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Investigating the Role of Carboxymethyl Cellulose and Polyvinyl Alcohol Additives on Concrete Performance: A Case Study from Jordan

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Abstract

This work searches for the influence of Carboxymethyl cellulose (CMC) and poly-vinyl acetate copolymer (PVA) on the mechanical properties of concrete. Different mixtures were prepared and evaluated at various proportions of the two polymers. The features evaluated included compressive strength, flexural strength, density and initial setting time. Using (0.05-0.1 wt. %) PVA increased density slightly from 2.42 to 2.45 g/cm^3 while using (0.3-1.0 wt. %) PVA reduced density from 2.42 to 2.33 g/cm^3. A similar performance was observed when CMC was added to concrete. The initial setting time increased upon the addition of both polymers. PVA improved compressive strength and flexural strength at low weight percentages of 0.05-0.1%. At higher weight percentages of 0.3-1%, polymer effect was reversed. Increasing the weight percentage of CMC from 0.1 to 0.5 % resulted in a decrease in comptressive strength from 28.5 to 24 MPa. PVA resulted in higher compressive strengths than CMC for mixtures in the study. The compressive strength was 28.5 MPa and 33.3 MPa at 0.1 wt.% CMC and PVA, respectively. The effect of these polymers was investigated via Fourier transform infra-red (FTIR) technique. FTIR spectral changes observed upon adding PVA and CMC to concrete highlight significant chemical and physical interactions, such as hydrogen bonding and matrix modification, which alters the composite's structural and functional properties. These findings underscore PVA's and CMC's potential to change cement-based materials by altering hydration behavior and promoting better integration within the matrix. This makes them suitable for advanced construction materials with enhanced performance characteristics

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Introduction

Polymers application in concrete have been increasing due to their effect on enhancing some of its mechanical, chemical and physical properties. Among the properties that could be affected: compressive strength, bend strength, durability, fracture toughness and permeability. In addition, and due to their chemical resistance, they could be used as an additive in concrete to be utilized in places where corrosion can be considered a real problem such as sewer and drainage systems. The good adhesive properties of some polymer concrete composites make them also suitable to be used in swimming pools.

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The polymers used with concrete are not limited to thermoplastic but also thermosetting, including car tires rubber, are utilized in certain cases due to the chemical and Polymer-concrete composites, known for their thermal stability. Concrete can be grouped into three main types. All types basically contain water, cement, aggregates and sand. Polymer Concrete (PC), is formed by polymerizing a mixture of monomer fibers and aggregate. It has a higher compressive and tensile strength than PIC. Therefore, it performs better when bends and tensions are present. Lastly, Polymer Modified Concrete (PMC), also referred to as Polymer Portland Cement Concrete (PPCC), is produced by incorporating polymers into traditional Portland cement, enhancing the composite's properties compared to other types. This type is supposed to have high resiststance to cracks, requires lower amounts for use in long and thin sections, and is used when high initial compressive power is needed Gonzalo et al. (2022), Babatunde et al. (2024).

Combining recycled or sustainable polymers with concrete presents several environmental benefits that align well with a focus on sustainability. Using recycled polymers helps reduce plastic waste, diverting it from landfills and oceans, and conserving natural resources by utilizing renewable sources. Additionally, the production of recycled polymers typically requires less energy than virgin polymers, resulting in a lower carbon footprint. Polymers can also enhance the durability and longevity of concrete structures, reducing the need for frequent repairs and replacements, which lowers the overall environmental impact. Furthermore, recycling polymers supports a circular economy by reusing materials and minimizing waste, contributing to more sustainable production and consumption patterns. By highlighting these environmental advantages, the content can effectively underscore the positive impact of using recycled or sustainable polymers in concrete, making it more relevant and compelling for a sustainability-focused publication. Rubber from car tires is added to concrete as powder to improve its properties and as an environmental solution for spent tires accumulation. The addition of rubber was found to reduce concrete weight, give better toughness, and enhance performance of concrete in hot and cold environments as described by Thomas et al. (2016) and Ayesha et al. (2019).

The effects of polymers on concrete properties have been extensively studied. Kim et al. (1995) investigated polyvinyl alcohol (PVA)-modified mortar and concrete, using up to 2 wt.% PVA relative to cement, and compared their structure and properties to those of unmodified samples. Using polarizing optical microscopy and scanning electron microscopy (SEM), they analyzed the interfacial transition zone and fracture surfaces. Results showed that PVA-modified mortar had greater fluidity, higher air void content, and reduced bleeding, indicating improved permeability. Additionally, the microstructure displayed decreased porosity in the interfacial zones around sand grains and coarse aggregate, along with a more uniform distribution of cement particles.

Ohama (1998) studied the impact of polymer latex on mortar and concrete, finding that polymers improved plasticity, workability, and water retention, while also enhancing the adhesion of porcelain tiles. Further research by Ion et al. (2013) and Ali et al. (2012) examined the effects of epoxy resin, polyurethane, and methylcellulose on workability, rheology, and mechanical properties such as compressive and flexural strength, showing enhanced fracture toughness, impermeability, durability, and bond strength. Sivakumar (2011) explored polymer modifications in concrete mechanics and structure. He introduced Latex polymer and styrene acrylic polymer, separately, at different loads from 0 to 25 weight percentage (wt.) % to concrete. Flexural strength improved up to 15 wt.% of polymer and then decreased from 15-25 wt. %. Therefore, an optimal dose of polymer should be used. These studies added further support to the conclusion that polymers significantly improve concrete performance.

Incorporating polymers into mortar and concrete has been shown to improve both physical and mechanical properties, resulting in increased strength and reduced permeability compared to traditional concrete. Cheng et al. (2022) investigated the influence of water-dispersed polymers on hydraulic cement, with and without aggregates, and found that even small polymer additions significantly enhanced cement properties. Styrene-butadiene rubber (SBR) is the most widely used polymer for modifying cement mortar; Maria et al. (2021) demonstrated that the polymer films, formed by styrene-butadiene-rubber (SBR) powder, exhibit strong adhesion to cement hydrates. When polymer latexes are mixed with fresh cement mortar or concrete, the polymer particles are uniformly distributed within the cement paste. This blend of conventional concrete materials with polymers produces composites with improved mechanical and physical qualities. The addition of SBR powder was to enhance concrete properties by reducing permeability, drying shrinkage, and expansions due to alkali-silica reactions and sulfate attacks. SBR powder improves workability by 90%, compressive strength by 23%, and flexural strength by 9.4%. By using polymers with distinct characteristics, polymer-modified concrete can be tailored to achieve specific properties, enabling the development of structural materials with customized attributes.

Muthukumar et al. (2005) evaluated Furan-based polymer concretes, concluding that they are cost-effective and offer excellent chemical resistance and mechanical properties. Research by Aggarwal et al. (2007) on epoxy and acrylic emulsion-modified mortars showed that these materials provided enhanced strength and better resistance to chloride ion penetration. Ohama (1997) studied the effect of monomer ratios in styrene butyl acrylate latex on mortar properties, finding that pore size distribution, flexural and compressive strengths, water absorption, and drying shrinkage were all significantly affected by both the monomer and polymer-cement ratios. This study aims to assess the impact of various polymer dosages on the mechanical and structural properties of concrete in both fresh and hardened states, identifying optimal dosages based on experimental findings.

Tripathi et al. (2024) found that polymers affect concrete properties by enhancing workability and later-age strength, durability, and resistance to frost and corrosion. However, they can retard early hydration, reducing overall strength gain, which can be mitigated through specific additives and curing methods. Babatunde et al. (2024) noticed that polymers enhance concrete properties by improving strength-to-weight ratios, durability, and chemical resistance. Polymer concrete (PC) surpasses traditional concrete, addressing challenges like shrinkage-cracking and enabling advanced applications, ultimately contributing to sustainable construction and reduced environmental impact. Another study by Kermani et al. (2024) revealed that polymers enhance concrete properties by improving flexural and compression strengths, increasing pull-off force, and providing stability against water absorption. The incorporation of treated polymer waste mix in cement composites results in environmentally friendly construction materials with superior mechanical and surface characteristics. Atiea et al. (2023) revealed that polymers, specifically styrene-butadiene rubber, enhance concrete's mechanical properties by 10% by weight. However, exceeding a 10 % polymer/cement ratio diminishes compressive, tensile, and flexural strengths. The addition of a superplasticizer further improves these mechanical capabilities significantly. Nodehi (2022) concluded that polymers enhance the mechanical and durability properties of concrete, resulting in higher strength development rates, improved impermeability, and resistance to corrosion and chemicals. Their incorporation, especially with fillers and cementitious materials, produces a cost-effective composite material for various applications. Kamal et al. (2022) explored the effect of utilizing polymeric resins instead of traditional Portland cement to enhance properties such as compression, tensile, flexure, and bond strength. The study identified optimal mixes, notably ES4, achieving impressive strengths of 1,040.00 MPa in compression and 44.60 MPa in tensile. Zhou et al. (2024) found that polymers, specifically super absorbent polymers (SAP), enhance concrete properties by improving compressive, tensile, and flexural strengths, reducing shrinkage, and preventing cracking. They act as internal curing agents, retaining moisture and promoting hydration during the concrete's hardening process.

Lidan et al (2023) in his work discussed how polymers, including PVA, interact with cement through hydrogen bonding and adsorption, affecting hydration reactions and altering cement properties. These interactions can influence compressive and flexural strength, enhancing the overall performance of cement-based materials. Jie et al. (2019) studied the FTIR spectrum of cement mortar with PVA. His study showed characteristic peaks at 3643 cm^{-1} ($Ca(OH)_2$), 973 cm^{-1} (C-S-H), and 1452 cm^{-1} refer to $CaCO_3$. Also, PVA incorporation enhanced hydration, while excessive amounts negatively impacted these spectral features.

Mishra et al. (2003) explored the influence of sodium salt of carboxymethyl-cellulose (CMC) on the properties of ordinary Portland cement. They examined variations in setting time, heat of hydration, compressive strength, and fracture toughness. FTIR and XRD techniques were used to identify the phase compositions of the material. The research indicated that carboxymethyl-cellulose (CMC) interacts with the hydrated products of cement, resulting in the formation of new phases when water is present. This interaction leads to the creation of strong bonds and the sealing of pores in the final products, which decreases water absorption and enhances corrosion resistance compared to ordinary Portland cement.

Farooque et al. (2010) studied the influence of the organic polymer carboxymethyl cellulose (CMC) on ordinary Portland cement, specifically its effects on compressive strength, setting time, porosity, and corrosion resistance, density, and water absorption. They found that adding the polymer significantly improves the acid resistance of the cement. The interaction between CMC and the cement reduces water absorption, porosity, and chemically bound water. X-ray diffraction analysis of OPC-CMC pastes after 4 months and 1 year showed new peaks and the disappearance of some existing peaks, indicating the interaction of CMC with the hydrated cementitious pastes.

The study utilized Portland cement type 42.5 and standard sand as fine aggregates, with carboxymethyl cellulose (CMC) and polyvinyl alcohol (PVA) as polymers. Cement samples were sourced locally, and various mixtures were prepared with different polymer weight percentages. These mixtures were tested for properties such as density, setting time, compressive strength, and flexural strength.

1 Materials and methods

Portland cement type 42.5 compressive strength was used in all mixtures in this work. The fine aggregates used in making all formulations were standard sand. The two Polymers used in this experiment were CMC and PVA.

1.1 Samples Preparation and Testing

Cement samples were brought from a local Jordanian manufactures. The polymers, CMC and PVA, were obtained from a local chemical supplier. Different mixtures were prepared using different weight percentages of the polymer with cement. Different mixtures of polymer and concrete containing 0.05, 0.1,0.2, 0.3, and 0.5 weight percentage (wt.%) were prepared by adding specific weighed masses of polymer. They were mixed for three minutes using a blender. Specimens for testing the concrete properties, such as density, setting time, compressive and bend strength, were prepared by placing the prepared formulations in special molds. The properties obtained were compared with those of standard concrete specimens without polymers. The density was tested by stainless steel calibrated densitycup.

1.2 Determination of the Setting Time

The setting time of cement was determined based on ASTM C191-08 [Vicat needle]. This test is very important and is universally adapted to determine time for the change of concrete mixture to a solid as adopted by researchers in this field such as Lajan et al. (2020) where the material is conditioned at a temperature of 25°C. This value is selected as standard reading for temperature to make the procedure universal and to give accurate readings for setting time. The hydration process is exothermic and needs water. A higher or a lower temperature will speed up or decelerate hydration process resulting in slower or higher setting time. The powdered solid components were mixed with the gauging water in a laboratory mixer as specified to make a paste of the required consistency. Test block is then made by filling the mold with the paste within the prescribed time, the mold was completely filled, and the surface is smoothed-off. The test block was then placed in an oven at 25°C and covered with nylon to prevent water evaporation and maintain it at prescribed temperature. The initial setting time was tested by placing the mold under a movable rod that bears the needle, then the needle C (1.13 mm diameter) was lowered gently until touched the surface of the paste under test at least 10 mm from the edge of the mold quickly released, then allowed to sink into the surface. The process was repeated at different locations at least 10 mm apart. The needle was allowed to penetrate to a point where it's 5±1 mm from the bottom of the mold. The period elapsing between the time when this condition is reached and the time of adding the water to the other components of the paste was recorded. Therefore, this test gives time for the period from water addition to the mixture until it reaches the required intensity reflected by the needle access to the specified levels. The time at which the needle penetrates only 0.5 to 1 mm from in the mixture is taken as the final setting time. This time reflects the transformation of concrete to the solid phase.

1.3 Determination of Compressive and Bend Strength

The compressive strength test samples were 150 mm cubes, tested in accordance with BS EN 1015-11:1999 and BS 6319. These standards are universal adapted to measure compressive and flexural strength for cement mixtures with polymers as indicated by researchers such as Ashwini et al. (2023) and Kalaimathi et al. (2022). The testing equipment consisted of a compression testing machine, a cube alignment jig, a caliper, weighing scales, and feeler gauges. Prior to testing, the cubes were stored in water and tested within one hour of removal to ensure they remained wet. Each cube was visually inspected, with surface water and grit wiped off. Any unprotected cubes or those with visible flaws, including broken edges of 20 mm or more in any direction, were excluded. All cubes were checked for compliance with squareness requirements per Section 7 of the standard. Feeler gauges were used to ensure proper contact between the cube and jig, and each cube was weighed to the nearest 5 g, with density calculated as described earlier. The bearing surfaces of the testing machine were cleaned to remove loose grit or debris, and no packing, aside from spacing blocks, was placed between the cube and platens. The load was steadily applied, with stress increasing at a rate between 0.2 MPa/s and 0.4 MPa/s, and the maximum load exerted on each cube was recorded.

The flexural strength test measures the theoretical maximum tensile stress in the bottom fiber of a test beam under load. Conducted according to the BS 6319 standard for concrete testing, the apparatus used included a compression testing machine and a bending device. The specimens the concrete beams, measuring 150 mm x 150 mm x 750 mm, were molded in compliance with Section 8 and cured as specified in Section 10 of the standard. A try-square, straight edge, and caliper were used to verify that each specimen adhered to the tolerance requirements set in Section 8. Additionally, the flatness tolerance for the bearing surfaces at the roller positions was established at 0.25 mm. During testing, each specimen was placed centrally in the machine with the troweled surface facing upward, ensuring that the rollers were aligned perpendicular to the beam's longitudinal axis, with no packing material between the specimen and rollers. All loading and support rollers the loading and support rollers were adjusted to ensure uniform contact with the specimen before applying the load. The load was then applied gradually, with stress increasing at a controlled rate of 0.03 to 0.06 MPa/s, maintained until specimen failure. The maximum load was recorded, with the loading increment set at 450 N/s, corresponding to a stress rate of 0.06 MPa/s for a 150 mm beam. Any failure occurring outside the middle third of the span between the supporting rollers invalidated the test.

2. Results and Discussions

Figure 1 shows variation of the density with the loading content of the two polymers: PVA and CMC**:** At low dosages (0.05%-0.1%), PVA tends to increase the density of concrete from 2.42 g/cm^3 to 2.45 g/cm^3 due to enhanced bonding and reduced porosity. However, at higher dosages (0.5%-1.0%), PVA reduces the density to 2.33 g/cm^3 as excess polymer will lead to water retention, incomplete hydration, and higher porosity. On the other hand, CMC also shows a slight increase in density at low dosages (0.05%-0.1%) from 2.41 g/cm^3 to 2.42g/cm^3 due to improved water retention and particle dispersion. However, at higher dosages (0.3%-0.5%), it reduces density to 2.35 g/cm^3 due to increased porosity and changes in the water-cement ratio.

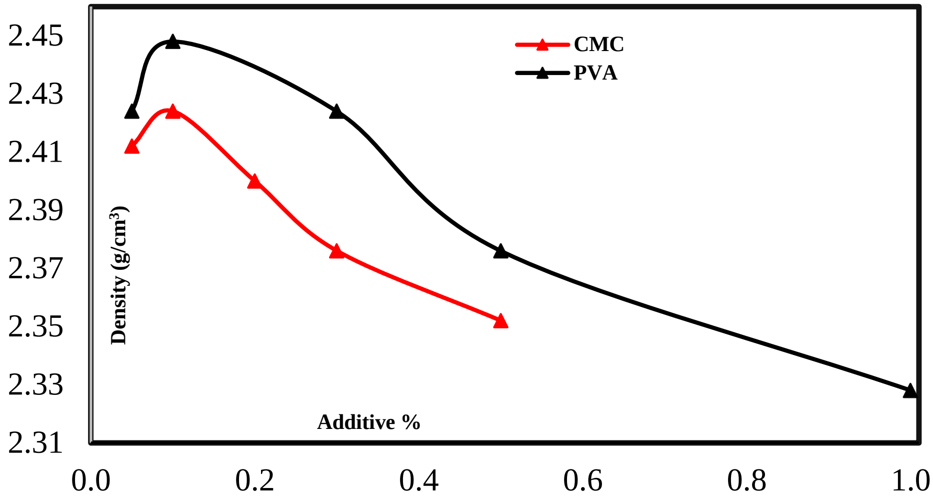

Fig 1. Effect of CMC and PVA on Concrete Density.

The effect of the modifiers on the initial setting time is presented in **Figure 2** illustrating the effect of PVA and CMC on the initial setting time of cement. In the case of PVA, the initial setting time increased from 126 minute (min) to 156 min when the weight percentage of PVA in the mixture increased from 0.05 % to 1.0 %. When CMC was increased from 0.05 to 1.0 wt. %, the initial setting time increased from 129 min to 171 min. The trends show that both additives increase the initial setting time, with a stronger effect observed at higher dosages.

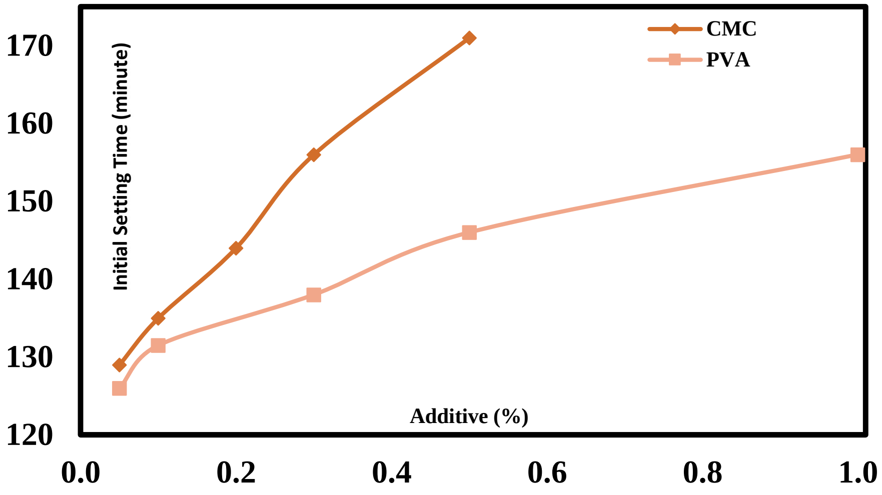

Fig 2. Effect of CMC and PVA on Concrete Initial Sitting Time

The same trend was noticed for the final setting time as can be seen in **Figure 3**. This plot shows the effect of PVA and CMC on the final setting time of cement. The data indicates that as the dosage of either additive increases, the final setting time also increases, with CMC generally having a stronger effect at higher dosages. These findings can be explained by the proposition that these polymers attract water which results in water retention in the final mixture. Also, the addition of these polymers to cement decreases water evaporation from the concrete surface. Hence, the hydration process will take a longer time as found by Li et al. (2020). Another proposition in delay of setting time is based on the increase of cement viscosity due to polymer addition. Higher viscosity will slow water molecules transfer, and hence slow hydration process as proposed by Stefan et. al (2019). The typical initial setting time is in the range of 60 min to 150 minutes for concrete. Therefore, if lower initial setting time is needed, PVA will be superior to CMC.

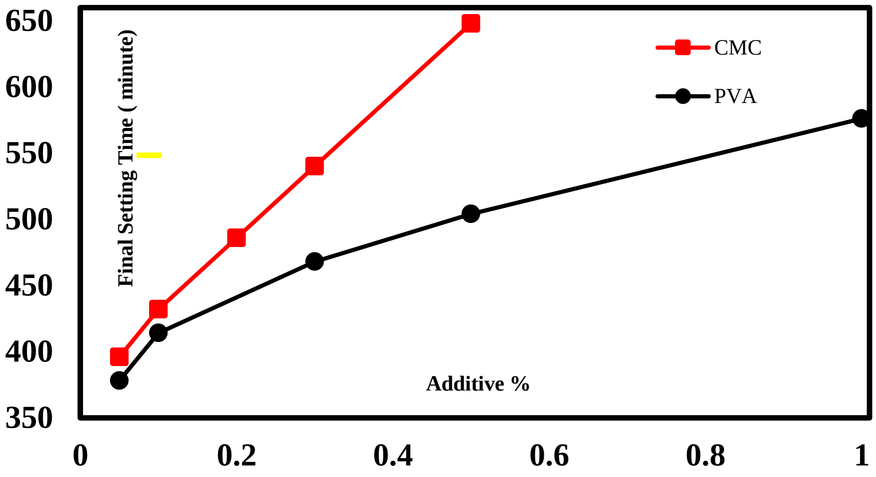

Fig 3 Effect CMC and PVA on Concrete Final Sitting Time.

Figure 4 shows cement compression strength effect by PVA: At low dosages (0.05%-0.1%), PVA enhances the compressive strength from 31.5 MPa to 33.0 MPa. This is due to better bonding, hydration and lower cracks. However, at higher concentrations (0.5%-1.0%), PVA reduces compressive strength from 28.5 MPa to 27.0 MPa. This reduction is related to the increase in porosity and hindrance to hydration. For CMC: Like PVA, CMC shows a slight improvement in compressive strength at low dosages (0.05%). However, at higher dosages (0.1%-0.5%), it significantly reduces compressive strength due to its retarding effects on cement hydration and potential increase in water retention. Also, it can be seen from Figure 4 that PVA results in higher compressive strengths than CMC for all mixtures in Figure 4. For example, the compressive strength is 33.0 MPa and 28.5 MPa at 0.1 wt.% PVA and CMC, respectively. This is due to better bonding and hydration afforded by PVA compared to CMC Jaroslav et al. (2015).

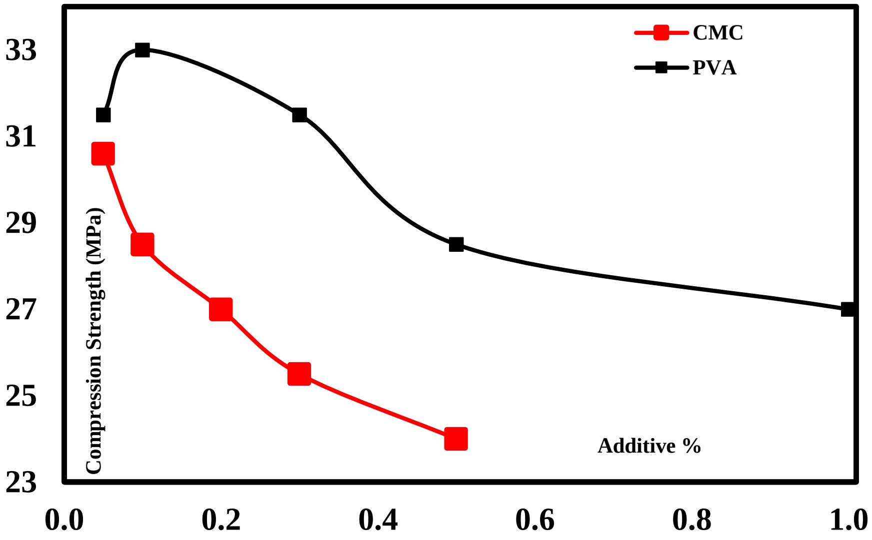

Fig 4 Effect of CMC and PVA on Concrete Compressive Strength.

Figure 5. shows that PVA and CMC have distinct effects on the flexural strength of cement. At low dosages (0.05 wt. %-0.1 wt. %) of PVA, the flexural strength increased from 5.25 MPa to 5.40 MPa. The enhancement in flexural strength is due to improved bonding and water retention, leading to a stronger cement matrix Idrees et al. (2022). However, at higher dosages (0.3 wt. %-1.0 wt. %), its impact becomes negative, where flexural strength dropped to 4.50 MPa, as it hinders hydration, reducing the overall strength. Similarly, CMC slightly improves flexural strength at low dosages (0.05 wt. %) by promoting better water retention and dispersion, but at higher

concentrations (0.1 wt. %-0.5 wt. %), it retards hydration, increase porosity, reduce integrity of mixture matrix and decrease strength. Also, as can be seen in Figure 5, that when polymer weight percentage was increased from 0.05 to 1.0 %, the flexural strength applying PVA was higher than when applying CMC at all percentages. In general, both additives show a negative effect on flexural strength at higher dosages, with CMC exhibiting a more pronounced reduction due to its stronger retarding effect on cement hydration Ashwini et al. (2023). Therefore, careful dosage control is necessary to optimize their benefits, with PVA being more effective at lower concentration.

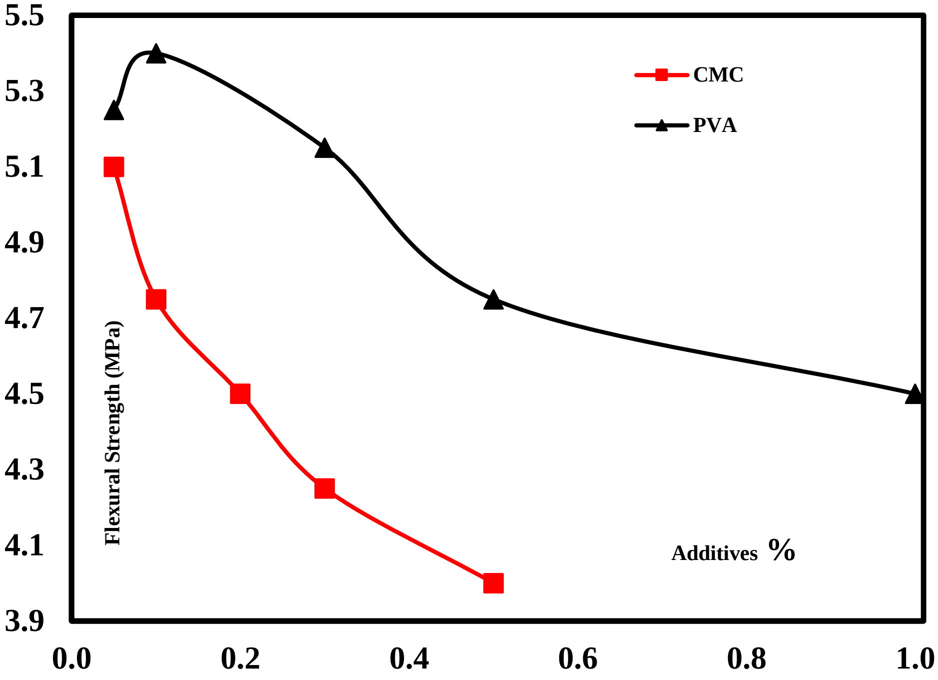

Fig 5 Effect of CMC and PVA on Concrete Flexural Strength.

Figure 6 shows the incorporation of carboxymethyl cellulose (CMC) into cement is evidenced by significant changes in the FTIR spectrum of Concrete curve compared to CMC-Concrete curve, reflecting its interaction with the cement matrix. The hydroxyl (-OH) groups of CMC contribute to a broad peak around 3200–3500 cm^{-1}, which may intensify or shift due to hydrogen bonding with hydration products like calcium silicate hydrates (C-S-H). The carboxylate ($-COO^-$) groups introduce distinctive asymmetric and symmetric stretching bands at 1600–1650 cm^{-1} and 1400–1450 cm^{-1}, respectively, indicating potential chelation with calcium ions. Additional peaks from aliphatic C-H stretching (2800–3000 cm^{-1}) and ether (C-O-C) stretching (1000–1150 cm^{-1}) confirm CMC's presence and possible overlaps with silicate vibrations in the cement for CMC-concrete curve. Moreover, interactions with cement hydration products may cause shifts in silicate (Si-O) and carbonate (C=O) peaks, signaling modifications to the matrix. CMC's water-retaining ability further influences the O-H bending vibrations near 1600 cm^{-1}, enhancing moisture retention. Collectively, these spectral changes demonstrate both the physical integration of CMC and its chemical role in altering the hydration and structural dynamics of the cement matrix.

Figure 6 shows the observed FTIR spectral changes upon adding PVA to cement reveal key interactions that enhance the composite material's properties. Chemical and physical interaction were observed from FTIR analysis that might contribute to the previously observed effects of polymer addition to cement. The FTIR spectrum analysis reveals significant changes in the interaction between CMC-Concrete curve compared to concrete curve alone. The new peaks observed in the PVA-Concrete composite, particularly at 3955 cm^{-1} and 3924 cm^{-1} indicate the formation of new chemical bonds. Additionally, the peak at 3984 cm^{-1} in CMC-Concrete curve is slightly shifted from the concrete curve peak at 3986 cm^{-1}, suggesting changes in the chemical environment of the functional groups, compared to the original peaks in CMC and concrete curves. These peaks suggest that the hydroxyl groups of CMC are interacting with the silicate or aluminate phases in the concrete, likely through hydrogen bonding or covalent bonding. This interaction alters the chemical environment of the functional groups, as evidenced by the shift in the wavenumber of certain peaks. These changes imply that the incorporation of CMC into the concrete matrix enhances the composite's structural integrity and potentially its antibacterial properties, making it a promising material for various applications. Similarly, the interaction between PVA-Concrete shows notable differences compared to concrete alone. The new peaks in the PVA-Concrete composite, such as those at 3953 cm⁻¹ and 3921 cm⁻¹, indicate the formation of new chemical bonds between the CMC and concrete components. These interactions are likely due to hydrogen bonding or covalent bonding between the hydroxyl groups of concrete and the functional groups in PVA. Furthermore, there is a slight shift in the peak at 3986 cm⁻¹ of the PVA-Concrete curve compared to the concrete core peak. The shift in the wavenumber of certain peaks suggests changes in the vibrational energy of the functional groups, indicating a modified chemical environment. Additionally, PVA's hydrophilic nature affects water retention, as seen in shifts in the O-H bending region, highlighting its influence on the hydration process. These interactions contribute to improved adhesion, flexibility, and water retention, making PVA a valuable additive affecting the performance of concrete-based materials.

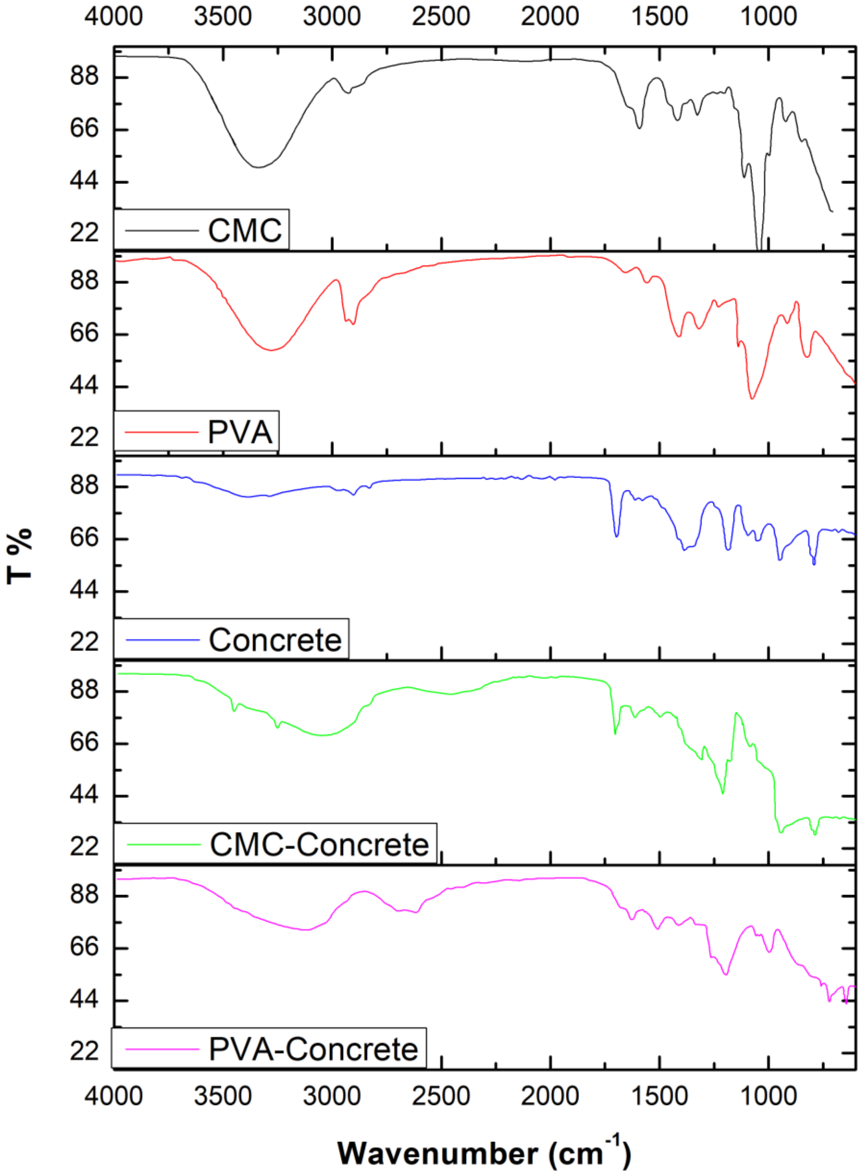

Fig 5. FTIR Transmission Spectrum Showing the Effect of Mixing Concrete with CMC Compared to Mixing Concrete With PVA.

Conclusions

This study presents the effects of PVA and CMC additions, added at different proportions from 0.05 wt. % to 1.0 wt. %, to the concrete mixture on density, initial setting time, compressive and flexural strength of concrete mixture. The initial and final setting time of the concrete mixtures did experience an increase upon increasing the weight percentage, from 0.05 to 1 %, for both polymers. On the other hand, the density initially decreased then slightly increased. It has been observed that the addition of PVA had a positive effect and resulted in improving both the compressive strength of the concrete. At 0.05-0.1 wt. % PVA compressive strength of concrete increased from 31.5 MPa to 33.0 MPa and it became 30.6 MPa at 0.05 wt. % CMC. On the other hand, for 0.5-1.0 wt.% PVA, a decrease in compressive strength from 28.5 MPa to 27.0 MPa is observed. PVA resulted in higher compressive strengths than CMC at all weight fractions. The compressive strength was 28.5 MPa and 33.3 MPa at 0.1 wt.% CMC and PVA, respectively. The same trend was obtained at the same weight percentages of both polymers for flexural strength. CMC exhibited a more pronounced reduction in compressive and flexural strength. Therefore, careful dosage control is necessary to optimize polymers benefits, with PVA being more effective at lower concentrations. FTIR spectral changes observed upon adding PVA and CMC to concrete revealed interactions with concrete matrix. These findings underscore PVA's and CMC's potential to change concrete-based materials by altering hydration behavior and promoting better integration within the matrix. This makes them suitable for advanced construction materials with enhanced performance characteristics.

Nomenclature

CMC	Carboxymethyl Cellulose.
PVA	Polyvinyl Alcohol.
FTIR	Fourier Transform Infrared Spectroscopy
PIC	Polymer Impregnated Concrete
PC	Polymer Concrete.
PMC	Polymer Modified Concrete
SBR	Styrene-Butadiene Rubber
SAP	Super Absorbent Polymers
MPa	Mega Pascal.
wt.%	Weight percentage.

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