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Cost Optimization of Geopolymer Concrete Pavement

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Abstract: ***In this study, concrete was prepared by complete replacement of sand and partial replacement of cement by Fly-Ash using different admixtures like NaOH- Na2SiO3 solution, CaO- Na2SiO3 solution, CaO- Na2SiO3 gel and Micro Silica in order to evaluate the effects of these admixtures on properties of HVFA concrete. Solutions and Gel were prepared by mixing both materials in different ratios. It was noted down in mix proportions.***
The study included determination of compressive strength and flexural strength with
(1) Variation in NaOH- Na2SiO3 solution (2) Variation in CaO- Na2SiO3 solution
(3) Variation in CaO- Na2SiO3 gel (4) Variation Micro Silica percentages
(5) Combination of above admixtures which gave better results. Durability tests like abrasion test and RCPT test were also conducted on HVFA concrete specimens.
Test results indicated a decrease in compressive as well as flexural strength when admixture percentage increased. Use of NaOH- Na2SiO3 solution is not even useful in lower percentages. It shows lower compressive and flexural strength than strength of concrete when made without use of any admixture. It was also found out that CaO- Na2SiO3 solution imparted more compressive as well as flexural strength than CaO- Na2SiO3 gel. But increase in Na2SiO3 shows decreased compressive as well as flexural strength. However Micro Silica showed better result than other admixtures and combination of CaO- Na2SiO3 solution and Micro Silica gave higher compressive as well as flexural strength than individual admixture. Graphs showing the above variations are also plotted under this thesis document. After completion of the project it was concluded that HVFA concrete has adequate compressive and flexural strength. Apart from this the cost per cubic meter of HVFA concrete is comparable to that of the conventional concrete as cement was also partially replaced by Fly-Ash. So it can be used for the construction of non-reinforced elements. Further research needed for checking suitability of HVFA concrete for reinforced elements and paver material.
Keywords: Fly-Ash; Micro Silica; HVFA concrete; Admixture

I. INTRODUCTION

We live in a very fast changing environment. Human beings have undergone many social, economic and psychological changes in search of their basic needs, i.e., food, clothing and shelter, which have given rise to two significant global trends known as urbanization and industrialization in modern times. Urbanization and industrialization from the nineteenth century had an influence on this world and this cycle continues. One of this phenomenon's major impact is the conversion of Earth's land cover from natural form to artificial. Owing to urbanization there is an increase in the built-up area and thus there has always been a need to produce new building materials. Such construction materials have two main aspects: strength and durability. As for proper development of residents' built-up areas, protection and structure life is critical. This leads to the creation of the most iconic building material widely known as concrete and is used for most building works.

Concrete is so heavily used in today's world that it is the world's most commonly used man-made construction material and is the world's second most widely used commodity only behind water. The concrete has coarse aggregates, fine aggregates, cement, plasticizer, and water. Concrete is commonly preferred because of the ease with which its constituents are available. Cement and admixture are the only artificial products. Cement can be manufactured quickly, at a minimal cost. India ranks second among the cement-producing nations after China with 320 million metric tons of production in 2019. However the main drawback of cement production is anthropogenic carbon dioxide production. Statistically, the cement kilns produce nearly 8 percent of the anthropogenic carbon dioxide.

Building scientists and structural engineers tried to replace the standard constituents of concrete with several different materials with developments in construction technology, and also tried to incorporate new components.

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In the early days of construction science research, the alternative components and binding materials were intended to reinforce the concrete, enhance its durability and longevity. But nowadays, the world is being subjected to a new threat of climate change and destruction of the ecosystem that has led to the idea of sustainable development to order the disorder. Scientists and engineers have been pushed by the idea of sustainable development to find these alternative binding materials and components that come from misplaced or so-called waste material. This situation has given rise to the idea of using fly ash as one of the binding materials and the concrete component. Green technology incorporates such waste materials in an innovative way to produce products or to offer services through reuse, recycling or recovery processes.

Fly ash is a high volume low-effect waste generated by fossil fuel burning, i.e., coal, and is therefore a major waste produced by thermal power plants. Coal-based thermal power plants meet about 70 per cent of India's electricity needs. Therefore, large quantities of fly ash are generated in India. The demand for power is rising day by day which will inevitably lead to increased output of fly ash in the future.

Sand is crucial for cement production as well as for concrete making. But not every kind of sand is suitable for building. The sand grains are too small to stick together in deserts, where wind has a free play. Sea sand is stronger but its salt content in reinforced concrete does not work well with steel. That makes river sand both a coveted and endangered mineral. A significant concern is also the loss of naturally accessible resources such as river sand. Sand is now being imported from other countries where there is plenty of sand, as the amount of river sand degrades every day. Also use of crushed sand increased due to unavailability of natural sand.

In India, aside from Portland cement, fly ash has been used extensively for several years now as an alternative binding material. In India, up to 93.26 million tons of fly ash were produced and 64.08 million tons of fly ash were utilized, according to one estimate in the first half of 2018-19. The production of fly ash posed a major problem for the environmental engineers, as their large volume became difficult to manage. Using fly ash as an alternative cement material in addition to Portland cement and also replacing sand in concrete manufacturing has provided a channel for not only managing the fly ash problem but also creating an economic and green building technology that is widely accepted in India today.

And we need to consider appropriate alternatives to combat the condition above. One such alternative is HVFA concrete with partial cement replacement, and complete fine aggregate replacement by Fly-Ash. Within the framework of this project, tests of the cubes and beams were performed to evaluate the two most critical concrete parameters, i.e., compressive strength & flexural strength. In addition, the mix designs have been altered to optimize the cost so that the research can be practically implemented in actual practice.

II. MATERIALS AND MIX DESIGN

Materials that consisted of cement (OPC 53), fly ash, CaO, Micro Silica, 10 mm aggregates, 20 mm aggregates, NaOH pellets, Na2SiO3 (extracted from RHA), plasticizer Master FlyAsh and water were used. Higher amount of Fly-Ash increases the specific area of material that increases amount of water to be used in concrete for achieving required workability. It also reduces early strength and increase final setting time of concrete. Therefore we used different combination of NaOH- Na2SiO3 solution, CaO-Na2SiO3 solution, CaO- Na2SiO3 gel and silica fumes for early final setting. Master FlyAsh plasticizer used for achieving required strength and workability and also for reduce water quantity. Different trials were taken with different proportions of materials and got better result in following material combination; cement (OPC 53), Fly-Ash, 10 mm aggregates, 20 mm aggregates, CaO-Na2SiO3 solution, silica fumes, Master FlyAsh plasticizer and water. Also higher strength achieved when Fly-Ash content reduced and cement, aggregate content increased with using only Master FlyAsh plasticizer and water, without other admixtures.

The design of any mix involving High Volume Fly-Ash is a fairly complicated process.

It involves a number of variables such as:

1) Ratio of Lime to Na2SiO3 solution
2) Selection and proportion of constituents of dry mix
3) Resting period for mix after molding
4) Proportions of plasticizer
5) Testing period
6) Curing method and time, etc.

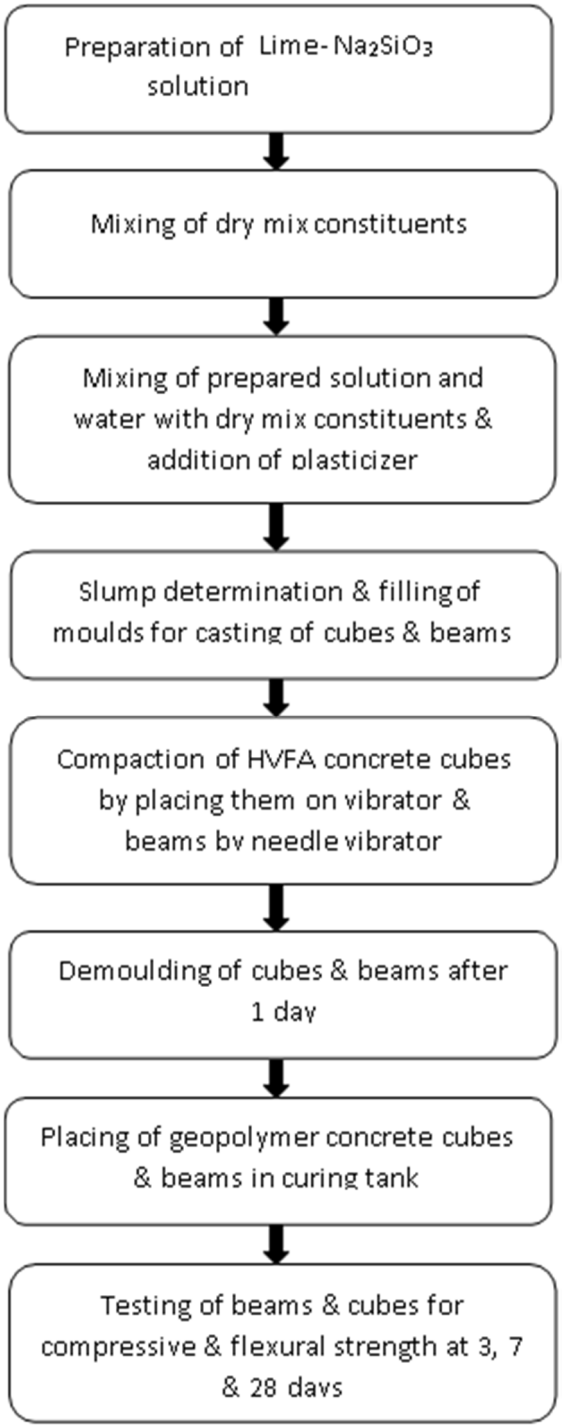
Various work in the field of HVFA concrete has been performed by adjusting these parameters in order to find the optimal configuration of an HVFA concrete mix. Many such researchers have used sand in their process in the case of HVFA concrete, and cement has been partially substituted by Fly-Ash which is not the case for this project. In addition, there is no literature review on the use of HVFA concrete with Fly-Ash replacing sand completely.

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For this project, rigorous systematic trials to refine the mix would have required a very large number of test mixes to provide an exact connection between all the variables. Furthermore, as mentioned earlier, one of the aims was to obtain a mix of sufficient standards at reduced material costs, with minimum cement and maximum use of Fly-Ash.
Considering the above shortcomings, it was decided to use trial and error method extensively for the purpose of development of a suitable mix.

III. RESEARCH METHODOLOGY & TESTING

Manufacture of High Volume Fly-Ash Concrete
Process Flowchart



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A. Testing Of HVFA Concrete

The beams & cubes were taken out of the curing tank at an interval of 3, 7 and 28 days. They should be left out for some time so that the water in the specimens gets evaporated. The weight of the specimens were taken afterwards. Cubes were tested for compressive strength in a compression testing machine and beams were tested for flexural strength in a flexure testing machine. The reading were noted down in the record book.

B. Compressive Strength Test

It is defined as the ability of a material to resist the compressive load coming on it without failure. It is the most important factor in designing a concrete mix. The major factors which influence the compressive strength are mix proportions and water cement ratio. The concrete specimen is placed in the compression testing machine and load is applied to it. The compressive strength can be calculated by the formula shown below:

Compressive Strength = Load (N) / Area of cube specimen (mm2)

The value of compressive load is given in KN by the compression testing machine & the area of cube specimen is 22500 mm2. So for simplicity purpose the compressive strength in N/mm2 can be calculated by load taken by the cube in KN after 28 days divided by 22.5.



Fig. 1&2 Weight measurement and Compression testing machine



Fig. 3 Compressive load reading in KN

C. Flexural Strength Test

It is defined as the ability of slab or beam to resist failure in bending. It is carried out using unreinforced concrete beam specimen of size 150*150*700 mm. With the help of a flexural test machine two point load is applied on the beam. The value of load (KN) after 28 days at which the beam fails is noted down. The flexural strength can be calculated as:

Flexural Strength = 3*Load (N)*Length (mm) / Width (mm)*Depth2 (mm2)

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The value of flexure load in KN is given by the flexure testing machine. The length between the supports is 600 mm & width & depth of beam is 150mm. For simplicity purpose the flexural strength is given as Load in KN divided by 4.5.



Fig. 4&5 Weight measurement and Flexural testing machine



Fig. 6 Flexural load reading in KN

IV. RESULTS

A. Variation in Compressive and Flexural Strength with different proportion of NaOH & Na2SiO3 Solution

The published literature review has suggested to give 1 day maturity to the prepared alkaline solution for geopolymer concrete. But in this project we are using Na2SiO3 extracted from RHA and we are testing effect of this solution on HVFA concrete. Therefore, we were using solution without given maturity in different proportions in small quantity as additional admixture. So the effect of different proportions of NaOH and Na2SiO3 solution for a fixed mix proportion was studied and the following observations were made:

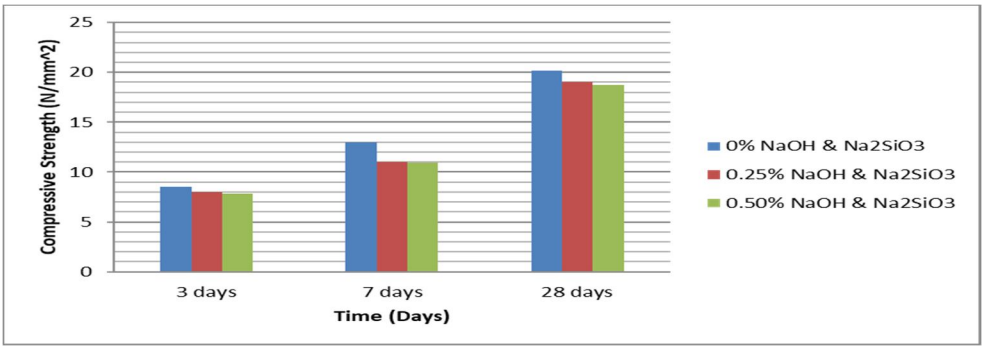


Fig. 7 Compressive strength v/s Time

Observation

Compressive Strength(N/mm2)	No solution	0.25% solution	0.50% solution
3 Days	8.5	8	7.83
7 Days	13	11	10.96
28 Days	20.2	19	18.75

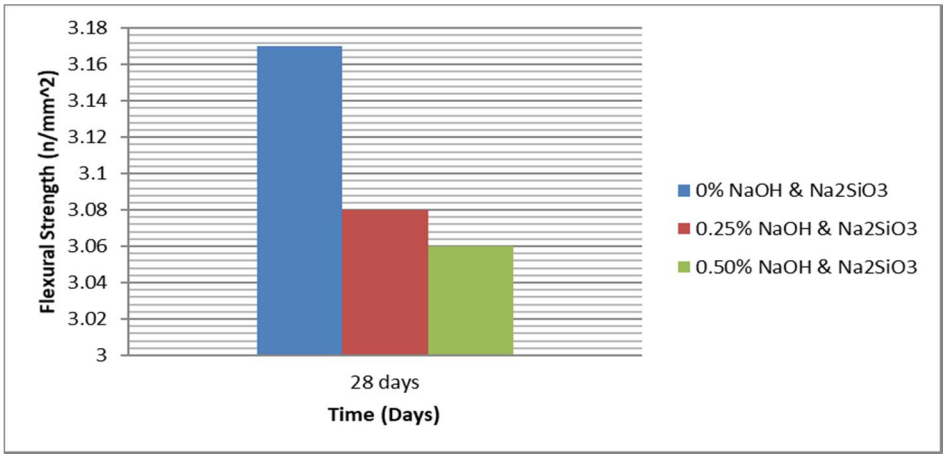


Fig. 8 Flexural strength v/s Time

Observation

Flexural Strength (N/mm2)	No solution	0.25% solution	0.50% solution
28 Days	4.95	5.07	5.57

B. Variation in Compressive and Flexural Strength with different proportion of CaO + Na2SiO3 Gel and CaO + Na2SiO3 Solution

Literature review shows that CaO helps in improving mechanical properties of HVFA concrete. So, in this project we make trials with CaO and Na2SiO3. When CaO mixes with Na2SiO3, it forms gel like material after 24 hours of retention. We can also use it directly after mixing of CaO and Na2SiO3. In this project we have make trials for different proportions of CaO + Na2SiO3 Gel and also for CaO + Na2SiO3 solution. Effect of both approach studied and following observations were made:

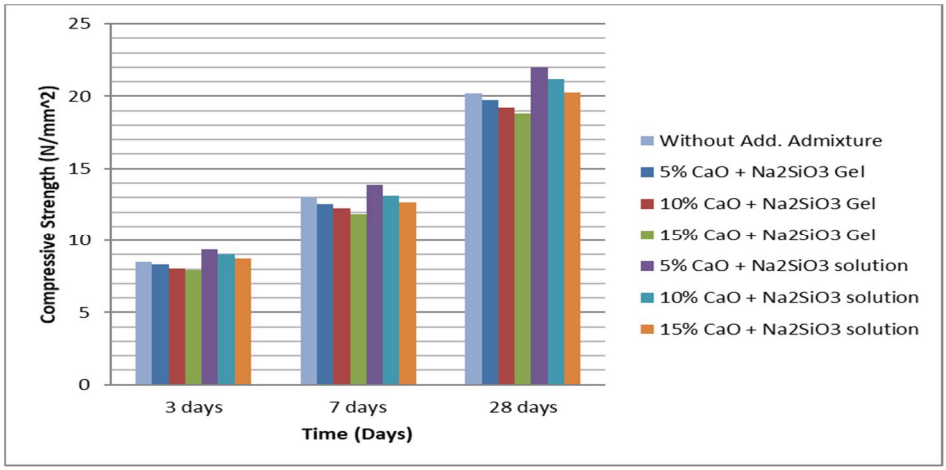


Fig. 9 Compressive strength v/s Time

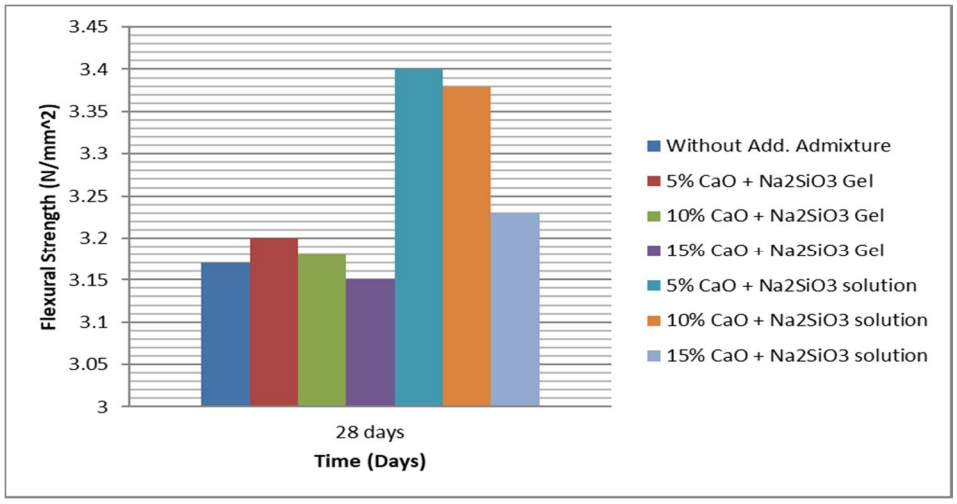


Fig. 10 Flexural strength v/s Time

Observation

Compressive Strength(N/mm2)	Without Add. admixture	5% CaO + Na2SiO3 Gel	10% CaO + Na2SiO3 Gel	15% CaO + Na2SiO3 Gel
3 Days	8.5	8.3	8.05	7.93
7 Days	13	12.58	12.26	11.88
28 Days	20.2	19.75	19.21	18.83
Flexural Strength(N/mm2)	Without Add. admixture	5% CaO + Na2SiO3 Gel	10% CaO + Na2SiO3 Gel	15% CaO + Na2SiO3 Gel
28 Days	3.17	3.2	3.18	3.15
Compressive Strength(N/mm2)	Without Add. admixture	5% CaO + Na2SiO3 Gel	10% CaO + Na2SiO3 Gel	15% CaO + Na2SiO3 Gel
3 Days	-	9.35	9.01	8.73
7 Days	-	13.9	13.15	12.68
28 Days	-	22	21.21	20.23
Flexural Strength(N/mm2)	Without Add. admixture	5% CaO + Na2SiO3 Gel	10% CaO + Na2SiO3 Gel	15% CaO + Na2SiO3 Gel
28 Days	-	3.4	3.38	3.23

C. Variation in Compressive Strength and Flexural Strength with Micro Silica and different CaO & Na2SiO3 Combination

Literature review shows that Micro Silica upto 5% of cement gives better mechanical as well as durability property. In previous trials ratio of Na2SiO3 to CaO was kept as 4:1. For trials, other combinations were tried with different ratios. And also trials made with combination of Micro Silica and CaO & Na2SiO3 solution. Effect of different ratios studied and following observations were made:

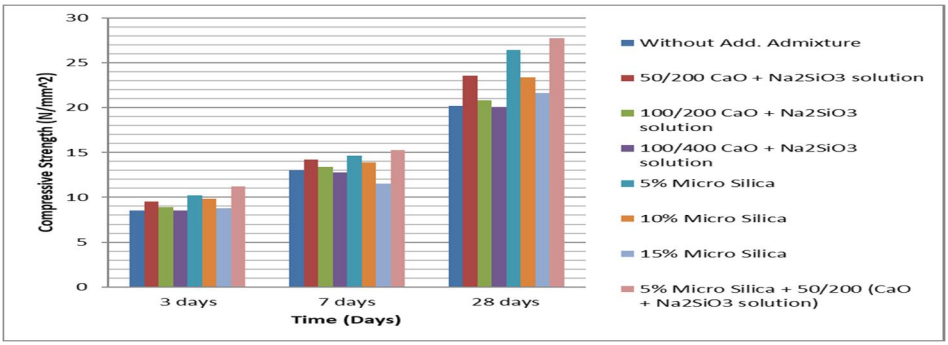


Fig. 11 Compressive strength v/s Time

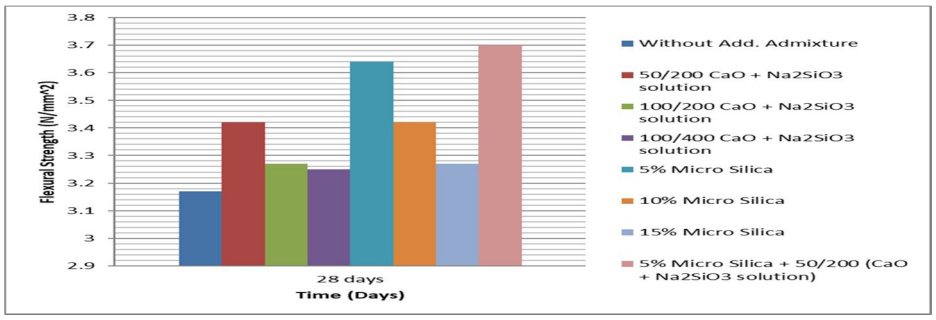


Fig. 10 Flexural strength v/s Time

Observation

Compressive Strength(N/mm2)	Without Add. admixture	(50/200)CaO +Na2SiO3 solution	(100/200)CaO +Na2SiO3 solution	(100/400)CaO +Na2SiO3 solution
3 Days	8.5	9.5	8.9	8.53
7 Days	13	14.2	13.4	12.8
28 Days	20.2	23.6	20.8	20.1
Flexural Strength(N/mm2)	Without Add. admixture	(50/200)CaO +Na2SiO3 solution	(100/200)CaO +Na2SiO3 solution	(100/400)CaO +Na2SiO3 solution
28 Days	3.17	3.42	3.27	3.25
Compressive Strength(N/mm2)	5% Micro Silica	(50/200)CaO +Na2SiO3 solution	(100/200)CaO +Na2SiO3 solution	(100/400)CaO +Na2SiO3 solution
3 Days	10.2	9.82	8.76	11.22
7 Days	14.62	13.87	11.53	15.3
28 Days	26.47	23.4	21.63	27.77
Flexural Strength(N/mm2)	5% Micro Silica	5% CaO + Na2SiO3 Gel	(50/200)CaO +Na2SiO3 solution	(100/200)CaO +Na2SiO3 solution
28 Days	3.64	3.42	3.27	3.7

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V. CONCLUSIONS

The prime focus of this study was the development of HVFA concrete which is industry-friendly, environment-friendly, offering required properties at minimum material cost, employing a simple method for its preparation and that can be used for the construction of non-reinforced elements by completely replacing sand and partially replacing cement by Fly-Ash.

To achieve this, concrete specimens of HVFA concrete were cast using a number of dry materials mentioned earlier in this thesis document. Trial mix was prepared by trial & error method for M20 grade of concrete. Effect of different admixtures on mechanical properties was tested. Based on the observations made in the experimental investigation, the following conclusions could be drawn:

The published literature review has suggested to use 5% Micro Silica in HVFA concrete. So effect of higher percentage also tested and it shows optimum compressive as well as flexural strength at 5%. The 28 days compressive strength without Micro Silica was 20.2 N/mm^2, after using 5% Micro Silica it increased to 26.47 N/mm^2. And for 10% Micro Silica & 15% Micro Silica it was reduced to 23.4 N/mm^2 & 21.63 N/mm^2 respectively. The 28 days flexural strength without Micro Silica was 3.17 N/mm^2 and for 5% Micro Silica it was increased to 3.64 N/mm^2.

There is no significant effect of NaOH-Na_2SiO_3 solution on mechanical properties of HVFA concrete. Ratio of NaOH to Na_2SiO_3 was kept as 1:1. It shows decreased strength values when NaOH-Na_2SiO_3 solution used in HVFA concrete.

The literature review shows that CaO helps in improving properties of HVFA concrete. In this project CaO used with Na_2SiO_3 as CaO-Na_2SiO_3 Gel and CaO-Na_2SiO_3 solution. A result shows that solution gave better compressive as well as flexural strength than gel. Ratio of CaO to Na_2SiO_3 was kept as 1:4. Different combinations were made and for 1:4 ratio it shows 28 days result for CaO (2.5 kg/m^3) & Na_2SiO_3 (10 kg/m^3) as 23.6 N/mm^2 and 3.42 N/mm^2 respectively for compressive strength and flexural strength.

Combination of Micro Silica (5%) and CaO (2.5 kg/m^3) & Na_2SiO_3 (10 kg/m^3) shows better results than individual admixture. It shows 28 days compressive strength as 27.77 N/mm^2 and flexural strength as 3.7 N/mm^2.

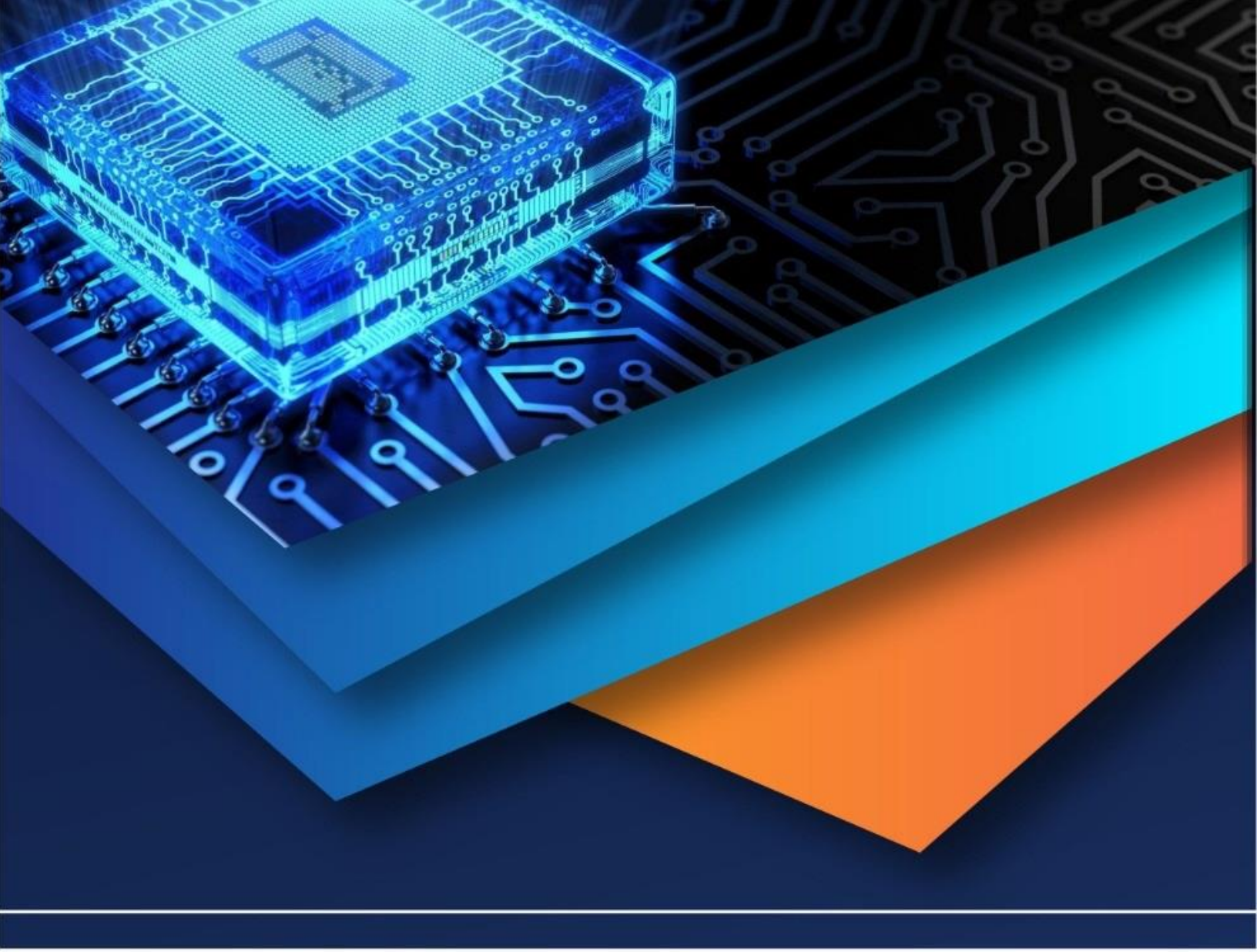
Different curing method tried for HVFA concrete. It shows good results when water curing used as curing method.

A results show that Master FlyAsh performs better for HVFA concrete as it considerably reduced water content and improves mechanical strength

REFERENCES

[1] ACAA (2003), Fly Ash Facts For Highway Engineers, Aurora, USA, American Coal, Ash Association.
[2] ACI Committee 232 (2004), Use Of Fly Ash In Concrete, Farmington Hills, Michigan, USA, American Concrete Institute.
[3] Desai, J.P. (2004), Construction And Performance Of High Volume Fly Ash Concrete Roads In India, Eighth CANMET/ACI International Conference On Fly Ash, Silica Fume, Slag And Natural Pozzolans In Concrete, Las Vegas.
[4] Fortune, J. (2005), Global Dimming, BBC, 22 March 2005.
[5] Heidrich, C. (2002), Ash Utilization – An Australian Perspective, Geopolymers 2002 International Conference, Melbourne, Australia, Siloxo.
[6] Malhotra, V.M. (1999), Making Concrete Greener With Fly Ash.
[7] Malhotra, V.M. (2002), High-Performance High-Volume Fly Ash Concrete.
[8] Malhotra, V.M. (2002), Sustainable Development And Concrete Technology.
[9] McCaffrey, R. (2002), Climate Change And The Cement Industry.
[10] Mehta, P.K. (2001), Reducing The Environmental Impact Of Concrete.
[11] Mehta, P.K. and R. W. Burrows (2001), Building Durable Structures In The 21st Century.
[12] Neville, A.M. (2000), Properties Of Concrete, Prentice Hall.
[13] Faiz Shaikh, Sachin Kerai and Shailesh Kerai (2016), Effect Of Micro-Silica On Mechanical And Durability Properties Of High Volume Fly Ash Recycled Aggregate Concretes (HVFA-RAC)
[14] Indubhushan Patnaikuni, Sujeeva Setunge, Mochamad Solikin, Xiao Ling and Binndu Boina (2013), High Strength High Volume Fly Ash Concrete.
[15] A. Borsoi, S. Collepardi, L. Coppola, R. Troli, M. Collepardi (2000), Effect of Superplasticizer Type on the Performance of High-Volume Fly Ash Concrete.
[16] N.P. Rajamane, Ambily P.S(2013), Fly Ash As a Sand Replacement Material In Concrete - A Study.
[17] Alaa M. Rashad (2015), A Brief On High-Volume Class F Fly Ash As Cement Replacement – A Study Guide For Civil Engineers.
[18] Mehta, P. K. (2004), High-Performance, High-Volume Fly Ash Concrete For Sustainable Development.
[19] A. A. Ramezanianpour & V. M. Malhotra, (1994), Fly Ash In Concrete.
[20] V. M. Malhotra, V. Sivasundaram (2004), High-Performance High-Volume Fly Ash Concrete.
[21] R. K. Singh (2015), Value Added Utilization Of Fly Ash- Prospective And Sustainable Solution.

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