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MICROSTRUCTURAL STUDY OF HIGH PERFORMANCE CONCRETE CONTAINING RICE HUSK ASH

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ABSTRACT

In the past few years the use of sustitutory cementing materials has become an integral part of high performance concrete mix design. The demand for the use of waste materials or the materials requiring less energy to produce is frequently used, for example fly ash, Silica fume (SF), Ground Granulated Blast Furnace Slag (GGBS) and Rice Husk Ash (RHA). In the present study we have used RHA, RHA is a by-product material obtained from the combustion of rice husk which consists of non-crystalline silicon dioxide with high specific surface area and high pozzolanic reactivity. It is used as pozzolanic material in mortar and concrete, and has demonstrated significant influence in improving the mechanical and durability properties of mortar and concrete. Besides mechanical properties micro structural properties through SEM is studied. An attempt is made to correlate the micro structural aspects with respect to the mechanical properties of High Performance Concrete.

Keywords: RHA, High Performance Concrete, Compressive Strength, Flexural Strength and Microstructure.

I INTRODUCTION

Concrete is most widely used man made construction material in the world, during 20th century there has been an increase in the consumption of mineral admixture by the cement and concrete industries. This rate is expected to increase. The increasing demand for the cement and concrete is met by the partially cement replacement. The current cement production rate of the world, which is approximately 1.5 billion tons per year, is expected to grow exponentially to about 3.5 billion ton per year by 2015. Most of the increase in cement demand is met by the use of supplementary cementing materials.Fly ash, silica fume, metakaolin, rice husk ash etc are some materials among them. The use of mineral additives, in concrete has been intensified a lot during the last decades. Among these additives, the fly ash is, definitely, the most used. However, other pozzolanas has recently attracted a special attention: the Rice Husk Ash (RHA). The use of pozzolanic or mineral admixtures is as old that of the art of concrete construction. Rice plant is one of the plants that absorbs silica from the soil and assimilates it into its structure during the growth. Rice husk is the outer covering of the grain of rice plant with a high concentration of silica, generally more than 80-85%. It is responsible for approximately 30% of the gross weight of a rice kernel. In this present study we have taken rice husk ash as a mineral admixture as partial replacement of cement in the concrete. Rice husk ash is obtained by burning rice husk in a controlled manner without causing any environmental pollution. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. The produced partially burnt husk from the milling plants when used as a fuel also contributes to pollution and efforts are being made to overcome this environmental issue by utilizing this material as a supplementary cementatious material. The chemical composition of rice husk ash is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions. Burning the Husk under controlled temperature below 800^0C can produce ash with silica in amorphous form. Rice husk is an agro-waste material which is produced in about 100 million of tons. Approximately, 20 Kg of rice husk is obtained for 100 Kg of rice. Rice husks contain organic substances and 20% of inorganic material. Rice husk ash (RHA) is obtained by the combustion of rice husk. The most important property of RHA that determines the pozzolanic activity is its amorphous phase content. RHA is a highly reactive pozzolanic material suitable for use in lime-pozzolan mixes and for Portland cement replacement. RHA contains a high amount of silicon dioxide, and its reactivity related to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific surface.

1.1 Objectives of the Study

The primary aim is to achieve value of RHA through their effective utilization, rather than viewing this as waste to contain in our Environment.

1. To find the effect of rice husk ash on the properties of concrete and cement when cement is partially replaced with rice husk ash.
2. To determine the optimum percentage of RHA as a partial replacement of cement.
3. To study the mechanical properties of concrete such as Compressive strength and Flexural strength.
4. To study the microstructure of concrete using Scanning Electron Microscope [SEM].
5. Correlating micro structural aspect to mechanical properties.

1.2 Scope for the study

As India is a major rice producing country, about 20 millions of RHA is produced annually. This RHA is a great environment threat causing damage to the land and the surrounding area in which it is dumped. Lots of ways are being thought of for disposing them by making commercial use of this RHA. RHA can be a good admixture for the high strength concrete. Still a lot of work has to be done studying different properties of concrete like chloride penetration, and behavior of RHA in reactive powder concrete, light weight concrete Short Crete concrete etc. There is still a lot of research to be done in the micro structural study of this Rice Husk Ash concrete. If we can know the bonding properties of this Rice Husk Ash concrete we can again try to increase the strength.

II METHODOLOGY

1. Three grades of concrete M60 M80 and M100 are choosen for the present experimental investigation and are designed as per ACI method.
2. The constituent materials selected confirm to relevant IS specifications.
3. This study is conducted to investigate the feasibility of using RHA to replace some part of cement in M60, M80 and M100 concrete.
4. Casting of cubes of size (100mmx100mmX100mm), and cylinders (100mm dia x200mm height), for testing under compression.
5. Casting of beam specimens (100mmx100mmx500mm), for finding Flexural strength.
6. Casting of cylinders specimens (150mmdiax300mm height), and testing for Stress-strain characteristics and obtaining modulus of elasticity of HPC using RHA.
7. To study SEM images of HPC concrete with and without RHA by placing it under Scanning Electron Microscope and Co relating their Mechanical Properties.

III RESULTS AND DISCUSSSIONS

3.1 Compressive strength of HPC containing RHA with 0% and 15% replacement of cement.

Grade	0% RHA strength (MPa)	15% RHA strength (MPa)
Compressive Strength		
M 60	65.41	61.10
M 80	84.31	80.31
M 100	101.45	91.81
Flexural Strength		
M 60	6.4	5.81
M 80	7.81	7.25
M 100	8.34	7.75

3.2 Correlation of SEM with Mechanical Properties.

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Fig. 1: Observation of SEM Images on the computer screen.

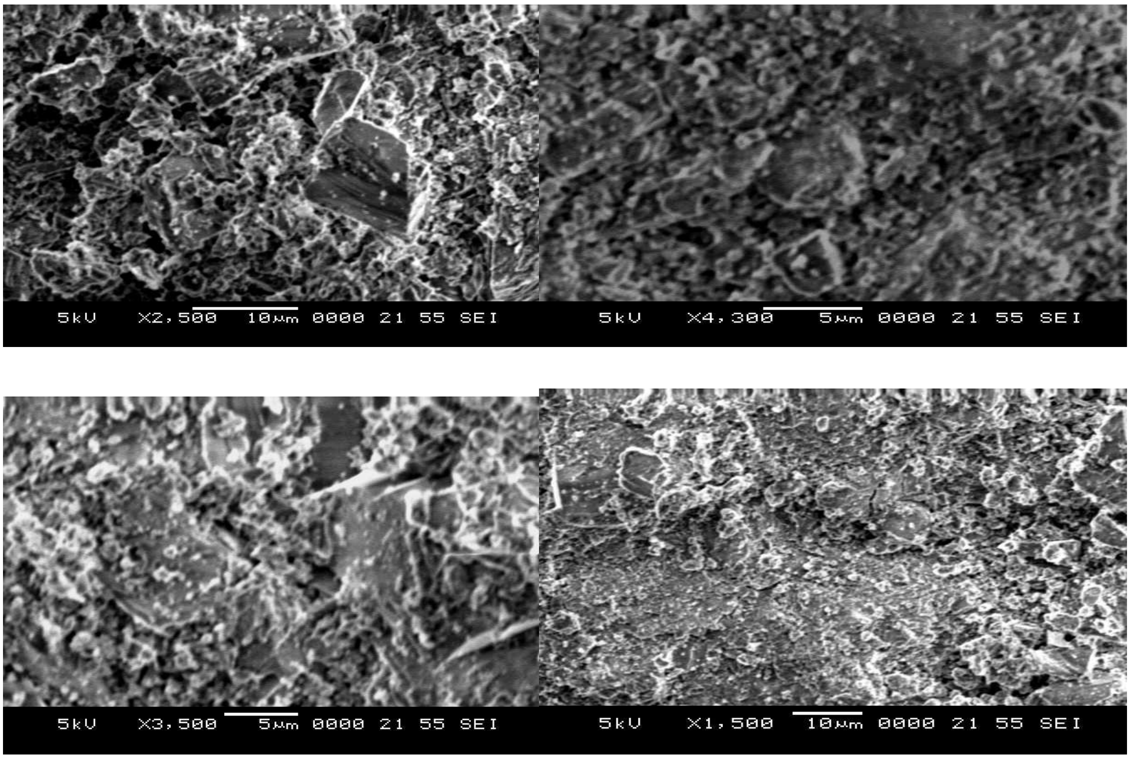


Fig. 2: SEM images of M 60 0% RHA

From the images it is well known that C.S.H gel structures, Calcium Hydroxide crystals which are present in the concrete will contribute to the strength. The images above clearly indicate the presence of large massive platy and Hexagonal Prism shaped and also elongated crystals which will contribute to the strength.

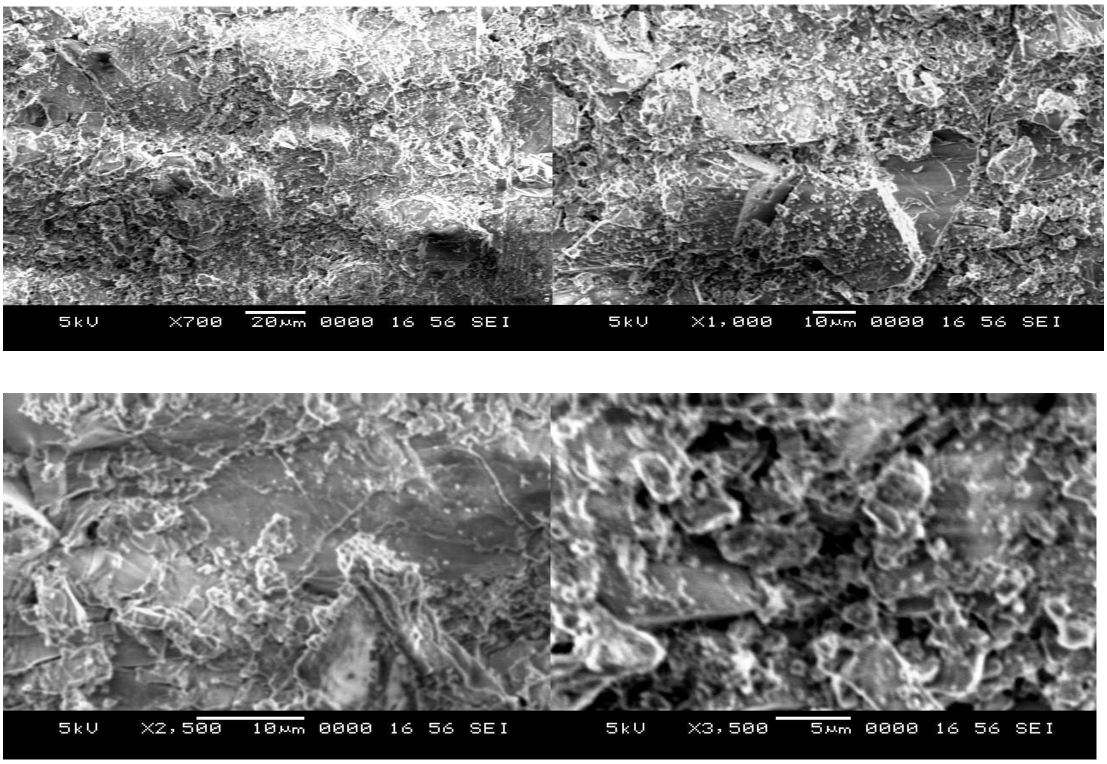
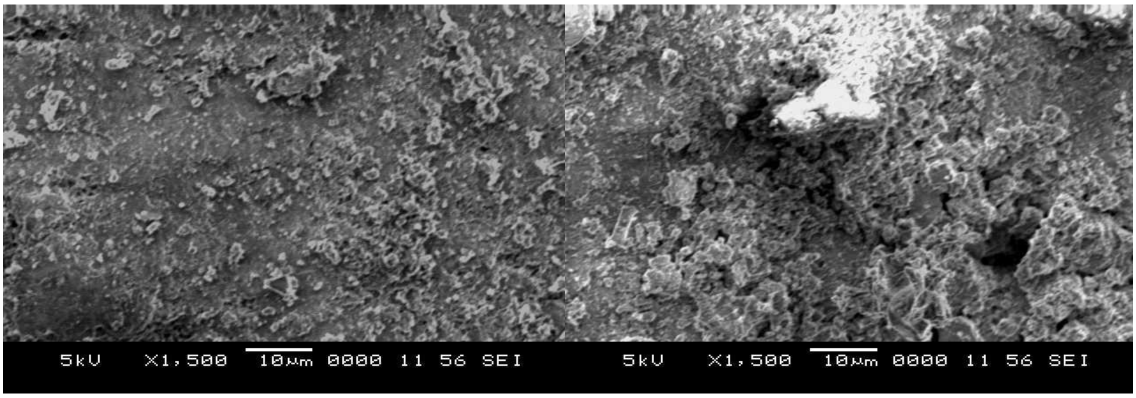


Fig. 3: SEM images of M 60 15% RHA.

From the images it is well known that the morphologies of Sulfoaluminate hydrates that is Ettringite phase (Aft) and Monosulfate (Afm) in concrete form the weakest part of concrete. The images above indicate the presence of needle like crystals which will absorb the water and expand. The Ettringite needle like crystals so formed in vacant spaces during hydration is known to cause distruption.



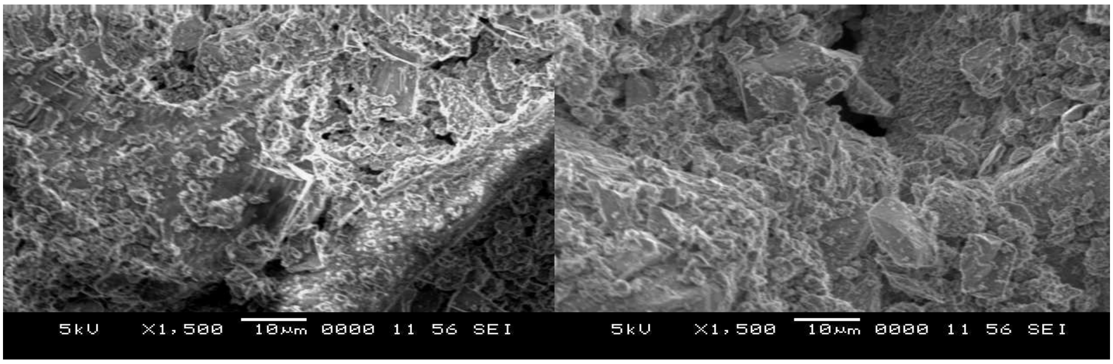


Fig. 4: SEM images of M 80 0% RHA

The above images show clearly the presence of Calcium Hydroxide crystals with distinctive hexagonal prism morphology to elongated crystals and some of the platy crystal like structures are also seen which will contribute to the strength. The formation of Etringite needle like structures are not seen which are the weaker part of the concrete structure. In the Paste-Aggregate interface also there is no formation of the "Duplex film". The pores formed in the Hydrated cement paste are also very small so the permeability is low and hence more strength.

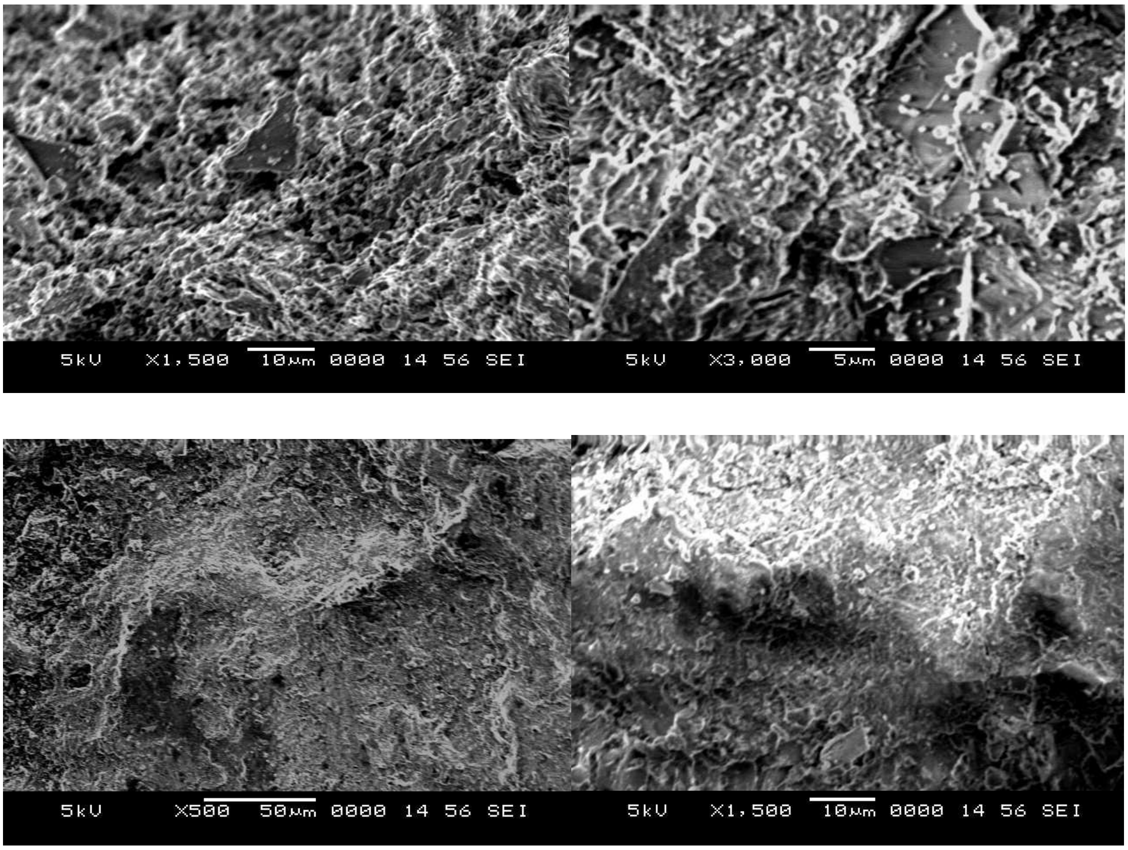


Fig. 5: SEM images of M 80 15% RHA.

The above images show clearly the presence of large capillary pores which absorb water and expand later. The formation of very thin hexagonal plates of Calcium Sulfoaluminate hydrates and Ettringite needles are seen and also the presence of incompletely hydrated cement particles can be seen and identified by their characteristic brightness which all contributes to the less strength of the concrete.

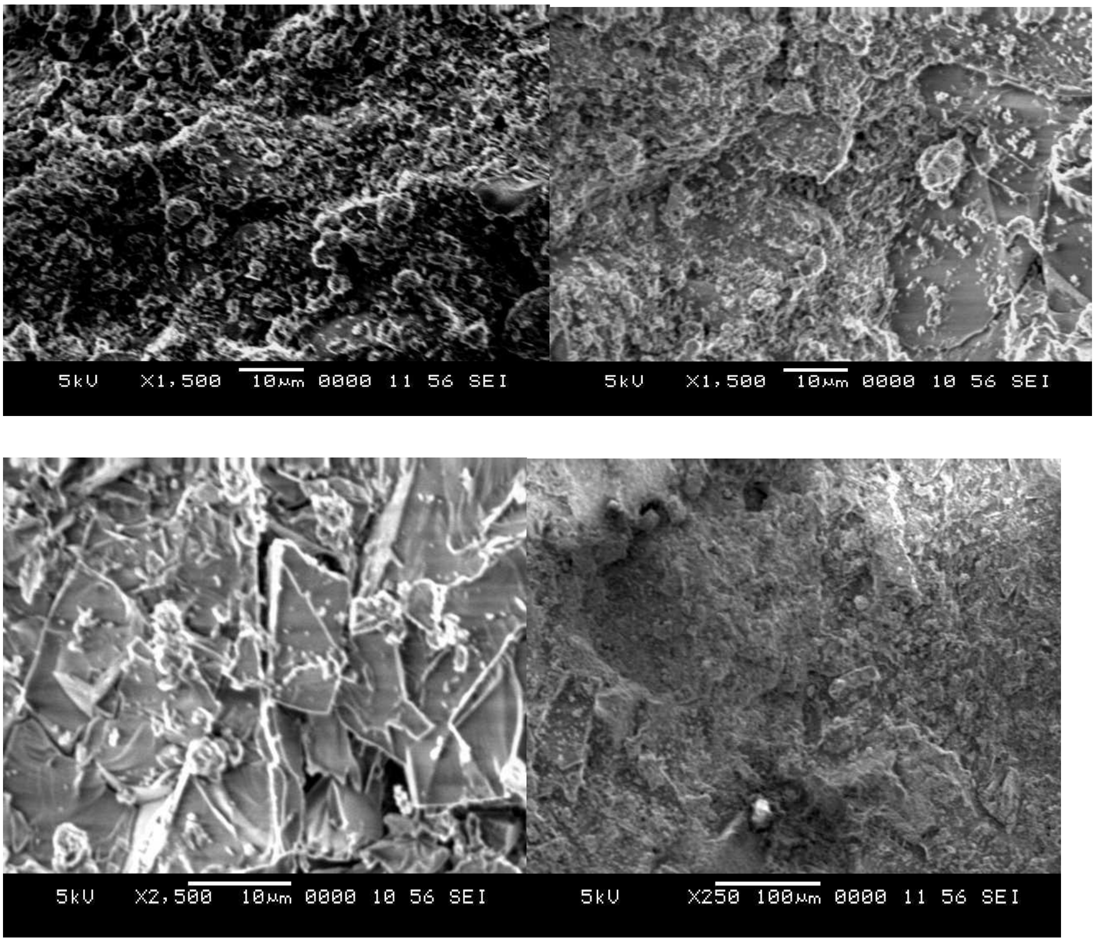


Fig. 6: SEM images of M 100 0% RHA

The above images show the presence of C-S-H gel structure which is crystalline in structure. The presence of the large crystals of calcium hydroxide is also seen. The formation of Calcium sulfoAluminate hydrates, Monosulfate (Afm) and Ettringite needles are also very less as compared to the concrete with 15% RHA. The pores of the concrete are also very small. There is no presence of Incompletely Hydrated Cement Particles.

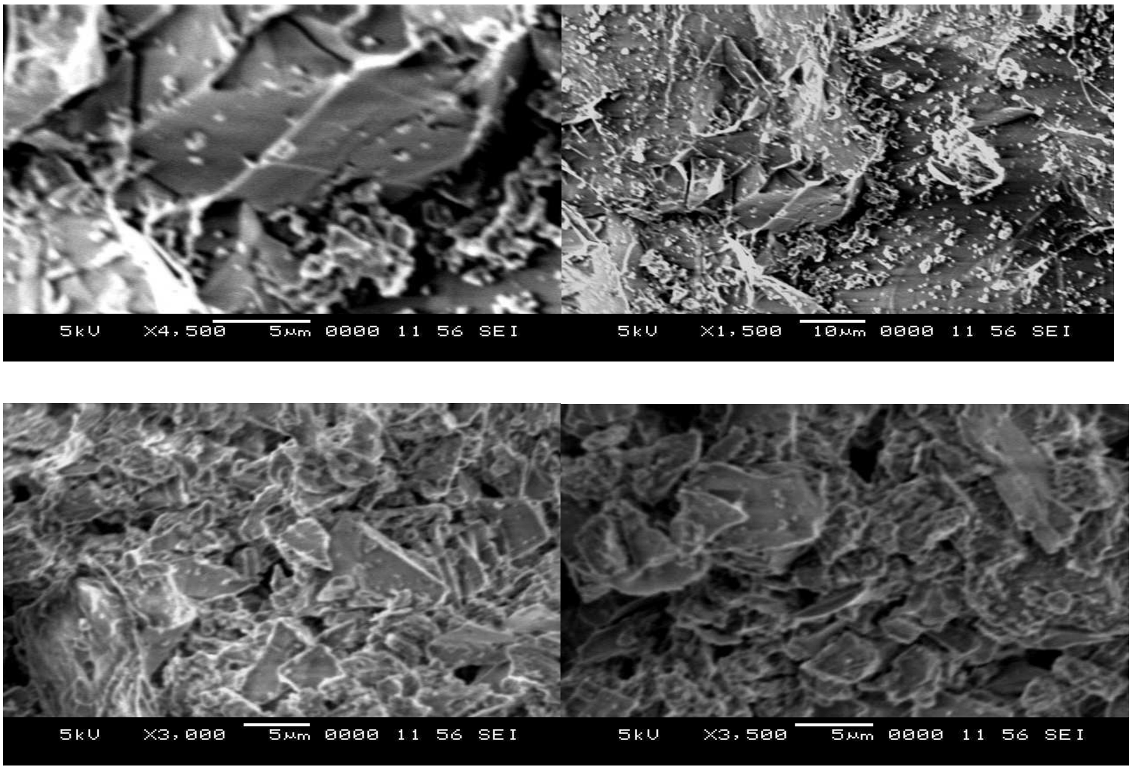


Fig. 7: SEM images of M 100 15% RHA.

The above images clearly show the presence of calcium sulfoaluminate hydrates Aft (ettringite) and AFm (Monosulfate) needle like structures. Monosulfate(Afm) appears as Hexagonal platy crystals. The formed monosulfate tends to crystallize in clusters, rossetes of irregular plates and those formed will grow into well developed thin hexagonal plates.

IV DISCUSSIONS AND CONCLUSIONS ON SEM IMAGES

From the images of M 60 0% RHA, M 80 0% RHA and M100 0% RHA it can be seen that the formation of small pore like structures are more and hence these contribute to the strength i.e CSH. The formation of calcium hydroxide [CH] crystals is less along the paste-aggregate interface. The pores formed in the Hydrated cement paste are also very small so the permeability is also low. It can be clearly seen in the M80 0% RHA that there is no formation of a thin layer “Duplex Film” consisting of calcium hydroxide crystals in the Paste-Aggregate interface .

From the images of M 60 15% RHA, M 80 15% RHA and M100 15% RHA, from M60 15% RHA it can be seen that the formation of the CH [crystals] is more. The small pore like structures i.e CSH gel like structures are very less and hence less strength. The formation of calcium Sulfo aluminate hydrates that is ettringite phase [Aft] and monosulfate [AFm] in concrete and the ettringite crystals formed in vacant spaces during early hydration and these crystals formed in confined space absorb water and expand and thus they have less strength.

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