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Effect Of Rice Husk Ash And Calcium Carbide Residue On Properties Of Concrete As Partial Replacement Of Cement

Vishvanath N. Kanthe[1], Ganesh B. Kawale[2], Minal M. Deshmukh[3], Suhas V. Dharne[4], Ritali S. Wagh[5]
[1]PhD, Associate Professor, Department of Civil Engineering, Guru Gobind Singh College of Engineering and Research Centre, Nashik, Maharashtra, India, kanthevn@gmail.com,
[2] PhD, Associate Professor, Department of Civil and Environmental Engineering, MET's Institute of Technology-Polytechnic, Nashik, India.
[3]Assistant Professor, Department of Civil and Environmental Engineering, MET's Institute of Technology-Polytechnic, Nashik, India.
[4]Assistant Professor, Department of Civil Engineering, Pune Vidyarthi Griha's College of Engineering and SS Dhamankar Institute of Management Nashik, India.
[5]Assistant Professor, Department of Engineering Science, Pune Vidyarthi Griha's College of Engineering and SS Dhamankar Institute of Management Nashik, India.

Abstract
In India, a significant amount of industrial and agricultural by-products such as fly ash (FA), rice husk ash (RHA), and calcium carbide residue (CCR) are generated, posing serious environmental challenges due to their disposal. To address this issue, it is essential to focus on the sustainable utilization of these by-products in concrete, particularly for infrastructure development. Cement, a primary component of concrete, contributes substantially to CO_2 emissions during its production. The incorporation of highly reactive pozzolanic materials like RHA and CCR as partial cement replacements can enhance both the strength and durability of concrete while mitigating environmental impacts. India, being the second-largest producer of rice globally, has abundant availability of RHA. In this experimental study, cement was partially replaced with a combination of CCR and RHA at varying proportions—5%, 10%, 15%, 20%, and 25%. The concrete was evaluated for its fresh, hardened, and durability properties. The results revealed a decrease in workability with increasing replacement levels. However, the compressive strength improved significantly, with MIX5 exhibiting a 34.7% increase, and flexural strength is showing a 15.11% improvement. MIX15 demonstrated optimal mechanical performance compared to the control mix. Ultrasonic pulse velocity (UPV) tests indicated excellent quality for MIX15. Additionally, water absorption was highest in the control mix and progressively decreased with higher replacement percentages, also resulting in a reduction in concrete density. The cost analysis further showed that the use of CCR and RHA as partial cement replacements led to a reduction in overall concrete cost.
Key words– *Calcium Carbide Residue, Rice Husk Ash, Carbon Dioxide, Concrete, Cement*

1.INTRODUCTION

For the development of the nation Construction Industry plays important role. In this modern period the construction is main objective over the globe. Therefore the demand of cement is also at higher peak and simultaneously cost too. The cost of cement is on the rising trend, due to increased demand and rising mining levies and a solution to this is decrease in prices would be a relief to the consumers of cement in the construction industry. Concrete is well known as a heterogeneous mixture of cement, aggregate and water. Among all these constituents of concrete, cement is most costly and demanding material. Many large scale construction projects around the world today use Portland cement as primary concrete binder. Production process for Portland cement requires large amount of energy to burn raw materials at temperature of up to 1500°C. Addition to that production of 1 ton of Portland cement releases as much as 900kg of CO2 into atmosphere[1]. Hence, it is important to find supplementary product for cement for replacement in concrete.

The quantity of calcium carbide waste in India is not publicly available information. However, it is estimated that the country produces around 100,000 metric tons of calcium carbide waste each year. This waste is a major environmental problem, as it is highly alkaline and can contaminate soil and water[1]. Calcium carbide waste is a by-product of the production of acetylene gas. Acetylene is a flammable gas that is used in a variety of applications, including welding, cutting, and metal fabrication[2]. Calcium carbide is produced by reacting calcium oxide with carbon at high temperatures. The reaction produces a mixture of calcium carbide and calcium oxide, which is called calcium carbide slag. The calcium carbide slag is then separated from the acetylene gas. The slag is a solid waste that is typically dumped in landfills. However, the slag is highly alkaline and can contaminate soil and water. Hence it is important to take another material for concrete which can replace cement and sand[3]. The use of pozzolanic material from waste product as partial replacement in concrete contribute to reduce the environmental problem through waste and enhance the strength properties of concrete[4].

1.1 Calcium Carbide Residue

Calcium Carbide Residue (CCR) is a by-product of the acetylene gas production process. After production process of acetylene gas, the remains or waste product of calcium carbide like calcium carbide residue poses very high water content. Primarily the CCR is obtained in slurry form and then the deposition of CCR is allowed to dry naturally. CCR contains high proportion of calcium hydroxide[5]. The main component of CCR is $Ca(OH)_2$, which can react with siliceous materials through pozzolanic reactions, resulting in a product similar to those obtained from the cement hydration process[6], [7]. The chemical composition of CCR varies depending on the production process, but it typically contains are Calcium (Ca), Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Sulfur (S). Fig. 1 describe the process of forming of CCR.

Fig.1 Process of forming Calcium Carbide Residue

1.2 Rice Husk Ash

Rice husk ash is a by-product of agriculture and is generated in rice mills. Rice husk (rice hull) is the coating of seeds or grains of rice. This coating protects the seed or grain during the growing season. The husk converts to hard materials, including opaline silica and lignin. When properly burnt, rice husk contains high amounts of silica (SiO_2)[8], [9], [10]. Hence it can be used as supplementary cementitious material in combination with cement to make concrete products. When paddy is milled, 80% of the weight is of rice and 20% of the weight obtained is husk[9],[11]. This husk can also be used as a fuel for steam or power generation and other purposes. Fig. 2 describe the process of forming of RHA.

Fig.2 Process of forming Rise Husk Ash

2. MATERIALS AND METHODOLOGY

The following materials were used for this research work. Ordinary Portland cement of 53 grades with specific gravity 3.15, river sand with specific gravity 2.6 and coarse aggregate with specific gravity 2.67 were used. Processed RHA with specific gravity 3.12 and CCR collected from local vendor. Water reducing admixture was used to control the flow ability of concrete. Fineness of RHA and CCR were carried out from 90 micron IS sieve and it found 98% and 96% passing, it seems to very fine material. IS 383 was used to conformed the properties of raw material[12]. Table 1 describe the mix design of concrete.

Table 1 Concrete Mix Design

Sr. No.	**Concrete mix**	**Cement (kg/m^3)**	**Sand (kg/m^3)**	**Aggregate (kg/m^3)**	**Water**	**RHA (kg/m^3)**	**CCR (kg/m^3)**	**Chemical Admixture**
1	MIX0	384	690	1168	192	0	0	1%
2	MIX5	364	690	1168	192	10	10	1%
3	MIX10	344	690	1168	192	20	20	1%
4	MIX15	326	690	1168	192	29	29	1%
5	MIX20	306	690	1168	192	39	39	1%
6	MIX25	288	690	1168	192	48	48	1%

3. RESULT AND DISCUSSION

3.1 Workability of fresh concrete

To check workability and flow ability of concrete at the time of casting the slump cone test was conducted for each concrete mix and the slump value was noted down. Fig. 3 describes the slump value of various concrete mixes. For control mix (MIX0) the slump value was 76 mm and for MIX5 the value was decreased by 1 mm that is 75 mm which does not affects much to the concrete workability. After MIX10 the workability was reducing 4 to 5 mm for every mix, the slump value was 68, 63, 58 and 55mm for MIX10, MIX15, MIX20 and MIX25 respectively. As the fine particles in concrete were increasing, the workability was reducing due to increase in surface area this can also be solve by adding high water reducing admixture[8], [13].

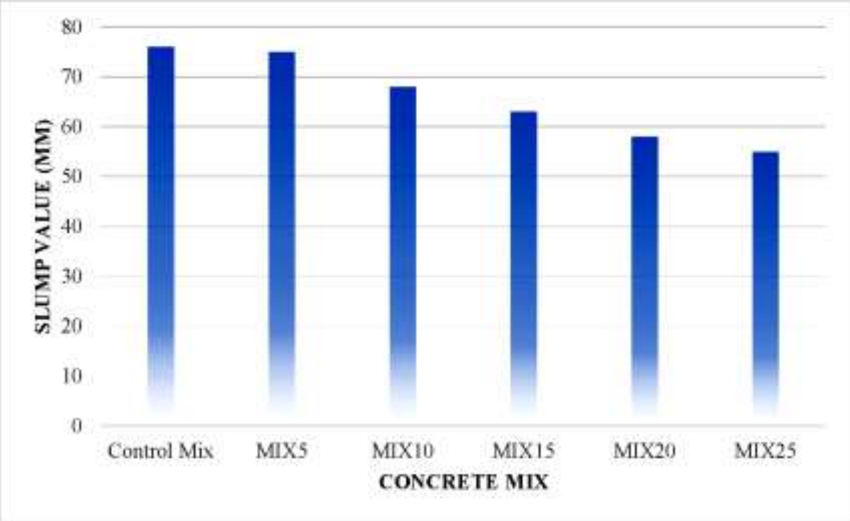

Fig.3 Comparison of slump value of fresh concrete.

3.2 Compressive strength of Concrete

Fig. 4 describes the compressive strength of various concrete mixes. Control Mix (MIX0) the compressive strength at 7 days was seem to be 22.4 N/mm^2 and for the same mix the compressive strength at 14 day was 27.11 N/mm^2 and at 28 days the compressive strength was 31.33 N/mm^2. From these results it comes to know that the compressive strength of concrete cubes was increasing and performance of the cubes was good, it is due to continuous curing. Comparatively, for 5% replacement of RHA & CCR (MIX5) the compressive strength of cube at 7 days was increased by 8.7% and compressive strength at 14 days was increase by 27.7% that of Control Mix. At 28 days the compressive strength was increased by 34.7%.

For 10% replacement of RHA & CCR (MIX10) at 7 days the compressive strength of cube was seem to be less as compared to control concrete cube by 16% but after continuous curing of cubes the compressive strength of cube at 14 days was increased by 3% that of control mix cube and the compressive strength 28 days was slightly increased that is 3.8%. For MIX15. the replacement of RHA & CCR (MIX15) the compressive strength of cubes was 20.08 N/mm^2 that is 10% less than control cube at 7 day but after continuous curing of concrete the compressive strength of at 14th and 28th days was 26.62 and 31.04 respectively which means the strength of cubes was slightly less than that of control concrete that is 1 and 0.5% respectively. For MIX20 and MIX25 in this mixes the compressive strength of concrete cubes was seen decrease as compared to control mix because of adding more amount of cementitious material ,20% and 25% the amount of finer particles increased. By increase in surface area the slump was affected and it directly affected the strength of concrete. From the above experimental review it is clear that MIX5 i.e. replacement of cement with RHA & CCR by 5% gives optimum strength without harming any property of concrete. The increase in strength of may be due to the high reactive material like RHA and decrease in strength due to addition of excess finer material in concrete[14],[15], [16].

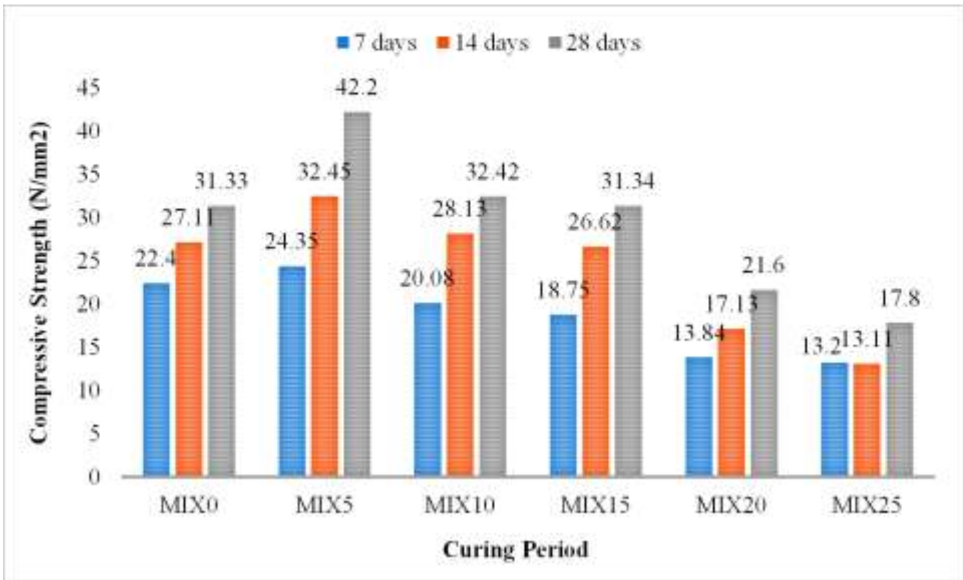

Fig.4 Comparison of compressive strength of various concrete mix.

3.3 Flexural strength of Concrete

The flexural test is a type of mechanical test is determines the ability of a material to withstand bending. Fig. 5 describes the flexural strength of various concrete mixes. The strength of control mix was seen 7.2 N/mm^2 at 28 days. For MIX5 the strength of concrete was increased by 15.11% and it was increased till MIX15. The flexure strength of MIX10 was 15.25% more than control mix and 22.05% more than MIX15 but after MIX15 there was slight decrease for MIX20 and MIX25 was seen, which is due to more volume of finer particles in CCR & RHA and due to these finer particles the water-cement ratio gets affected[3].

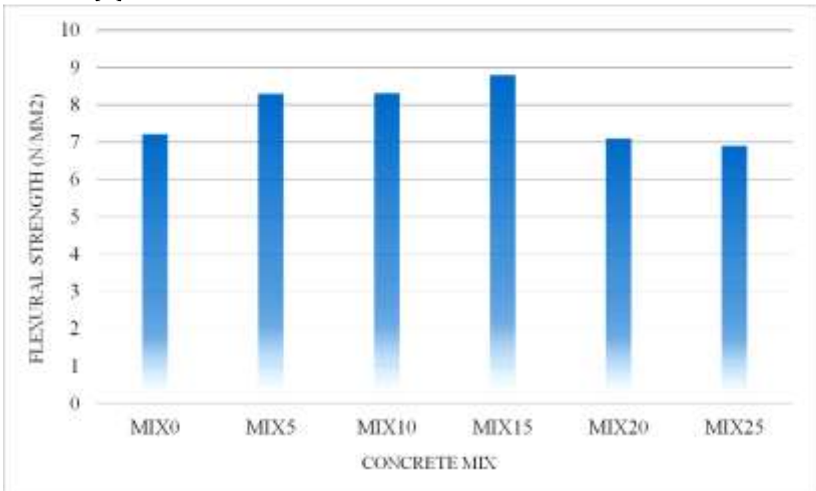

Fig.5 Comparison of Flexural strength of concrete at different mixes.

3.4 Ultrasonic Pulse Velocity of concrete-

Fig. 5 describes the UPV values of various concrete mixes. The velocity of control mix at 28 days was seen 3.8 kmph that means the cube was performing good. At same time for MIX5, MIX10 and MIX15 the velocity was seen 5.2 kmph, 5.4 kmph and 5.8 kmph respectively, which indicates that the performance of the concrete is excellent. From MIX0 to MIX15 the velocity was increasing and the performance of concrete was excellent but after MIX15 the velocity of MIX20 & MIX25 is slightly reduced but was good as compared to MIX0. On an average the ultrasonic pulse velocity of the concrete was seen 4.8 at 28 days which means the performance of concrete was excellent.

For control mix velocity at 7 days and 14 days was 3.5 kmph and 3.6 kmph respectively, whereas for MIX5 the velocity was 4.7 kmph and at 14th day it was increase to 4.9 kmph the velocity was increase up to m15 and it was seen 4.9 kmph and 5.0 kmph for 7th and 14 days respectively but after mix 15 the velocity was reduce but was good in compare to mix zero the velocity of mix 20 watch 3.8 and 4.1 kmph respectively for 7th and 14 days and 3.6 and 3.8 kmph mix 25 at 7th and 14 days from the experimental study above the velocity of 14 day was seen increasing in compared to 7 days. But the result of 28 day was excellent and the velocity of was increasing rapidly it may due to the dense particle packing formation in concrete[17], [18].

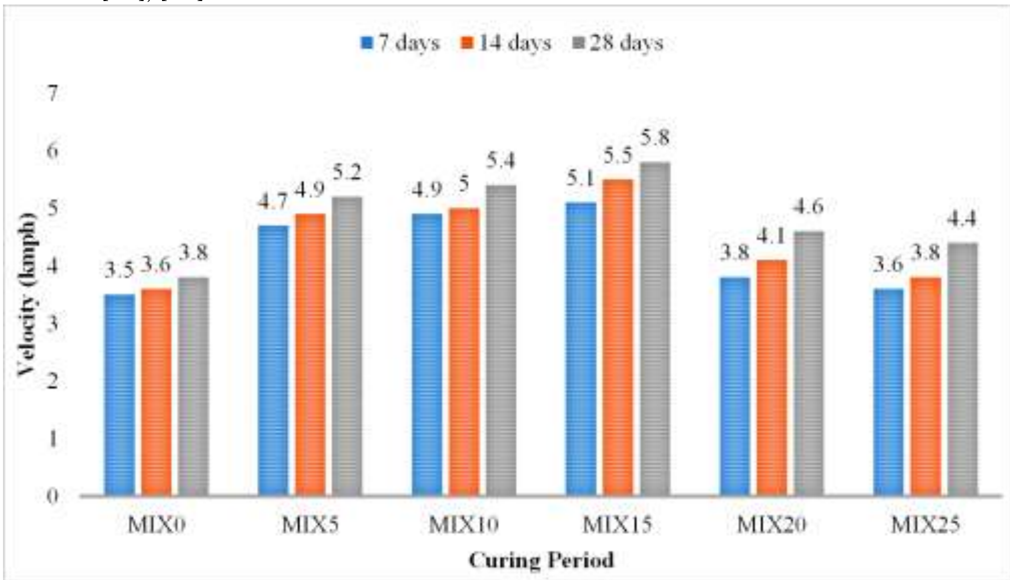

Fig.6 Comparison of Ultrasonic Pulse velocity at various curing ages.

3.5 Water Absorption of concrete

Fig. 7 describes the water absorption capacity of various concrete mixes. After 28 days curing of cubes the weight of each cube was taken and after that they were kept in tree with water touching you and the height of 3mm and allowed to water absorption for 24 hours. The weight after 24 hour was recorded and water absorption was noticed for each mix. For control mix (MIX0) the value of water absorption was 3.26% whereas for MIX5 the water absorption was less as compared to control mix that is 2.57%. The water absorption was 2.18% for MIX10 like that way the percent water absorption was reduced by 1.68%, 1.43% and 1.38% for MIX15, MIX20 and MIX25 respectively. This reduction in water absorption to increase in mixed proportion is due to use of fine particles present in CCR & RHA which makes concrete dense and less voids present in dense concrete causes less water absorption[15], [17], [18], [19].

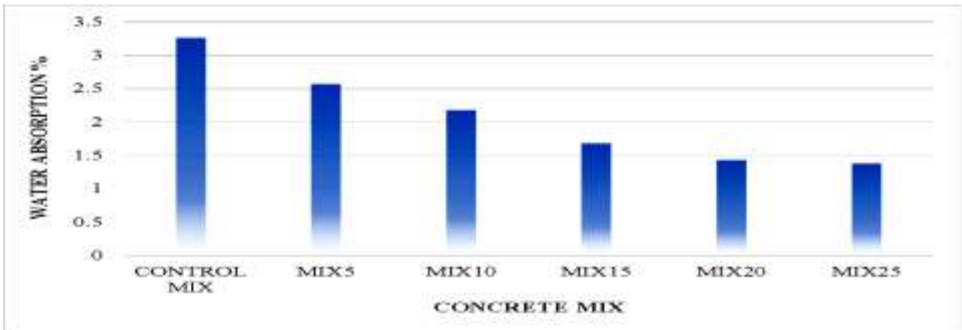

Fig.7 Percentage Water Absorption of concrete

3.6 Density of Concrete

Fig. 8 describes the density of various concrete mixes. The density of concrete can be determine where mass is average weight of cube in kilograms and volume is size of cube in M^3 that is 0.15 x 0.15 x 0.15 M^3 for control mix the mass was seen to be 8.69 kilo and the volume is 3.37×10^{-3} M^3 that is $8.690/3.375\times10^{-3}$ is equal to 2575 kg per M^3 whereas the density of MIX5 was reduced by 0.5% and 0.9% for mix 10 as the cementitious material replace in more amount the density was reducing. For MIX15 the density was reduced by 4.5% and for MIX20 & MIX25 the density was decreased by 5.36% and 5.65% respectively. As the percentage replacement of cement is increase the weight of concrete is decreasing and also the density of concrete reducing. Also, due to more amount finer particles are used as cement replacement the percentage voids content is less and the concrete becoming dense[9], [13], [18], [20].

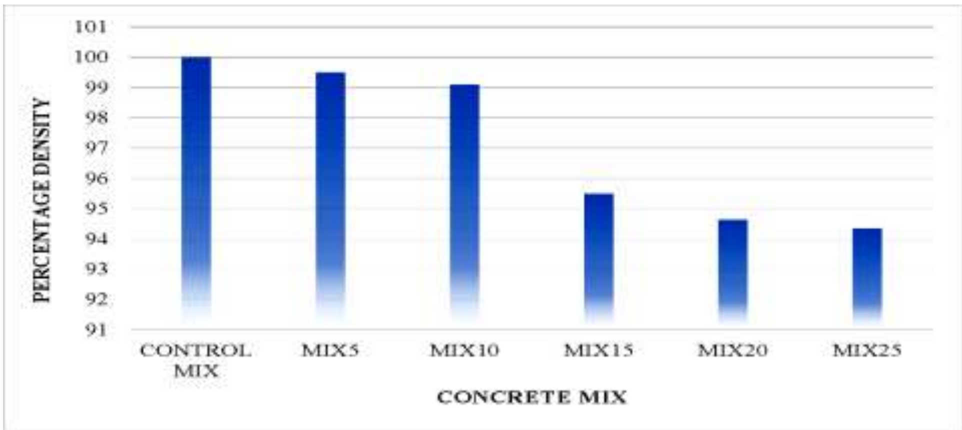

Fig.8 Comparison of reduce in density of concrete.

3.7 Cost analysis

Table 2 describe the cost comparison of concrete mixes. The cost considered for cost analysis is the cost incurred for purchasing the material during the project without considering labor, transportation and electricity charges[21]. All the materials were purchased from local vendor at Nashik, Maharashtra. RHA was bought online but it is freely available in huge quantity in free of cost. The CCR is also available free of cost in industries.

Table 2 Cost of material per M^3 of concrete.

Concrete Mix	Material Cost (Rs)					Total Cost (Rs)	Difference (Rs)
	Cement	Sand	Aggregates	RHA	CCR		
MIX0	2995.2	4754.1	3714.24	0	0	11463.54	00.00
MIX5	2839.2	4754.1	3714.24	40	50	11397.54	66.00
MIX10	2683.2	4754.1	3714.24	80	100	11331.54	132.00
MIX15	2542.8	4754.1	3714.24	116	145	11272.14	191.40
MIX20	2386.8	4754.1	3714.24	156	195	11206.14	257.40
MIX25	2246.4	4754.1	3714.24	192	240	11146.74	316.80

4.CONCLUSIONS

1. The workability of concrete is obtained nearly similar in both Control mix (MIX0) and MIX5. But after increase in percentage replacement of cement, quite decrease in slump value is seen which is due to more quantity of fine particles. This problem can be overcome by high water reducing admixtures.
2. At the replacement of cement by 5% achieves maximum strength and up to 15% replacement the strength of concrete is equal to the control mix, hence replacement up to 15% is recommended. It is due to higher silica and calcium contents present in RHA and CCR which is responsible to form C-S-H gel after reaction with water.
3. The flexural strength of concrete was achieved maximum at 15% cement replacement by RHA and CCR in increasing manner which is due to the dense particle packing in concrete.
4. Excellent improvement results of the ultrasonic pulse velocity test are observed up to 15% cement replacement. Higher velocity indicates good quality, dense particle packing and continuity of materials.
5. As the replacement up to 15% shows strength similar to that of control mix, the consumption of cement can be reduced.
6. This type of concrete mix make economical and sustainable and which reduce the environmental issue regarding its disposal.

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Conflict of Interest

NA

5.REFERENCES

[1] H. Sun *et al.*, "Properties of Chemically Combusted Calcium Carbide Residue and Its Influence on Cement Properties," *J. Mater.*, vol. 8, no. 1, pp. 638–651, 2015, doi: 10.3390/ma8020638.

[2] M. Adamu, Y. E. Ibrahim, M. E. Al-atroush, and H. Alanazi, "Mechanical Properties and Durability Performance of Concrete Containing Calcium Carbide Residue and Nano Silica," *J. Mater.*, vol. 14, no. 1, pp. 1–28, 2021.

[3] V. N. Kanthe, S. V Deo, and M. Murmu, "Use of Mineral Admixture in Concrete for Sustainable Development," *Int. J. Innov. Res. Sci. Eng.*, vol. 3, no. 3, pp. 279–284, 2017.

[4] V. N. Kanthe, S. V Deo, and M. Murmu, "Assessment of Environmental Impact and Formation Factor for Triple Blend Concrete," *Iran. J. Energy Environ.*, vol. 11, no. 2, pp. 146–151, 2020, doi: 10.5829/ijee.2020.11.02.08.

[5] C. Rattanashotinunt, P. Thairit, W. Tangchirapat, and C. Jaturapitakkul, "Use of calcium carbide residue and bagasse ash mixtures as a new cementitious material in concrete," *J. Mater.*, vol. 46, no. 1, pp. 106–111, 2013, doi: 10.1016/j.matdes.2012.10.028.

[6] K. Amnadnua, W. Tangchirapat, and C. Jaturapitakkul, "Strength , water permeability , and heat evolution of high strength concrete made from the mixture of calcium carbide residue and fly ash," *J. Mater.*, vol. 51, no. 1, pp. 894–901, 2013, doi: 10.1016/j.matdes.2013.04.099.

[7] S. Horpibulsuk, C. Phetchuay, and A. Chinkulkijniwat, "Strength development in silty clay stabilized with calcium carbide residue and fl y ash," *Soils Found.*, vol. 53, no. 4, pp. 477–486, 2013, doi: 10.1016/j.sandf.2013.06.001.

[8] V. N. Kanthe, "Effect of Superplasticizer on Strength and Durability of Rice Husk Ash Concrete," *Iran. J. Energy Environ.*, vol. 12, no. 3, pp. 204–208, 2021, doi: 10.5829/ijee.2021.12.03.04.

[9] V. N. Kanthe, S. V. Deo, and M. Murmu, "Early age shrinkage behavior of triple blend concrete," *Int. J. Eng. Trans. B Appl.*, vol. 33, no. 8, pp. 1–14, 2020, doi: 10.5829/IJE.2020.33.08B.03.

[10] Vishvanath N. Kanthe, S. V. Deo, and M. Murmu, "Review on the Use of Industrial and Agricultural By-Product for Making Sustainable Concrete," in *Urbanization Challenges in Emerging Economies@ASCE*, 2018, pp. 530–538.

[11] V. N. Kanthe, S. V. Deo, and M. Murmu, "Early age shrinkage behavior of triple blend concrete," *Int. J. Eng. Trans. B Appl.*, vol. 33, no. 8, pp. 1459–1464, Aug. 2020, doi: 10.5829/IJE.2020.33.08B.03.

[12] IS: 383 - 2016, "Coarse and Fine Aggregate for Concrete Specification," *Bur. Indian Stand.*, vol. 1, no. 3, pp. 1–21, 2016.

[13] Vishvanath N. Kanthe, S. V. Deo, and M. Murmu, "Modulus of elasticity of blended concrete containing multiple admixtures for sustainability infrastructural materal," *Innov. Infrastructural Solut.*, vol. 60, no. 7, pp. 1–10, 2022, doi: doi.org/ 10.1007/s41062-021-00599-6.

[14] A. K. Sharma, S. D. Thanvi, and M. Singh, "' Study on Strength of Concrete (M 30 Grade) by Partial Replacement of Cement with Appropriate % of Ground Granulated Blast Furnace Slag (GGBS), Calcium Carbide Residue (CCR) and Fly Ash (FA) ,'" *Int. Res. J. Eng. Technol.*, vol. 6, no. 8, pp. 489–494, 2019.

[15] V. N. Kanthe, S. V Deo, and M. Murmu, "Microstructural study of blended concrete containing multiple admixtures," *J. Build. Pathol. Rehabil.*, vol. 2, no. 8, pp. 1–10, 2023.

[16] T. Dighe, D. Jagale, A. Sanap, S. Gavahane, P. Pawar, and V. N. Kanthe, "A REVIEW ON UTILIZATION OF RICE HUSK ASH IN CONCRETE," *Int. Res. J. Mod. Eng. Technol. Sci. (*, vol. 1, no. 2, pp. 5–7, 2023.

[17] A. B. Shejwal, S. S. Demse, S. J. Pagare, R. Saurabh, and V. N. Kanthe, "Effect of heat of hydration on the properties of concrete with different cementitious material," *Int. Journalof Sci. Manag.*, vol. 13, no. 3, pp. 46–50, 2024.

[18] V. N. Kanthe, T. A. Kulkarni, P. A. Padalkar, and V. V Pawar, "Strength and Durability Performance of Fly Ash Concrete with and without Superplasticizer," *IOP*, vol. 1, no. 1, pp. 1–6, 2024.

[19] P. Padalkar, C. Joshi, V. Kanthe, and T. Kulkarni, "Use of Fly Ash and Common Salt for The Stabilization of Black Cotton Soil," *Int. Journalof Sci. Manag.*, vol. 13, no. 3, pp. 61–67, 2024.

[20] "Effect on Autogenous Healing in Concrete by Fly Ash and Rice Husk Ash," *Iran. J. Energy Environ.*, vol. 10, no. 2, 2019, doi: 10.5829/ijee.2019.10.02.13.

[21] V. Kanthe, S. Deo, and M. Murmu, "Combine Use of Fly Ash and Rice Husk Ash in Concrete to Improve its Properties," *Int. J. Eng.*, vol. 31, no. 7, pp. 1012–1019, 2018, doi: 10.5829/ije.2018.31.07a.02.