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Article

A Study on the Effect of polymeric Additives on the Viscosity and Workability of Concrete Mixtures

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Abstract: This study investigates how polymeric additives affect rheological and mechanical features of concrete mixtures. The focus was placed on the role of these additives in controlling the viscosity of the cement paste and enhancing workability on one hand, and enhancing the long-term strength of concrete on the other. Two types of polymers were examined: Polycrete (PC) and Epoxy Resin, within a range of concentrations and temperatures (20–80 °C), to evaluate and compare their performance. The results showed that Polycrete (PC), at a concentration of 100 ppm, significantly reduced the viscosity of the concrete mixture at 30 °C, which positively influenced the casting and compaction process. However, further increases in concentration beyond this point led to a gradual rise in viscosity and a slight reduction in compressive strength. On the other hand, Epoxy Resin demonstrated an opposite trend; it increased the viscosity of the mixture and delayed cement hydration, especially at higher concentrations (20–30%), which negatively affected the fresh properties. Nevertheless, its performance at later ages (28–90 days) was more favorable, showing improved mechanical strength and durability due to forming a polymeric network in the cementitious matrix.These findings indicate that the selection of the polymer depends on the intended engineering purpose: Polycrete is more effective in improving fresh properties and reducing viscosity, whereas Epoxy Resin is more suitable for enhancing long-term strength and durability.

Keywords: viscosity, Polymers (PC, Epoxy resin), compressivr strength in concrete mix.

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1. Introduction

It Incorporating chemical admixtures has revolutionized concrete production through making various concrete kids capable, i.e., pumped, ready mix, self- compacting, polymer, Polymers have gained wide application in construction because they can modify the fresh and hardened properties of concrete [1]. These compounds, synthesized in different chemical forms, are primarily used to improve workability, adhesion, impermeability, and flexural strength [2].

Despite their benefits, polymers interact with cement during hydration, often delaying setting and affecting early strength development [3]. This aspect is not always well understood by site engineers who directly use these materials. Commonly employed polymers in concrete include epoxy resins, unsaturated polyester resins, styrene butadiene latexes, styrene acrylics, and ethylene-vinyl acetate. Furthermore, polymer-based admixtures, especially polycarboxylate ethers (PCE), are widely recognized as highly effective plasticizers that enhance flow and plasticity in fresh concrete [4].

2. Materials and Methods

Polymer concrete is an effective alternative to Portland cement systems due to its superior durability, chemical resistances, and stability under freeze–thaw cycles (Figure 1). Produced by binding aggregates with thermosetting resins like epoxy, methyl methacrylate or unsaturated polyester, it offers excellent mechanical performance and can be tailored to specific requirements including viscosity, strength, and curing temperature. These advantages make polymer concrete highly suitable for repair works, protective layers, and specialized structural applications (Table 1).

Which has the following specification :

Typical properties achieved with w/p ratio of 0.16

PROPERTIES	VALUES	TEST STANDARDS
Color & appearance	Grey powder	-
Mixed density, [g/cc]	2.25±0.05	ASTM C D 1475
Application life, [minutes]	30	ASTM C 308
Compressive strength [N/mm²] @ 7 days @ 28 days	 ≥ 40 ≥ 50	ASTM C579
Flexural strength @28 days, [N/mm²]	> 7	ASTM C 580
Slant shear bond strength @ 28 days [N/mm²]	≥ 4	ASTM C882
Adhesion strength to concrete @ 28 days [N/mm²]	≥ 1.5	ASTM D 4541
Water permeability @ 5 bars	≤ 10 mm	EN 12390-8
Application thickness Minimum, [mm/layer] Vertical, [mm/layer] Overhead, [mm/layer] Horizontal, [mm/layer]	 5 up to 40 up to 15 up to100	
Application temperature, [°C]	5 to 45	

All values given are subject to 5-10% tolerance

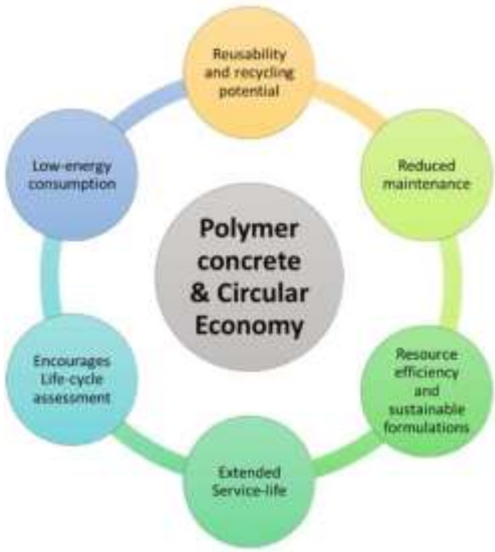

Figure 1. Producing polymer concrete in line with the circular-economy values.

Epoxy resins are commonly used to enhance the workability of cement mortar; however, they are known to retard cement hydration. According to Anagnostopoulos et al., high proportions of epoxy (20–30%) increase the setting time and delay early strength development, while significantly improving long-term strength (28–90 days) and overall mechanical properties (Table 2). Li et al. reported that adding 5–20% epoxy reduces compressive strength, particularly under wet curing conditions, due to the reaction of epoxy with C_3A and C_3S, which causes a noticeable delay in hydration. Small proportions of epoxy (<10%) fail to form a stable polymeric network, resulting in reduced compressive strength, although an improvement in flexural strength was observed at a 3% addition. Furthermore, elevated temperatures have been found to reduce the retarding effect of epoxy on cement hydration (Table 3).

Table 2. Technical Specifications and Mechanical Properties of Ekafix Epoxy Components

Ekafix component A	Epoxy Resin
Ekafix component B	Epoxy Hardener
colour	Grey
Mixed density	1.7 kg/liter
Chloride lon content	≤ %0.05
Glass transition temperature	≥ 45 °c
Compression strength	
1st Day	30 N/mm²
7th Day	75 N/mm²
Flexural strength	
1st day	17 N/mm²
7th day	25 N/mm²
Adhesion strength	
On concrete	3 N/mm²
On steel	3.5 N/mm²
Application thickness	Min:2 mm, Make:30mm
Mixed product usage time	40min .(20 °C)
Temperature resistance	-15 °C /+90 °C
Full strength recovery time	7 Day

Table 3. Comparison between polycrete (pc) and Epoxy resin concrete

Property	Polycrete (pc)	Epoxy resin concrete
Binder type	Usually polyester or modified acrylic resin	Epoxy resin (thermosetting)
Compressive strength	Very high (exceeds normal concrete)	Higher than pc ,especially under high loads
Tensile and flexural strength	Good	Significantly better than pc
Chemical resistance	Excellent (acids,alkalis,chemicals)	Excellent (even better for concentrated acids)
Permeability resistance	Excellent	Excellent
flexibility	Low(rigid and hard)	Higher flexibility (better impact resistance)
Cost	Relatively lower	Higher (epoxy is expensive)
Ease of application	Easier than epoxy (less sensitive to temperature)	Requires careful mixing and controlled curing
Typical application	Industrial floors, aggressive environmental, treatment plants)	Heavy-duty floors, crack repairs, high-performance coatings)

3. Results

Polymer Influence on viscosity

Table 4 shows the concrete mix rise viscosity and drop at many temperatures 20, 30, 40, 50,60 and 80 C⁰ while adding PC. These shifts happen in various proportions according to the percentage of PC added at the same and other temperatures. As a result, in concrete mix , the temperature and how quick is the polymer degradation are directly related [5]. Yet, other circumstances show a negative relationship. Figure 2. shows the viscosity of concrete mix overall rises and drops at one temperature by raising the PC percentage at fixed rates because the oxygen compound ratio of slowly drops in the mixture dur to it degrading with more PC, and then decreases the concrete mix viscosity [6]. Finally, most polymer is not degraded because there are no compounds of the oxygen in the mix, and thus the crude oil viscosity rises [7].

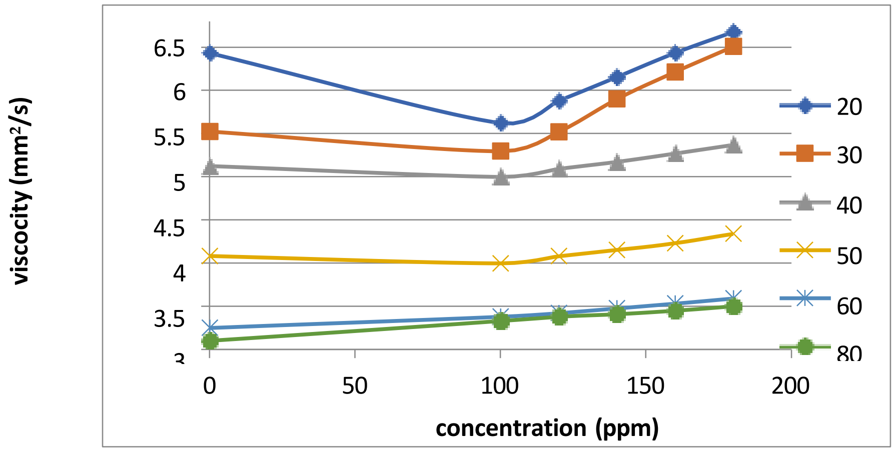

Figure 2. PC concentration effect on the viscosity concrete mix.

Table 5 shows that at 80 C°, concrete mix viscosity rises when it is added in various ratios from the PC because when the temperature rises, compounds of oxygen decomposition in PC fastens. So, according to Figure 3, the equilibrium state speed rises [8]. As a result, all these compounds deplete and viscosity of crude oil grows at ever addition of the PC ratio. Also, the two Table 2 show a growth in the viscosity of crude oil grows at 20, 30, 40, 50 and 80 C° in the addition of the polymer (Epoxy resin). This concrete mix viscosity rises at different rates according to the percentage of polymer (Epoxy resin) at one and many temperatures [9].

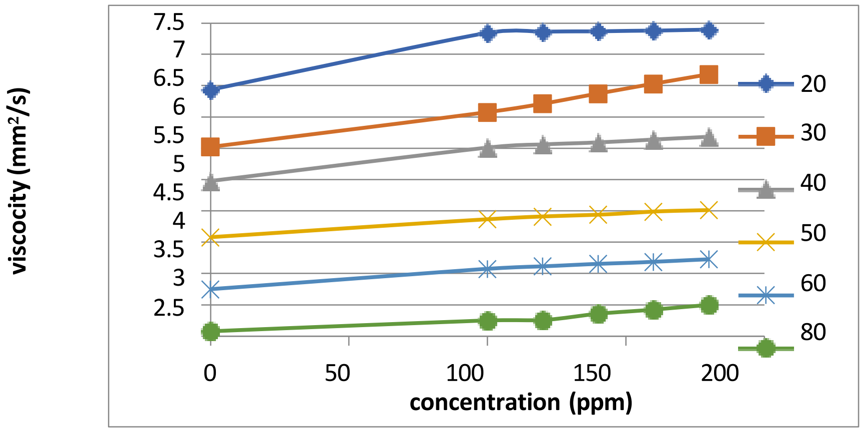

Figure 3. polymer (CMC) concentration effect on the viscosity concrete mix.

Figures 4. and Tables 6. show that the fluid flow at 20, 30,40, 50 and 80 C° stable even following adding the polymer. Yet, at 40 C° the fluid flow is turbulent followed by stabilization on polymer addition. So, the polymer expands the fluid viscosity [10].

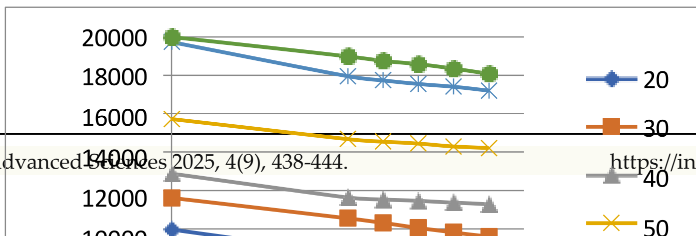

Figure 4. Polymer (Epoxy resin) concentration influence on the Re of concrete mix at different levels of temperature.

Also, there is a stable fluid movement at temperatures (20 and 30Cº), following 100 ppm of a polymer turbulent flow. Concentrations of polymer rises when the fluid flow slowly is almost stable. Yet, in 40, 50 ,60 and 80 Cº, the fluid flow is troubled and kept on one flow when the polymer concentration rises [11]. Yet, this shift drops as the polymer has no decomposition if its concentration is high. Also, oxygen compounds drops slowly when the decomposition of the compounds happens this polymer (Figure 5 and Table 7).

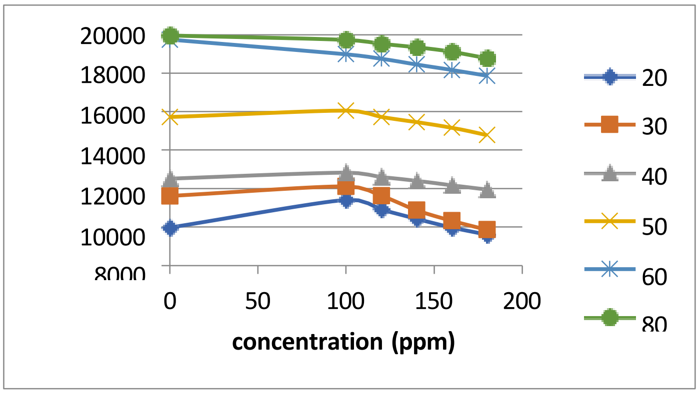

Figure 5. PC concentration effect on the Re of concrete mix at many temperature.

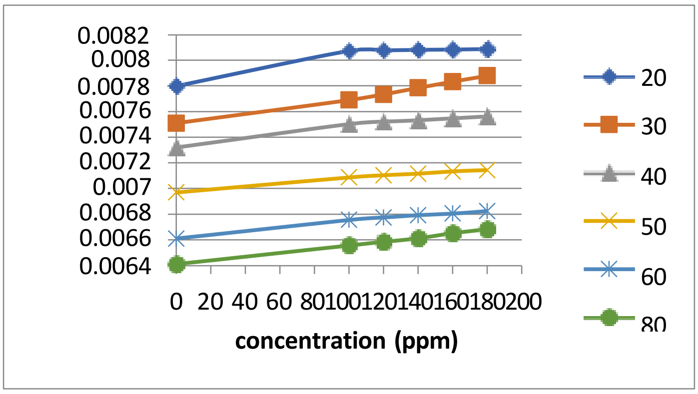

Figure 6. polymer (Epoxy resin) concentration influence on the f of concrete mix of temperatures

The workability relations to viscosity of concrete mixtures and polymer concentration shows a distinct trend: viscosity decreases with increasing polymer content up to an optimal point, then gradually increases beyond that [12]. This behavior depends on the polymer interaction to cementitious matrix at temperatures 20, 30, 40,

and 50 °C. However, at a higher temperature of 60 °C, the mixture viscosity tends to increase more steadily as the polymer concentration rises [13],[14]. The optimal performance in terms of workability and ease of casting/compaction was observed at a polymer concentration of 100 ppm and a temperature of 20 °C as Tables 10 and 11 and Figures 8 and 9 show [15].

4. Conclusion

In this study, the effect of adding two types of polymers (Polycrete and Epoxy resin) on concrete mixtures was evaluated, with a focus on their influence on kinematic viscosity, workability, and compressive strength at different concentrations and temperatures. The experimental analysis shows:

1. Polycrete (PC): Demonstrated the most effective performance in reducing the viscosity of the concrete mixture at a concentration of approximately 100 ppm and within a temperature range of 30–50 °C.At 30 °C and 100 ppm, viscosity decreased significantly,which enhanced workability and compaction and reduced internal friction among the mixture components. This improvement was reflected positively on castability while maintaining an acceptable compressive strength, with no significant reduction observed under these conditions. However, exceeding this concentration led to a gradual increase in viscosity due to mixture saturation, which consequently caused a reduction in compressive strength at higher dosages.
2. Epoxy Resins:At higher concentrations (20–30%), epoxy resins significantly increased mixture viscosity and delayed cement hydration, which reduced the initial workability and made casting and compaction more difficult. At moderate concentrations (5–10%) and a temperature range of 30–50 °C, the negative effect on workability was less pronounced but still less efficient compared to Polycrete. Despite the increase in viscosity, the results revealed that epoxy resins provided a remarkable improvement in long-term mechanical properties (28–90 days), as they form a strong polymeric network that enhances the durability of the cementitious matrix.

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