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REVIEW ARTICLE Open Access

Natural and Chemical Admixtures in Concrete- A Review

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Abstract:
To understand the effect of different natural and chemical admixtures on the properties of conventional and high strength concrete, an extensive literature review was done. It is known that chemical admixtures are composed of substances that are added to concrete to improve different aspects in fresh and hardened states and polycarboxylate PCE is one of the admixtures that have significantly contributed to the development of conventional concrete. Since the effect of different types of chemical admixtures can arise when concrete particles containing admixtures is dumped after a building has been demolished or when they are thrown out into the surroundings, Therefore, it is required to identify alternative admixtures that improve the qualities of concrete without negatively impacting the environment. Various natural organic elements have been studied incorporated in concrete and mortar in the past and recently. There are Organic admixtures such as molasses, black gram, potato starch, egg white, and cactus adhesive juice etc. are among the organic substances that enhance the workability, compressive strength, tensile strength, plasticity, and durability, etc. throughout this work the behaviour of natural plant extracts used as admixtures and fibres in concrete with and without the combination of certain types of other admixtures have been explored.

Keywords: *Natural Organic Admixtures, Chemical Admixtures, Durability of Concrete*

1. Introduction-Admixtures in Concrete-

Normal Strength concrete possesses excellent properties that made it the most used construction material globally, annually more than 11 billion cubic meters are being used on the construction sites [1], however, to provide special needs, concrete properties both in the fresh and hardened states needs to be modified and enhanced. For this reason, there are certain types of materials and several types of admixtures such as minerals, natural and chemical are used with the concrete to provide the required characteristics.

Admixtures are known as additional ingredients that are added to concrete in addition to the conventional wet-mixed components of water, cement, and aggregate. There are certain objectives beyond using admixtures in concrete. They have the potential to decrease the expenses associated with concrete construction, modify the properties of both fresh and hardened concrete, ensure the concrete's quality along the processes of placement, transportation, mixing, and curing, and provide all the means to manage unforeseen circumstances that may arise during concrete operations.

Since exceedingly long times ago different civilizations such as ancient Egyptians employed animal blood, fruit extracts, keratin, casein, and egg white as admixtures in construction. On the other hand, the use of admixtures dates to ancient civilizations; however, the need for sustainable concrete and specific requirements in concrete necessitated accelerating the shift toward using natural admixtures that have superior performance and are eco-friendly substitutes in concrete. Besides from the above-mentioned materials, natural polymer from plants, mulberry and grape extracts, palm oil fuel ash, metakaolin, rice husk ash, GGBS, fly ash, and silica fume have all been utilized as substitutes or admixtures in concrete. [2-7].

There are plenty of studies that have shown that the use of mineral, chemical and natural admixtures can drastically change the concrete properties both in the hardened and fresh state and will greatly influence concert's long-term behaviour and performance [8-15].

The successful use of admixtures is dependent on the use of proper batching and concreting procedures. Most admixtures are delivered in liquid form and are mixed into the concrete at the concrete batch plant or on the jobsite. There are certain types of admixtures that are used truly little and in a very small amount and they are mixed mostly manually from premeasured containers such as colouring admixtures, expansion agents, and pumping aids.

The efficiency of an admixture depends on several factors, such as the kind and quantity of cement utilized, water content, mixing duration, and the slump range and air temperature of the concrete. The alteration of the concrete composition, such as reducing the water-cement ratio, increasing the cement content, using an alternative type of cement, or adjusting the aggregate and its gradation, may occasionally provide outcomes like those achieved using admixtures.

The classification of concrete admixtures can be made based on their respective functionalities. Generally, admixtures are poured into the mixtures in very small percentages, often ranging from 0.2% to 2%, in the form of powdered or liquid substances.

There are five distinct classes of additives, namely air-entraining, water-reducing, retarding, accelerating, and plasticizers (super-plasticizers). The remaining varieties of admixtures can be classified as special additives, which can be used to serve various purposes such as reducing shrinkage, inhibiting corrosion, enhancing workability, reducing alkali-silica reactivity, promoting bonding, improving moisture resistance, and providing colouring [16].

In figure 1 the categories of admixtures that are commonly used in concrete is illustrated.

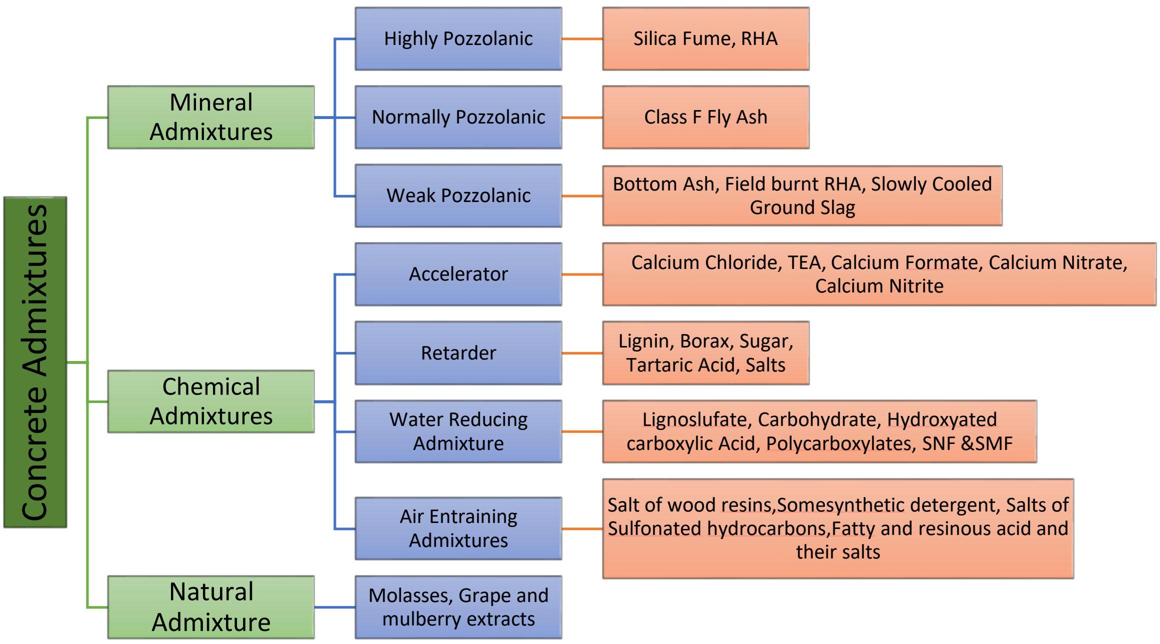

Figure 1: Concrete admixture hierarchy

2. Chemical Admixtures

Chemical admixtures are composed of substances that are added to concrete to improve its properties; polycarboxylate PCE is one of the admixtures that have significantly contributed to the development of concrete; since its invention in 1981, the use of this technology has opened the ways for several technical improvements within the contemporary concrete construction industry and has attracted extensive application in the realm of concrete building. In 2017, the utilization of polycarboxylate ether (PCE) constituted around 7.23 million metric tons, this corresponds to around 77.6 percent of the total volume of water-reducing admixtures that was used in that state. The 2015 International Conference (ICCC) which was held in Beijing featured an in-depth discussion of compositions and synthesis methodologies pertaining to Polymeric Carbon Electrodes (PCEs) [17].

Chemical admixtures should be used carefully because adding the wrong amounts can change the way concrete works in many ways over time. For example, using calcium chloride as an accelerator can cause the reinforcement to rust. Using too much air-entraining admixture can make the concrete weaker, which could cause structural problems. Using too much plasticizer can cause the concrete to separate or bleed. With the growth of the chemical industry, new types of admixtures have begun to be utilized. They consist of self-curing additive, shrinkage reducing/compensating additives, corrosion inhibitors, alkali-silica reactivity inhibitors, etc [18].

The insertion of admixtures into a batch of concrete requires the regulation of the discharge rate, the time of the batching process, and the amount of material supplied. During the loading stage, the rate of additive injection should be adjustable to provide equal dispersion throughout the concrete mixture. Table 1 provides a summary of the appropriate periods for admixture addition during the mixing cycle.

Table 1: Preferred point of addition in the mixing cycle for different admixture types [19]

Admixture type	Point of addition	Notes
a) All water reducing admixture (except super plus sizers use it for flowing concrete production) particularly when a retarding effect is required.	After initial mixing period of up to 30s of aggregates, cement, and part of the gauging water, should be dissolved in a proportion of the remainder of the gauge in water.	premixing with moist aggregate is often sufficient to partially hydrate the cement.
b) Air entraining agent c) Accelerators (except powders) d) Emulsified water proofers.	Dissolved in gauging water which can be added directly to the premixed cement and aggregates.	These materials are not particularly sensitive to the point of addition and the main ambition is to obtain the maximum dispersion through the mix.
e) Powdered water proofers f) Powdered accelerators	Premixed with dry mix ingredients before addition of the gauging water.	In order to aid the dispersion of this type of mix it is advisable to sprinkle the admixture over the mix during the dry cycle.
g) Superplasticizer for flowing concrete	After the mixing cycle just prior to placing.	
h) Third generation superplasticizers	With gauging water	

3. Mineral Admixtures

Mineral admixtures are added to enhance certain properties of several types of concretes both in the long term and short term, they can be categorized as highly pozzolanic such as silica fume or normally pozzolanic such as class F fly ash and weak pozzolanic such as bottom ash, field burnt RHA, and slowly cooled ground slag. The impact of silica fume (SF) on the immediate and long-term properties of concrete is widely recognized, compared to fly ash (FA) which exhibits its positive impacts over an extended duration. Adding FA and SF slightly increases the compressive strength property but contributes more to the enhancement of the transport qualities of concrete. [13, 20, 21].

Silica fume is one of the highly pozzolanic mineral admixtures that is used specifically for obtaining early compressive strength and increasing the toughness of the concrete, high tensile strength, modulus of elasticity and flexural strength and also it is intentionally used for decreasing the permeability of chloride and water intrusion.[22] It is also known that abrasion resistance, durability, bond strength and electrical resistivity of concrete is increased using certain amount of silica fume 5% and fly ash 20% [23].

Table 2 shows the studies performed to determine the effect of silica fume alone and with other admixtures on concrete properties.

Table 2: Silica fume used with several types of concretes.

Sources	Concrete Mix or Mortar Type Studied	Replacement %	% Other admixtures used with SF	Properties Studied
Mazloom, M., et al 2004[24]	High strength Concrete mix w/c= 0.35	0%, 6%, 10% and 15%	Super plasticizer	Slump, Compressive strength, Secant Modulus of Elasticity, Strain due to creep, shrinkage, swelling and moisture movement
Adamu, M., et al 2022[25]	Date fiber reinforced concrete	0 %, 5 %, 10 % and 15 %	0 %, 1 %, 2 % and 3 % DPF	Response surface methodology (RSM) used to predict strength, densities, and water absorption of the concrete and the use of optimization techniques to obtain the most favorable combinations of silica fume and the DPF.
Şeker, B.Ş., M. Gökçe, and K.J.C.S.i.C.M.	Ultra-low density foam concrete	5% Constant	Synthetic foam additive	The study has focused on investigating the compressive

Toklu 2022 [26]				strength and thermal conductivity characteristics of foam concrete over an extended period.
Ulucan, Z.Ç., K. Türk, and M.J.R.J.o.N.T. Karataş 2008[27]	Self-compacting concrete	SF5% SF10% SF15% SF20%	Fly ash at 4 different %with SP ViscoCrete 3075 was used in the SCC	This research has studied the correlation between the compressive strength of self-compacting concrete (SCC) and ultrasonic pulse velocity (UPV), with a specific focus on the influence of various types and quantities of mineral admixtures.
Amudhavalli, N., J.J.I.j.o.e.s. Mathew, 2012 [21]	Normal weight concrete M35	0 %, 5 %, 10 %, 15 % and 20%	super plasticizer-CONPLAST-SP 430 in the form of sulphonated Naphthalene polymers	Compressive strength, split tensile strength, and flexural strength at ages 7 and 28 days, as well as durability research on acid attack, were also investigated, and the percentage of weight loss was compared to that of conventional concrete.
Gonen, T., S.J.B. Yazicioglu 2007 [20]	High strength Concrete mix w/c= 0.5 and 0.38	15% FA and 10% Silica Fume used	Sikament FFN super plasticizer (SP), supplied from SIKA, was used as 2% of cement weight	Short-term and long-term tests, including compressive strength, porosity, capillary absorption, wet–dry cycle, and accelerated carbonation, were used to determine the performance of the concrete mixtures.

In contrast, a study was conducted by [28] to determine the most effective method for reusing coal bottom ash (CBA), coal fly ash (CFA), and rice husk ash (RHA) as substitutes for regular Portland cement in pervious concrete. The preceding concrete specimens consisted of a fly ash content of 30% by volume, with a water-to-cement ratio of 0.21. A range of analytical techniques, including Fourier transform infrared spectroscopy, field emission-scanning electron microscopy, X-ray fluorescence spectroscopy, and X-ray powder diffraction, were utilized to examine the ash components and earlier concrete samples.

The quality of the previous concrete was assessed by evaluating its water permeability, compressive strength, and the characteristics of toxicity that is a leaching procedure which is abbreviated by (TCLP toxicity characteristics leaching procedure)-named as released metals.

The results of this study suggest that the addition of a certain range of replacement materials, such as CBA and CFA, within porous concrete can yield in increased compressive strength when it is compared to the control group. Furthermore, the study considered two samples that had a specific range of single-ash replacement with RHA, which were sintered at temperatures of 550 and 900 °C.

After 90 days, it was seen that the compressive strength of the five previous concrete samples, which were replaced with binary mixtures of RHA (sintered at 550 and 900 °C), CBA, CFA, and CBA (sintered at 1100 °C), was significantly higher when it is compared to both the control sample group and the single-ash RHA partial replacement (sintered at 550 and 900 °C).

Water permeability result was ranged from 0.101 to 0.313 cm/sec, and this result meets the regulatory requirements that are established for TCLP- in all the specimens. It can be seen that ash components have lowered the carbon footprint of pervious concrete in the range of 9.9–20.6% in 1 m3 when it is compared with standard control specimen. As per the results, the replacement of CBA, CFA, and RHA produced adequate compressive strength and water permeability in cement materials.

4. Natural Admixtures

Due to their inverse environmental impacts and implications, it is recommended that the use of chemical and mineral admixtures in concrete be minimized, and the use of biodegradable components in concrete is the current trend for sustainable and eco-friendly concrete [29] Thus, the application of natural admixtures to improve the characteristics of concrete could result in durable and cost-effective concrete, taking into account the current severe weather conditions. There are numerous studies as can be seen from Table No.2 that have used different types of natural admixtures and studied the fresh and hardened properties of concrete.

Table 3: Natural admixtures used with different types of concrete.

Sources	Natural Admixture Type	Replacement %	% Other Admixtures or Materials Used	Properties Studied
Babu, T.R. and D.J.C.s.i.c.m. Neeraja 2017 [8]	Broiler Hen Egg	0%, 0.25%, 0.50%, 0.75%	Class F fly ash	The study aimed to optimize the dosage of NAD in concrete blended with FA by evaluating the compressive strength, slump, modulus of elasticity and splitting tensile strength,
Mbugua, R., R. Salim, and J.J.M. Ndambuki 2016 [29]	Gum Arabic Karroo as a water reducing admixture	0%, 0.3% 0.5% 0.7% 0.8% 1.0% 2.0% 3.0% 0.7% 0.8%	No	The research involved the examination of compressive strength, density, slump test, and XRD features. Several

		1.0% 2.0% 3.0%		doses of GAK have been used, with the control group consisting of neat concrete.
Patel, G. and S.J.I.J.o.A.E.R. Deo 2016 [30]	Natural Organic Material Gramflour, Ghee and Triphala	0.5% and 1%	No	The study encompassed a review of many qualities of concrete in both its fresh and hardened states, including compressive strength, workability and splitting tensile strength.
Pathan, S.B., V.J.I. Singh 2017 [31]	Molasses as a time retarding admixture	0.4%, 0.6% and 0.8%	Treated wastewater in the range of 0.4,0.6 and 0.8 % used	Both fresh and hardened state properties of concrete were studied such as workability tests, flexural strength, compressive strength and splitting tensile strength
Ali, B., L.A.J.C. Qureshi 2019 [32]	Sugarcane molasses	0 %, 0.01%, 0.05%, 0.1%, 0.5%, and 1%	(RAC) recycled aggregate concrete and natural aggregate concrete (NAC) were used for the study.	The mechanical features of recycled aggregate concrete (RAC) and natural aggregate concrete (NAC), including the split tensile strength and compressive strength were studied. furthermore, several parameters such as sorptivity coefficient, water absorption, chloride penetration, and acid attack resistance are analyzed to evaluate the durability of the concrete mixes.
Mahmood, H.F., H. Dabbagh 2021 [5]	Grape and mulberry extracts	GE 0.25% & ME 0.35%	Ploy Carboxylate Ether 1%	Slump, compressive strength, splitting tensile strength and modulus of elasticity
Al Khafaji, Z.S., F.J.I.J.o.C.E. Ruddock 2018 [7]	3 Different types of Sugar (Granulated, Caster and Brown)	0.5%, 1.5%, 2.5% and 5%	No	The setting time of cement paste and impact of types and ranges of sugar on the heat of hydration were studied.
Etuk, B.R., et al 2012 [33]	Shells of periwinkle, oyster, and snail	0%, 5%, 10%, 15%, 20%, 25% and 30%	No	The present research was an attempt to explore the effect of using shells ash as admixtures on the setting time and compressive strength of cement paste and mortar.

As it can be seen from the table above there are different types of natural admixtures that have been used with concrete depending on the types of admixture ranging from 0.01 % up to 30 % natural admixture by weight of cementitious material used , as an example (Subash et al., 2021) Studied the utilization of natural rubber latex NRL which is used instead of the deduction of a specific amount of water, they have adopted the 4%, 5% and 6% as the latex to water ratio and have studied the characteristics of NRL modified concrete with the unmodified concrete. The behaviour of concrete because of this addition with respect to workability and the mechanical behaviours were investigated in their research.

The workability of concrete tends to decrease with increasing amounts of NRL due to the formation of a passive layer surrounding the calcium silicate hydrate and calcium aluminate, resulting in increased viscosity of the concrete. The exceptionally high compressive strength of concrete is generally attributed to the polymerization of latex monomer and the filling of the concrete's pores with NRLparticles. Due to the modification phase's addition of polymer, the specimen's ductility has incre ased while its tensile and flexural strengths have increased. Impermeability and Density of concrete have been improved due to the presence of NRL particles that coat the apparent pores and spaces within its microstructure.

According to the research, the cast specimen exhibiting a latex to water ratio of 5% yielded the most favourable outcomes among all the specimens. The tests conducted on the hardened phase of this material demonstrate its superior performance in terms of compressive strength, flexural strength, and split tensile strength. [34].

The utilization of natural rubber latex (NRL) as an environmentally friendly addition to improve the flexural strength characteristics of concrete pavements has been investigated in separate research conducted by [34]. A recent work conducted by [35] has presented experimental results pertaining to the behaviour of NRL-modified concrete under acidic and sulphated conditions, employing various latex-to-water ratios. The study focused on examining the mechanical characteristics of NRL-modified concrete by modifying the time of curing. Specifically, alterations were made to the water-to-cement ratios, dry rubber content-to-cement ratios, as well as the compressive and flexural strengths.

The mechanical strength growth of the amended concrete was examined by the researchers using scanning electron microscopy and energy-dispersive X-ray analysis methods. The findings of the study indicated that an increase in rubber content led to a loss in compressive strength. However, it was observed that there were ratios of rubber content-to-cement that resulted in ideal flexural strengths, which varied depending on the water-to-cement ratio. The researchers further produced a mix design chart for NRL-concrete pavements, which aids in the selection of economically viable mix components that satisfy both engineering and financial goals.

According to [35]'s findings, the addition of a sufficient amount of latex to concrete has a substantial impact on its resistance to attack by H_2SO_4 and Na_2SO_4. Considering Na_2SO_4 alone, the strength improvement in modified concrete was 86.2% greater than the corresponding value in conventional concrete after 84 days. However, physical studies revealed a significant volume change linked with latex in modified specimens exposed to H_2SO_4, suggesting that hydrocarbon compounds are attacked by acidic chemicals.

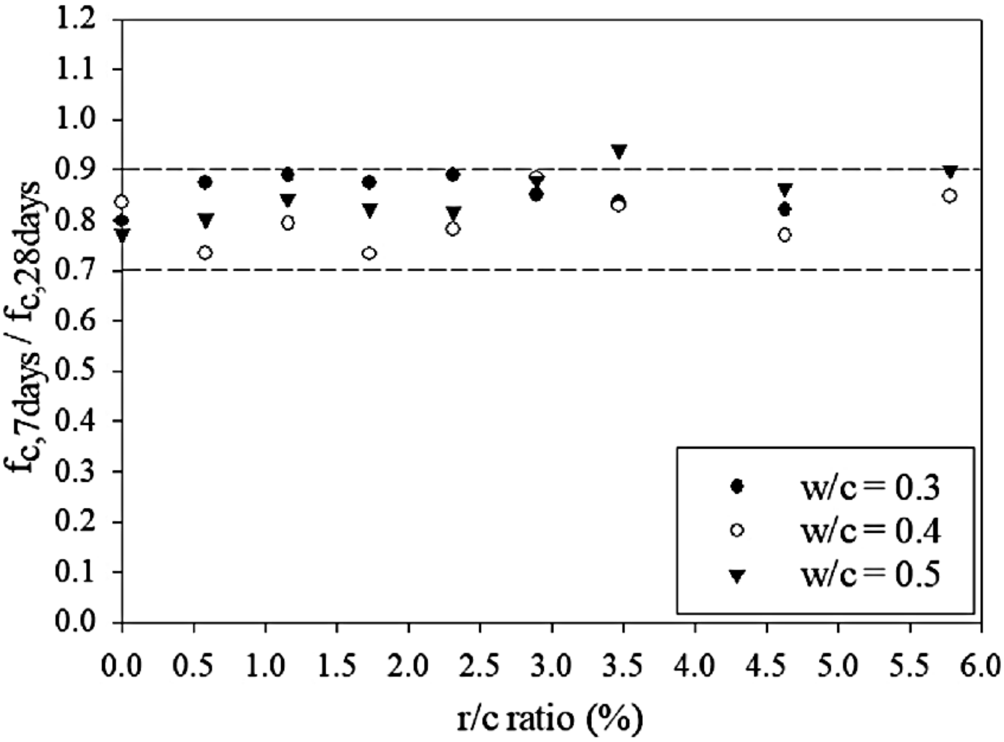

Figure 2: The Normalized compressive strength (fc,7days/fc,28days) is been studied for various r/c ratios [35]

Table 4: Effects of Tree Products as Admixtures in Concrete

Tree Product	Effect	Reference
Pine extract	Increased compressive strength, decreased water demand	[36]
Eucalyptus extract	Increased compressive strength, decreased water demand	[37]
Cypress extract	Increased compressive strength, decreased water demand	[38]
Sawdust	Increased workability, decreased shrinkage	[39]
Bark	Increased strength, decreased permeability	[40]
Lignin	Increased strength, decreased permeability	[41]

As it can be seen, tree products can have several beneficial effects on concrete, including increased strength, decreased water demand, and improved workability. These effects can be attributed to the various compounds found in tree products, such as lignin, tannins, and humic acids.

The use of tree products as admixtures in concrete is still a relatively new area of research, but the results so far are promising. As more research is conducted, it is likely that we will learn even more about the potential benefits of these materials.

5. Molasses, Fruit and other Animal and Tree Products as Admixture in Concrete

Molasses are considered the most common natural extracts that have been used as admixtures in self-compacting and normal weight concrete production [42] besides there are some other extracts like; grapefruit, mulberry [5] papaya leaf [43] rain tree pod extracts [44] viscous biopolymer from cactus extract [45]. Although their utilization has not been specified as admixtures, there are some other natural materials that is been used for different purposes in concrete as it can be seen from figure No.3 such as Banana leaf ash [46], Cashew leaf ash [47] Coir [48] Caryota urens [49] Samanea Saman pods, sticky rice pulp, and human hair [50] etc.

Figure 3: Tree products used in concrete.

In order to provide further clarification on the utilization of molasses in concrete, this discourse will go into the subject matter. A study was conducted by [51] to examine the effects of varying ratios of molasses (0%, 0.25%, 0.50%, and 1% by weight of cement) on the characteristics of recycled aggregate concrete (RAC). Furthermore, three different water-cement (W/C) ratios (0.45, 0.50, and 0.55) were investigated. The study focused on evaluating the fresh density, workability, compressive strength, sorptivity coefficient, water absorption, and chloride penetrations of the RAC samples. The findings of the study suggest that incorporating 0.25-0.50% molasses in RAC can enhance its strength and durability. According to the study conducted by [51], it was found that the blends containing blank molasses exhibited the highest levels of durability and strength when the water-to-cement ratios were set at 0.55 and 0.50, respectively.

Figure 4 illustrates the variations in compressive strength and splitting tensile strength of samples prepared with different concentrations of polymeric sulfonate (05S - 0.5% and 1S - 1%) as well as molasses (05M - 0.5% and 1M - 1%) and technical formaldehyde (05MTF - 0.5% and 1MTF - 1%).

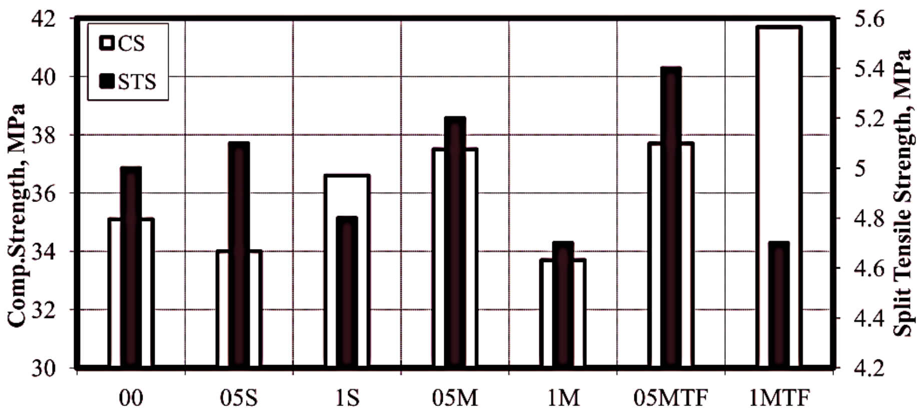

Figure 4: Variation in splitting tensile strength and compressive strength when 0.5% Molasses used [6].

To evaluate the performance of recycled aggregate concrete by incorporating cane molasses (a by-product of the sugar industry) as a plasticizer, [52] examined the fresh properties of cement pastes prepared with varying dosages of molasses (0.25–0.75% by weight of cement).

Furthermore, the properties of recycled aggregate concrete in both its fresh and hardened states were examined over a period of 365 days, including compressive strength, splitting tensile strength, and shear strength. X-ray diffraction analysis was conducted at all stages. They have found that the use of molasses decreased the water required for normal consistency but increased the setting times and workability.

Through analytical discussions and experiments, it was also found that adding up to 0.25 percent molasses greatly increased the mechanical performance of recycled aggregate concrete. From these results, the use of molasses in concrete containing recycled aggregates is very promising, this is subject to dosage restrictions [52].

To assess the effectiveness of using cane molasses, a by-product of the sugar industry, as a plasticizer in recycled aggregate concrete, [52] have conducted a study focusing on the fresh characteristics of cement pastes. The study involved the preparation of cement pastes with different doses of molasses, ranging from 0.25% to 0.75% by weight of cement.

In addition, an investigation was conducted on the characteristics of recycled aggregate concrete in its fresh and hardened states for a duration of 365 days. This investigation encompassed the evaluation of several qualities such as compressive strength, splitting tensile strength, and shear strength. X-ray diffraction analysis was performed throughout all stages of the study. The study revealed that the use of molasses resulted in a reduction in the quantity of water needed to achieve normal consistency, while simultaneously leading to longer setting time and improved workability. Through a series of experimental trials and in-depth analytical discussions, it was ascertained that the incorporation of molasses in recycled aggregate concrete, up to a maximum concentration of 0.25 percent, resulted in notable improvements in its mechanical properties. The findings of this study indicate that the incorporation of molasses in concrete that includes recycled aggregates has potential benefit, provided that appropriate dosage limitations are observed (Rashid, Tariq et al., 2019).

6. Durability Concerns of Natural Admixtures in Concrete

The capability of concrete to resist abrasion, chemical attack, weathering, and other degradation is crucial; thus, the admixtures and construction materials that are used with concrete have a significant influence on the durability of concrete during the service life of buildings and structures, [53]. However, Gjrv [54] pointed out that materials utilized, design, and workmanship are very crucial for creating high-quality construction that will increase the durability of concrete.

The interaction between structures made of concrete and their surrounding environment has a significant impact on the processes of degradation. To achieve environmental sustainability, it is imperative to use an ecologically conscious approach towards the construction of concrete and civil engineering projects. This entails the consideration of several elements, including the selection of materials, the design of the structure, the methods employed in construction, and the maintenance required. The purpose of this action is to advance the principles of environmental sustainability. [55].

The durability of concrete can be influenced by several physical, chemical, and biological factors. The variables under consideration might potentially arise from a variety of factors, including weathering conditions such as variations in temperature and moisture, abrasion, the presence of biological agents, or exposure to natural or industrial effluents and gases. [56].

The examination of durability concerns pertaining to concrete structures necessitates a more comprehensive comprehension of the inherent properties of construction materials. The durability of concrete is influenced by several factors such as the material composition, structural integrity, design considerations, and environmental exposure conditions, as stated by [57]. The importance of material quality in relation to the durability of concrete cannot be overemphasized.

Researchers from [58] investigated the flexural and compressive strength and durability of high-performance concrete that includes additional cementitious materials. They found that the selection and combination of these materials should be based on the specific physical properties needed for the concrete's expected performance and durability, as well as the conditions it will be exposed to.

In the manufacturing of concrete, chemical admixtures are employed to create a variety of durability attributes an experimental work conducted by [59] to examine the application of viscosity-enhancing admixtures, such as water-soluble synthetic and organic polymers. According to [60] the use of polymers as admixtures improves the durability and mechanical properties of concrete by enhancing the adhesion of the mixing components due to the interweaving polymer film. As high range water reducer admixtures (HRWRA), chemical admixtures have influenced the rheological and mechanical behaviour of cement-based systems. This enables for a period during which concrete may be cast in pristine condition. Poly naphthalene sulphonate (PNS), polycarboxylate (PC), and polyacrylate are examples of these non-renewable, oil-based chemical additives (PA).

They include formaldehyde, which, if unintentionally or deliberately released into the environment, may have hazardous impacts on the ecosystem [61].

Recently, there has been an increase in interest in the use of organic admixtures to affect various characteristics of concrete since they are abundant, and their synthesis is not overly complex. Because they are renewable, they contribute to sustainable green building. Various authors, including [53, 59, 61, 62] among others, have reported the use of organic admixtures, including starch and its derivatives, to modify different properties of cement and concrete. Cassava (CA) and maize (MS) are widespread in sub-Saharan Africa and are both excellent suppliers of starch, which has a wide range of industrial applications. [63] Stated that the thickening effect of starches and their derivatives may be investigated by analysing the interaction between amylose and amylopectin molecules, the two macromolecule types that make up starch units.

On the other hand, the effect of natural admixtures on the durability of concrete has been studied by T. Selvaraj 2020 [45] examined the influence of natural admixtures on the durability of concrete using bio-additives made from cactus extract and added into cement concrete mixes in order to produce sustainable concretes. The characteristics of the modified concretes in their fresh and hardened states were assessed. Fourier Transform Infrared Spectroscopy (FT-IR) was also used to examine the interaction of cement particles during hydration reactions with cactus extract, and X-ray Diffraction (XRD) and Thermo Gravimetric Analysis were used to analyse the microstructural properties of the modified cement concrete (TGA). Consequently, FT-IR demonstrated that the addition of polysaccharides to concrete was found to improve its water retention, which reduced early drying and shrinkage cracks. Cactus extract was also found to increase the workability of the concrete by making it more viscous. The study also showed that modified concretes had better mechanical capabilities and durability. Polysaccharides were found to affect the hardened properties of the concrete, meanwhile fats and proteins affected its workability and durability. Overall, this bio-based additive can be considered one of the eco-friendly and one of the most cost-effective natural admixtures for creating the so-called sustainable cement composites with improved workability, mechanical strength, and durability.

7. Conclusion

From the findings of experimental and analytical studies to reveal the behaviour of conventional and high strength concrete incorporating several types of natural organic material, mineral and chemical admixtures; the following points can be concluded.

There are diverse types of plant extracts and tree products that have been used as admixture and the mechanical and durability properties of concrete is enhanced at certain ratios, for example using ghee, gram flour and triphala grapefruit, mulberry, papaya leaf, rain tree pod extracts, viscous biopolymer from cactus extract. Although their utilization has not been specified as admixtures, there are some other natural materials that is been used for different purposes in concrete such as Banana leaf ash, Cashew leaf ash Coir, Caryota urens, sticky rice pulp, Samanea Saman pods and human hair etc. using these types of admixtures can significantly enhance the fresh and hardened properties of concrete.

The analysis indicates that mineral admixtures, including ground granulated blast furnace slag, fly ash, metakaolin, silica fume, and rice husk ash, can be categorized into two distinct groups: chemically active mineral admixtures, characterized by high reactivity as pozzolans, and micro filler mineral admixtures, exhibiting low to moderate reactivity as pozzolans. Fine aggregate (FA), ground granulated blast furnace slag (GGBS), and rice husk ash (RHA) are examples of micro filler mineral admixtures, whereas silica fume (SF) and metakaolin (MK) are chemically active mineral admixtures. The utilization of a mineral addition with reduced particle size and increased specific surface area is often helpful in the production of concrete with high density and impermeability. However, it is important to note that this approach might result in decreased workability and need a higher water content. To address this issue, the incorporation of an effective superplasticizer can provide the necessary compensation.

Although there are numerous types of chemical admixtures, the successful use of admixtures is contingent upon the use of proper batching and concrete techniques. Many admixtures are provided in liquid form and are applied to the concrete at the plant or project site.

Several variables affect the efficiency of an admixture, including the kind and quantity of cement, water content, mixing time, slump, and concrete and air temperatures. Changes to the concrete mixture, such as lowering the water-cement ratio, adding more cement, utilizing a different type of cement, or modifying the aggregate and aggregate gradation, can sometimes produce results comparable to those obtained by adding admixtures.

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