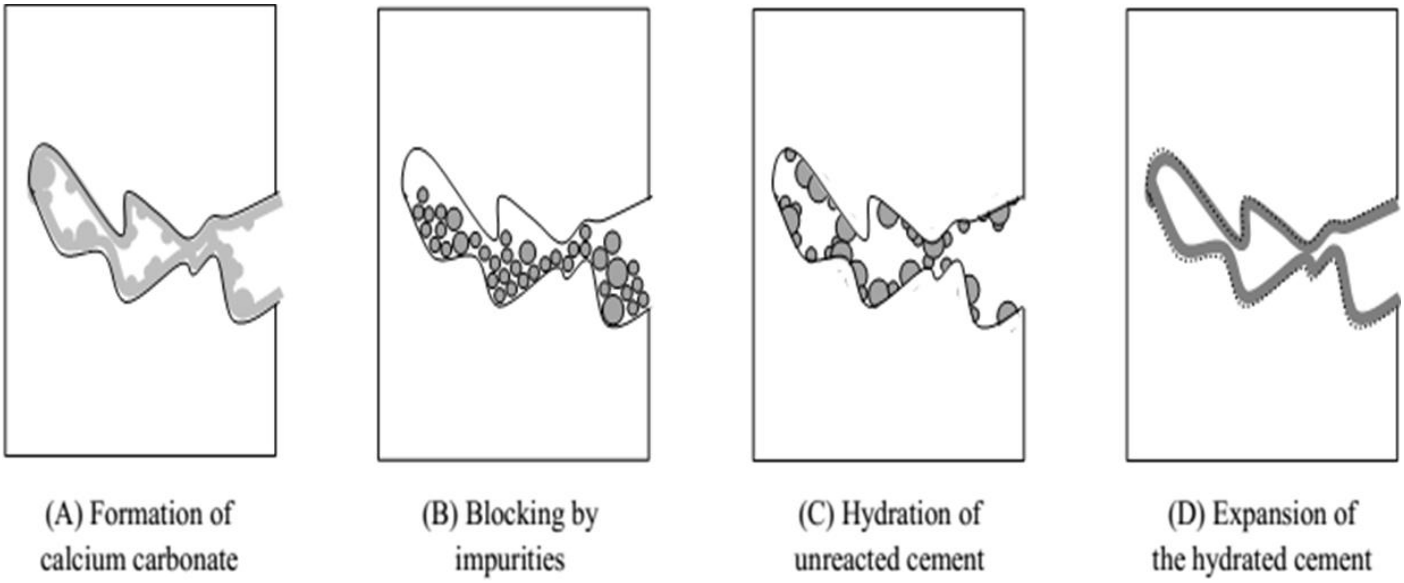

Fig 7a Possible Mechanisms for Autogenous /Natural Self-Healing

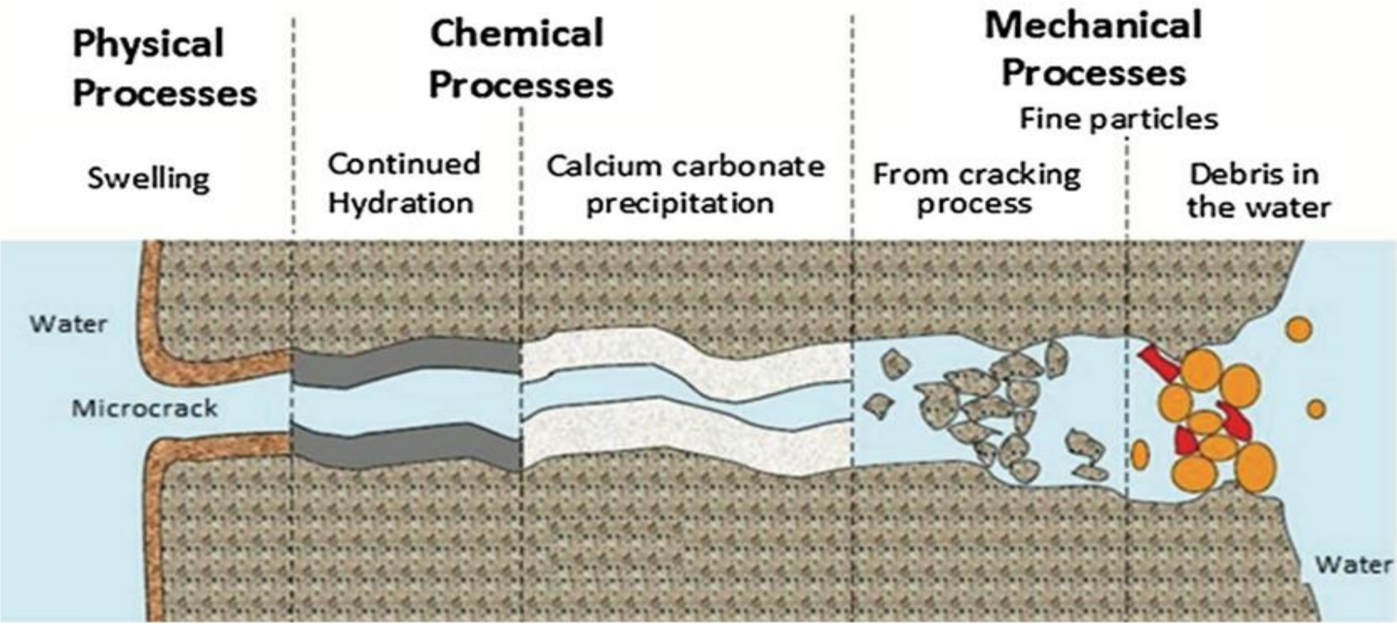

Fig 7b Autogenous or Natural Self-Healing Occurs due to Physical, Chemical, and Mechanical Processes in Cementitious Materials

➢ *Autonomic Self-Healing*

When a sufficient healing agent is put to concrete, an artificial healing process known as "autonomic concrete healing" takes place, allowing for the mending or plugging of cracks at room temperature without the need for outside assistance [7]. In this way, Self-healing via chemicals and biological.

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➢ *Self-Healing Via Chemicals*

Concrete that automatically repairs on its own injecting synthetically into the fissures. Concrete that is chemically healing could be created through combining new concrete with a reagent chemical (liquid), like glue. There are several methods for chemically repairing concrete, such as the hollow pipette and the encapsulation strategy. Concrete may cure itself chemically in two ways: actively and passively. In contrast to passive mode, active mode necessitates alternative sources of chemical reagents.

➢ *Self-Healing Via Biological*

Utilizing microorganisms for creating self-healing concrete allows for the environmentally sound process of biologically mending concrete. Microorganisms were chosen because they can flourish in a variety of environments, including soil, water, acidic springs, and oil reservoirs. Microorganisms often fall into one of three categories: bacteria, viruses, or fungi. The ability of specific strains of bacteria to precipitate specific beneficial chemicals makes them the most successful of the aforementioned microorganisms to be employed for self-repair or self-healing concrete. In this approach, spores, an immobile form on silica gel, microbiological broth poured onto newly placed concrete, and other methods are employed to add microorganisms to the concrete, as well as the vascular network approach. Because the environment of concrete doesn't support significant microbial growth, spores are typically employed in place of microbial broth. Additionally, the encapsulation approach can be used in challenging concrete environments, although it is highly expensive and difficult. Furthermore, using a network vascular technique to expand microbial broth over a cement matrix can protect against unfavourable actual concrete circumstances, although this technique is complicated and difficult to implement with current technology.

III. MATERIALS USED

➢ *Cement*

The investigation employed commonly available Portland Cement of OPC 53 grade (IS 12269: 1987) from the local market. According to IS 4031-1988, the cement's various qualities have been examined. The physical qualities of Cement are given in Table 1.

Table 1 Physical Properties of Cement

S.No	Physical Properties	Values	Reference Code
1	Specific gravity	**3.145**	-
2	Consistency	**32%**	IS: 4031-1968 Part 4
3	Initial setting time	**31 minutes**	IS: 4031-1968 Part 5
4	Final setting time	**610 minutes**	IS: 4031-1968 Part 5
5	Fineness	**6.7 %**	IS: 4031-1968 Part 1
6	Soundness	**2 mm**	IS: 4031-1968 Part 3

➢ *Fine Aggregate*

The fine aggregate employed in this investigation was found to be hard and durable and free of clay. As to IS: 383 - 1970, the fine aggregate size is less than 4.75mm. The physical qualities of fine aggregate are given in Table 2.

The fine aggregate complies with IS: 383(1970) Zone-II.

Table 2 Physical Properties of Fine Aggregate

S.No	Physical Properties	Values	Reference Code
1	Specific gravity	**2.61**	IS: 2386 (Part2) 1963
2	Fineness modulus	**2.17 %**	IS: 2386 – (Part 3) 1963
3	Maximum size	**4.75mm**	
4	Zone confirmed	**II**	IS: 383- 1970

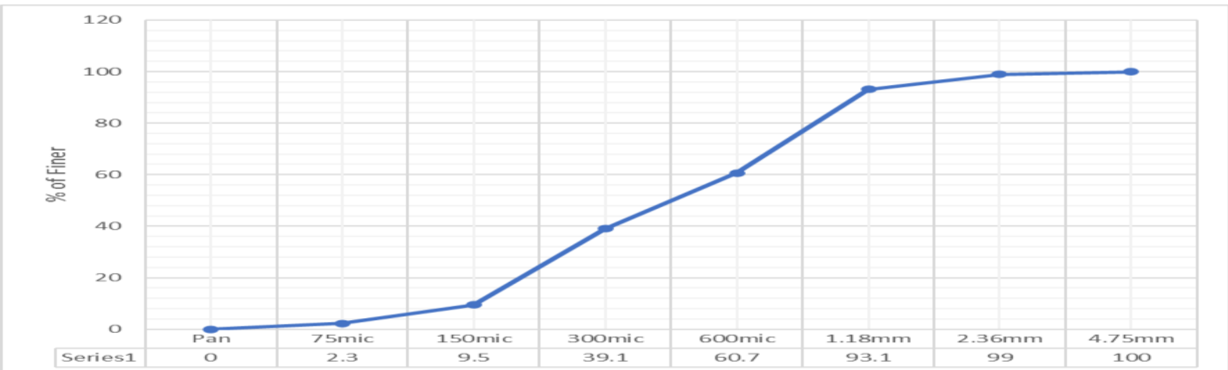

Fig 8 Sieve Analysis

➢ *Coarse Aggregate*

The study's coarse aggregate is 20 mm in size. the coarse aggregate qualities that were established in accordance with IS 2386, and they are given in Table 3.

Table 3 Physical Properties of Coarse Aggregate

S.No	Physical Properties	Values	Reference Code
1	Specific gravity	**2.69**	IS: 2386 (Part2) 1963
2	Impact strength	**22.75 %**	IS: 2386 – (Part 4) 1963
3	Crushing strength	**24.75 %**	IS: 2386 – (Part 4) 1963
4	Maximum size	**20 mm**	

➢ *Ground Granulated Blast Furnace Slag*

The GGBS can be purchased from Irugur, Coimbatore, Tamil Nadu-based JSW cement. Here are GGBS's physical and chemical characteristics.

Table 4 Physical Properties of GGBS

S.No	Physical Properties	Values
1	Specific gravity	**2.83**
2	Fineness	**7.24 %**

Table 5 Chemical Properties of GGBS

Chemical Properties	Percentage
Silicon dioxide (SiO_2)	**34.81**
Aluminium oxide (Al_2O_3)	**17.92**
Ferric oxide (Fe_2O_3)	**0.66**
Calcium oxide (CaO)	**37.63**
Potassium oxide (K_2O)	**0.58**
Magnesium oxide (MgO)	**7.80**
Sulfur trioxide (SO_3)	**0.20**
Sodium oxide (Na_2O)	**0.16**
Loss of ignition (LOI)	**0.65**

➢ *Sugarcane bagasse ash*

The SCBA is purchased from Sri Krishna sugar industries from Pollachi, Coimbatore, Tamil Nadu. Here are SCBA physical and chemical characteristics.

Table 6 Physical Properties of Sugarcane bagasse ash

S. No	Physical Properties	Values
1	Specific gravity	**1.84**
3	Fineness	**10.81 %**

Table 7 Chemical Properties of Sugarcane bagasse ash

Chemical Properties	Percentage
Silicon dioxide (SiO_2)	55.05
Aluminium oxide (Al_2O_3)	5.10
Ferric oxide (Fe_2O_3)	2.62
Calcium oxide (CaO)	5.09
Potassium oxide (K_2O)	4
Magnesium oxide (MgO)	4.82
Sodium oxide (Na_2O)	0.94

➢ *Bacillus Subtilis*

Concrete can benefit from the use of the bacterial species Bacillus subtilis as a self-healing agent. When concrete fractures, it releases urease, a naturally occurring compound that hardens concrete. By catalyzing the hydrolysis of urea into carbon dioxide and ammonia, which then react with the calcium hydroxide in the cement paste to create calcium carbonate, this substance aids in the repair of cracks. As a result of this reaction, the calcium carbonate that has just created is firmly bonded to the concrete around it. Additionally, the microorganisms increase the concrete's durability and decrease water seepage.

➢ *Water*

Water is a key component of concrete because it interacts with cement in chemical reactions, and for mixing concrete and curing specimens, potable water from a local laboratory that meets IS 456 2000 standards and has a pH

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value between 6.5 and 8.5 was used. Concrete should be made with drinking-water quality water.

IV. TEST

➢ *Compressive Strength*

The test is conducted using specimens that have been curing for 7, 14, and 28 days, and the cube size is 150x150x150mm. The M30 mix grade of IS 10262-2009 is used to design the concrete mix. The cubes are examined using a compression testing equipment with a 2000KN capability. Concrete specimens in the compression testing equipment have undergone compression testing in accordance with IS 516-1959(5). The test cube is positioned so that its cast faces are not in touch with the testing machine's platens. According to the applicable IS code, load has been applied at a continuous rate of stress equal to 15 mpa/min, and the load at which the specimens failed has been recorded. The compressive strength is thus determined from the findings.

➢ *Split Tenslie Strength*

The test is conducted on specimens that have been curing for 7, 14, and 28 days, and the cylinder dimension is 150 x 300 mm. The concrete mix design is done in accordance with IS 10262-2009 of M30 mix grade. The cubes are examined using a compression testing equipment with a 2000KN capability. A cylindrical specimen is placed horizontally between the compression testing machine's loading surfaces for the test, and then the load is applied until the cylinder fails along the vertical surface while the diameters are recorded. The split tensile strength is thus determined from the findings.

V. RESULTS AND DISSCUSSIONS

A. *Compressive Strength Test*

In this study the cubes are prepared conventional concrete, conventional concrete with GGBS, conventional concrete SCBA, conventional concrete with bacteria, bacteria with GGBS, bacteria with SCBA and also bacteria with GGBS and SCBA. There are 90 cubes in all that are tested, and they are cured for 7, 14, and 28 days. Three different age periods of bacteria-infected concrete are cast, each with three cubes. Concrete containing bacteria that is also cast with GGBS and SCBA. A 150mmx150mmx150mm cube is its size. Compressive strength, which is both a desirable property of concrete qualities and one of the most crucial and practical factors, is also quantitatively connected to compressive strength.

Comparing GGBS 20% and GGBS 40% concrete to regular concrete, the compressive strength of the latter is improved. Compared to regular concrete, the strength of bacterial concrete is reduced. When compared to conventional and bacterial concrete, the strength of the bacterial concrete with GGBS 20% and GGBS 40% is increased. Both a table and a bar chart with the compressive strengths of conventional, GGBS, and bacterial concrete are donated.

Table 8 Compressive Strength with Replacement of GGBS and bacteria with GGBS

Specimen	Compressive strength		
	7 days	**14 days**	**28 days**
Conventional concrete [C]	**17.92**	**26.96**	**36.02**
GGBS 20% [G1]	**16.59**	**26.35**	**38**
GGBS 40% [G2]	**17.27**	**27.13**	**37.21**
Bacteria 10% [B]	**17.01**	**26.72**	**33.14**
GGBS 20% + bacteria 10 % [GB1]	**16.48**	**26.36**	**40.26**
GGBS 40% + bacteria 10 % [GB2]	**16.97**	**26.96**	**37.47**

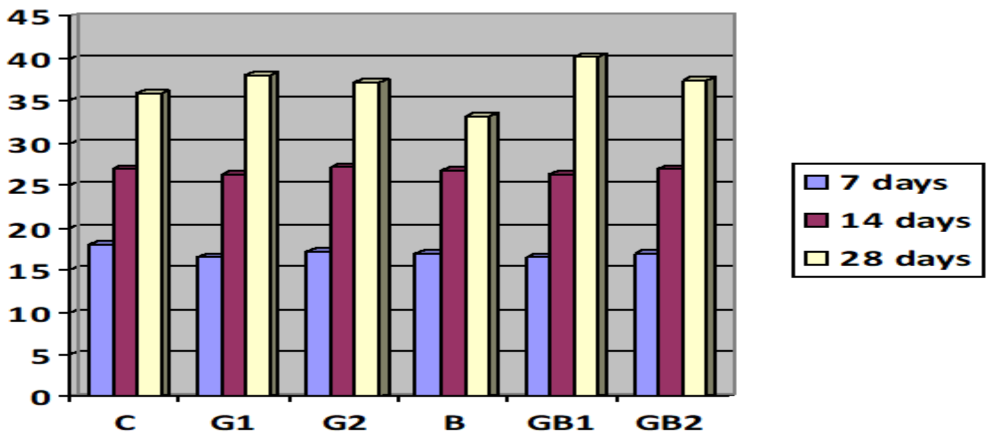

Fig 9 a Compressive Strength Result

When compared to regular concrete, the compressive strength of SCBA 10% concrete is lower. Comparing SCBA-infused bacterial concrete to conventional and bacterial concrete, the strength is reduced. The compressive strength for conventional, SCBA, and bacterial concrete is provided in a table and bar chart.

Table 9 Compressive Strength with Replacement of SCBA and Bacteria with SCBA

Specimen	Compressive strength		
	7 days	14 days	28 days
Conventional concrete [C]	17.92	26.96	36.02
SCBA 10%[S]	12.75	20.66	31.77
Bacteria 10% [B]	17.01	26.72	33.14
SCBA 10% + bacteria 10% [SB]	12.72	20.84	32.14

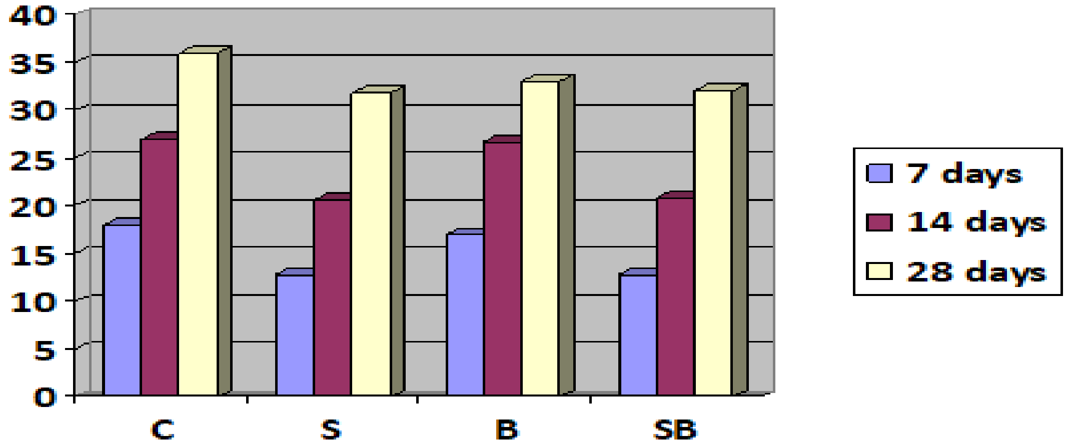

Fig 9 b Compressive Strength Result

The compressive strength of bacteria concrete with GGBS 20% and SCBA 10% is increased when compared to conventional concrete and bacterial concrete. The bacterial concrete with GGBS 40% and SCBA 10% strength is decreased compared to conventional concrete and bacterial concrete. The compressive strength for both conventional, bacterial and bacterial with GGBS and SCBA concrete in table as well as bar chart are provided.

Table 10 Compressive Strength with Replacement of GGBS & SCBA and bacteria with GGBS & SCBA

Specimen	Compressive strength		
	7 days	**14 days**	**28 days**
Conventional concrete [C]	**17.92**	**26.96**	**36.02**
Bacteria 10% [B]	**17.01**	**26.72**	**33.14**
GGBS 20% + SCBA 10% + bacteria 10% [GSB1]	**17.77**	**27.21**	**40.98**
GGBS 40% + SCBA 10% + bacteria 10% [GSB2]	**15.46**	**24.91**	**33.42**

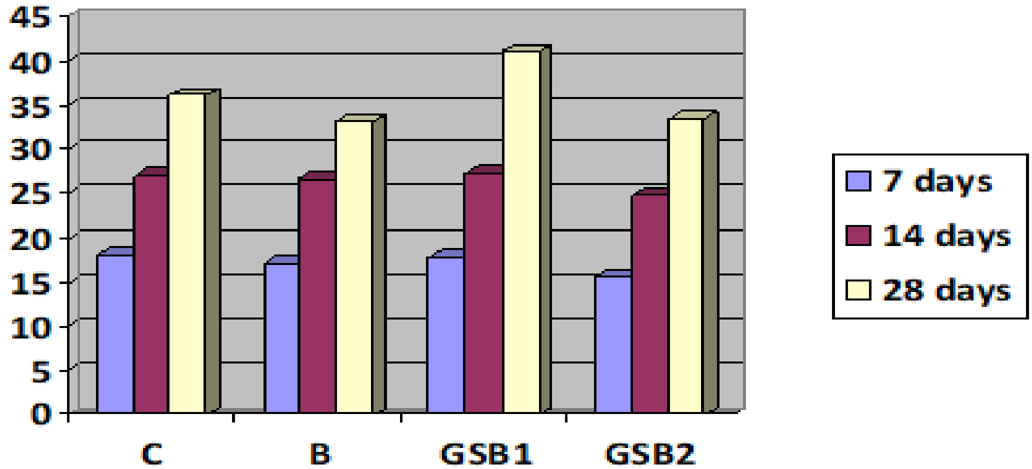

Fig 9 c Compressive Strength Result

B. Split Tenslie Strength Test

In this study the cylinders are prepared conventional concrete, conventional concrete with GGBS, conventional concrete SCBA, conventional concrete with bacteria, bacteria with GGBS, bacteria with SCBA and also bacteria with GGBS and SCBA. Totally 90 cubes are tested with curing period of 7days, 14days and 28days. Concrete with bacteria for 3 different age periods, for every age period 3 cylinders are casted. Bacterial concrete with GGBS and SCBA also casted. The size of cylinders 150mmX300mm.

In comparison to ordinary concrete, GGBS 20% concrete has a lower split tensile strength, while GGBS 40% concrete has a higher split tensile strength. Compared to regular concrete, the strength of bacterial concrete is reduced. When compared to conventional concrete, bacterial concrete with GGBS 20% has a lower strength, and when compared to both conventional and bacterial concrete, it has a higher strength. Both a table and a bar chart with the split tensile strengths of conventional, GGBS, and bacterial concrete are donated.

Table 11 Split Tensile Strength with Replacement of GGBS and bacteria with GGBS

Specimen	Split tensile strength		
	7 days	14days	28 days
Conventional concrete [C]	**1.8**	**2.5**	**3.50**
GGBS 20% [G1]	**1.73**	**2.3**	**3.42**
GGBS 40% [G2]	**1.75**	**2.55**	**3.53**
Bacteria 10% [B]	**1.7**	**2.48**	**3.47**
GGBS 20% + bacteria 10 % [GB1]	**1.73**	**2.32**	**3.43**
GGBS 40% + bacteria 10 % [GB2]	**1.74**	**2.53**	**3.50**

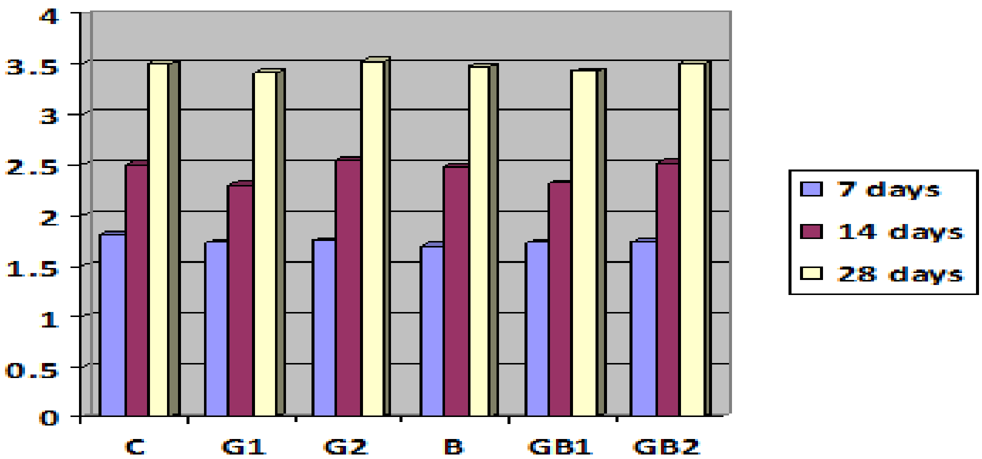

Fig 10 a Split Tensile Strength Result

When compared to regular concrete, SCBA 10% concrete has lower split tensile strength. When compared to bacterial and conventional concrete, the strength of the bacterial concrete containing SCBA is reduced. Both a table and a bar chart with the split tensile strengths of conventional, SCBA, and bacterial concrete are donated.

Table 12 Split Tensile Strength with Replacement of SCBA and bacteria with SCBA

Specimen	Split tensile strength		
	7 days	14 days	28 days
Conventional concrete [C]	1.8	2.5	3.50
SCBA 10%[S]	1.56	1.94	2.68
Bacteria 10% [B]	1.7	2.48	3.47
SCBA 10% + bacteria 10% [SB]	1.55	2	2.71

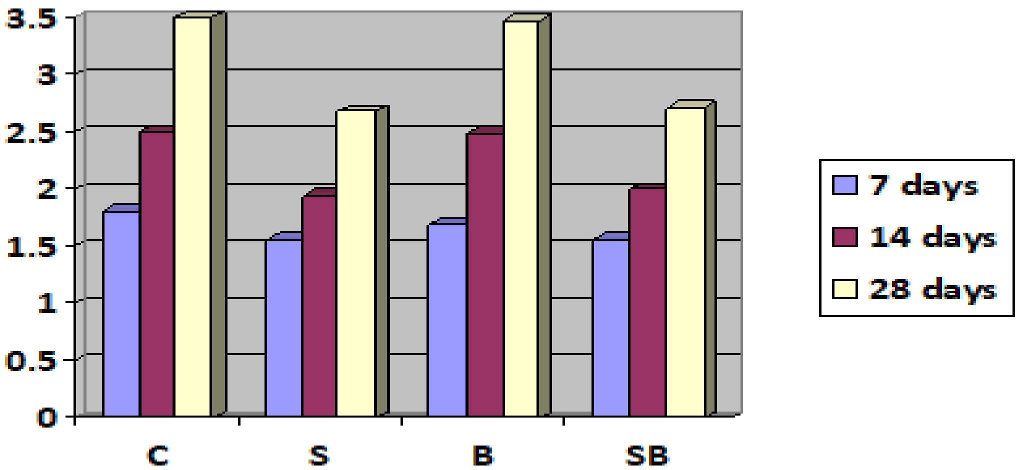

Fig 10 b Split Tensile Strength Result

When compared to conventional concrete and bacterial concrete, bacteria concrete containing GGBS 20% and SCBA 10% had a higher split tensile strength. In comparison to conventional concrete and bacterial concrete, the strength of the bacterial concrete with GGBS 40% and SCBA 10% is reduced. Both a table and a bar chart with the split tensile strengths of conventional, bacterial, and bacterial with GGBS and SCBA concrete are donated.

Table 13 Split Tensile Strength with Replacement of GGBS & SCBA and bacteria with GGBS & SCBA

Specimen	**Split tensile strength**		
	7 days	14 days	28 days
Conventional concrete [C]	1.8	2.5	3.50
Bacteria 10% [B]	1.7	2.48	3.47
GGBS 20% + SCBA 10% + bacteria 10% [GSB1]	2.01	2.54	3.54
GGBS 40% + SCBA 10% + bacteria 10% [GSB2]	1.72	2.29	3.24

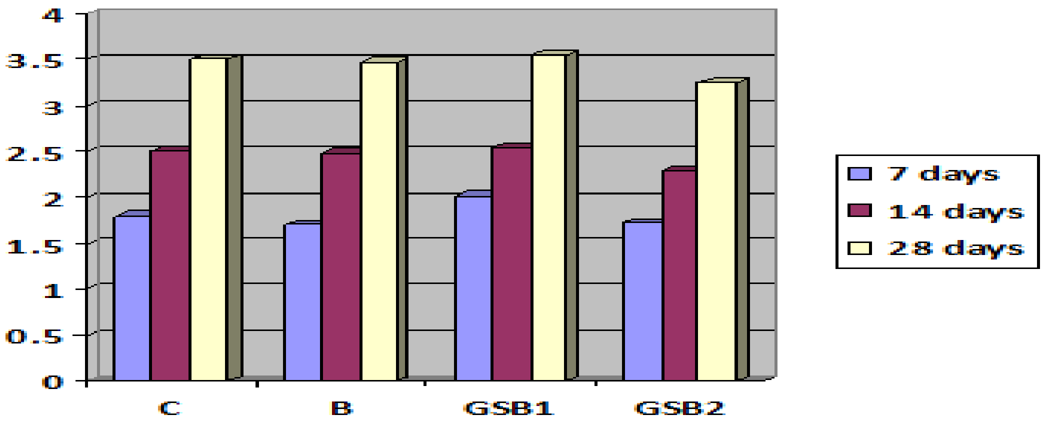

Fig 10 c Split Tensile Strength Result

VI. CONCLUSIONS

- It has been found that adding GGBS and SCBA to fresh concrete as a partial replacement for cement and bacteria increases workability compared to the conventional concrete.
- Bacillus subtilis powder, which has been shown to be both safe and economical.
- The mixture that replaced 30% of the cement with GGBS (20%), SCBA (10%), and bacteria (10%) displayed good compressive and tensile strength characteristics. This can be as a result of the superior composition and high quality of the CSH gel produced at this proportion.
- When compared to conventional concrete, the compressive strength of GGBS 20% and GGBS 40% concrete is increased.
- When compared to conventional concrete, the strength of bacterial concrete is reduced.
- When compared to conventional and bacterial concrete, the strength of the bacterial concrete with GGBS 20% and GGBS 40% is increased.
- SCBA 10% concrete's compressive strength is lower than that of conventional concrete. Compared to both conventional and bacterial concrete, the strength of the bacterial concrete containing SCBA is reduced.
- Comparing bacterial concrete with GGBS 20% and SCBA 10% to conventional concrete and bacterial concrete, the compressive strength of the bacteria concrete with GGBS 20% and SCBA 10% is improved, whereas the strength of the bacteria concrete with GGBS 40% and SCBA 10% is lowered.
- By using it in cost-effective building methods, the higher silica content can be used to create silica compounds and reduce the environmental impact issues associated with the disposal of bagasse ash.

REFERENCES

[1] He, Xiaohong, et al. "Self-Healing Concrete: A Scientometric Analysis-Based Review of the Research Development and Scientific Mapping." Case Studies in Construction Materials (2022): e01521.
[2] Sarkar, Manas, et al. "Evaluation of the crack-healing performance and durability of bacteria integrated alkali-activated fly ash composites." Journal of Building Engineering 54 (2022): 104642.
[3] Venkatraman, G., and V. Vanathi. "Quantification of Self-Healing Effect of Bacillus Subtilis on Cementitious Material." International Journal of Sustainable Construction Engineering and Technology 13.3 (2022): 183-194.
[4] Rollakanti, Chiranjeevi Rahul, and Kota Srinivasu. "Microstructural and Nondestructive testing analysis of Self-healing concrete with Pseudomonas fluorescens Bacteria, Calcium Lactate and M-Sand." NeuroQuantology 20.6 (2022): 8764-8778.
[5] Tesfamariam, Belay Brehane, et al. "Investigation of Self-Healing Mortars with and without Bagasse Ash at Pre-and Post-Crack Times." Materials 15.5 (2022): 1650.

ISSN No:-2456-2165

[6] Rollakanti, Chiranjeevi Rahul, and Kota Srinivasu. "Experimental Investigations on Self-Healing Concrete with Pseudomonas Fluorescens Bacteria and Calcium Lactate." Mathematical Statistician and Engineering Applications 71.4 (2022): 803-816.

[7] Dharmabiksham, B., and KallempudiMurali. "Experimental investigation on the strength and durability aspect of bacterial self-healing concrete with GGBS and dolomite powder." Materials Today: Proceedings (2022).

[8] Parashar, Arun Kumar, et al. "An experimental investigation on mechanical properties of calcined clay concrete embedded with bacillus subtilis." Materials Today: Proceedings 44 (2021): 129-134.

[9] Elavarasan, S., et al. "Experimental study on partial replacement of cement by metakaolin and GGBS." Materials Today: Proceedings 37 (2021): 3527-3530.

[10] Venkat, G. Naga, K. Chandramouli, and V. NagendraBabu. "Comparative study on mechanical properties and quality of concrete by part replacement of cement with silica fume, metakaolin and GGBS by using M− Sand as fine aggregate." Materials Today: Proceedings 43 (2021): 1874-1878.

[11] Khalil, Muhammad Jahanzaib, Muhammad Aslam, and Sajjad Ahmad. "Utilization of sugarcane bagasse ash as cement replacement for the production of sustainable concrete–A review." Construction and Building Materials 270 (2021): 121371.

[12] Danish, Aamar, Mohammad Ali Mosaberpanah, and Muhammad UsamaSalim. "Past and present techniques of self-healing in cementitious materials: A critical review on efficiency of implemented treatments." Journal of Materials Research and Technology 9.3 (2020): 6883-6899.

[13] Chaitanya, M., et al. "Prediction of self-healing characteristics of GGBS admixed concrete using Artificial Neural Network." Journal of Physics: Conference Series. Vol. 1716. No. 1. IOP Publishing, 2020.

[14] Rauf, Momina, et al. "Comparative performance of different bacteria immobilized in natural fibers for self-healing in concrete." Construction and Building Materials 258 (2020): 119578.

[15] Danish, Aamar, Mohammad Ali Mosaberpanah, and Muhammad UsamaSalim. "Past and present techniques of self-healing in cementitious materials: A critical review on efficiency of implemented treatments." Journal of Materials Research and Technology 9.3 (2020): 6883-6899.

[16] Sidiq, Amir, Rebecca Gravina, and FilippoGiustozzi. "Is concrete healing really efficient? A review." Construction and Building Materials 205 (2019): 257-273.

[17] Kumar, VR Prasath, K. Gunasekaran, and T. Shyamala. "Characterization study on coconut shell concrete with partial replacement of cement by GGBS." Journal of Building Engineering 26 (2019): 100830.

[18] Byoungsun, Park, and Cheol Choi Young. "Investigating a new method to assess the self-healing performance of hardened cement pastes containing supplementary cementitious materials and crystalline admixtures." Journal of Materials Research and Technology 8.6 (2019): 6058-6073.

[19] Chithambar Ganesh, A., et al. "An experimental study on effects of bacterial strain combination in fibre concrete and self-healing efficiency." KSCE Journal of Civil Engineering 23.10 (2019): 4368-4377.

[20] Gardner, Diane, et al. "A survey on problems encountered in current concrete construction and the potential benefits of self-healing cementitious materials." Case studies in construction materials 8 (2018): 238-247.

[21] Joy, Milan, and Sneha M. Varghese. "Experimental Study on Strength Characteristics of Self–Healing Concrete with Fly Ash." International Journal of Engineering Research & Technology (IJERT) ISSN (2018): 2278-0181.

[22] Kusuma, K., et al. "Self-Healing Cocrete." Ratio 340.657.6 (2018): 1335-1394.

[23] Bharanedharan G, et al. "Studies on Self-Healing Sustainable Concrete Using Bacterial Carbonate Precipitate."International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 24 (2018) pp: 16719-16728.

[24] Sangeetha, P., R. Vijayalakshmi, and S. Ramanagopal. "Study on effect of bacterial in bagasse ash concrete." Int J CivEngTechnol 8.6 (2017): 45-52.

[25] Hawileh, Rami A., et al. "Performance of reinforced concrete beams cast with different percentages of GGBS replacement to cement." Archives of Civil and Mechanical Engineering 17.3 (2017): 511-519.

[26] Mangi, Sajjad Ali, et al. "Utilization of sugarcane bagasse ash in concrete as partial replacement of cement." IOP conference series: materials science and engineering. Vol. 271. No. 1. IOP Publishing, 2017.

[27] Reddy, G. Nithin Kumar, G. HarshaVardhan, and S. VijayaBhaskar Reddy. "Partial replacement of cement in concrete with sugarcane bagasse ash and its behaviour in aggressive environments." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278 1684 (2016).

[28] Souradeep, Gupta, and Harn Wei Kua. "Encapsulation technology and techniques in self-healing concrete." Journal of Materials in Civil Engineering 28.12 (2016): 04016165.

[29] Babu, N. Ganesh, and S. Siddiraju. "An experimental study on strength and fracture properties of self healing concrete." International Journal of Civil Engineering and Technology 7.3 (2016): 398-406.

[30] Madhavi, Etaveni, and T. DivyaBhavana. "Strength properties of a bacterial concrete with flyash and GGBS." Int. J. Eng. Res. Technol 5 (2016): 546-548.

[31] Priya, K. Lakshmi, and R. Ragupathy. "Effect of sugarcane bagasse ash on strength properties of concrete." Int. J. Res. Eng. Technol 5.4 (2016): 159-164.
[32] Roig-Flores, Marta, et al. "Self-healing capability of concrete with crystalline admixtures in different environments." Construction and Building Materials 86 (2015): 1-11.
[33] Qian, Chun Xiang, et al. "Self-healing and repairing concrete cracks based on bio-mineralization." Key Engineering Materials. Vol. 629. Trans Tech Publications Ltd, 2015.
[34] Depaa, R. A. B., and T. Felix Kala. "Experimental investigation of self healing behavior of concrete using silica fume and GGBFS as mineral admixtures." Indian Journal of Science and Technology 8.36 (2015): 87644.
[35] Karri, Santosh Kumar, GV Rama Rao, and P. MarkandeyaRaju. "Strength and durability studies on GGBS concrete." SSRG International Journal of Civil Engineering (SSRG-IJCE) 2.10 (2015): 34-41.
[36] Wang, J. Y., et al. "Application of hydrogel encapsulated carbonate precipitating bacteria for approaching a realistic self-healing in concrete." Construction and building materials 68 (2014): 110-119.
[37] Stuckrath, Claudia, et al. "Quantification of chemical and biological calcium carbonate precipitation: performance of self-healing in reinforced mortar containing chemical admixtures." Cement and Concrete Composites 50 (2014): 10-15.
[38] Wang, J. Y., et al. "Self-healing concrete by use of microencapsulated bacterial spores." Cement and concrete research 56 (2014): 139-152.
[39] Talaiekhozani, Amirreza, and MuhdZaimiAbdMajid. "A review of self-healing concrete research development." Journal of Environmental Treatment Techniques 2.1 (2014): 1-11.
[40] Huang, Haoliang, Guang Ye, and Denis Damidot. "Effect of blast furnace slag on self-healing of microcracks in cementitious materials." Cement and concrete research 60 (2014): 68-82.
[41] Arivalagan, S. "Sustainable studies on concrete with GGBS as a replacement material in cement." Jordan journal of civil Engineering 8.3 (2014): 263-270.
[42] Dong, Biqin, et al. "A microcapsule technology based self-healing system for concrete structures." Journal of Earthquake and Tsunami 7.03 (2013): 1350014.
[43] Li, Victor C., and Emily Herbert. "Robust self-healing concrete for sustainable infrastructure." Journal of Advanced Concrete Technology 10.6 (2012): 207-218.
[44] Wu, Min, BjörnJohannesson, and MetteGeiker. "A review: Self-healing in cementitious materials and engineered cementitious composite as a self-healing material." Construction and Building Materials 28.1 (2012): 571-583.
[45] Van Tittelboom, Kim, et al. "Influence of mix composition on the extent of autogenous crack healing by continued hydration or calcium carbonate formation." Construction and Building Materials 37 (2012): 349-359.
[46] Doshi, Tejas, and M. B. Patil. "Influence of Bacteria on The Strength and Durability Properties of Concrete Incorporating GGBS."
[47] Waghmare, Ashish P., et al. "Self-Healing Concrete or Bio-Concrete used in Construction Industry."
[48] Wang, Jianyun, et al. "Use of silica gel or polyurethane immobilized bacteria for self-healing concrete." Construction and building materials 26.1 (2012): 532-540.
[49] Gandhimathi, A., et al. "Experimental Study on Self–Healing Concrete." Emerging Trends in Engineering Research (2012): 978-93.
[50] Yang, Yingzi, En-Hua Yang, and Victor C. Li. "Autogenous healing of engineered cementitious composites at early age." Cement and concrete research 41.2 (2011): 176-183.
[51] Parks, Jeffrey, et al. "Effects of bulk water chemistry on autogenous healing of concrete." Journal of materials in Civil Engineering 22.5 (2010): 515-524.
[52] Srinivasan, R., and K. Sathiya. "Experimental study on bagasse ash in concrete." International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship 5.2 (2010): 60-66.
[53] Hearn, Natalya, and C. T. Morley. "Self-sealing property of concrete—Experimental evidence." Materials and structures 30.7 (1997): 404-411.