EFFECT OF IRON TAILING POWDER (ITP), RICE HUSK ASH (RHA) AND SILICA FUME (SF) - BASED MINERAL ADMIXTURES ON ACID CORROSION RESISTANCE OF CONCRETE

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Abstract *Exposure of concrete to acidic environments can cause the degradation of concrete component are severely affect the durability of concrete. As solid wastes are produced during industrial activity, iron tailing powder (ITP), rice husk ash (RHA) and silica fume (SF) can be used as admixtures to produce concrete and improve its durability and strength of concrete. This paper focuses on the preparation of concrete using a ternary mineral admixture system consisting of ITP, RHA and SF to investigate the acid corrosion resistance of concrete in acetic acid solution at different cement replacement rates and different water ratios.*

The tests were performed by compressive strength analysis, mass analysis, ap- parent deterioration analysis, and microstructure analysis by mercury intrusion porosimetry and scanning electron microscopy. The results show that when the water ratio is certain and the cement replacement rate is greater than 15%, especially at 20%, the concrete shows strong resistance to acid erosion. when the cement replacement rate is certain and the water ratio is less than 0.46, especially at 0.43, the concrete shows acid-resistant. Microstructural analysis shows that the ternary mineral admixture system composed of ITP, RHA and SF promotes the formation of hydration products such as C-S-H and AFT, improves the compactness and compressive strength of concrete, and reduces the connected porosity of concrete, which can obtain good over- all performance. In general, concrete prepared with a ternary mineral admixture system consisting of ITP, RHA and SF has better acid erosion resistance than ordinary concrete. The use of different kinds of solid waste powder to replace cement can adequately decline carbon emissions and protect the environment. Material are added to concrete mixtures, they can lead to improvements in various properties of concrete, such as strength , durability, workability and resistance to environmental factors like corrosion and sulfate attack .

Keywords: Iron tailing powder, Rice husk ash, Silica fume, Acid erosion, Compressive strength.

1. INTRODUCTION

Corrosion is serious problem for reinforcement in concrete. Chloride ions and Sulphate ions infiltrate in to the concrete and cause reinforcement corrosion. Rust is the main form of corrosion. Steel reinforcements are in a passive condition which is protected by concrete. This protective layer gets damaged when chloride and Sulphate ions enters into the concrete. This cause formation of rust in reinforcement bars. The volume of rust is greater than volume of steel bars, this is not good for reinforced structures. There are several chemical inhibitors used in construction field to resist corrosion. This chemical inhibitor causes harmful effect on environment.

Calcium stearate is a green corrosion inhibitor which has no harmful effect on environment. Calcium stearate (C36H70CaO4) is a carboxylate of calcium which is in the form of white waxy powder. Calcium stearate is manufactured by dissolving stearic acid in hot water and NaOH and white precipitate is formed. This precipitate is filtered, washed and dried. Calcium stearate is added to concrete by partially replacing cement. Compressive strength test is conducted to check whether calcium stearate cause any negative effect to concrete. By adding calcium stearate diameter of capillaries get reduced due to formation of waxy like substance in concrete. This cause microstructure of concrete improved and results in reduction of corrosion rate and water absorption rate.

Effect of corrosion on concrete

In recent century, the use of concrete has increased tremendously in all types of construction varying from industrial, residential, water storage, and infrastructure and so on. It is interesting to note that the word 'concrete' comes from the Latin word 'concretus' which means compact or condensed. This material is generally highly durable and can be made to possess superior mechanical properties, such as high compressive and flexural strengths. It is typically made out of Portland cement, supplementary cementitious material, water, aggregates, and depending on its application and the requirements of a specific project, different types of chemical and mineral additives may be used in its production. When it comes to resistance to different types of chemicals, the durability of concrete is quite influenced by its manufacturing process (curing methods, finishing, etc.) and the materials that are used. It is well known that concrete deteriorates when exposed to chemical attack under acidic environments (Fig.1). 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.

Deterioration of Concrete Structure

The main objectives of the study is to find extensive literature survey pertaining to chemical attack of materials specifically acids on concrete. Determination of effect of acids on compressive strength of concrete through experimentation.To study the effect of acid attack on concrete by varying following things:-

a. Duration of attack.
b. Concentration of acids.
c. Type of acid.
d. Method of attack

2. LITERATURE STUDIES

Brian et al., suggests that the resistance to acid attack is related to the impenetrability of the concrete rather than the particular cement type used. Requirements for resistance to acid attack are thus often expressed simply in terms of limitations on concrete composition such as minimum cement content or maximum free water–cement ratio. Resistance to other chemical attack is often only required in specialist applications such as chemical plants, or in contaminated land. The conditions may vary widely and most standards either do not address such issues or recommend the user to seek specialist advice.

Ravindra et al.,explains that Portland cement-based concretes are vulnerable to acid attack and it is generally acknowledged that, for a given acid strength severity of attack, the acid attack resistance is not greatly influenced by the strength of the concrete. The depth of attack increases with Copper Slag content. The presence of Copper Slag increases the intensity of the acid attack. As the sulphuric acid leaching technique has been used in metal recovery from Copper Slag (Wang et al., 2013), this probably explains the low resistance of Copper Slag to H2SO4 acid attack.

Natural waters et al., usually have a pH of more than 7 and seldom less than 6. Even waters with a pH greater than 6.5 may be aggressive if they contain bicarbonates. Any water that contains bicarbonate ion also contains free carbon dioxide, which can dissolve calcium carbonate unless saturation already exists. Water with this aggressive carbon dioxide acts by acid reaction and can attack concrete and other portland cement products whether or not they are carbonated. A German specification, DIN 4030, includes both criteria and a test method for assessing the potential of damage from carbonic acid-bearing water.

3. MATERIALS AND MIX RATIOS USED

OPC 53 Grade Cement

In this investigation Ordinary Portland bond of 53Grade (ACC cement) has been obtained and has been utilized.

OPC 53 Grade

Coarse aggregates

Coarse aggregates are particles more note less that 4.75mm however for the most part run between 9.5mm to 37.5mm in measurement. They can either be from essential, auxiliary or reused sources. Essential or virgin aggregates are either land or marine-won. Rock is a coarse marine-won total, arrive won coarse aggregates incorporate rock and smashed shake. Rock constitute the dominant part of coarse aggregate utilized in concrete with pulverized stone making up the greater part of the rest of.

In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.

20mm Size aggregates

Fine aggregates

Fine aggregates are fundamentally sands won from the land or the marine condition. Fine aggregates by and large comprise of normal sand or smashed stone with most particles going through a 4.75mm sieve.

The fine total utilized in this examination is waterway sand which is acquired from nearby organization and appeared in figure

Fine aggregates

Iron tailing powder

Tailings are the materials left over, after the process of separating the valuable fraction from the worthless fraction of an ore. Tests on Iron Ore Tailings procured from Kudremukh, Lakya Dam site were conducted. The properties of the IOTs are indicated in table below

Iron Ore Tailings

Silica Fume:

Silica fume, also referred to as microsilica or condensed silica fume, is another material that is used as an artificial pozzolanic admixture. Condensed silica fume is essencially silicon dioxide in noncrystalline form. It has spherical shape. It is extremely fine with particle size less than 1 micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement particles. Silica fume has specific surface area of about 20,000 m^2/kg, as against 230 to 300 m^2/kg.

Silica fume

Rice husk ash

Considering that rice husk ash was used in this exploratory effort, M/s N.K.R Enterprises, Hyderabad, is the recipient. One important rural commodity that is determined by paddy is rice husk ash. Because there is so much siliceous material in rice husk ash, it exhibits pozzolanic properties.

Rice husk ash

Mix design of M40 Grade concrete used

Concrete Mix proportions for Trial Number

1. Cement = 438 kg/m^3
2. Water = 197 kg/m^3
3. Fine aggregates = 717.12 kg/m^3
4. Coarse aggregate = 1115 kg/m^3
5. Water-cement ratio = 0.45

Final trial mix for M40 grade concrete is 1:1.63:2.54 at w/c of 0.45

Mix proportions of Conventional Concrete with different ITP, RHA and SF

Materials	Cement (kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Water (liters)	Iron tailing powder	Rice husk ash	Silica fume
0%IT+0%RHA+0%SF	438	717.12	1115	197	0	0	0
5%IT+2.5%RHA+2.5%SF	394.2	717.12	1115	197	21.9	10.95	10.95
10%IT+5%RHA+5%SF	350.4	717.12	1115	197	43.8	21.9	21.9
15%IT+7.5%RHA+7.5%SF	306.6	717.12	1115	197	65.7	32.85	32.85
20%IT+10%RHA+10%SF	262.8	717.12	1115	197	87.6	43.8	43.8
25%IT+12.5%RHA+12.5%SF	219	717.12	1115	197	109.5	54.75	54.75

4. EXPERIMENTAL STUDY

Mixing of concrete

Measured quantities of coarse aggregate, fine aggregate and cement were spread out over an impenetrable solid floor. Steel strands are included arbitrarily while blending the solid. The blend again and again until consistency of shading was accomplished the season of blending will be 10 15 minutes.

Concrete mixing

Casting and curing of test specimens

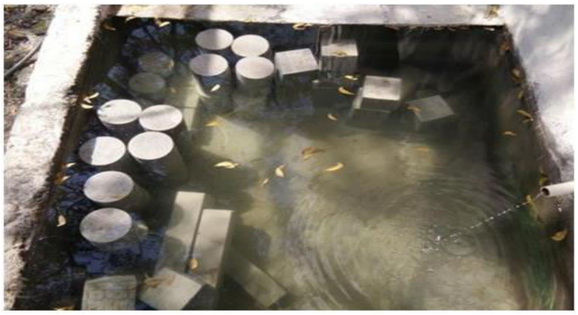
The specimens of standard cubes (150mm x 150mmx 150mm), Standard prisms (100mm x 100mm x500mm) and standard cylinders (150mm diameter x300mm height) were casted.

Placing and compacting

The segments of shape were covered with form oil and a comparable covering of form oil was connected between the contact surfaces of the base of the molds and the base plate so as to guarantee that no water evades during the filling. At that point the solid is filled in the molds layer insightful by appropriate compaction. Lastly the molds are leveled once they completely filled. Utilization of slurry on the last solid surface makes solid surface plain by filling the voids. One thing must be noticed that compaction of cement ought to be done before the start of solid beginning settling time.

Curing

The test example 3D shapes, crystals and chambers were put away in a spot, free from vibration, in most air at 90% relative mugginess and at a temperature of 27 ± 2c for 24 hours ± ½ hour from the season of expansion of water to the dry fixings. At that point the solid 3D shapes, crystals and chambers are expelled from molds and put for restoring for 3 days, 7 days, and 28 days.



Test specimens kept for curing

Tests to be conducted on concrete

Workability

Slump flow test

The concrete slump test is utilized for the estimation of a property of crisp cement. The test is an exact test that estimates the functionality of crisp cement. All the more explicitly, it gauges consistency between bunches.

Compaction factor test

Compaction factor test is the functionality test for cement directed in research facility. The compaction factor is the proportion of loads of mostly compacted to completely compacted cement. It was created by Road Research Laboratory in United Kingdom and is utilized to decide the usefulness of cement.

Compressive strength of concrete

This test was directed according to ([9] IS516-1959). The 3D shapes of standard size 150x150x150mm were utilized to locate the compressive quality of cement. Examples were set on the bearing surface of CTM, of limit 200T without whimsy and a uniform pace of stacking connected till the disap pointment of the 3D shape. The most extreme burden was noted and the compressive quality ([21] AS Alnuaimi,) was determined.

Compressive strength test machine

Tensile strength of concrete

This test was led according to IS516-1959. The chambers of standard size 150mmx300mm were utilized discover the quality of cement. Examples are set on the bearing surface of CTM, of limit 200T without flightiness and a uniform pace of stacking is connected till the disappointment of chamber. The most extreme burden was noted and the quality was determined. Split rigidity testing Procedure from IS5816-1999

Durability of concrete

Durability of concrete might be characterized as the capacity of cement to oppose enduring activity, compound assault, and scraped area while keeping up its ideal building properties.

Sturdiness is characterized as the ability of cement to oppose enduring activity, synthetic assault and scraped spot while keeping up its ideal building properties. It typically alludes to the term or life expectancy of inconvenience free execution. Various cements require various degrees of strength relying upon the presentation condition and properties wanted. For instance, concrete presented to tidal seawater will have unexpected prerequisites in comparison to indoor cement.

In the present investigation solidness of SCC was led because of impact of corrosive and sulfates

Mixing acid

Specimen tested after acid attack

XRD SEM AND FEM ANALYSIS

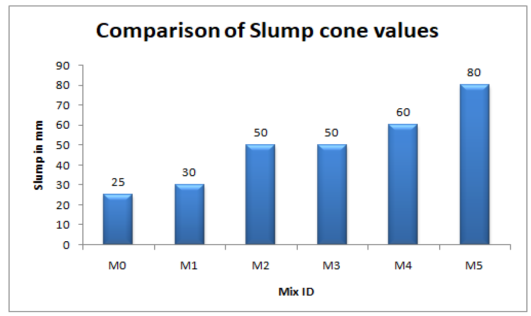
There are many techniques which have been used to study microstructure. Indirect or bulk techniques give information on average features of the whole microstructure. Examples of indirect techniques are thermogravimetry (TG), X-ray diffraction (XRD) and FTIR Spectroscopy, which can be used to determine the amounts of certain phases in the sample. Methods used to obtain information about the pore-size distribution, such as mercury intrusion porosimetry (MIP) and methanol absorption, are also indirect techniques as they give no information as to how the pores are arranged in space. The other group of techniques is a microscopical technique which provides information about the way in which the component phases are arranged in the microstructure.

The advantage of indirect techniques is that they provide information in a quantitative form so that different samples can be compared objectively. In contrast, information derived from direct techniques usually takes the form of images. Images are extremely valuable in conveying a vivid impression of the microstructure, but comparisons between different samples are more subjective and rely on the experience and interpretation of the observer. As most of the findings presented here have been obtained by XRD, microscopy, and FTIR spectroscopy techniques, their application to the study of the microstructure of concrete will be discussed in more detail.

5. RESULTS AND ANALYSIS

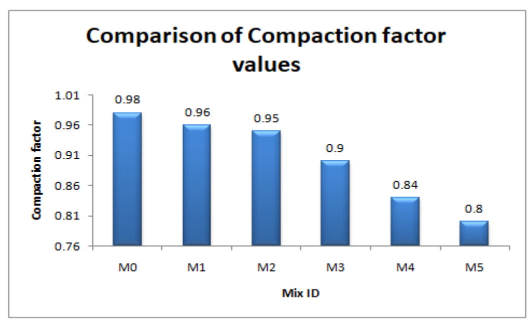
Workability of concrete

Slump cone test



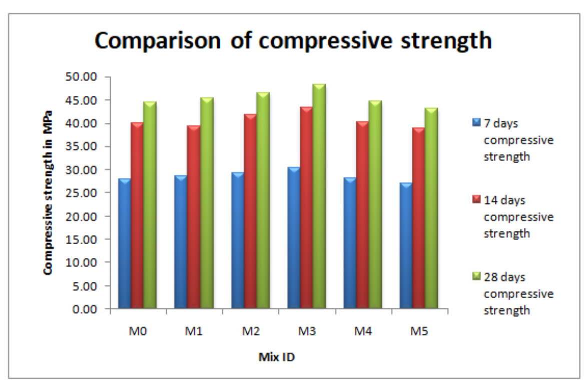
Comparison of slump cone test

Compaction factor test



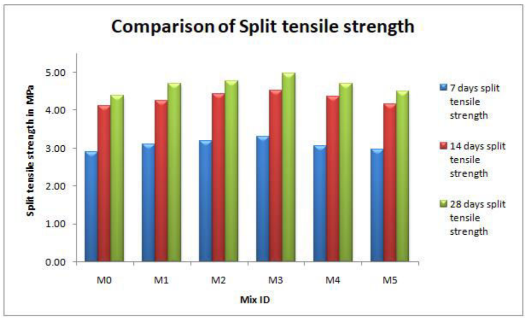
Comparison of compaction factor test

Compressive strength



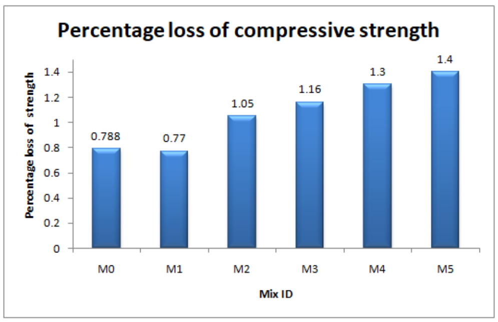
Comparison of compressive strength

Split tensile strength

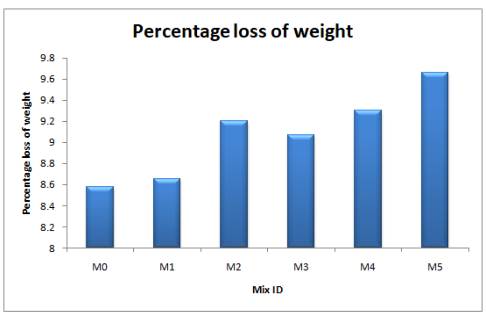


Comparison of split tensile strength

Acid resistance results

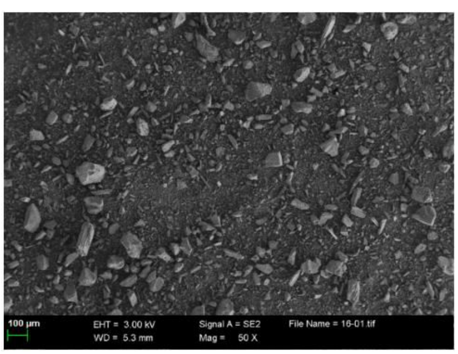


Percentage loss of compressive strength

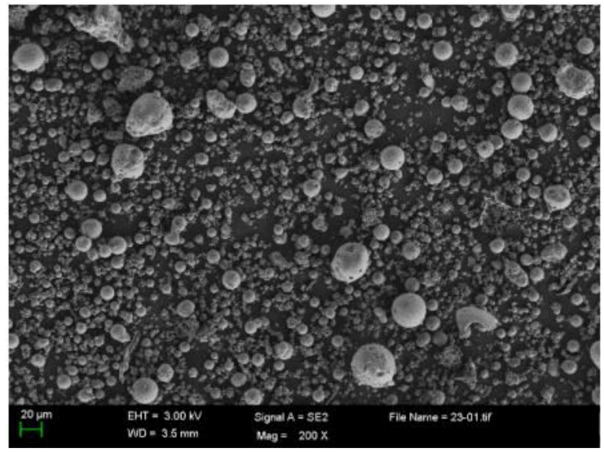


Percentage loss of weight

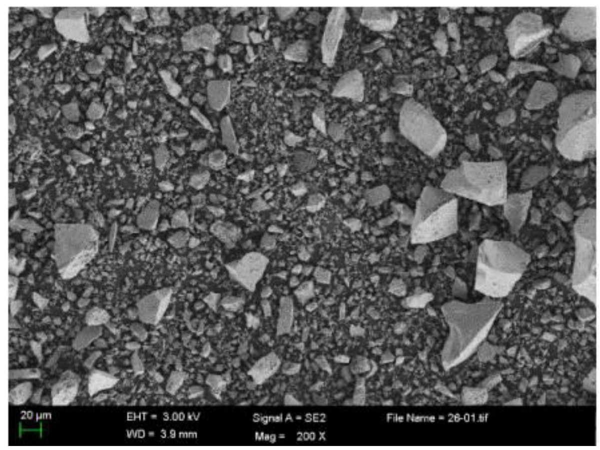
SEM Results



Iron tailing powder SEM picture

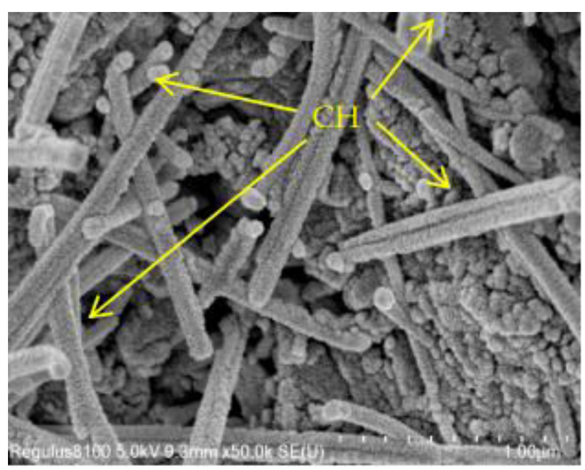


Rice husk ash SEM picture

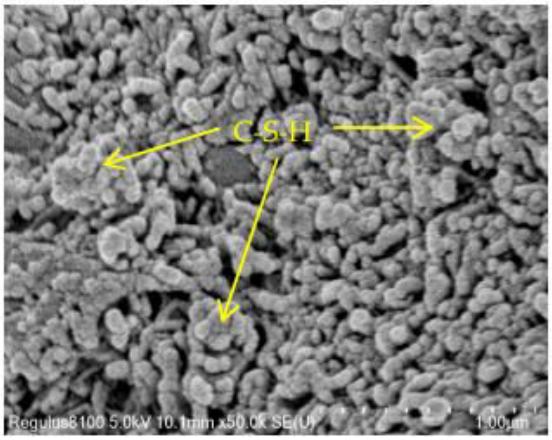


Silica fume

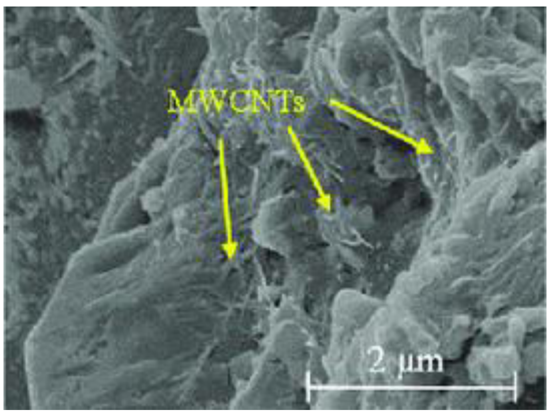
SEM Results for concrete



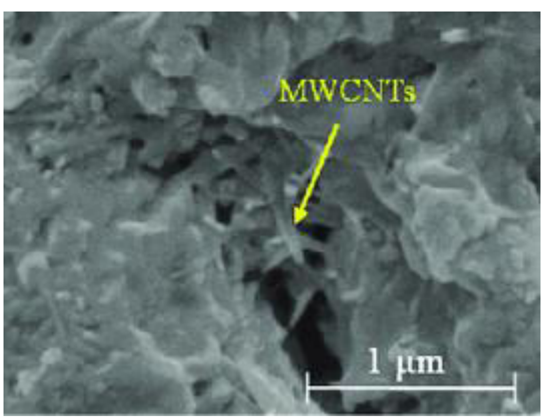
SEM Results for 0% Iron tailing powder +0%Rice husk ash+0%Silica fume



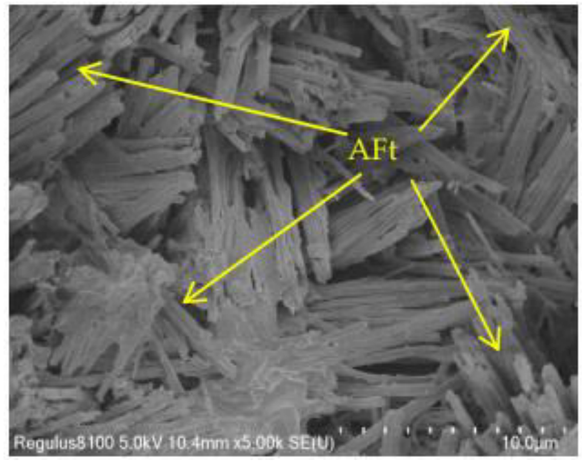
SEM Results for 5% Iron tailing powder +2.5%Rice husk ash+2.5%Silica fume



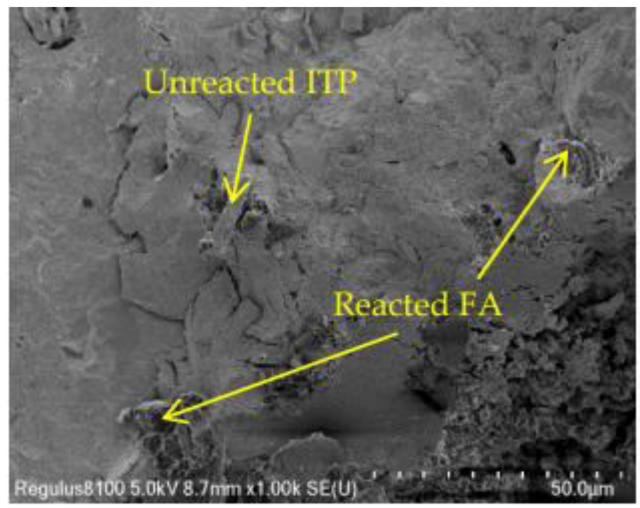
SEM Results for 10% Iron tailing powder +5%Rice husk ash+5%Silica fume



SEM Results for 15% Iron tailing powder +7.5%Rice husk ash+7.5%Silica fume



SEM Results for 20% Iron tailing powder +10%Rice husk ash+10%Silica fume



SEM Results for 25% Iron tailing powder +12.5%Rice husk ash+12.5%Silica fume

6. CONCLUSIONS

The study focuses on the durability of ITP-RHA-SF ternary mineral admixture concrete under acetic acid erosion. The compressive strength, compressive strength loss, and mass loss of concrete were analyzed by different CRRs and different w/b, and the mi-cro structure of concrete was conducted using SEM. The following conclusions can be derived:

1. The mineral doping system reduces the permeability of the erosion medium. To a certain extent, it can alleviate the erosion of acid solution concrete through MIP and

SEM, which confirms that the concrete has lower internal porosity and better density.

2. The ITP-RHA-SF ternary mineral admixture concrete has better acid erosion resistance than OPC concrete.
3. The value of slump increases with increase in the percentage of Iron tailing powder, Rice husk ash and Silica fume from Mix 1 to mix 6 in M40 grade concrete.
4. The value of compaction factor decreases with increase in the percentage of Iron tailing powder, Rice husk ash and Silica fume from Mix 1 to mix 6 in M40 grade concrete.
5. The optimal value of compressive strength for 7days, 14days and 28days curing period are observed at 15%ITP+7.5%RHA+7.5%SF in M40 grade concrete.
6. The optimal value of split tensile strength for 7days, 14days and 28days curing period are observed at 15%ITP+7.5%RHA+7.5%SF in M40 grade concrete.
7. The values of percentage loss of compressive strength and percentage loss of weight in M40 grade concrete increases with increase in the percentage of ITP, RHA and SF.

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