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# Effect of Red Mud and Silica Fume on Cement Concrete in the Fresh and Hardened State

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***Abstract: Concrete is most used construction material in the civil engineering structure. Concrete is the world's most consumable product next to water. The red mud and silica fume has been used as a partial replacement of cement in cement concrete. The red mud is by product of alumina from bauxite ore and silica fume is obtained from silicon industry. By utilizing these two products as a partial replacement of cement in cement concrete, the concrete can be made as environmental friendly. In the present work, fresh properties and hardened properties of control concrete are compared with concrete made with red mud and silica fume. To test fresh properties slump cone and compaction factor tests are conducted. To test hardened properties compression test and split tensile tests are conducted at 28 and 56 days of curing. Control concrete of M30grade is designed using IS 10262:2009 provision. To make concrete with red mud andsilica fume, cement is replaced by 6%, 12%, 18%, 24% and 30% of red mud by its weight and silica fume is varied from 2%, 4%, 6%, 8% and 10% by the weight of cement.***

## I. INTRODUCTION

Concrete as it is known today came into use in 1824 with the invention of Portland cement by Joseph Aspdin. Until then, pozzolanic binders i.e., lime-pozzolana mortars and concrete were used throughout the world. The large-scale production of ordinary Portland cement is posing environmental problems and also causing unrestricted depletion of natural resources. The raw materials used for the production of ordinary Portland cement are limestone, clay, silica, iron oxide materials and gypsum. The fuel for producing cement is coal. It is learnt that for every tonne of ordinary Portland cement produced, about one tonne of carbon dioxide is released into the atmosphere leads to global warming. Increased use of suitable industrial waste materials having pozzolanic characteristics that can replace energy consuming Portland cement is one of the ways to meet the challenge. Replacement of certain amount of Portland cement with industrial by-products such as Red mud, Silica fume derives the technical advantage of modification of the properties of the fresh and hardened concrete. This includes slower rate of setting and hardening, lower heat of hydration, improved durability in acidic environments. Industrial by-products that would otherwise be discarded as harmful environment pollutants can thus be efficiently used as cement replacement in concrete. Some of the important industrial by-products are:

1) *Red Mud:* Red mud is a waste material generated by the Bayer process widely used to produce alumina from bauxite. Bauxite has the highest content of alumina with minerals like silica, iron oxide and impurities in minor or trace amount. The primary alumina production process consists of three stages; mining of bauxite followed by refining of bauxite to alumina by the Bayer process and finally melting of alumina to aluminium. In the Bayer process the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure to produce alumina is known as a red mud or bauxite residue. About 1 tonne of alumina is produced from 3 tonnes of bauxite and about 1 tonne aluminium is produced from 2 tonnes of alumina. Depending on the raw materials processed, 1-2.5 tonnes of red mud is generated per tonne of alumina produced.
2) *Silica Fume:* Silica fume, also known as microsilica, is an amorphous (non-crystalline) polymorph of silicon dioxide**.** It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy. Production and consists of spherical particles with an average particle diameter of 150 mm. The main field of application is as pozzolanic material for high performance concrete. It is sometimes confused with fumed silica However, the production process, particle characteristics and fields of application of fumed silica are all different from those of silica fume. Silica fume is a by-product in the carbothermic reduction of high-purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc furnaces in the production of silicon and ferrosilicon alloys. Because of its extreme fineness and high silica content, silica fume is a very effective pozzolanic material. Addition of silica fume also reduces the permeability of concrete to chlorideions, which protects the reinforcing steel of concrete from corrosion.

## II. STATEMENT OF PROBLEM

A comparative evaluation of strength characteristics of control concrete of grade $M_{30}$ and concrete produced by replacing cement by red mud (6%,12%,18%,24% & 30%) and silica fume (2%,4%,6%,8% and 10%) by weight of cement as a partial replacement.

## III. OBJECTIVE OF STUDY

The following are the main objective of study

*A.* To evaluate the fresh properties of control concrete of $M_{30}$ grade and concrete made by replacing cement with red mud (6%,12%,18%,24% & 30%) and silica fume (2%,4%,6%,8% and 10%) by the weight of cement Slump cone test and compaction factor test are conducted to study the fresh properties of concrete.

*B.* To find the compression strength of control concrete of $M_{30}$ grade and concrete made by replacing cement with Red mud (6%,12%,18%,24% & 30%) and silica fume (2%,4%,6%,8% and 10%) by the weight of cement at 28days and 56 days of curing.

*C.* To find the split tensile strength of control concrete of $M_{30}$ grade and concrete made by replacing cement with Red mud (6%,12%,18%,24% & 30%) and silica fume (2%,4%,6%,8% and 10%)by the weight of cement at 28days and 56days of curing.

## IV. MATERIALS AND METHODOLOGY

### *A. Cement*

In this present work Ultratech cement of 43 grade ordinary Portland Cement (OPC) was used for casting cubes and cylinder for all concrete mixes. The cement was of uniform colour i.e. Grey with a light greenish shade and was free from any hard lumps. The various tests conducted on cement are initial and final setting time, specific gravity and compressive strength, testing on cement was done as per IS: 8112-2013. The specific and composting limits of Portland cement are reported in below Table1.

Table 1: Physical Properties of Cement

| Sl.No. | Particulars | Experimental Results | As Per Standard IS:8112-2013 |
|---|---|---|---|
| 01 | Specific gravity | 3.15 | |
| a | Initial Setting | 50min | 30 Minutes (Min) |
| b | Final Setting | 200min | 600 Minutes (Max) |
| 02 | Compressive Strength(MPa) | | |
| a | 3 Days | 24.10 Mpa | 23 MPa(Min) |
| b | 7 Days | 36.14 Mpa | 33 MPa(Min) |
| c | 28 days | 44.20 Mpa | 43 MPa(Min) |

### *B. Fine Aggregate*

The sand used for this project was locally procured and conformed to grading zone II as per IS: 383-2016. The Specific Gravity of natural sand was found to be 2.43. Fineness modulus is 2.13 and the fine aggregate used was in SSD (Saturated surface dry condition)

Table 2: Sieve analysis of fine aggregate

| Sl no. | IS sieve size | Weight of Sample Retained ($W_1$g) | % Weight Retained ($W_1/W_2$)*100 | Cumulative % Weight Retained 'C' | % Finer N=100 - C |
|---|---|---|---|---|---|
| 01 | 4.75mm | 34 | 3.4 | 3.4 | 96.6 |
| 02 | 2.36mm | 14 | 1.4 | 4.8 | 95.2 |
| 03 | 1.18mm | 206 | 20.6 | 25.4 | 74.6 |
| 04 | 600µ | 327 | 32.7 | 58.1 | 41.9 |
| 05 | 300µ | 396 | 39.6 | 97.7 | 2.3 |
| 06 | 150µ | 22 | 2.2 | 99.9 | 0.1 |

The fine aggregate belongs to Zone II (as per IS: 383- 2016) FM = 2.89

### *C. Coarse Aggregate*

Locally available coarse aggregate having the maximum size of 20mm were in the present work. The specific gravity of coarse aggregate was found to be 2.56 and the coarse aggregate used was in SSD (Saturated surface dry condition)

### *D. Red Mud*

Red mud is procured from 'HINDALCO STEEL INDUSTRY', Belgaum, Karnataka.

Table 3: Elemental Red mud analysis

| Sl.No. | Ingredients | Red mud in % |
|---|---|---|
| 01 | Iron oxide( $Fe_2O_3$) | 38.3 |
| 02 | Aluminium oxide($Al_2O_3$) | 21.6 |
| 03 | Silicon Di-oxide ($SiO_2$) | 11.4 |
| 04 | Calcium oxide(CaO) | 1.47 |
| 05 | Sodium oxide ($Na_2O_3$) | 6.87 |

### *E. Silica fume*

Silica fume is procured from ‘SRI SAIDURGA ENTERPRISES’, Bangalore, Karnataka.

Table 4: Elemental silica fume analysis

| Sl. No. | Elemental oxides | Silica fume (%) |
|---|---|---|
| 01 | Silicon Di-oxide ($SiO_2$) | 96.07 |
| 02 | Aluminium oxide($Al_2O_3$) | 0.5 |
| 03 | Iron oxide($Fe_2O_3$) | 1.4 |
| 04 | Calcium oxide(CaO) | 0.5 |
| 05 | Magnesium oxide(MgO) | 0.3 |
| 06 | Potassium oxide ($K_2O$) | 0.7 |
| 07 | Sodium oxide ($Na_2O_3$) | 0.3 |
| 08 | Sulphur Tri-oxide ($SO_3$) | 0.33 |

### *F. Water*

Potable tap water is used for the preparation of specimens and for curing specimens.

## V. MIX DESIGN

The proportioning of the ingredients of concrete is an important phase of concrete technology as it ensures quality and economy. In pursuit of the goal of obtaining concrete with desired performance characteristics the selection of component materials is the first step, the next step is a process called mix design by which one arrives at the right combination of the ingredients. The Mix Design procedure adopted in the present work to obtain M30 grade concrete is in accordance with IS: 10262-2009.

Table 5: Mix proportions

| W/C Ratio | Water ($Kg/m^3$) | Cement ($Kg/m^3$) | Fine Aggregate ($Kg/m^3$) | Coarse Aggregate ($Kg/m^3$) |
|---|---|---|---|---|
| 0.45 | 197 | 438 | 596 | 1070 |

Table 6: Trial mix proportion

| Trail no. | W/C | Water ($Kg/m^3$) | Cement ($Kg/m^3$) | Fine agg ($Kg/m^3$) | Coarse agg ($Kg/m^3$) | Mix Proportions |
|---|---|---|---|---|---|---|
| 01 | 0.4 | 197 | 493 | 582 | 1044 | 1:1.2:2.11 |
| 02 | 0.45 | 197 | 438 | 596 | 1070 | 1:1.36:2.44 |
| 03 | 0.5 | 197 | 394 | 610 | 1094 | 1:1.54:2.7 |

Table 7: Concrete mix designation

| Mix Designation | Description |
|---|---|
| M0 | Control concrete |
| M1 | 6% red mud+2% silica fume+92% cement |
| M2 | 12% red mud+4% silica fume +84% cement |
| M3 | 18% red mud+6% silica fume +76% cement |
| M4 | 24% red mud+8% silica fume +68% cement |
| M5 | 30% red mud+10% silica fume +60% cement |

## VI. CASTING OF SPECIMENS AND TESTING PROCEDURES

Cement, sand and aggregates were taken in the mix proportion of 1:1.36:2.44, corresponding to M30 grade concrete of which cement is replaced by red mud( 6%, 12%, 18%,24%and 30%) and silica fume (2%,4%,6%,8%and10%). and the concrete was produced by dry mixing all the ingredients homogenously. To this dry mix, required quantity of water is added (W/C=0.45) and the entire mix was homogenously mixed. This wet concrete was poured into moulds which were compacted through hand compaction in three layers. After the compaction, the specimens were given smooth finish. Then after 24hours, the specimens were de-moulded and transferred to curing tank where they were cured for required number of days.

For evaluation of compressive strength, specimens of dimension 150x150x150mm were prepared. And for evaluating the split tensile strength, cylindrical specimen of diameter 150mm and length 300mmwere prepared. They were tested on 3000KN capacity compression testing machine as per IS: 516-1999. The compressive strength and split tensile strength is calculated by using the following equation,

$$F=P/A$$

Where, F = Compressive strength of specimen (MPa)
P = Maximum load applied on the specimen (N)
A = Cross sectional area of the specimen ($mm^2$)

$$F=2P/(\pi DL)$$

Where, F = Split tensile strength of specimen (MPa)
P = Maximum load applied on the specimen (N)
D = Diameter of the cylindrical specimen (mm)
L = Length of cylindrical specimen (mm)

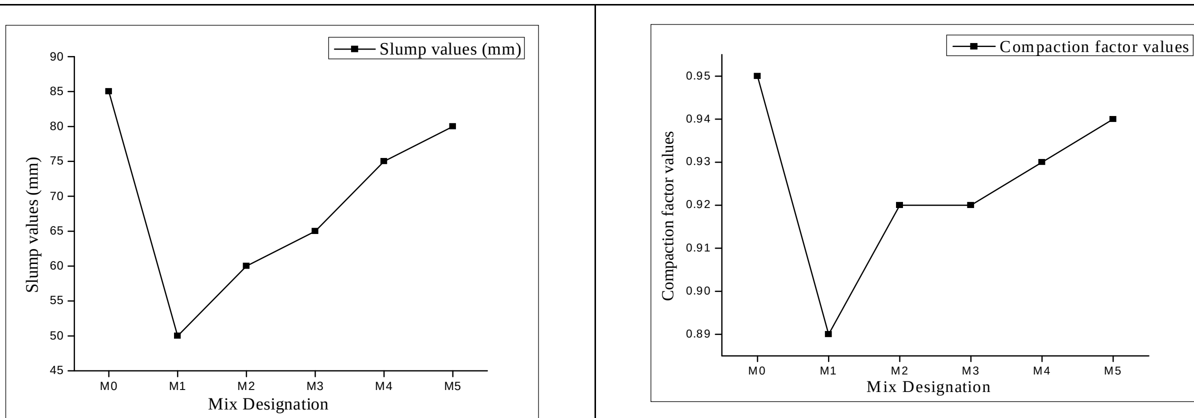
## VII. EXPERIMENTAL RESULTS

### *A. Fresh Properties Of Concrete*

**T**he test conducted on fresh properties for Control concrete and Concrete made with red mud( 6%, 12%, 18%,24%and 30%) and silica fume(2%,4%,6%,8%and10%) are Slump test and Compaction factor test.

Table 8:Slump and compaction factor values for control concrete and concrete made with red mud and silica fume

| Mix Designation | Slump values (mm) | Compaction factor values |
|---|---|---|
| M0 | 85 | 0.95 |
| M1 | 50 | 0.89 |
| M2 | 60 | 0.92 |
| M3 | 65 | 0.92 |
| M4 | 75 | 0.93 |
| M5 | 80 | 0.94 |




Graph 1: Slump and compaction factor values for control concrete and concrete made with red mud and silica fume

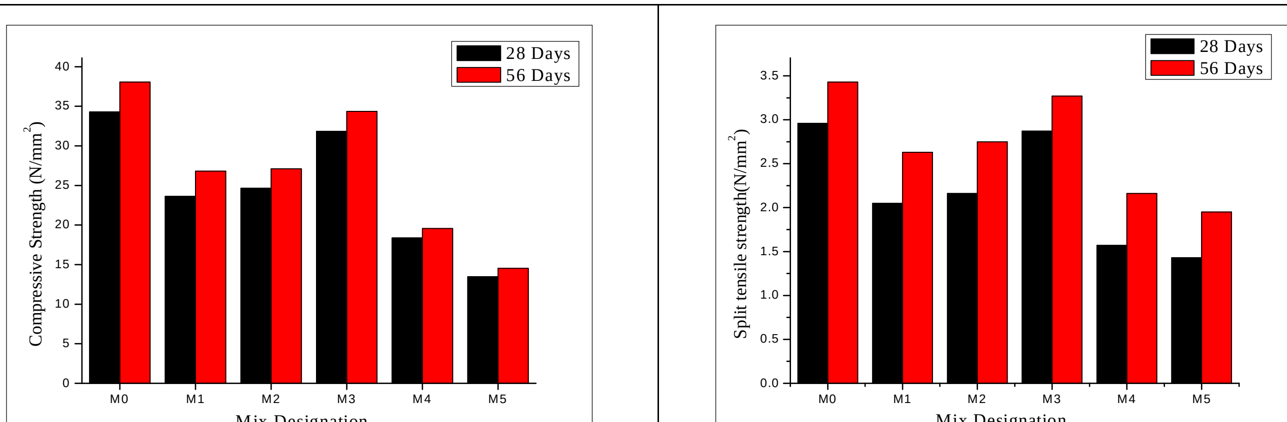
### B. *Harden Properties Of Concrete*

1) *Compressive Strength And Split Tensile Strength Test Results:* For each concrete mix, the compressive strength is determined on three 150X150X150mm cubes and split tensile test conducted on 150mm diameter and 300mm length cylinderat 28 and 56 Days of curing.

Following table gives the compressive strength and split tensile strength test results of control concrete and concrete made with red mud and silica fume.

Table 9: Overall Results of Compressive Strength and Split tensile strength test

| Mix Designation | Compressive strength(N/mm$^2$) | | | | Split tensile strength(N/mm$^2$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 28 Days | Percentage of increase/decrease | 56 Days | Percentage of increase/decrease | 28 Days | Percentage of increase/decrease | 56 Days | Percentage of increase/decrease |
| M0 | 34.29 | --- | 38.07 | --- | 2.96 | --- | 3.43 | --- |
| M1 | 23.62 | 31.11 | 26.81 | 29.57 | 2.05 | 30.74 | 2.63 | 23.32 |
| M2 | 24.66 | 28.08 | 27.10 | 28.81 | 2.16 | 27.02 | 2.75 | 19.82 |
| M3 | 31.84 | 7.14 | 34.36 | 9.74 | 2.87 | 3.04 | 3.27 | 4.66 |
| M4 | 18.36 | 46.45 | 19.55 | 48.64 | 1.57 | 46.95 | 2.16 | 37.02 |
| M5 | 13.47 | 60.71 | 14.52 | 61.85 | 1.43 | 51.68 | 1.95 | 43.14 |




Graph 2: Compressive Strength and Split tensile strength test results of control concrete and concrete made with red mud and silica fume.

## VIII. OBSERVATIONS AND DISCUSSIONS

In the present work the effect of red mud and silica fume on concrete in the fresh and hardened state is investigated and the following observations were made from the experiments conducted.

From the observations made on fresh properties of concrete it is noted that by the addition of red mud and silica fume the workability decreases compared to control concrete. But the concrete made by the combination of red mud and silica fume had shown improved in workability as red mud and silica fume content is increased. But it is less compared to control concrete.

At 28 days curing period, the compression strength of mix M3 is higher than all mixes when it is compared with combination mixes. But M1, M2, M3, M4 and M5 is having less compressive strength by 31.11%, 28.08%, 7.14%, 46.45%, 60.71% respectively when it is compared with control concrete.

At 56 days curing period, the compression strength of mix M3 is higher than all mixes when it is compared with combination mixes. But M1, M2, M3, M4 and M5 is having less compressive strength by 29.57%, 28.81%, 9.74%, 48.64%, 61.85% respectively when it is compared with control concrete.

At 28 days curing period, the split tensile strength of mix M1, M2, M3, M4, M5 is having less split tensile compared to control concrete by 30.74%, 27.02%, 3.04%, 46.95%, 51.68% respectively. But mix M3 is having highest split tensile strength when it is compared in combination mixes.

At 56 days curing period, the split tensile strength of mix M1, M2, M3, M4, M5 is having less split tensile strength compared to control concrete by 23.32%, 19.82%, 4.66%, 37.02%, 43.14% respectively. But mix M3 is having highest split tensile strength when it is compared in combination mixes.

It is observed that concrete made with combination of red mud and silica fume behaves exactly as control concrete in setting time and the specimen can be demoulded as control concrete.With the increase in red mud content and silica fume content the strength also increases in both compression and split tensile at both the age of curing. The strength starts to decrease after M3 mix there is drastic drop in the strength in the mixes M4 and M5. The concrete made with the combination of red mud and silica fume mix M3 achieves sufficient strength even at 28 days and 56 days but slightly less than control concrete.

## IX. CONCLUSIONS

*A.* Workability of concrete gets affected with addition of red mud and silica fume to the concrete.

*B.* As the percentage of red mud and silica fume increases workability also increases.

*C.* Concrete made with 18% red mud, 6% silica fume and 76% cement ( mix M3) is having highest compressive and split tensile strength in comparison with combination mixes.

*D.* Compressive strength result shows that mix M3 ( 18% red mud, 6% silica fume and 76% cement) is having only 7.14% and 9.74% less strength compared to control concrete at 28 days and 56 days of curing.

*E.* Split tensile strength result shows that mix M3 (18% red mud , 6% silica fume and 76% cement) is having only 3.04% and 4.66% less strength compared to control concrete at 28 days and 56 days of curing.

*F.* Concrete made with the combination of red mud and silica fume mix M3 achieves sufficient strength even at 28 days of curing. But slightly less than control concrete.

*G.* The work concludes that red mud and silica fume can be used together as supplementary materials for cement and can be used as a partial replacement for cement in concrete.

## REFERENCES

[1] Prof. Vishal S. Ghutke & Prof. Pranita S Bhandari , "Influence of Silica Fume on Concrete",(2014),(IOSR).

[2] R R Rathod, P M Kulkarni, V S Shingade & S S Deshmukh, "Suitability of Red Mud as an Admixture in Concrete" , (July 2015), (IJMTER).

[3] Lakhbir Singh, Arjun Kumar & Anil Singh, "Study of Partial Replacement of Cement by Silica Fume" , Vol 4, Issue 7 (2016), (IJAR)

[4] Ramkumar, Er. Jitender Dhaka, "Partial Replacement of Cement With Silica Fume and its Effects on Concrete Properties" , Vol 4, Issue 1, (September- 2016), (IJTRE).

[5] Sowmyashree T, Siddu Karthik C S, Manjunath C S and Arpitha D J, "Study on Mechanical Properties of Red Mud as a Partial Replacement of Cement with Hydrated Lime for M40 Grade concrete with Superplasticiser", Vol 5 ,Issue 4, (April-2016), (IJRET).

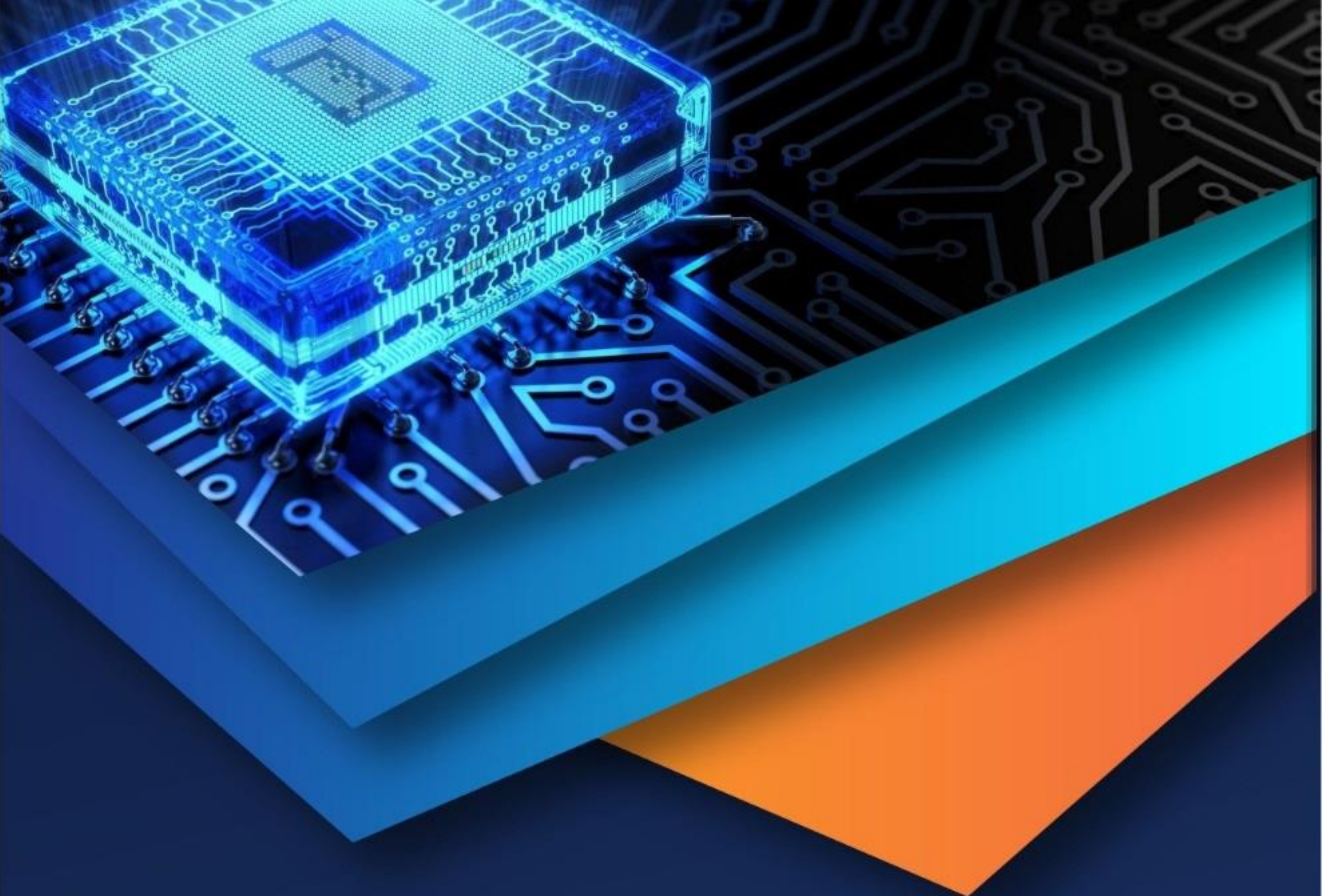
[6] Mahin Sha O B, Remya C P, Salja P A & Shifal K S, "Red Mud Concrete", Vol 3, Issue 4 (April 2016), (IRJET).

[7] Praveer Singh, Mohd.Afaque Khan and Abhishek Kumar, "The Effect on Concrete by Partial Replacement of Cement by Silica Fume: A Review" , Vol 3, Issue 3 (March- 2016) , (IRJET).

[8] Gurdeep Singh and Rajwinder Singh Bansal , "Effect of Partial Replacement of Cement by Silica Fume and Sand by Quarry Dust on Strength and Durability of Concrete" , Vol 4 , Issue 9 (Septmeber -2017),(IRJET).

[9] Akarsh .N.K, Nithin. H.P, arun kumar. R and Rajashekar.S.C, "An investigation on Workability and Strength Characteristics of Red Mud Concrete " , Vol 7, Issue 5 (May- 2017),(IJESC).

[10] P. Syam Sai and Chandana Sukesh , "Strength Properties of Concrete by Using Red Mud as a Replacement of Cement With Hydrated Lime" , Vol 8 , Issue 3 (March- 2017), (IJCIET).
[11] Concrete Technology, M S Shetty
[12] Concrete Manual , M L Gambir
[13] IS CODES
[14] IS:10262:2009 (Mix design)
[15] IS:456:2000 (Plain and reinforced concrete code of practice)
[16] IS:383:1970 (Specifications for Coarse and fine aggregates)
[17] IS:8112:2013 (Specifications and tests for 43 grade OPC)
[18] IS:516:1959 (Specification for compressive strength)
[19] IS:5816:1999 (Specification for split tensile strength)

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