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# Study of Concrete with Rice Husk Ash, Fly Ash and Quarry Sand

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***Abstract: The experimental study undertaken to investigate the influence of partial replacement of natural sand with quarry sand and cement with fly ash and rice husk ash in concrete. Three types of replacement proportion of natural sand with quarry sand by 15%, 30% and 45% were carried out in the concrete mixes and replacement of 30% cement content with fly ash (FA) and rice husk ash (RHA) was carried out in concrete mixes(5% RHA, 25% FA and 7.5% RHA, 22.5% FA). The compressive strength. Split tensile strength and Flexural strength indicate that concrete incorporating quarry sand without the inclusion of fly ash and RHA exhibited lower compressive strength than the control concrete at all ages. This weakness was overcome by the inclusion of fly ash into the quarry sand concrete in which it resulted in the enhanced strength at almost all conditions. It can be concluded that quarry sand can be utilized as partial replacement material to natural sand in the presence of fly ash and rice husk ash to produce concretes with fair ranges of compressive strength.***

***Keywords: Fly ash, Rice husk ash, quarry sand, XRD, SEM analysis***

## I. INTRODUCTION

In recent years, tremendous efforts have been taken in the area of concrete Engineering and Technology to research and study the utilization of by-products and waste materials in the production of concrete. The successful utilization of these materials will result in the reduction of environmental load, waste management cost and concrete production cost, besides enhancing the properties of concrete in both fresh and hardened state. Efforts in this area have been focused in identifying and optimizing the benefits of different types of cement replacement materials as well as identifying alternative materials as aggregates in concrete .Fly ash, silica fume, ground granulated blast furnaces lag and rice husk ash are the commonly researched cement replacement materials with the aim to achieve enhancement in the properties of concrete and to produce concretes to meet special purposes. In concrete the fine aggregate is usually natural sand. The use of sand in construction results in excessive sand mining which is objectionable. Due to rapid growth in construction activity, the available sources of natural sand are getting exhausted. Also, good quality sand may have to be transported from long distance, which adds to the cost of construction. In some cases, natural sand may not be of good quality. Therefore, it is necessary to replace natural sand in concrete by an alternate material either partially or completely without compromising the quality of concrete. Quarry sand is one such material which can be used to replace sand as fine aggregate. The present study is aimed at utilizing Quarry sand as fine aggregate replacing natural sand. Fly ash and rice husk ash as binding material replacing cement. The study on concrete includes determination of compressive strength, flexural strength and split tensile strength of different proportion mixes.

## II. EXPERIMENTAL PROGRAM

In the first stage of this investigation, the compressive strengths of different proportion of fly ash and rice husk ash of concrete are observed by replacing cement by fly ash and rice husk ash at different levels of replacement namely 22.5%FA 2.5%RHA, 25%FA 5%RHA, 22.5%FA 7.5%RHA ,20%FA,10RHA. In the second stage in every combination of first stage of FA and RHA, quarry sand is added 15% , 30% and 45%. The compressive strength of concrete are obtained at age of 7, 14, 28, 56 and 90 days. Only one grades of concrete M25 was selected for the study. The strength properties of concrete with fly ash, rice husk ash and quarry sand replacement are compared with the compressive strength of concrete are obtained at age of 7, 14, 28, 56 and 90 days.. The strength properties of concrete with fly ash, rice husk ash and quarry sand replacement are compared with that of controlled concrete. The micro structural study was carried out by SEM and XRD analysis

## III. MATERIALS

### *A. Coarse Aggregate*

The specific gravity and water absorption are 2.67gn/cc and 0.8% respectively. The tests were conducted as per IS: 383 – 1970

 

### B. Cement

Ordinary Portland cement of 43-grade was used in this study conforming to IS: 12269-1987. The physical properties are: Specific gravity is 3.15 gm/cc Normal consistency is 28.3%.

### C. rice husk ash

RHA was obtained from Rice husk ash used was obtained from YASH AGRO, Chimur, Chandrapur Sieving was carried out by passing it through 90 micron sieve and then it is use for research purpose. RHA was considered in the present study as a replacement of cement. The specific gravity of RHA used is 2.1gm/cc as per Specific gravity Test (IS: 2386 (Part III) 1963).

### D. Fly Ash

Fly ash used was obtained from Koradi Power Plant Nagpur. The fly ash, also known as pulverised fuel ash, is produced from burning pulverized coal in electric power generating plants. Specific gravity of fly ash is 2.29gm/cc.

### E. Quarry Sand

Quarry Sand was obtained from Sidheshwar quarry, Pachgaon. Plant: 360, Surgaon, Nagpur. The cheapest and the easiest way of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade which would be free from all impurities is known as Quarry Sand. specific gravity of quarry sand is 3.09gm/cc.

### F. Chemical Admixture

In this project, super-plasticizer is used as high range water reducer. AC-PLAST-BV 430 (Apple Chemie India Private Limited Company, Nagpur) as a high range water reducing admixture for obtaining a workability.

## IV. MIX DESIGN

The concrete mix M25 were designed in accordance with IS 10262-2009. The mixes of three different combination for M25 grade concrete as per Table 1

### A. Experimental Investigation

Fly ash and RHA was collected and its properties were tested. The specimens were cast, water cured and tested for studying the variation in strength properties due to the replacement of cement with fly ash and RHA and natural sand with quarry sand after curing for required period. compressive strength and flexural strength are carried out as per IS : 516-1959 and IS : 5816-1999. The micro structural analysis was carried out XRD analysis , SEM Analysis. The workability test were carried out on fresh concrete as per IS 1199-1959.

TABLE 1 MIXES COMBINATIONS

| Mix Type | Identification |
|---|---|
| Phase1 (Replacement cement by FA and RHA | |
| Controlled Mix | M25-A |
| CM70%+FA30% | M25-A1 |
| CM70%+FA27.5%+RHA 2.5% | M25-A2 |
| CM 70%+FA 25%+5%RHA | M25-A3 |
| CM 70%+FA 22.5%+7.5%RHA | M25-A4 |
| CM70%+FA 20%+10%RHA | M25-A5 |
| Phase-2 (Replacement natural sand by quarry sand and cement by FA and RHA) | |
| CM70%+FA30%+15%QS | M25-B1 |
| CM 70%+FA 25%+5%RHA+15%QS | M25-B2 |
| CM 70%+FA 22.5%+7.5%RHA+15%QS | M25-B3 |
| CM70%+FA30%+30%QS | M25-B4 |

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| | |
|---|---|
| CM 70%+FA 25%+5%RHA+30%QS | M25-B5 |
| CM 70%+FA 22.5%+7.5%RHA+30%QS(critical mix) | M25-B6 |
| CM70%+FA30%+45%QS | M25-B7 |
| CM 70%+FA 25%+5%RHA+45%QS | M25-B8 |
| CM 70%+FA 22.5%+7.5%RHA+45%QS | M25-B9 |

Table 2 Workability Test

| M25 Concrete | Slump mm | Compaction factor |
|---|---|---|
| Mix Type | | |
| Phase1 | | |
| M25-A | 120 | .0.90 |
| M25-A1 | 130 | 0.87 |
| M25-A2 | 100 | 0.86 |
| M25-A3 | 100 | 0.86 |
| M25-A4 | 100 | 0.85 |
| M25-A5 | 90 | 0.86 |
| Phase-2 | | |
| M25-B1 | 120 | 0.85 |
| M25-B2 | 110 | 0.87 |
| M25-B3 | 110 | 0.84 |
| M25-B4 | 100 | 0.83 |
| M25-B5 | 90 | 0.84 |
| M25-B6 | 80 | 0.78 |
| M25-B7 | 70 | 0.78 |
| M25-B8 | 70 | 0.81 |
| M25-B9 | 60 | 0.80 |

TABLE 3 Compressive Strength

| M25 Concrete | Compressive strength N/mm2 | | | |
|---|---|---|---|---|
| Mix Type | 7 days | 14 days | 28days | 90 days |
| Phase1 | | | | |
| M25-A | 20.24 | 24.2 | 32.74 | 38.90 |
| M25-A1 | 17.75 | 25.40 | 26.62 | 32.80 |
| M25-A2 | 20.00 | 25.45 | 26.91 | 33.45 |
| ,M25-A3 | 22.00 | 26.00 | 27.42 | 33.80 |
| M25-A4 | 23.6 | 26.93 | 27.90 | 36.74 |
| M25-A5 | 22.22 | 24.22 | 25.82 | 35.11 |
| Phase-2 | | | | |
| M25-B1 | 24.30 | 28.00 | 29.00 | 30.40 |
| M25-B2 | 25.30 | 28.30 | 29.12 | 31.70 |
| M25-B3 | 24.40 | 28.54 | 31.56 | 35.12 |
| M25-B4 | 25.10 | 26.55 | 27.20 | 29.00 |
| M25-B5 | 26.60 | 28.80 | 29.70 | 36.20 |

| | | | | |
|---|---|---|---|---|
| M25-B6 | 28.00 | 29.22 | 31.80 | 37.15 |
| M25-B7 | 28.40 | 29.40 | 30.10 | 32.00 |
| M25-B8 | 27.80 | 28.80 | 29.50 | 31.10 |
| M25-B9 | 25.55 | 28.17 | 28.80 | 34.68 |

Table 4
Split Tensile Strength

| M25 Concrete | Spit tensile strength N/mm2 | |
|---|---|---|
| Mix Type | 28 days | 90 days |
| Phase1 | | |
| M25-A | 3.15 | 3.90 |
| M25-A1 | 2.26 | 3.80 |
| M25-A2 | 2.83 | 3.65 |
| M25-A3 | 2.26 | 3.8 |
| M25-A4 | 2.85 | 3.74 |
| M25-A5 | 2.8 | 3.11 |
| Phase-2 | | |
| M25-B1 | 3.41 | 3.48 |
| M25-B2 | 3.63 | 3.80 |
| M25-B3 | 2.96 | 3.70 |
| M25-B4 | 2.93 | 3.10 |
| M25-B5 | 3.73 | 3.95 |
| M25-B6 | 5.31 | 5.42 |
| M25-B7 | 3.67 | 3.70 |
| M25-B8 | 3.67 | 3.72 |
| M25-B9 | 3.53 | 3.82 |

Table 5
Flexural Strength

| M25 Concrete | Flexural strength N/mm2 | |
|---|---|---|
| Mix Type | 28 days | 90 days |
| Phase1 | | |
| M25-A | 5.15 | 5.91 |
| M25-A1 | 4.19 | 5.80 |
| M25-A2 | 4.42 | 5.65 |
| M25-A3 | 5.54 | 5.80 |
| M25-A4 | 5.68 | 5.74 |
| M25-A5 | 4.81 | 5.11 |
| Phase-2 | | |
| M25-B1 | 5.41 | 5.52 |
| M25-B2 | 5,51 | 5.72 |
| M25-B3 | 5.62 | 6.11 |
| M25-B4 | 5.55 | 5.95 |
| M25-B5 | 5.75 | 5.90 |
| M25-B6 | 6.31 | 6.89 |
| M25-B7 | 5.60 | 5.79 |
| M25-B8 | 5.67 | 5.80 |
| M25-B9 | 4.53 | 5.15 |

*B. Observations on workability and strength of concrete*

The workability of concrete with addition of fly ash since fly ash gives ball bearing effect but reduces strength where as rice husk ash reduces workability since it is a pours material which absorb water and rice husk ash slightly increase strength more content of silicon di-oxide .

Compressive strength increases with the increase in the percentage of Rice Husk Ash up to7.5% replacement (22.5%Fa and 7.5% RHA) of Cement '

Compressive strength again increase by quarry sand at early age period but reduce workability due to more water absorption as compare to natural sand and it has rough surface texture.

A Mix with replacement of cement by 22.5% Fly ash and 7.5% RHA and 30% quarry sand as a replacement to natural sand gives maximum strength.

The Maximum Splitting Tensile and flexural strength are obtained for Concrete mix with Partial replacement in cement by 22.5 % Fly Ash ,and 7.5 % RHA and Natural sand by 30% Quarry Sand.

The analysis of experimental data showed that the addition of the quarry sand improved the strength properties of concrete which are at par with strength conventional concrete. From above testing results, it is inferred that quarry sand may be used as an effective replacement material for fine aggregate.

Rice Husk Ash ( RHA) can be used with admixtures for increasing the strength of concrete as a partial replacement of cement.

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Fly ash act as a admixture in order to increase the workability of concrete which has been reduced by addition of both RHA and Quarry sand.

## V. X-RAY DIFFRACTION ANALYSIS

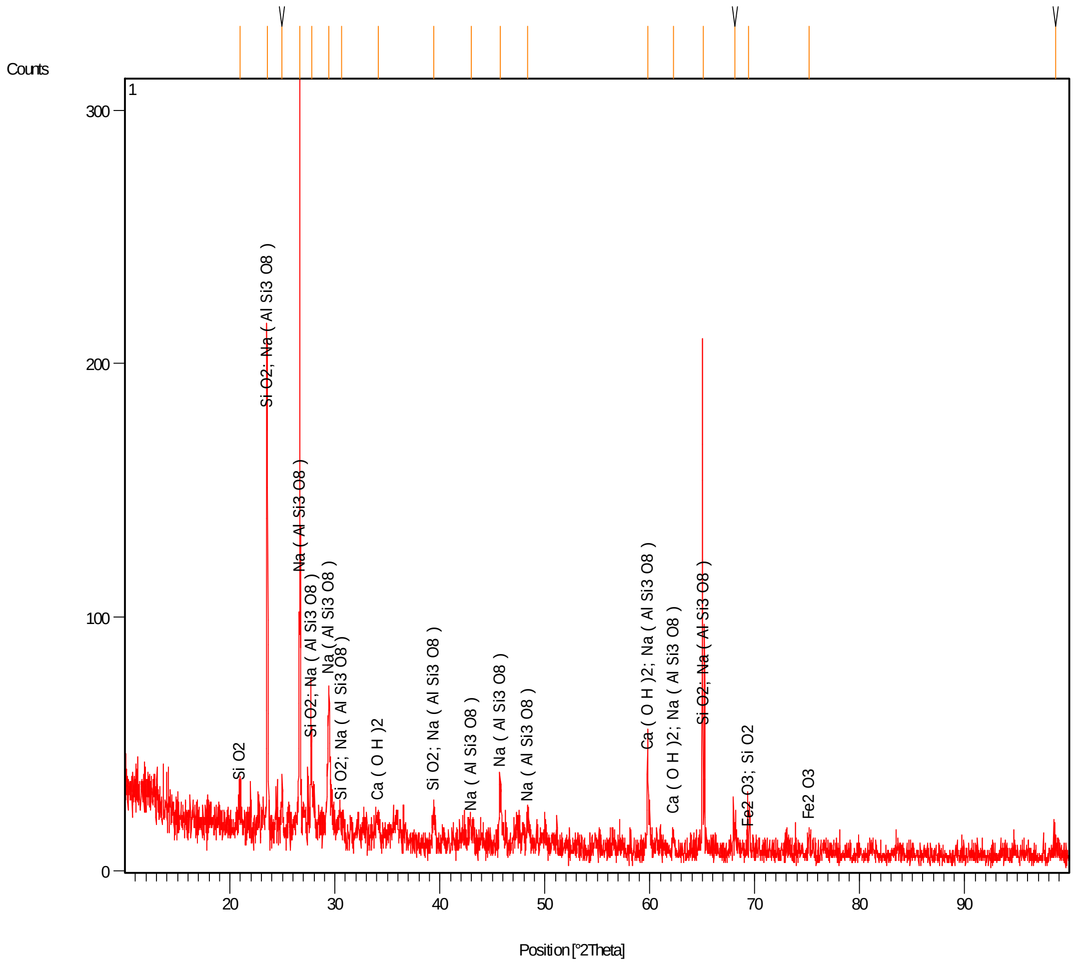


Fig. 1 X-ray diffraction peaks of M25 Grade concrete (controlled mix)(M25 –A)

TABLE 6
PATTERN LIST OF M25 GRADE CONCRETE (CONTROLLED MIX)(M25-A)

| Sr no | Compound name | Chemical formula | Displacement [2 Th] | Scale Factor | Score |
|---|---|---|---|---|---|
| 1 | Hematite (Iron oxide) | $Fe_2O_3$ | -0.081 | 0.065 | Unmatched Strong |
| 2 | Tridymite (Silicon oxide) | $Si\ O_2$ | 0.186 | 0.357 | 12 |
| 3 | Portlandite(calcium hydroxide ) | $Ca(OH)_2$ | 0.173 | 0.199 | 1 |
| 4 | Albite high (heated) | $Na(Al\ Si_3\ O_8)$ | -0.069 | 0.077 | 13 |

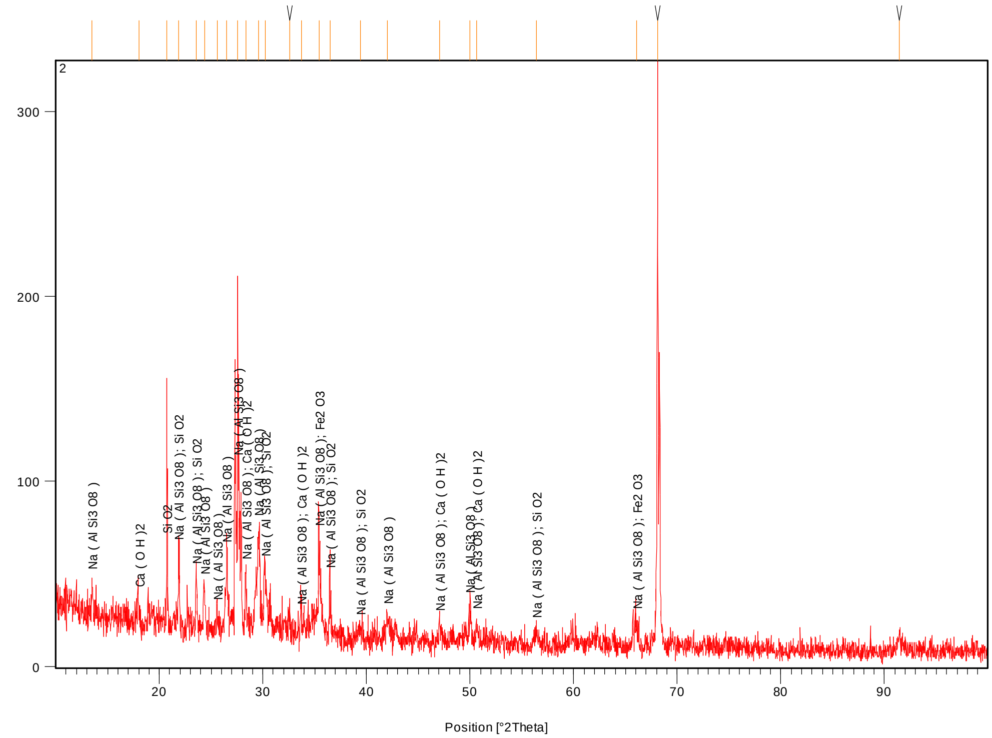


Fig . 2 X-ray diffraction peaks of M25 Grade concrete (Critical mix - B6)

TABLE 7
PATTERN LIST OF M25 GRADE CONCRETE ( CRITICAL MIX - B6)

| Sr no | Compound name | Chemical formula | Displacement [2 Th] | Scale Factor | Score |
|---|---|---|---|---|---|
| 1 | Albite high (heated) | Na ( Al $Si_3$ $O_8$ ) | -0.068 | 0.135 | 18 |
| 2 | Tridymite | Si $O_2$ | 0.121 | 0.087 | 13 |
| 3 | Hematite | $Fe_2$ $O_3$ | -0.133 | 0.110 | 2 |
| 4 | Portlandite | Ca ( O H $)_2$ | -0.203 | 0.105 | 2 |

*A. Observations On X Ray Diffraction*

1) *Controlled concrete M25 - Grade concrete (M25 -A):* Quantitative estimate of mineral phase -The mineral phase of Albite($NaAlSiO_3O_8$) Present in high percentage indicated by High peaks and calcium hydroxide ($Ca(OH)_2$, silicon oxide ($SiO_2$), Iron Oxide(Fe2 O3) of lower percentage indicated by smaller peaks. It is indicated in fig1 and table 7.
2) *Critical mix M25- Grade concrete (M25 – B6):* Quantitative Estimate of mineral phase- The mineral phase of Albite($NaAlSiO_3O_8$),silicon di oxide($SiO_2$),Iron Oxide($Fe_2O_3$) Present in high percentage indicated by High peaks and low percentage of calcium hydroxide ($Ca(OH)_2$, smaller peaks. It is indicated in fig2 and table
3) *Discussion on XRD analysis* - As compare chemical composition of control mix and critical mix it is found that critical mix contain high percentage of silicon di oxide and iron di oxide because of that concrete containing RHA and quarry sand gives more strength.

An interesting observation is that ternary blend comprising fly ash and rice husk ash showed lower amount of portlandite (calcium hydroxide) shows that calcium chloride get completely consumed in the ternary blended concrete of critical mix.

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Therefore use of two supplementary cementitious materials such as fly ash and rice husk ash are complementary in the sense that rice husk ash contribues to early age strength which not possible with the use of single use single fly ash alone.

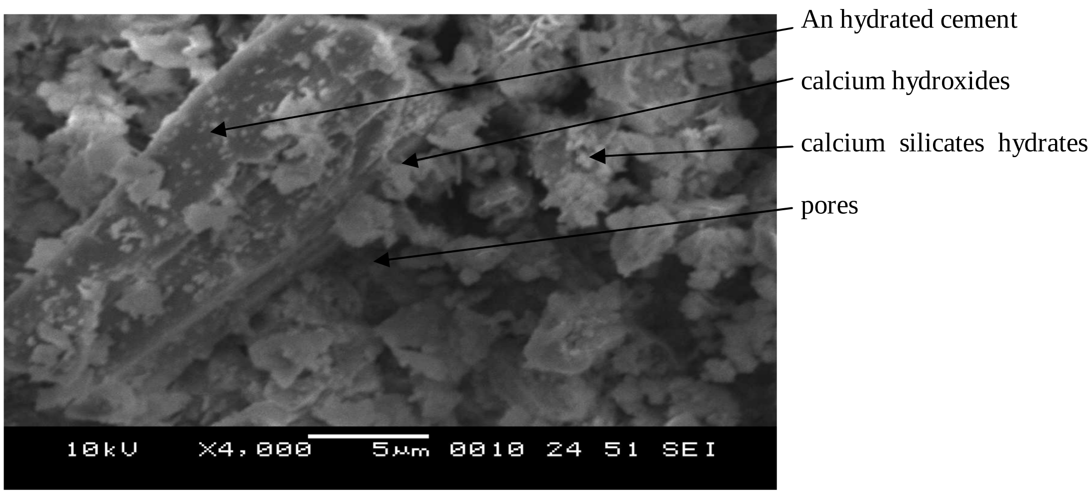


Fig. 3 SEM for M25 concrete (controlled Mix) under X-2000 magnification

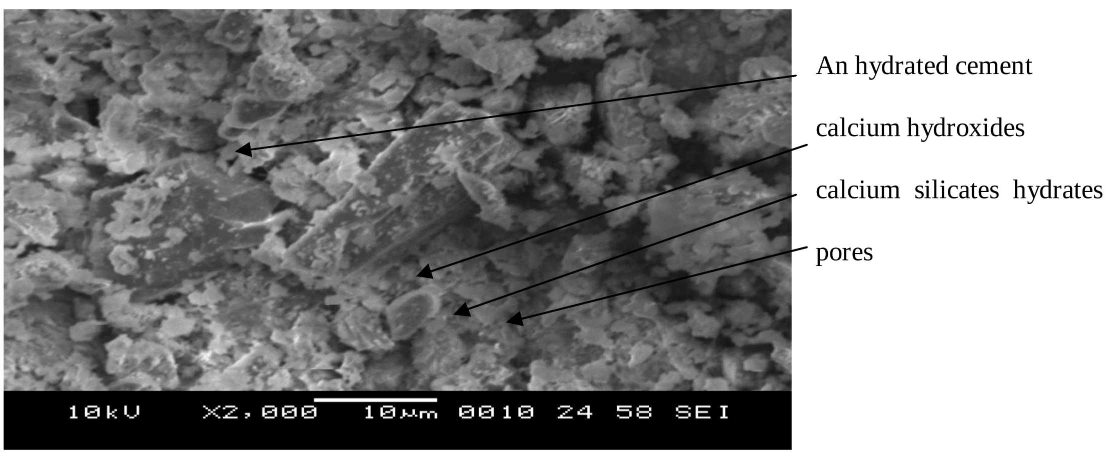


Fig 4 SEM for M25 Concrete(controlled Mix) under 4000 Magnification

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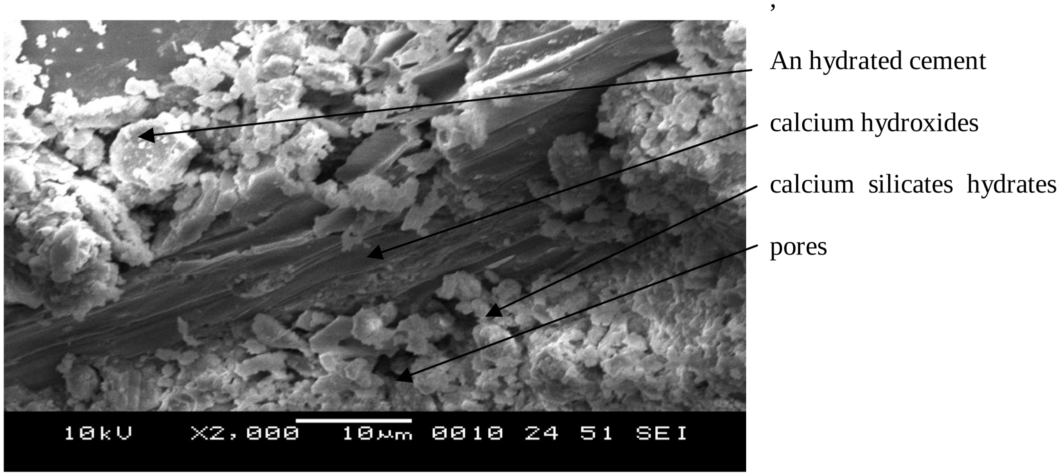


Fig. 5 SEM for M 25 concrete( critical Mix) under X-2000magnification

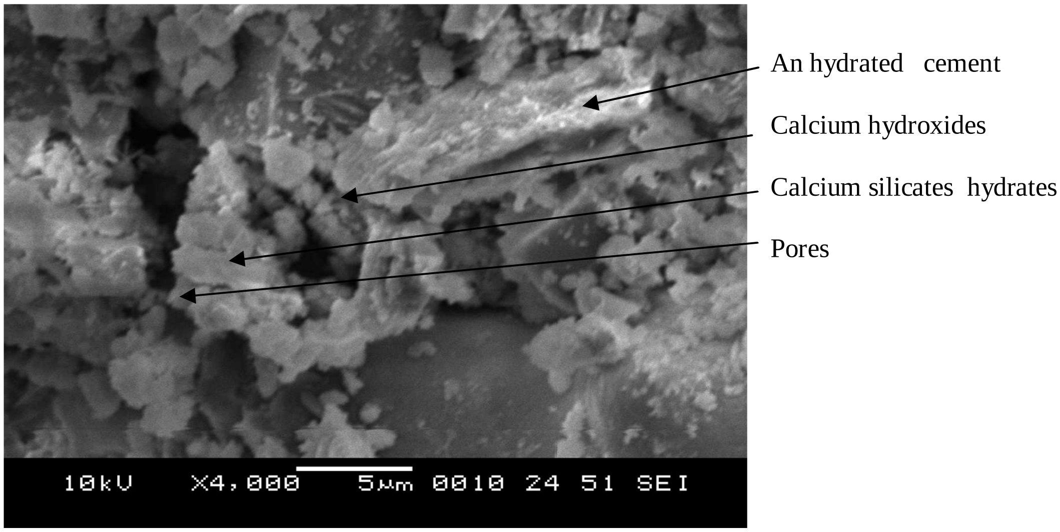


Fig. 6 SEM for M 25 concrete( critical Mix) under X-4000magnification

### *B. Discussion on SEM analysis*

The images of concrete sample with natural sand and manufactured sand are taken at various magnifications to identify the shape and texture of the particles. The SEM analysis shows that micro structure of critical mix concrete is dense. It is indicated in figures 3, 4, 5, and 6.

## VI. CONCLUSION

The workability of concrete increases with addition of fly ash since fly ash gives ball bearing effect but reduces strength where as rice husk ash reduces workability since it is a pours material which absorb water and rice husk ash slightly increase strength more content of silicon di oxide Compressive strength increases with the increase in the percentage up to Rice Husk Ash up to7.5% replacement (22.5%Fa and 7.5% RHA) of Cement ‘ compare to natural sand and it has rough surface texture. A Mix with replacement of cement by 22.55 Fly ash and 7.5% RHA and 30% quarry sand as a replacement to natural sand gives maximum strength. The Maximum Splitting Tensile and flexural strength achieved by Concrete mix by Partial replacement of cement by 22.5 % Fly Ash and 7.5 % RHA and Natural sand by 30% Quarry Sand. As per Chemical composition of control mix and critical mix it is found that critical mix contain high percentage of silicon di oxide and iron di oxide because of that concrete containing rice husk ash and quarry sand gives more strength. The SEM analysis shows that micro structure of critical concrete containing fly ash , rice husk ash and quarry sand is dense. .

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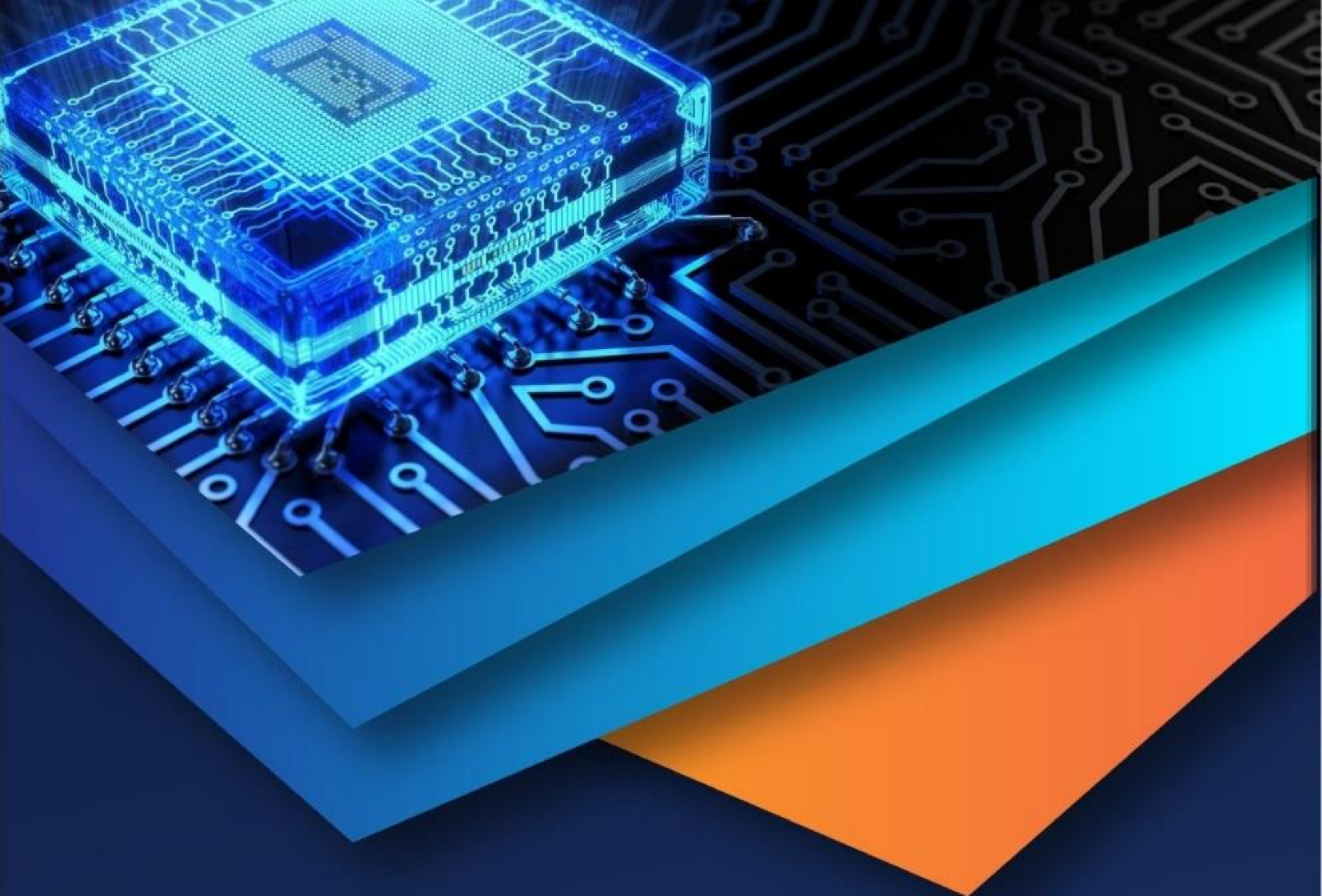

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