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Experimental Investigation on Concrete with Zeolite Powder, Silica Fume and Cashew Nut Shell Ash

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Abstract: ***This experimental investigation explores the impact of incorporating zeolite powder as a partial replacement for fine aggregate, along with silica fume and cashew nut shell ash (CNSA) as partial replacements for cement in concrete. Zeolite, a natural aluminosilicate mineral, is known for its pozzolanic properties, which can enhance the mechanical and durability characteristics of concrete. Silica fume, a byproduct of silicon and ferrosilicon alloy production, is renowned for its high silica content and fineness, contributing to the strength and density of concrete. Cashew nut shell ash, an agricultural waste product, offers a sustainable alternative to traditional cementitious materials, potentially reducing the environmental footprint of concrete production.***

This experimental study investigated the effects of partially replacing fine aggregate with zeolite powder (5%,10% and 15%) and cement with silica fume (3%,6%,9%,12% and 15%) and cashew nut shell ash (5%,7.5%,10%,12.5%,15% and 17.5%) on the properties of concrete. This study underscores the viability of using zeolite powder, silica fume, and CNSA in sustainable concrete production, contributing to the development of more environmentally friendly construction materials. Further research is recommended to explore the long-term performance and environmental benefits of these alternative materials in concrete applications.

Keywords: Zeolite Powder, Silicafume, Cashew Nut Shell Ash, Compressive strength and Split tensile strength.

I. INTRODUCTION

One significant method of getting rid of solid waste from other sectors is by using waste components in concrete mixtures. The composite material known as concrete is made up of coarse gravel and a cement that is fluid initially and solidifies over time. The majority of concretes that are used, like Portland cement concrete or concretes that are created with several hydraulic cements include a base of lime. Cement is currently the most significant building material and is likely to remain so for some time to come. The standards for the materials used in engineering and construction are always getting higher.

By-product of the production of silicon and ferrosilicon alloys is silica fume. It is a spherical powder with an average diameter of 150 mm, composed of ultrafine particles. The main use is as a pozzolanic material for high-performance concrete.Silica fume is an ultrafine material because the spherical particles in it have an average diameter of about 0.15 μm. It is therefore approximately 100 times smaller than a normal cement particle. Silica fume can have a bulk density of between 130 (undensified) and 600 kg/m3 depending on the degree of densification in the silo.

Zeolite powder, a microporous, aluminosilicate mineral, is increasingly being utilized in construction as a replacement for fine aggregates in concrete mixtures. This innovative application stems from zeolite's unique properties, such as high surface area, excellent ion-exchange capacity, and strong adsorption capabilities. When used in concrete, zeolite powder can enhance the material's mechanical strength, durability, and resistance to chemical attacks. By partially substituting fine aggregates with zeolite, the concrete mix not only becomes more environmentally friendly but also exhibits improved workability and reduced shrinkage. This approach aligns with sustainable construction practices, as it often involves utilizing natural or synthetic zeolites, which are abundant and relatively low-cost.

The incorporation of cashew nut shell ash (CNSA) as a partial replacement for cement in concrete is an innovative and sustainable approach gaining attention in the construction industry. Cashew nut shells, a by product of the cashew nut processing industry, are typically considered waste and often discarded. However, when these shells are combusted, they produce an ash rich in silica, alumina, and other pozzolanic materials, making CNSA a viable supplementary cementitious material.

The use of CNSA in concrete mixes can improve the material's durability and resistance to chemical attacks while also reducing the overall environmental impact associated with cement production.

II. OBJECTIVES

The following are the study's objectives:

1) Improve the workability and flowability of concrete without compromising its strength, by partially replacing fine aggregate with zeolite powder.
2) Enhance the durability and resistance of concrete to chemical attacks and degradation, by incorporating silica fume and cashew nut shell ash.

III. MATERIALS

1) *Cement:* Cement is one material that possesses cohesive and adhesive properties. Cement holds the mineral fragments together to create a solid whole when mixed with water. This description mentions a surprising amount of cementing ingredients. In building projects, cement is used to bind materials such as stones, sand, and bricks. We only looked at cement used in construction—more especially, cement used in concrete constructions.
2) *Fine aggregate:* Fine aggregate is an essential building material that is essential to the durability and structural soundness of many civil engineering projects. Fine aggregate, which is often formed of sand, crushed stone, or gravel with particles smaller than 4.75 mm, is the basis for concrete mixes.
3) *Coarse aggregate:* Coarse aggregate, an essential component of concrete, is what gives the material its overall strength, durability, and structural integrity. It is made up of materials like crushed stone, gravel, or recycled concrete, and it gives the concrete mix the bulk and stability it needs. The size and shape of the coarse aggregate particles, which usually range from 4.75 mm to 20 mm, are what determine how workable, strong, and durable the concrete
4) *Water:* Water is a crucial component of construction materials since it is needed for many functions like curing, mixing cement concrete, and creating mortar. The strength of the motor and cement concrete are directly impacted by the quality of the water utilized during construction.
5) *Zeolite Powder:* Zeolite powder is a natural, microporous mineral material that has been crushed into a fine powder, often used for its absorbent, detoxifying, and filtering properties.
6) *Silicafume:* Silica fume, also known as microsilica, is a byproduct of silicon metal production, consisting of extremely fine particles of amorphous silica with a diameter of less than 1 μm. It is used as a supplementary cementitious material in concrete to improve its strength, durability, and resistance to corrosion and chemical attack.
7) *Cashew Nut Shell Ash:* Cashew nut shell ash (CNSA) is a byproduct obtained from the combustion of cashew nut shells. When used as a partial replacement for cement in concrete and mortar, CNSA can enhance certain properties of the mixture and offer environmental and economic benefits. This practice involves incorporating a specific percentage of CNSA into the cement mix, which can contribute to sustainable construction practices by utilizing agricultural waste and reducing the carbon footprint associated with cement production.

IV. RESULTS AND DISCUSSIONS

1) *Compressive strength test:* 150 x 150 x 150 mm cube specimens were cast, and for varying concrete mix proportions, they were tested in compression testing equipment for seven and twenty-eight days of curing time.

Table 1: - Compressive Strength Results of Concrete with Partial Replacement of Fine aggregate by zeolite powder.

S.No	% of Zeolite Powder	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	33.76	49.51
2	5%	36.62	52.98
3	10%	39.17	55.88
4	15%	37.54	53.83

Table 2: - Compressive Strength Results of Concrete with Partial Replacement of Cement by Silica Fume.

S.No	% of Silicafume	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	33.76	49.51
2	3%	35.72	52.54
3	6%	36.88	53.85
4	9%	39.74	57.79
5	12%	36.64	52.97
6	15%	36.41	52.38

Table 3: - Compressive Strength Results of Concrete with Partial Replacement of Cement by Cashew Nut Shell Ash.

S.No	% of Cashew Nut Shell Ash	Compressive strength results, N/mm^2	
		7 days	28 days
1	0%	33.76	49.51
2	5%	35.98	51.48
3	7.5%	35.86	52.05
4	10%	37.78	53.89
5	12.5%	36.07	52.66
6	15%	35.34	51.82
7	17.5%	35.19	51.06

Table 4: - Combined Replacement of Compressive Strength Results of Concrete with Partial Replacement of fine aggregate by 10% of zeolite powder and Cement by 9% of Silica fume + 10% of Cashew Nut Shell Ash.

S.No	10% Zeolite powder 9% of Silica fume +10% of Cashew Nut Shell Ash	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	33.76	49.51
2	10% Zeolite powder 9% of Silica fume +10% of Cashew Nut Shell Ash	44.35	63.28

2) *Split tensile strength:* At the age of 7 and 28days, the cylindrical specimens (150mm diameter x 300mm height) were tested for evaluating the split tensile strength. The experiment is performed by putting a cylindrical sample horizontally between a compression testing machines.

Table 5: - Split tensile Strength Results of Concrete with Partial Replacement of Fine aggregate by zeolite powder.

S.No	% of Zeolite Powder	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	3.42	4.89
2	5%	3.67	5.18
3	10%	3.82	5.53
4	15%	3.71	5.32

Table 6 : - Split tensile Strength Results of Concrete with Partial Replacement of Cement by Silica Fume.

S.No	% of Silicafume	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	3.42	4.89
2	3%	3.64	5.22
3	6%	3.73	5.38
4	9%	4.01	5.76
5	12%	3.68	5.23
6	15%	3.49	5.15

Table 7: - Split tensile Strength Results of Concrete with Partial Replacement of Cement by Cashew Nut Shell Ash.

S.No	% of Cashew Nut Shell Ash	Split tensile strength results, N/mm^2	
		7 days	28 days
1	0%	3.42	4.89
2	5%	3.54	5.01
3	7.5%	3.63	5.14
4	10%	3.96	5.65
5	12.5%	3.61	5.24
6	15%	3.48	5.07
7	17.5%	3.37	4.99

Table 8: - Combined Replacement of Split tensile Strength Results of Concrete with Partial Replacement of fine aggregate by 10% of zeolite powder and Cement by 9% of Silica fume + 10% of Cashew Nut Shell Ash.

S.No	10% Zeolite powder 9% of Silica fume +10% of Cashew Nut Shell Ash	Split tensile Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.42	4.89
2	10% Zeolite powder 9% of Silica fume +10% of Cashew Nut Shell Ash	4.58	6.45

V. CONCLUSION

1) The Normal Concrete Compressive Strength Results for 7 and 28 days is 33.76 and 49.51N/mm^2.
2) The optimum compressive strength results of concrete with partial replacement of fine aggregate by 10 % of Zeolite Powder at 7 and 28 days is 39.17 and 55.88 N/mm^2.
3) The optimum compressive strength results of concrete with partial replacement of cement by 9 % of silica fume at 7 and 28 days is 39.74 and 57.79 N/mm^2.
4) The optimum compressive strength results of concrete with partial replacement of cement by 10 % Cashew nut Shell Ash at 7 and 28 days is 37.78 and 53.89 N/mm^2.
5) By combination of a Concrete mix is prepared by partially Replacing Fine aggregate with 10 % Zeolite powder and cement with 9 % Silica Fume and 10% Cashew nut shell Ash at 7 and 28 days is 44.35 and 63.28 N/mm^2.
6) The Normal Concrete Split tensile Strength Results for 7 and 28 days is 3.42 and 4.89 N/mm^2.
7) The optimum split tensile strength results of concrete with partial replacement of fine aggregate by 10 % of Zeolite Powder at 7 and 28 days is 3.82 and 5.53 N/mm^2.
8) The optimum split tensile strength results of concrete with partial replacement of cement by 9 % of silica fume at 7 and 28 days is 4.01 and 5.76 N/mm^2.
9) The optimum split tensile strength results of concrete with partial replacement of cement by 10 % Cashew nut Shell Ash at 7 and 28 days is 3.96 and 5.65 N/mm^2.
10) By combination of a Concrete mix is prepared by partially Replacing Fine aggregate with 10 % Zeolite powder and cement with 9 % Silica Fume and 10% Cashew nut shell Ash at 7 and 28 days is 4.58 and 6.45 N/mm^2.

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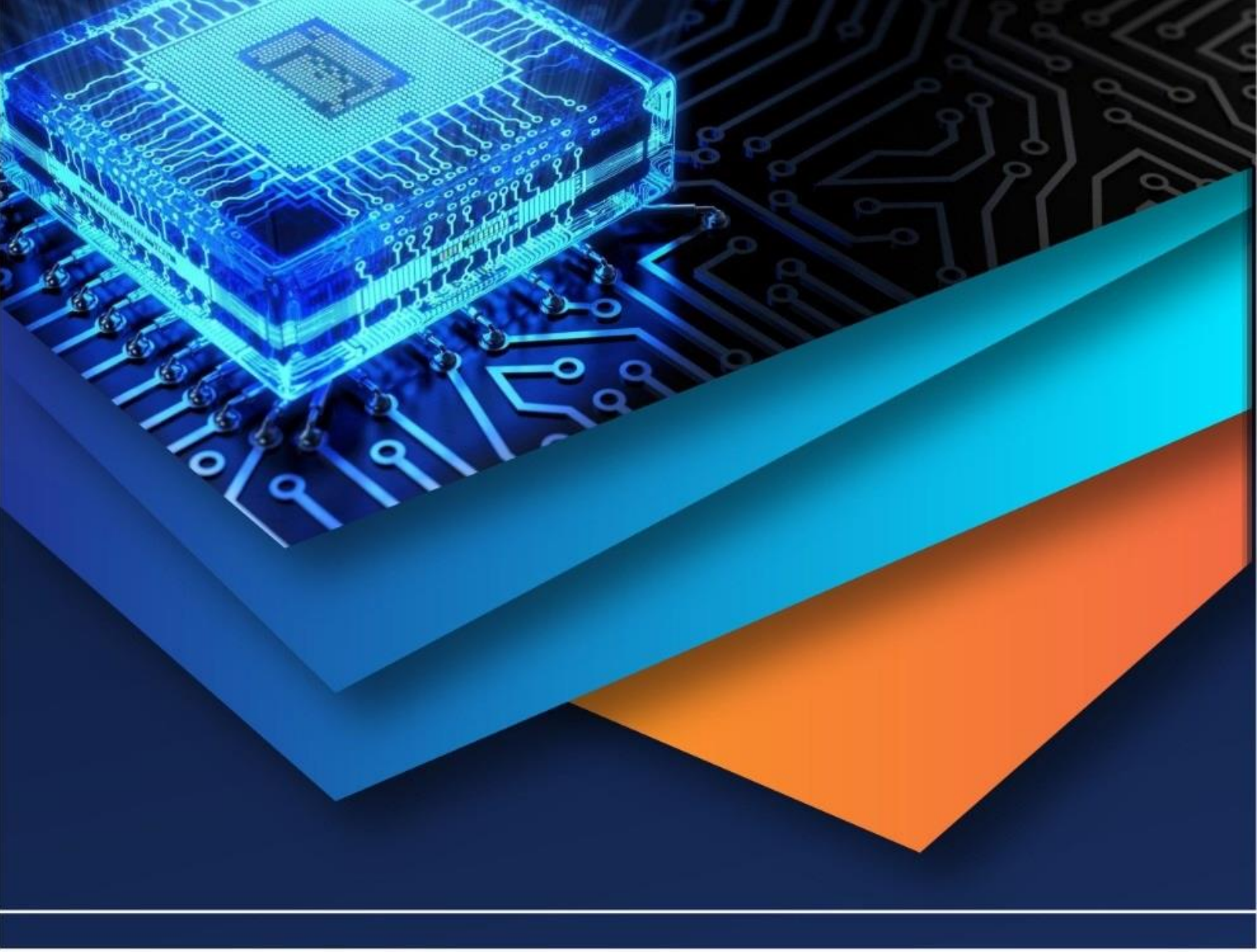

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