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ROLE OF SUPPLEMENTARY CEMENTITIOUS MATERIALS IN IMPROVING THE STRENGTH AND DURABILITY PROPERTIES OF CONCRETE : A REVIEW

Darshit Dobariya
M.Tech. (Civil) Construction Engineering & Management, BVM Engineering College, Vallabh Vidhyanagar, Gujarat, India
Email- darshitdobariya111@gmail.com

Mr. Jaydeep J. Chavda
Ph.D. Research Scholar, Gujarat Technology University (GTU), Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

Prof. (Dr.) J. R. Pitroda
P.G. Coordinator Construction Engineering & Management, Civil Engineering Department, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

Dr. Indrajit N. Patel
Professor & Principal, BVM Engineering College, Vallabh Vidyanagar, Gujarat, India

Mr. Chirag Patel
Owner, Design cell infra. Support Pvt. Ltd. Vallabh Vidhyanagar, Gujarat, India

Abstract- Concrete places play a vital role in the construction sector of any country all over the world. As it is a basic material in any construction-related work, concrete is the second most utilized material across the world after water. The material, which is used up to such an extent, will require construction improvement. Cement is one of the basic components of concrete, but it also contributes to global warming quite significantly. So, a constant innovation process is required in the case of the use of cement in concrete. In general, it has been showed that adding SCMs to concrete mixtures is a helpful strategy for maximizing sustainability, durability, and performance in building projects like infrastructure development in a country. In this paper, we investigate the use of Supplementary Cementitious Material (SCMs) in concrete as a partial replacement of cement. Encourage the supplement product as a construction material is the main objective of this literature study. So, the purpose of this is to better understand how to use SCMs to improve the durability and strength characteristics of concrete. Several SCMs were added to concrete mixtures, such as metakaolin, fly ash, slag and silica fume, zeolite, and titanium dioxide in order to evaluate their effects on permeability, environmental sustainability, and mechanical qualities. According to the outcomes, adding SCMs to concrete increases its strength through improving hydration and the formation of new cementitious compounds. It also has a less permeability.

Keywords: *Concrete, Compressive Strength (CS), Durability, Strength, Supplementary Cementitious Material (SCMs), Titanium Dioxide (TiO_2), Zeolite*

I. INTRODUCTION

Concrete is the material that is used the most worldwide, after water. Due to its low cost and durability, Concrete is a widely used product. The top three Qualities that concrete should have been resistance against acid attacks, rapid chloride permeability and water absorption. As well, it is hard to reduce the costs associated with sustaining, protecting, replacing and renovating already existing concrete structures. So, in this project we used natural Zeolite Powder and Titanium Dioxide as a Supplementary Cementitious Materials. In order to improve the strength and longevity of concrete construction, two additional minerals that are being added to concrete mixtures more frequently are zeolite and titanium dioxide. These substances provide special advantages that can greatly enhance concrete's performance in a range of applications. A manufactured or natural mineral having a porous structure that has the ability to collect and release water molecules is called zeolite. Zeolite can be added to concrete mixtures to increase workability and decrease permeability. Zeolite can also help concrete mend itself by encouraging the growth of second calcium carbonate crystals in cracks, which increase the structure's overall toughness. Natural zeolite powder added to blended cement improves its performance and increases the material's resistance to extreme environmental conditions. One of the most often utilized nano-additives in cement-based products is titanium dioxide. Conversely, titanium dioxide is a photocatalytic substance that can be added to concrete to improve its air-purifying and self-cleaning qualities. An environment that is cleaner and more sustainable can result from titanium dioxide's ability to decompose organic contaminants on concrete surface when exposed to sunshine. Titanium dioxide is a scentless, nonflammable powder that has been produced in large quantities and utilized in many different applications due to its exceptional photocatalytic, electrical, anticorrosion and chemical stability [2].

1.1 Supplementary Cementitious Materials

Cement is the primary component of concrete, requires a large amount of organic matter extracted from unique elements like handles. They produced a significant amount of CO_2 emissions. To reduce cement waste and its negative impact on the environment, SCMs are used to fix cement to a moderate degree. Moreover, trade throw-away is decreased by adding SCMs to outcome details. It could reduce the amount of concrete cement in the concrete under specific circumstances. Fly ashes, silica fume and slag cement (ground, granulated blast furnace slag) are typical examples. These can be used separately, in various combinations, or with blended or Portland cement. In order to increase strength, decrease permeability, improve economy or affect other concrete attributes, supplementary cementing materials are frequently added to concrete mixtures [12].

1.2 Benefits and implementation of using SCMs:

Following are the various benefits of using SCMs in Concrete.

1. Growing in long-term toughness but gaining solidity more slowly (silica smoke is irregular; it gets stronger shortly).
2. Extending longevity by decreasing penetration.
3. Lowers the possibility of inbreaking at the temperatures of lowest peak hydration.
4. Set time is delayed by reducing the rate of hydration.
5. Decreases the quantity of product of the CH reaction.
6. By doing this, there is a chance of oxychloride development, the source of the early joints seen in some mid-western pavements-being minimized.

II. LITERATURE REVIEW

Babak Ahmadi et al. (2010) examined and contrasted with different pozzolanic admixtures, the efficiency of a locally quarried zeolite in improving the mechanical and durability qualities of concrete is assessed. Three components comprised the experimental tests: the pozzolanic reactivity of silica fume and natural zeolite were investigated using a thermos gravimetric technique in the first section. The finding in this instance suggested that while natural zeolite had good pozzolanic reactivity, it was not as reactive as silica fume. In the second section, several concrete mixtures were tested for durability and physical properties using zeolite and silica fume in place of cement in varying amounts [6].

Ali Nazari et al. (2010) found that when natural titanium (NT) quantity increased, cementitious materials' water absorption tended to decrease first, then rise. And also discover that, mostly as a result of NT agglomeration in the cement paste, the water absorption of cementitious materials begins to increase when the NT level surpasses 4% [4].

Meysam Najimi et al. (2012) has researched on the application of natural zeolite as SCMs. When comparing concrete with and without natural zeolite replacement, certain mechanical and durability characteristics of concrete prepared with 15% and 30% natural zeolite are examined. The outcomes demonstrate the significant effectiveness of using natural zeolite on concrete drying shrinkage, corrosion rate, water penetration, and chloride ion penetration; however, an acidic environment did not yield satisfying results. And it was discovered that adding 15% natural zeolite to concrete was a suitable way to increase its strength and durability [22].

HASEBE, M et al. (2013) has conducted studies on the fresh and hardened properties, concentrating on the w/c and TiO_2 ratios, in order to better understand the fundamental characteristics of mortar and concrete employing titanium oxide as an additive. In order to provide additional performance, such as brightness retention and self-cleaning effects on the surface, as well as strength development and crack management of the specimen itself, adequate TiO_2 admixture in concrete might be helpful. The concrete's compressive strength increased by approximately 27% when fine material was substituted. Even through the unit cement concentration of the mortar was lower, mortar with less than 10% TiO_2 had nearly the same carbonation depth as non-TiO_2 [16].

Mostafa Jalal et al. (2013) has examined high strength self-compacting concrete (HSSCC) comprising nano TiO_2 and industrial waste ash, fly ash, combined with rheological, thermal, and Microstructural features that contribute to strength increase and durability. In the result of the strength, clearly, adding TiO_2 nanoparticles up to 4wt% can increase flexural strength based on the results obtained from (cement+TiO_2) mixtures. However, adding 5% of nanoparticles result in a lower flexural strength rather than adding 4wt%, while this is still higher than those mixtures containing 1%, 2% and 3% of nanoparticles. The result of the connections between compressive strength and flexural and split tensile strengths indicates that the increase rate of flexural and split tensile strength in HSSCC mixes including TiO_2 nanoparticles is significantly greater than that of mixtures containing Fly Ash. The inclusion of TiO_2 nanoparticles significantly reduced the results of both water absorption and capillary absorption, since the nanoparticles function as nano-fillers and increase the concrete's resistance to water permeability [23].

Mahdi Valipour et al. (2013) has researched on the impact of adding 10%, 20%, and 30% natural zeolite to cement in place of cement was compared to the effects of adding metakaolin (5%, 10%, and 15%) and silica fume (5%, 7.5%, and 10%), as well as water-to-cement ratios of 0.35, 0.40, 0.45, and 0.50. In the result of compressive strength, using lower percentage of zeolite is higher compressive strength. ZE1 (40kg/m3), ZE2 (80kg/m3) and ZE3 (120kg/m3) zeolite using in different concrete mixtures. Values of compressive strength at the 28 day is ZE1=47 MPa, ZE2=39MPa and ZE3=32MPa. Increasing the level of zeolite in water absorption is constant. Although, Zeolite is a naturally occurring pozzolan that needs a lengthy time to fully hydrate; following three days of wet curing, this pozzolan at a 10% replacement level achieved workable result in terms of the durability of the concrete. Due to the fact that zeolite is more affordable, readily available, and natural. [19].

S. Rao et al. (2015) has examined on the work, two nanomaterials were tested in two types of self-compacting mortars (binder: sand at 1:1 and 1:2). Nano silica in a colloidal state and nanotitanium in amorphous form. Beyond the early ages, the mixes, including nano-TiO_2, exhibit a more monotonic evolution of the compressive strength. All mixtures achieve compressive strength values greater than 90 MPa for older ages, with fairly similar values for the equivalent mixes containing each of the nanomaterials. When both nano-SiO_2 and nano-TiO_2 are added, the water absorption by immersion (open porosity) rises in comparison to the reference mortars (1:1 and 1:2). Comparing the 1:2 family mixes to the 1:1 family mixes, there is a minor drop in porosity. And he found that NT had a greater impact than NS on cementitious materials ability to withstand carbonation [28].

Hainan Li et al. (2015) has examined on the impact of nano-TiO_2 (NT) on cement mortar microstructures and mechanical characteristics. Using different proportion of NT, the strength of cement-based material is discussed by their testing tensile/ flexural strength. And tests on cement-based material's water absorption and water-vapour permeability are used to assess their durability. The finding indicates that adding 3% NT may significantly boost the tensile and flexural strengths (i.e., toughness is enhanced). And as a result of durability tests, 3% NT may significantly improve the compactness and durability of cement-based materials. The result demonstrate that 3% NT can lower the water absorption ratio by 40-65%, water absorption coefficients by more than 40%, and water-vapour permeability coefficients by 43.9% [14].

Ali Akbar Ramezanianpour et al. (2015) has performed on the using natural zeolite in the replacement of cement. 0%, 10% and 15% (by weight) natural zeolite are using with different w/c ratios like 0.35, 0.40, 0.45, and 0.50. Each of the selected mixes, compressive strength was measured at various ages of 7, 28, 90, and 270 days. Adding 10% by weight of natural zeolite to combinations with w/c values 0.35, 0.40, 0.45, and 0.50 enhanced their 28-day compressive strength by 5.6%, 5.4%, 11.9% and 11.3%. For w/c values 0.35, 0.40, 0.45, 0.50, respectively, the 28-day compressive strength of mixes containing 15% natural zeolite were 4%, 2%, 11.5%, and 11% greater than those of reference concretes. 10% natural zeolite replacement level performed better than 15% replacement level by a little margin. When 10% by weight of Portland cement was substituted with natural zeolite, the maximum 28-day water permeability of combinations with w/c of 0.35, 0.40, 0.45, and 0.50 decreased by 18%, 15%, 16%, and 28%. These improvement went up to 30%, 42%, 29%, and 44%, respectively, when the replacement amount was raised to 15% [3].

Rui Zhang et al. (2015) has researched on the use of TiO_2 on the properties of cement-based materials, when 25 nm nano-TiO_2 was added to cement-based materials, the hydration process, the growth of compressive strength, and the drying shrinkage were all the tests are studied. In the result, because of the pore-refining action and its acceleration of cement hydration, nano-TiO_2 improved the compressive strength of cement mortar. The cement hydration process was expedited for two hours by 5 wt.% nano-TiO_2, and the most likely pore size was decreased by 19.4%, 48.5%, and 54.4%, respectively. The mainly examined and addressed the effects of nano-TiO_2 hydrophilicity on the water loss and volume stability of cured cement pastes. Moreover, 30 nm-sized nano-SiO_2 was employed fora comparative analysis. Cement-based products with nano-TiO2 additives have less drying shrinkage because of the decreased water loss brought about by the particles' improved porosity and decreased hydrophilicity [27].

C. Manoj Kumaar et al. (2015) has researched on the pervious concrete is combined with 2% grade M35 titanium oxide and tested experimentally on samples with aggregate ratios of 80:20 and 90:10 (fine aggregate: course aggregate). In the concrete mix, for M35 grade, the pervious concrete mix has arrived. There were four different mixes made. In these mixtures, titanium dioxide was added at 0% and 2% by weight of cement. In order to examine the infiltration rates and strengths of these mixes, the CA:FA ratio that was used was 80:20 and 90:10. After 7,14, and 28 days of curing, the pervious concrete specimens will undergo the compressive strength test. Up until the specimen is crushed, the weight will be applied without shock and raised gradually at a rate of 35kg/cm. And calculated by taking the average of three values. And the result of the compressive strength, increased by around 21% by decreasing the aggregate ratio from 90:10 to 80:20. To determine the permeability of the pervious concrete mixes, the samples were tested under a constant head permeameter, where the outflow pipe in the inlet chamber is set up so that a constant water head of 50 mm is maintained above the top of sample. The amount of water that percolated through the sample within a known time interval (60 seconds) were recorded to determine the permeability in mm/hour. And when 2% of the cement content is substituted with TiO_2 particles, the permeability value of pervious concrete with aggregate ratios of 80:20 and 90:10 increase by 10% and 15% respectively [8].

Baoguo Ma et al. (2015) has researched on the strength and durability of concrete using the Titanium Dioxide. In the result of the tensile and flexural strength increase with increasing natural titanium (NT) content up to 3%. Then increasing the NT, the flexural and tensile strength decrease slightly. At 28 days, when the NT content is 3%, the mortar's water-vapour permeability coefficient drops by 43.9%, the water absorption ration drops by 40-65%, and the water absorption coefficient falls by more than 40%. So, that shows the durability, toughness and compactness of the structure can all be greatly increased by 3% NT [7].

Ping Duan et al. (2015) has experimented on the impact of adding nano-TiO_2 to fluidized bed fly ash-based geopolymer on its characteristics. nano-TiO_2 integrated fluidized bed fly ash geopolymer: compressive strength, drying shrinkage, carbonation, and microstructure. And the experimental findings show that adding TiO_2 increases the compressive strength of geopolymer at both early and later ages, as the amount of nano-TiO_2 increases. After 28 days, the introduction of 5% nano-TiO_2 to the geopolymer exhibits a more noticeable strength augmentation impact. According to microstructure studies, adding nano-TiO_2 encourages the growth of geopolymer and produces a compact microstructure with fewer fractures. The addition of nano-TiO_2 particles increases the geopolymer's resistance to carbonation and decreases its drying shrinkage [26].

A Haamidh and S Prabavathy et al. (2016) has researched on a Zeolite Plastered Concrete (ZPC) and Conventional Concrete (CC) were examined with respect to their strength attributes. Additionally, the way does it affect the durability features of concrete, such as its carbonation depth and fire resistance, at three distinct temperatures— 250, 500, and 750 degrees Celsius. At 7, 14, 28, 56, and 90 days, the compressive strength values for the specimens with and without Zeolite plastering were recorded and analysed. At day 7, the compressive strength value of CC is 19.194 MPa and value of ZPC is 18.920 MPa. and at day 90, compressive strength value of CC is 29.562 MPa and value of ZPC is 29.428 MPa. So, there is not much deviation in strength. For concrete that has been plastered with zeolite, the carbonation depth is significantly lower, and it varies significantly over time. It may be reported that zeolite plasters lower carbonation depth, preventing the concrete reinforcement [1].

Taras Markiv et al. (2016) has researched on natural zeolite being used in concrete in place of cement. The mechanical and durability characteristics of 10% natural zeolite and superplasticizer concrete, as well as 10% natural zeolite, superplasticizer, and air-entraining agent concretes, in contrast to natural zeolite-free concretes. In the mixture proportions, Z0P (0% Natural Zeolite + 1.22% Superplasticizer), Z0PA (Z0P + 0.3% Air-entraining agent % of cement), Z10P (315kg/m3 Cement + 10% Natural Zeolite + 1.64% Superplasticizer) and Z10PA (Z10P + 0.3% Air-entraining agent {% of cement}). The specimens were subjected to strength testing on days 1, 28, 56, 90, and 180. In the result of the compressive strength, the concrete including zeolite, superplasticizer, and air-entraining agent (Z10PA) had 19.4% less strength at day one compared to the control concrete, which did not include zeolite. When zeolite was used in place of cement for 90 days of hardening, there was a little drop in strength; however, after 180 days, the compressive strength of the zeolite-containing concrete was stronger than that of the cement-free concrete. In the water absorption result, both the concrete including natural zeolite, superplasticizer, and air-entraining agent (Z10PA) and the concrete containing natural zeolite and superplasticizer (Z10P) exhibited water absorption rates of 4.9% and 5.3%, respectively. Their absorption was greater than that of the zeolite-free concrete (Z0P and Z0PA) [34].

Memduh Nas et al. (2018) has examined on this study is to highlight the potential for using natural zeolite in the production of concrete and to primarily examine how would affect the material's strength and durability. Concrete with 300 kg/m^3 and 400 kg/m^3 binder containing 10% and 15% natural zeolite showed an increase in 28-day compressive strength. The concrete that produced the maximum compressive strength was 10% natural zeolite replacement. Comparing the replacement ratio of 20% natural zeolite to the reference concretes, there was an average 42% decrease in the total chloride ion permeability [21].

Alireza Joshaghani et al. (2018) has researched on increase the resistance of mortar mixes to combined sulfate and chloride degradation by adding titanium dioxide in place of part of the lime-stone cement. In the Rapid chloride permeability test , the samples were put in a unique holding device where the anode was in contact with the NaOH solution and the cathode was in contact with the S2, S3, S4, and S5 [S2= NaCL (165 g/L), S3= NaCL (165 g/L) + Na_2SO_4 (27.5 g/L), S4= NaCL (165 g/L) + Na_2SO_4 (55 g/L), S5= NaCL (165 g/L) + Na_2SO_4 (27.5 g/L) + $MgSO_4$ (27.5 g/L) solutions, and the anode was in contact with the NaOH solution. For every experiment, a test period of 28, 90, and 180 days was used. When 3 and 5% of OPC was substituted out for TiO_2, the permeability level increased from moderate to low class. S4 had a lower chloride ion penetrability among the solution compared to the solutions compared to the other solutions of the same age and composition. This result is consistent with the samples' mass decrease. On the other hand, the S5 solution had the lowest performance among the samples [5].

Mehdey Fazilati et al. (2019) has researched on the durability properties using the Amorphous Silicate Tuff (ASH) as a SCMs in concrete. The 24 concrete mix samples were created by substituting AST for 0-40% of the Portland cement and varying the water to binder ratios from 0.45 to 0.6. Tests for bulk electrical conductivity, compressive strength, rapid chloride permeability, and rapid chloride migration were performed at different ages. In the mix design, the AST to binder percentages were considered 0%, 5%, 10%, 20%, 30%, and 40%. The water to binder ratios were 0.45, 0.50, 0.55 and 0.60. Samples with AST = 5% have a higher compressive strength than other samples, including the control sample, across all age ranges. When compared to the control sample, the specimen with AST = 5% and W/b = 0.45 showed a 15.7% increase in 28-day compressive strength. Additionally, the sample with W/b = 0.55 and AST = 30% with a value of 160% shows the greatest increase in compressive strength of the 90-day specimens in comparison to the 7-day specimen. In RCPT test, various prepared concrete samples underwent at 7, 28, 42, and 90 days. Based on the RCPT data, the 90-day sample with W/b = 0.45 and AST = 5%, and a flux slightly higher than 1000 C, found the greatest resistance to chloride-ion penetration. Consequently, this concrete mix design has a chloride ion penetrability of 'Moderate', which is quite near too 'Low' [20].

Dr. R. Uma Maheswari et al. (2019) has found the small percentage of the titanium dioxide added to concrete then increase concrete structures strength and durability. So, in that study, different proportions of titanium dioxide powder (0%, 0.5%, 1%, 1.5%, and 2%) are incorporated into the concrete. The proportions of the M35-grade concrete mix were discovered. Tests on hardened concrete, including split tensile strength, compressive strength, and flexural strength tests, were conducted experimentally after the material had cured for 28 days. The M35 grade of concrete tube has greater compressive strength with 1.5% TiO_2 replacement. In the same way, the concrete cylinder split tensile strength indicates a higher value when 1.5% TiO_2 substitution is made instead of normal concrete. Therefore, using a lower amount of titanium dioxide produces worthwhile outcomes [11].

T.R. Praveenkumar et al. (2019) has researched on the using titanium dioxide and rice husk ash (RHA) in concrete as a pozzolanic materials used in the replacement of cement. RHA was utilized in a single 10% dose, and TiO_2 nanoparticles were added in various replacement amount (ranging from 0% to 5%) to partially replace cement. The mechanical and durability performance of the blended cement concrete mixes, such as their resistance to acid attack and chloride penetration, compressive, flexural, and splitting tensile strengths, have been examined. The maximum strengths and durability performances were found in concrete mixtures that include 3% TiO_2 nanoparticles in place of some cement and 10% RHA. Strengthening and durability qualities have decreased when

TiO_2 nanoparticles concentration is increased over 3%. Consequently, the optimal replacement amount may be regarded as this 3% nano-TiO_2 replacement [33].

Chang Bok Yoon et al. (2020) has performed that the water-repellent properties can be achieved inside concrete by impregnating natural zeolite, which has a large number of pores. An assessment was conducted on the mechanical properties and durability of cement mortar combined with naturally water-repellent zeolite. ZWR 1%, 3%, and 5% (ZWR: Zeolite + Water Repellent impregnation) were used with cement powder to make cement mortars, and compressive strength, carbonation test was evaluated. After 7, 28, 56, and 91 days, the compressive strength result fell into the following order: OPC > ZWR1% > ZWR3% > ZWR5%. ZWR1% indicated 90% strength, ZWR3% 86% and ZWR5% 82% compressive strength in comparison to OPC. As the ZWR content increased the compressive strength grew at a slower pace. And in the water penetration test, it shows that as the treatment advanced, the hydration product and ZWR filled the micropores, increasing the test specimen's water tightness. So, it has been proven that while durability performance increased, compression strength tended to decline with increasing ZWR mixed content [10].

Chalapati Harish et al. (2020) has researched for M25 grade concrete, 10% zeolite was mixed with ordinary Portland cement (OPC), and mechanical property assessments including compressive strength, split tensile testing and for durability assessment including water permeability testing, and rapid chloride permeability testing were completed. The M25 grade concrete mix's compressive strength when 90% cement and 10% zeolite are substituted for OPC. For the result of that cubes shows that the 12.89% compressive strength are increasing while 10% zeolite are added to cement. The M25 grade of concrete was tested for rapid chloride permeability by replacing regular Portland cement with 90% cement and 10% zeolite. After that the result of RCPT test for these concrete mixtures tested at 60 days and 8% increase in the durability [9].

Hanusha Durisety et al. (2020) has investigated on the qualities and functionality of concrete the has zeolite added to it. Additionally, adding zeolite to concrete increase its mechanical strength. Compared to regular Portland cement, it is far stronger. Studies have been conducted on the impact and modifications to the characteristics of concrete when zeolite take the place of different cement concentration, which range from 5%, 10%, 20%, 25%, and almost 40%. Zeolite have been discovered to improve the stability of the cement mixture in concrete. When axing concrete containing zeolite was found to have a higher compressive strength than concrete containing regular Portland cement. As a result, cement can be replaced with it. Through pore refinement, zeolite has increased the strength, longevity, and hardness of concrete. Zeolite reduces permeability and prevents damaging reactions like the alkali-silica and alkali carbonate reactions that lead to concrete cracking in mortar and concrete [15].

K.Lokesh et al. (2020) has examined on the zeolite and fly ash are used to partially replace cement-based concrete, and the results are compared to regular concrete. Zeolite is used to partially replace cement in concrete in the following proportions: 5%, 15%, 20%, and 25%; fly ash is used in the following proportions: 5%, 10%, 15%, 20%, 25%. The examples were casted and tested for their mechanical and durability attributes. 5 types of mix design proportion are a=100%cement, b=85%C+10%Z+5%FA (Cement+Zeolite+FlyAsh), e=50%C+40%Z+20%FA. Concrete's compressive strength increase by 20% and 10% after 28 and 60 days, respectively, with zeolite and fly ash replacement. The RCPT values over 28 and 60 days showed increases of up to 20% and 10%, respectively, in zeolite and fly ash, and declines of up to 40% and 20%, respectively [18].

Shiva Ji Gond et al. (2020) has examined the zeolite can be used as place of cement in terms of strength, workability and durability. In the study, they are using the I.S. method for mix design and selected M20 grade concrete. Using varying proportions of zeolite powder, they produced concrete mixtures to create cubes: 0% NA + 100% C, 10% NZ + 90% C, 20% NZ = 80% C, and 30% NZ + 70% C. In the result of the compressive strength, the maximum value is 20.44 N/mm2 was achieved when 10% of the cement was substituted with zeolite powder. When decrease in the proportions of cement with zeolite, value of compressive strength is increasing. Around 4% value decreasing in the strength. Concrete has the ability to absorb CO_2 without releasing any of it with the use of zeolite. However, from an economical and technological perspective, it lowers construction costs without sacrificing strength [30].

Patricia Kara De Maeijer et al. (2020) has researched to substitute cement in concrete with ultra-fine fly ash, a unique by-product of a dry, closed separation process. Two different types of ultra-fly ashes were utilized: one with a particle size of d_{90} < 9.3 lm (FA1) and the other with d_{90} < 4.6 lm (FA2). Cement was substituted with FA1 and FA2 at 0%, 15%, 25%, 35%, and 50% paste and mortar levels. At the concrete level, various ratios of FA1 and FA2 were used to substitute cement at 0%, 15%, and 25%. The result of the compressive strength, for Portland cement, after 28 days, containing FA2 at 25% cement replacement was already the same as the reference concrete with 0% replacement. And for slag cement, at 91 days, the concrete mix containing 15% FA1 cement replacement and 25% FA2 cement replacement met the reference concrete value in terms of compressive strength. And in the terms of durability, the resistivity, chloride migration coefficient, and alkali-silica reaction (ASR) were all positively impacted by substituting ultra-fine fly ash (FA2) for cement, but the carbonation resistance was negatively impacted [25].

P.V. Madhuri et al. (2021) has researched was done to see how concrete performed in terms of durability and mechanical properties at lower water-binder ratios when zeolite replacement amount was higher. Mechanical properties include testing for flexural strength, split tensile strength and compressive strength. Aspects of durability such as sulphuric acid attack and chloride attack using the Rapid Chloride Penetration Test (RCPT). 10% replacement strength is greater than 15% replacement strength, according to specimen's compressive strength data. Compared to ordinary mix, there is a minor drop in strength at 10%. The result of the Rapid Chloride Penetration Test for zeolite additives at 10%, 15% and 20% showed that the penetration of chloride decreased as the additive amount increased, with modest penetration recorded at 20%. A 10% zeolite addition also enhances carbonation resistance, reduces shrinkage, sulphate resistance, and chloride permeability [24].

T V Reshma et al. (2021) has used nanoparticles to partially substitute cement in concrete, such as zinc oxide and titanium dioxide, to improve the structural performance of the mixture. In order to examine the mechanical, durability of concrete, different percentages of ZnO (0, 1, 2, 3, 4, and 5) and TiO_2 (0, 0.5, 1, 1.5, 2, and 2.5) were added to the cement weight, both with and without polypropylene fibers. At 7, 14, 28, and 90 days after curing, tests are conducted to determine mechanical parameters such as flexural, compressive, and split tensile strength. After 28 days of curing, experiments are conducted using durability tests such as water absorption, sorptivity test, and chemical assault. Total 10 different mixes are made for the tests, with five of the mixes (Mix-1, 2, 3, 4, 5) including different amount of nanomaterials with concrete. In a similar way, five other mixes (Mix- 1F, 2F, 3F, 4F, and 5F) with different amounts of nanomaterials are made with concrete and PPF. By weight of cement, 0.6% (2.619 kg) of fibers are utilized in these mixtures. For the compressive strength, concrete with a Mix-4 composition, which replaces 2% of TiO_2 with 4% ZnO, has the highest strength at all ages. For durability test result, when the amount of nanomaterials increase, the proportion of water absorption falls. Mix-5 shows the least amount of water absorption. And PPF combined with 2.5% TiO_2 and 5% ZnO provides the greatest protection against water absorption [31].

Iswarya Gowram et al. (2021) has performed that the durability of Fly Ash, Silica Fume with Natural Zeolite on high-strength concrete are compared in this study. 300 concrete examples underwent tests for water absorption, quick chloride permeability and compressive strength both before and after an acid assault. Cementitious components were substituted for 5%, 10% and 15% of the cement with the same amount of Natural Zeolite being kept constant [17].

Garima Rawat et al. (2023) has researched on the results of partially replacing some of the cement in concrete with different division of nano-titanium dioxide (nano-TiO_2 [NT]). Using Portland Pozzolana cement, NT was added by weight of cement to the C20/C25 grade of concrete, partially replacing 0, 0.5, 1.5, 2.0, 2.5, and 3.0%. So as a result, a reduced crystalline $Ca(OH)_2$ content is required for the production of calcium-silicate-hydrate (C-S-H) gels, flexural and splitting tensile strengths are affected when TiO_2 nanoparticle concentrations above 1.5%. TiO_2 nanoparticles were added, and this greatly decreased both water absorption and apparent porosity because the nanoparticles function as nano fillers and strengthen the concrete's resistance to water permeability [13].

Following table 1 represents the critical outcomes from the literature.

Table.1 critical outcomes from literature review

Sr. No	Authors	SCM Used	%Change in Strength	%Change in Durability	Remark
1.	Babak Ahmadi et al. (2010)	Zeolite	3.96% decrease	9.84% increase	-
2.	Ali Nazari et al. (2010)	TiO_2	21.32% increase	4% increase	-
3.	Meysam Najimi et al. (2012)	Zeolite	15% increase	17% increase	-
4.	HASEBE.M et al. (2013)	TiO_2	7-27% increase	10% decrease	M35 grade of concrete
5.	Mostafa Jalal et al. (2013)	TiO_2	15% increase	5% decrease	-
6.	Mahdi Valipour et al. (2013)	Zeolite	14.4% decrease	Constant	Good for environment
7.	S. Rao et al. (2015)	TiO_2	20% increase	2-5% increase	-
8.	Hainan Li et al. (2015)	TiO_2	65.6% increase	43.9% decrease	Toughness is enhanced
9.	Ali Akbar Ramezanianpour et al. (2015)	Zeolite	11.5% increase	44% increase	Reduces the cost of construction
10.	Rui Zhang et al. (2015)	TiO_2	3-8% increase	54.4% decrease	-
11.	C. Manoj Kumaar et al. (2015)	TiO_2	21% increase	15% increase	M35 grade of concrete
12.	Baoguo Ma et al. (2015)	TiO_2	57.3% increase	65% decrease	Toughness is enhanced
13.	Ping Duan et al. (2015)	TiO_2	51% increase	31.67% decrease	M35 grade of concrete
14.	A Haamidh et al. (2016)	Zeolite	No change	3-5% decrease	Zeolite plastered concrete (ZPC)
15.	Taras Markiv et al. (2016)	Zeolite + Superplasticizer	Constant	20% increase	M40 grade of concrete
16.	Memduh Nas et al. (2018)	Zeolite	5% increase	42% decrease	-
17.	Alireza Joshaghani et al. (2018)	TiO_2	18.90% increase	66.3% increase	-
18.	Mehdey Fazilati et al. (2019)	Silica tuff	15.7% increase	Moderate	24 samples were tested.

19.	DR.R.UMA MAHESWARI et al. (2019)	TiO_2	20% increase	18.8% increase	M35 grade of concrete
20.	T.R.Praveenkumar et al. (2019)	TiO_2 + rice husk ash	Constant	3% decrease	-
21.	Chang Bok Yoon et al. (2020)	Zeolite	8% decrease	10% increase	ZWR
22.	Chalapati Harish et al. (2020)	Zeolite	12.89% increase	8% increase	-
23.	Hanusha Durisety et al. (2020)	Zeolite	7-8% increase	5% increase	-
24.	K.LOKESH et al. (2020)	Zeolite	20% increase	20% increase	-
25.	Shiva Ji Gond et al. (2020)	Zeolite	4% decrease	29% increase	Reduces the cost of construction
26.	Patricia Kara de Maejier et al. (2020)	Fly Ash	10% increase	16% increase	-
27.	P.V. Madhuri et al. (2021)	Zeolite	10% decrease	20% increase	-
28.	T.V. Reshma et al. (2021)	ZnO + TiO_2	12.9% increase	4.3% decrease	-
29.	Iswarya Gowram et al. (2021)	Fly ash, silica fume, zeolite	13.19% decrease	18% increase	300 concrete samples tests
30.	Garima Rawat et al. (2023)	TiO_2	Constant	4.89% increase	C20/C25 grade of concrete

III. TESTS ON STRENGTH AND DURABILITY OF CONCRETE

Following are the common test which are performed in concrete :

3.1 Strength test of concrete:

A. Compressive strength (IS 516:1959)
B. Split tensile strength (IS 5816:1959)
C. Flexural strength [IS 516 (Part-1 Sec-1)] - 2021

Concrete is a material which is used to carry a compressive load in any structural elements. After performing the mix design calculation for desire grade of concrete, the usual most common strength test as tested above. Test are performed on the concrete specimen before the concrete is actually used for its structural purpose [29].

3.2 Durability test of concrete:

A. Water permeability (IS 3085:1965)
B. Rapid chloride permeability (ASTM C 1202)
C. Sulphate attack (ASTM C1012) - 2024
D. Water carbonation test [IS-516 (Part-2 Sec-4)] - 2021
E. Alkali aggregate reaction (IS 2386-7)

Concrete's durability is its capacity to tolerate a wide range of physical and environmental factors for a long time without degrading or losing its structural integrity. The durability of concrete can be impacted by abrasion, chemical erosion, exposure to extreme weather, and other external factors. The long-term durability of concrete structures is contingent upon the use of appropriate construction procedures, mix design, and maintenance protocols. Use of high-quality materials, appropriate curing procedures, and routine inspections are some of the techniques that can assist improve concrete's durability and increase the lifespan of buildings [32].

IV. CONCLUSION

By Using SCMs to analyse critical literature on concrete's strength and durability, the following conclusion can be derived:

A. There is a need to partial replacement of cement with SCMs as stated above like zeolite, titanium dioxide, etc. are must be encourage.
B. The strength and durability aspect of the concrete are seeing to be improved with use of SCMs in concrete. i.e. zeolite and titanium dioxide.
C. By observing above literature, it can be said that the TiO2 and zeolite are proven to be effective SCMs.
D. TiO2 and Zeolite increase compressive strength of concrete and the optimum percentage replacement of SCMs is between 3-4% and 10-13% respectively.

E. In majority of the cases, the use of the SCMs as a partial replacement of cement in concrete not only improved durability and strength aspects but also improved the cost of the concrete produced, which ultimately help in the construction cost and enhancing the economy of the structure.

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VI. CONFLICTS OF INTEREST

The authors have declared no conflict of interest.

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