International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

Experimental Study Of Chemical Attack On Fiber Reinforced Concrete

Channappa[1], Asst. Prof., **Gurunank Dev Engineering College Bidar India, channareddy789@gmail.com**
Dr. Pradeep Kumar Reddy[2], Asst. Prof, **Sharanbasav University Kalaburgi & India, pradeepreddybidar@gmail.com**

Abstract: **Concrete has been employed in building and it is uncovered to the action of acidic environment for as lengthy as concrete has been used when concrete is to be employed underneath situation in which it will be uncovered to the effect of acids. "Considerations ought to be taken of these effects and appropriate precautions taken. However normally these precautions are not drastic and do no longer contain the decision and use of substances or production of concrete. The outcomes of acid on concrete can also be examined by way of thinking about the characteristics of acid that can impact concrete, the elements of specific concrete contain that might also be affected by way of these factors. The consequences of interaction of acids with concrete and sooner or later the precautions that need to be taken to avoid the undesirable overall performance of the concrete due to its interaction with acids.**

Keywords — carbonation fiber reinforced concrete, hydrochloric acid, sulphuric acid,

I. Introduction

Acid resistance is one of the critical durability factors determining the life cycle performance and maintenance of concrete in an aggressive acid environment. Aggressive environmental conditions with an acid attack occur in many industry sectors (chemical, mining, mineral processing, cooling towers [1], [2], [3]), agriculture [4], [5], [6], [7], as well as in sewage systems, where concrete is used for build sewer pipes, maintenance holes, pumping stations, wastewater collection systems, and treatment plants. Acid attack in the concrete sewage system is characterized by the changeability of the aggressive medium. Sewers can be divided into two main zones: sewage flow zone and sewer atmosphere. Each of these zones has a different type of acid corrosion. In the sewage flow zone, wastewater containing substances like inorganic or organic acids, lime-dissolving carbonic acid, ammonium, magnesium salts, and fatty acids [8], [9] is the most critical aggressive medium. Strong acids, e.g., hydrochloric, sulfuric, and nitric acids, can react with all cement stone matrix components and dissolve them to form precipitates of calcium, aluminum and iron salts, and silica gel.

Concrete:

If you've ever walked on a sidewalk, driven on a road, or stood in a building, chances are you've encountered concrete. Put simply, concrete is a mixture of cement, water, and aggregates (like sand and gravel) that hardens over time to create a solid, strong substance. It's used in all sorts of construction projects because it's affordable, durable, and can be moulded into nearly any shape.

Composition of Concrete:

Concrete is composed of three main ingredients - cement, aggregates, and water. Cement is the binding agent that holds the concrete together, while aggregates, such as sand and gravel, provide strength and bulk.

The water is used to hydrate the cement and activate the chemical process that hardens the concrete. This is why the ratio of cement to water is an essential factor in determining the strength and durability of the concrete.

Fiber Reinforced Concrete:

Fiber Reinforced Concrete is a composite material consisting of fibrous material which increases its structural integrity. It includes mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce the bleeding of water.

II. Literature Review

Shripad Umaleet.al-[1]"In recent century, the use of concrete has increased tremendously in all types of construction varying from industrial, residential, water storage, infrastructure and so on. This material is generally highly durable and can be made to possess superior mechanical properties, such as high compressive and flexural strengths. When it comes to resistance to different types of chemicals, the durability of concrete is quite influenced by its manufacturing process (curing methods,

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.

finishing, etc.) and the materials that are used. It is well known that concrete deteriorates when exposed to chemical attack under acidic environments. Concrete structures may be subjected to acidic environments under variety of conditions such as acid spills, acid rains, drainage sewers, chemical factories, hot springs, industrial effluents, etc. In above cases, the acid that affects concrete may be different. Also, the duration of attack may range from few seconds to years. In the present study, an attempt is made to study the effect on acid exposure on strength of concrete through experimentation.

Abdulrahman Fahad Al Fuhaidet.al[2] - "Reinforced concrete (RC) has been commonly used as a construction material for decades due to its high compressive strength and moderate tensile strength. However, these two properties of RC are frequently hampered by degradation. The main degradation processes in RC structures are carbonation and the corrosion of rebars. The scientific community is divided regarding the process by which carbonation causes structural damage. Some researchers suggest that carbonation weakens a structure and makes it prone to rebar corrosion, while others suggest that carbonation does not damage structures enough to cause rebar corrosion. This paper is a review of the research work carried out by different researchers on the carbonation and corrosion of RC structures. The process of carbonation and the factors that contribute to this process will be discussed, alongside recommendations for improving structures to decrease the carbonation process. The corrosion of rebars, damage to passive layers, volume expansion due to steel oxidation, and crack growth will also be discussed. Available protection methods for reducing carbonation, such as rebar structure coating, cathodic protection, and modifier implementation, will also be reviewed. The paper concludes by describing the most significant types of damage caused by carbonation, testing protocols, and mitigation against corrosion damage."

D.Bhuniaet.al[3] - "Within the framework of the research project by the government of different countries it has been observed that the buildings which were built between 1961and 1992, at present they are showing the critical signs of serious deterioration. The impact of aggressive environment on the occurrence of failure is more than evident. Considering the issues related to the concrete durability, in this study an initiative has been taken in order to ascertain the effects of carbonation on the concrete properties. This paper describes an experimental investigation carried out to study the effects of carbonation on the mechanical properties of plain concrete. Ordinary Portland cement (OPC) with a constant water/cement ratio of 0.5wasused in this study. Compressive strength and depth of carbonation using phenolphthalein solution were measured in order to observe the effect of carbonation."

K. Kawai et.al[4] - "In this paper, Author has proposed a prediction method for the deterioration of concrete due to sulfuric acid. Concrete cylinder specimens were immersed in various concentrations of sulfuric acid. Also, sulfuric acid was circulated over the surface of concrete. It was found that the rate of concrete deterioration caused by sulfuric acid depended on pH value of acid solutions. Also, time of exposure of concrete to acid plays a crucial role in rate of deterioration. Paper also monitors depth of erosion."

T.G. Nijland, et.al[5] -"explain that Acid attack is the dissolution and leaching of calcium hydroxide, from the cement paste of hardened concrete. This action results in an increase in capillary porosity, loss of cohesiveness and eventually loss of strength. In some situations, acid attack may be accompanied by crack formation and eventually disintegration, especially when the structure is subjected at one side to water pressure. Unlike sulphate attack the products formed from acid attack are not expansive, and leaching will only occur in structures that are relatively permeable. In high performance concrete systems containing cement pastes with a low content of calcium hydroxide, acid attack is relative slow and may involve only the finely divided calcium hydroxide crystals incorporated in the interstices of the calcium silicate hydrates, C-S-H."

III. OBJECTIVE

1) An extensive literature survey pertaining to chemical attack of materials specifically acids on concrete.

2) Determination of effect of acids on compressive strength of concrete through experimentation.

3) To study the effect of acid attack on concrete by varying following things:-

- Duration of attack.
- Concentration of acids.
- Type of acid.
- Method of attack.

4. Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous cover concrete and may reduce the pH to 8 or 9, at which the passivating/oxide film is no longer stable.

5. Carbonation process involves the following two stages: First, the atmospheric carbon dioxide (CO_2) reacts with water in the concrete pores to form carbonic acid (H_2CO_3).

6. This is followed by reaction of the carbonic acid with calcium hydroxide [Ca $(OH)_2$] to form calcium carbonate ($CaCO_3$).

7. This process leads to cause a reduction in the pH value of the pore solution from 12.5 to 13.5 to around 8 to 9

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.

IV. MATERIAL AND METHODOLOGY

Cement:

Cement is a fine, soft powder used as a binder because it hardens after contact with water. It is produced from a mixture of limestone and clay that's charred and then ground up.

Fine aggregate:

Fine aggregate is a type of aggregate used in concrete that is smaller than 4.75 mm in size. It is typically made up of sand, crushed stone or recycled concrete, and is used to fill the voids in the concrete mixture, provide a smooth finish, and improve the workability of the concrete. Fine aggregates are typically classified based on their size, shape, and texture.

Size: The size of fine aggregate is typically measured in millimeters, and it can range from 0.075 mm to 4.75 mm in diameter.

Manufactured Sand (M SAND):

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

Coarse aggregates:

Coarse aggregates are irregular broken stone or naturally-occurring rounded gravel used for making concrete. Materials which are large to be retained on 4.7 mm sieve size are called coarse aggregates, and its maximum size can be up to 63 mm.

Glass-fiber reinforced concrete

Glass-fiber reinforced concrete, or GRC, is an innovative and lightweight concrete. With the opportunity to cast virtually unlimited shapes, profiles and textures – GRC can bring your project to life without limitations. It uses alkali-resistant glass fibers as reinforcement instead of the steel used in conventional precast. Uniquely agile, versatile and sustainable, this material is quickly becoming a choice solution for architects, designers and builders globally

Material	Water	Cement	Fine aggregate	Coarse aggregate	Glass fibre
Kgs/m3	174.22	3.34	8.36	14.78	0.055
Ratio	0.40	1	2.33	3.99	2%

Table.1 material ratio for light weight concrete

TEST ON HARDENED CONCRETE:

Compressive Strength Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

Apparatus: Compressive Testing Machine

Formula for Compressive Strength:

Compressive Strength = Load / Cross-sectional Area

Procedure for Concrete Cube Test

1. Remove the specimen from the water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140 kg/cm^2/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.
9. Compressive Strength of Concrete at Various Ages
10. The strength of concrete increases with age. The table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

Age	Strength percent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

Table.2 Compressive Strength of Concrete at Various Ages

ACID ATTACK ON CONCRETE:

Concrete is susceptible to acid attack because of its alkaline nature. "The components of the cement paste break down during contact with acids as a process of disintegration. Most pronounced is the dissolution of calcium hydroxide which occurs according to the following reaction":

$$2\ HX + Ca(OH)_2 \rightarrow CaX_2 + 2\ H_2O$$

(X is the negative ion of the acid)

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.

ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

The "decomposition of the concrete depends on the porosity of the cement paste and the attention of the acid, the solubility of the acid calcium salts (CaX2) and on the fluid transport via the concrete conduits. Insoluble calcium salts may percolate in the voids and can slow down the attack. Acids such as nitric acid, hydrochloric acid and acetic acid are very aggressive as their calcium salts are easily soluble and eliminated from the assault front. Other acids such as phosphoric acid two are less harmful as their calcium salt due to their low solubility, inhibit the attack by using blockading the pathways within the concrete such as interconnected cracks, voids and porosity. Sulphuric acid interaction with concrete surface leads to serious adverse to concrete as it combines an acid assault and a sulfate attack"

Fig. 1Making of concrete cubes

Fig.2 Compression test on concrete cube

HYDROCHLORIC ACID

Hydrochloric acid, also known as muriatic acid or spirits of salt, is an aqueous solution of hydrogen chloride (HCl). It is a colourless solution with a distinctive pungent smell. It is classified as a strong acid. It is a component of the gastric acid in the digestive systems of most animal species, including humans. Hydrochloric acid is an important laboratory reagent and industrial chemical.

Production:

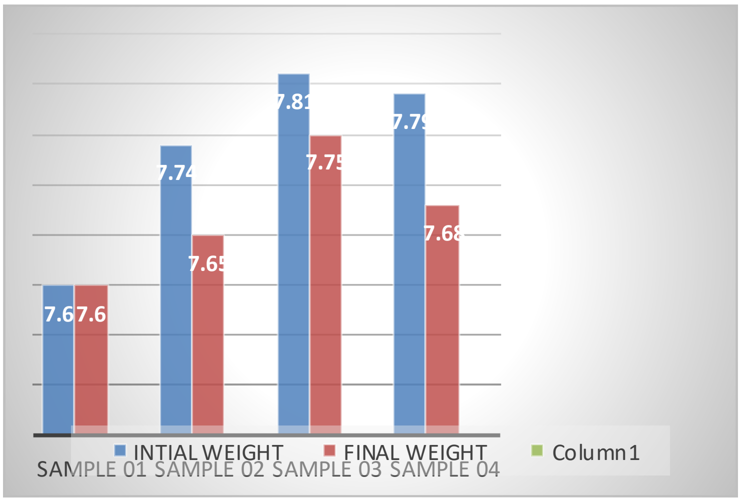
Hydrochloric acid is usually prepared industrially by dissolving hydrogen chloride in water. Hydrogen chloride can be generated in many ways, and thus several precursors to hydrochloric acid exist. The Large-scale production of hydrochloric acid is almost always integrated with the industrial scale production of other chemicals, such as in the chloralkali process which produces hydroxide, hydrogen, and chlorine, the latter of which can be combined to produce HCl. Hydrogen chloride is produced by combining chlorine and hydrogen:

$$Cl_2 + H_2 \rightarrow 2\ HCl$$

As the reaction is exothermic, the installation is called an HCl oven or HCl burner. The resulting hydrogen chloride gas is absorbed in deionized water, resulting in chemically pure hydrochloric acid. This reaction can give a very pure product, e.g. for use in the food industry.

Sl. No	Grade of concrete	Wt of concrete cube before curing in HCL In Kgs	Wt of concrete cube after curing in HCL In Kgs	Cured in different % of HCLsolution	3 days strength (MPa)
1	M25	7.60	7.60	Water	7.35
2	M25	7.74	7.65	3% HCL	6.93
3	M25	7.81	7.75	3% HCL	7.12
4	M25	7.79	7.68	3% HCL	7.05

Table.3 hydrochloric acid test on concrete



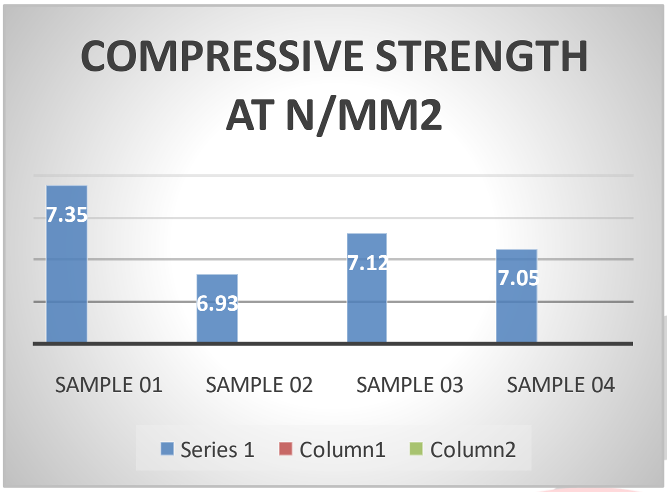
Graph. 1 .Weight of concrete before and after curing in HCL

Table.4 sulphuric acid test on concrete

DOI : 10.35291/2454-9150.2024.0398
© 2024, IJREAM All Rights Reserved.

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-10, Issue-07, Oct 2024

Sl. No	Grade of concrete	Wt of concrete cube before curing in H2SO4 In Kgs	Wt of concrete cube after curing in H2SO4 In Kgs	Cured in different % of H_2SO_4 solution	3 days strength (MPa)
1	M25	7.60	7.60	Water	8.93
2	M25	7.80	7.99	3% H_2SO_4	10.8
3	M25	7.75	7.92	3% H_2SO_4	09.50
4	M25	7.79	7.87	3% H_2SO_4	09.42



Graph. 2. 3 days strength (MPa) for different samples

SULPHURIC ACID

Mattling acid or Oil of Vitriol are two other names for sulphuric acid. It is highly acidic. At greater concentrations It works as an oxidising and dehydrating agent. It's a clear, syrupy liquid with no odour and no colour. It is water soluble and it produces heat when dissolved in water. It's a common ingredient in fertiliser production. It's also employed in wastewater treatment and chemical production.

Anhydrous sulphuric acid is a polar liquid with a dielectric constant of roughly 100. It is the most important heavy industrial chemical, with widespread use in a variety of industries.

$SO_3 + H_2O \rightarrow H_2SO_4$(g) (−101 kJ/mol)

Uses of H2SO4 (sulphuric Acid)

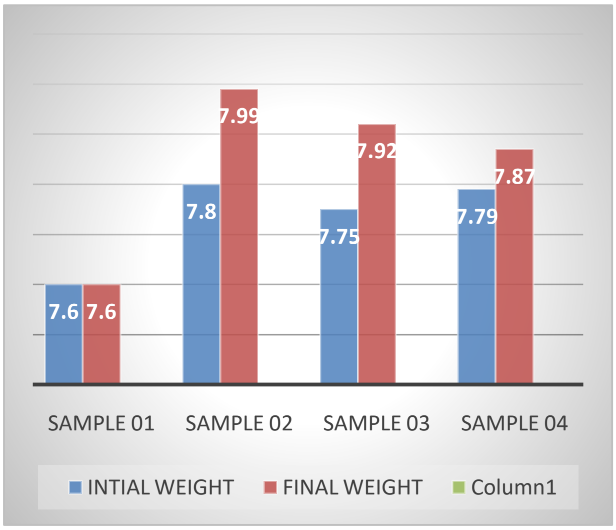
1)It's utilised in fertiliser production.

2) It's utilised in the steel and iron industries.

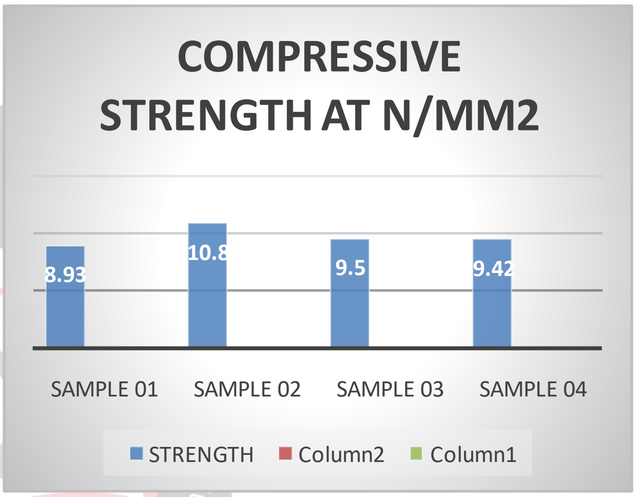
3) It's widely utilised in the chemical industry.

4) it's utilized in the petroleum refining process.

5) Phosphoric acid is made from it.



Graph. 3 .Weight of concrete before and after curing in H2SO4 in Kgs



Graph. 4. 3 days strength (MPa) H2SO4 in Kgs

Uses of Conc 3% HCLand 3% H2SO4

Concrete cube curied in 3days

CARBONATION

Carbon dioxide from air reacts with the calcium hydroxide in concrete to form calcium carbonate which reduce the

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.

alkalinity of the concrete and increase the risk of reinforcement corrosion.

Carbonation of concrete is a slow and continuous process progressing from the outer surface inward, but slows down with increasing diffusion depth.

Cement paste contains 25-50 wt% calcium hydroxide ($Ca(OH)_2$), which mean that the pH of the fresh cement paste is at least 12.5. The pH of a fully carbonated paste is about 7.

The concrete will carbonate if CO_2 from air or from water enters the concrete according to:

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

When $Ca(OH)_2$ is removed from the paste hydrated CSH will liberate CaO which will also carbonate. The rate of carbonation depends on porosity & moisture content of the concrete.

The carbonation process requires the presence of water because CO_2 dissolves in water forming H_2CO_3. If the concrete is too dry (RH <40%) CO_2 cannot dissolve and no carbonation occurs. If on the other hand it is too wet (RH >90%) CO_2 cannot enter the concrete and the concrete will not carbonate. Optimal conditions for carbonation occur at a RH of 50% (range 40-90%).

Carbonation has three effects: it increases mechanical strength of the carbonated concrete, reduces permeability and it also decreases alkalinity, which is essential for corrosion prevention of the reinforcement steel. Reinforcement in concrete will not corrode, if the pH of concrete is maintained around 13. Carbonation reduces the pH level of concrete. Below a pH of 10-11, the steel's thin layer of surface passivation dissolves and corrosion is promoted. The pH of carbonated concrete drops to about 7, thus, carbonation provides a favorable condition for corrosion. The depth of carbonation increases with an increase in water / cement ratio. It is to be noted that corrosion of reinforcement will start if entire cover to the steel is carbonated, but presence of moisture and oxygen is essential.

Carbonation rate is normally high in dry weather, but possibility of corrosion is less due less moisture content.

Chemical used: phenolphthalein

Procedure

The extent / depth of carbonation is determined by treating freshly broken / core cut concrete surface or a drilled powder obtained from various depths, with a phenolphthalein indicator. A purple red colouration will be obtained where the highly alkaline concrete has been unaffected, but carbonated portion will remain uncoloured. The change of colour corresponds to a pH of about 8.3.

Phenolphthalein: sparyed on breaked fresh harden concrete (3% of hcl and h2so4andwater days curried concrete cubes tested. 0% of carbonation

V. Conclusion

- Acidic curing environment have a negative effect on the "compressive, flexural and tensile strengths as well as density of concrete cured in acidic water. It reveals that the structure exposed to severe acidic environment conditions did not achieved the desired serviceability"
- The strength of concrete decreased with increase in duration of curing age and percentage concentration of acid in the curing water.
- A near linear relationship between loss of weight and strength is observed as the percentage of acid increased in the curing water.
- The "structures that exposed to severe acidic environment should be given a special attention while designing the structure especially while selecting the concrete compositions and a higher safety factor should be adopted . If possible special cements should be allowed reducing the deterioration effect due to the harsh acidic environment"
- To make structure durable acid resistant Novolac Epoxy floor resins be provided which protects the structure against hundreds of different chemicals and acids and gives the highest level of protection.
- The influence of water/cement ratio is very much significant on the strength of the concrete since the strength of the concrete depends on water/cement ratio. The depth of carbonation depends on water/cement ratio higher water/cement ratio contributes to higher carbonation depth.
- Increase in curing period reduces the carbonation depth. The resistant power of the concrete to carbonation is increased with sufficient and substantial curing periods.
- If porosity increases carbonation depth also increases hence a linear relationship exist between accelerated carbonation and porosity.
- Addition of SCMs like GGBS and SF reduce the porosity of concrete and reduce the depth of carbonation.
- The application of surface coatings and provision of proper cover considerably reduces the rate of carbonation. The service life of the concrete can be enhanced

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.

REFERENCES

1.Ankita Dhotre. Sri. P. I. Cholappanavar. "Developing an Individual Excel Sheet for Design and Analysis of Footing and Column" www.Ijraset.com. Volume 10,issuesep 2022.

2.Varsha S Danavandi, Shaik Kabeer Ahmed. "Developing Civil Engineering Design Software Using Ms Excel."Https://Troindia.In/.Volume-4, Issue-5 2017.

3.B. Madhusudhana Reddy, H. SudarsanaRao and M.P. George "EFFECT OF SULPHURIC ACID (H2SO4) ON BLENDED CEMENT (FLY ASH BASED) AND IT'S CONCRETE" 2012 Vol. 2 (2) April-June, international journel of applied engineering and technology.

4.H. SudarsanaRao , V. Venkateswara Reddy and S.G. Vaishal " EFFECTSOF ACIDITY PRESENT IN WATER ON STRENGTH ANDSETTING PROPERTIES OF CONCRETE" 29th Conference on OUR WORLD IN CONCRETE & STRUCTURES: 25 - 26 August 2004, Singapore Article, international journal of impact engineering.

5.Seyed M. Joorabchian "DURABILITY OF CONCRETE EXPOSED TO SULFURIC ACID ATTACK" Theses and dissertations 1-1-2010,international journal of civil engineering and technology(IJCIET).

6. Bryant Mather "EFFECTS OF SEA WATER ON CONCRETE" MISCELLANEOUS PAPER NO. 6-690 December 1964,journal of construction division .

BIOGRAPHIES

ASST. PROF, CIVIL ENGINEERING, GURU NANAK DEV ENGINEERING COLLEGE BIDAR , KARNATAKA, INDIA

ASST. PROF, CIVIL ENGINEERING, FACULTY OF ENGINEERING & TECHNOLOGY (COEDUCATION)

SHARNBASVA UNIVERSITY KALABURAGI, KARNATAKA, INDIA

 DOI : 10.35291/2454-9150.2024.0398 © 2024, IJREAM All Rights Reserved.