Effect of Polypropylene fibres on Properties of Fresh Geopolymer Concrete Based on GGBFS

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ABSTRACT— This investigation aims to improve some of fresh properties of geopolymer concrete based on ground granulated blast furnace slag, this paper summarizes the influence of polypropylene fibres (0.05%, 0.1%) by volume of binder content on the fresh properties of geopolymer concrete, Concrete specimens with and without polypropylene fibres were prepared, cured in laboratory conditions. Specimens were tested for workability, setting time. The results show that the inclusion of polypropylene fibres is affects the fresh properties of geopolymer concrete, decrease the workability of concrete, reduce time of slump losses, reduction in final setting time. Most of the previous research focused on studying the effect of using polypropylene fibres on concrete in the hardened state. There was an urgent need to study its effect on fresh properties of geopolymer concrete. Polypropylene is one of the most affordable and widely available polymers. In this study, polypropylene fibres were added to GPC in various percentages to improve fresh and hardened properties of geopolymer concrete. Generally, Superplasticizer used to improve the workability of GPC, but the additive used in this study did not achieve the desired result.

Index Terms— Geopolymer concrete, polypropylene fiber, workability, setting time, slump and slump loss.

1 INTRODUCTION

Concrete is the most commonly used building material [1]. The annual global consumption of concrete was estimated to be around 8.8 billion tonnes. Portland's manufacturing the global cement market is growing at a rate of 10% per year. Every tonne of Portland cement produced contributes approximately one tonne of CO2 [2]. To overcome this problem, the concrete that will be used should be eco-friendly. Geopolymer Concrete is a new and environmentally friendly building material and replacement for Portland cement concrete. The term "geopolymer" was first used Davidovits. Geopolymer concrete (GPC) is a relatively new material. that does not necessitate the use of Portland cement as a binding agent binder. Presence fiber in concrete is one technique for enhanced the structural properties of concrete [3].

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Polypropylene fibers are synthetic fibres that are produced as a by-product of the textile industry. Locally available, come in a variety of aspect ratios [4]. Polypropylene fibres have a low specific gravity and a low cost [5].
application allows for the reliable and effective utilization on fresh properties of concrete, reduction slump values, time of slump losses, a significant reduction in plastic shrinkage cracking and a reduction final setting time. Concrete has low tensile strength, poor deformation resistance, and poor crack resistance in the construction industry. Since the late 1960s, synthetic fibres such as polypropylene have been primarily used in concrete materials. Since that date, its use has increased in many fields, the most important of which is the field of structural engineering [6]. As a result, the PPF can keep water and other harmful ions out of concrete. PPF can be used to increase the durability of concrete [7]. Reduce cracks of concrete, many benefits of using PPF in concrete mixtures have been mentioned by researchers in hardened state [8], but few experimental studies effect on fresh properties and engineering properties of geopolymer concrete, in this study investigates the effect of polypropylene fiber (PPF) on fresh properties of geopolymer concrete.

2 RESEARCH OBJECTIVES

The main objective of this study the effect of polypropylene fibers on fresh properties of geopolymer concrete.

3 EXPERIMENTAL PROGRAM

3.1 Materials

The experimental work in this paper is part of an extended experimental study on Investigation and Improvement of Fresh Geopolymer Concrete Properties. ground granulated blast furnace slag (GGBFS) [9], were used as a binder material with constant content 450kg/m^3. The chemical and physical composition of GGBFS is reported in table1.

The coarse aggregate used was natural crushed stone with a nominal maximum size of 19 mm, and the fine aggregate used was natural sand with a fineness modulus of 2.76. SS solution and sodium hydroxide (SH) solution were mixed together to prepare the alkaline activator. SH solution was prepared by dissolving SH pullets in potable water and sodium silicate (SS) solution was supplied by a local commercial producer. The SH had a chemical composition of 60.25% Na_2O and 39.75% H_2O, and the SS had a chemical composition of 31.00% SiO_2, 11.98% Na2O, and 57.00% H_2O.

TABLE 1: CHEMICAL & PHYSICAL COMPOSITION OF GGBFS.

Item	Percentage by weight (%)	Range (%)
Chemical Composition		
Silicon dioxide (SiO_2)	35.40	32 - 38
Aluminum oxide (Al_2O_3)	17.40	14 - 18
Calcium oxide (CaO)	36.87	32 - 38
Magnesium oxide (MgO)	6.83	6 - 10
Ferric oxide (Fe_2O_3)	1.40	0.70 - 1.50
Manganese Oxide (MnO)	0.35	0.30 - 0.90
Titanium dioxide (TiO_2)	0.11	0.10 - 0.50
Sulfide Sulfur (S)	0.24	0.20 - 0.50
Physical composition		
Specific Gravity	2.80	2.70 - 2.95
Fineness (m^3/ Kg)	409	320 - 410

The used naphthalene -based superplasticizer [10], was locally supplier. physical and the chemical properties is schemed in Table 2. The used polypropylene fiber is a high-performance monofilament polypropylene fiber developed as a crack controlling additive for concrete and mortar. properties are reported in Table 3.

TABLE 2: PROPERTIES OF SUPERPLASTICIZERS.

Colour:	Brown liquid
Specific gravity:	1.210 -1.250 at 25°C
Chloride content:	Nil to BS 5075 Part 1
Freezing point:	0°C
pH:	6-11

TABLE 3: PROPERTIES OF POLYPROPYLENE FIBER.

Specific gravity	0.91g/cm^3
Alkali content	Nil
Sulphate content	Nil
Air entrainment	Air content of concrete will not be significantly increased
Chloride content	Nil
Constituents	100% virgin polypropylene
Fiber diameter Fiber length	30-32 micron 18mm
Elongation	20-25%
Youngs modulus	3000-3500 MPa
Tensile strength	600 to 700 MPa
Melting point	160°C

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3.2 Mixing Proportions

Guidelines, standards, codes for designing a mix of 1m3, the total binder content was kept constant as 450 kg/m3. The ingredient contents of binder were calculated based on their weight ratio. The optimal scope of mixture proportions was selected according to the relevant studies [11],[12], GGBFS based geopolymer concrete: four mixes were designed with constant GGBFS content, varying water/ binder ratio, with varying of poly-propylene fiber, constant superplasticizer. The details of the mixtures are as shown in Table 4. The focus will be on samples (GPC2, GPC5, GPC8) in order to study the blending fiber with concrete to study the effect of fibers on the fresh properties of concrete in the fresh state.

TABLE 4: MIX PROPORTIONS

Mix No.	GGBFS	F.A	C.A	W/ B ratio	SH	SS	W	MS	PPF (%)	Slump Value (mm)
GPC2		547	1093	0.45	41	131	112	1	0	220
GPC5		547	1093	0.45	41	131	112	1	0.1	90
GPC6		547	1093	0.45	41	131	112	1	0.1	95
GPC7	450	547	1093	0.45	41	131	112	1	0.1	80
GPC8		547	1093	0.45	41	131	112	1	0.05	140
GPC9		547	1093	0.45	41	131	112	1	0.05	150

Note: GGBS (Ground Granulated Blast-furnace Slag), SH (Sodium Hydroxide), SS (Sodium Silicate), CA (Coarse Aggregates), FA (Fine Aggregates), MS (Solution Modulus), W(Water), PPF (polypropylene

Fibers).

3.3 Specimen preparation

The alkaline solutions of (NaOH) should prepare before 24 hours of casting. Na2SiO3 were added to NaOH at the required ratio about (20 - 30 min) before actual mixing of the concrete. The mixing method of AAS is presented as follows [13]. GGBS, fine aggregate, coarse aggregate and polypropylene fibers were dispersed randomly into the mixes. The addition of fibers was found to reduce the workability were dry- to ensure homogeneity of the mixture. Then, AL and SP were added into mixture and mixed for another 3-5 min as shows in figure1,[14]. The fresh AAS was then cast into different moulds (Cube with size of 100 *100*100mm) for compressive test, cylinder with size of 100 * 200 mm for splitting tensile test. All specimens were then stored in room temperature until the day of testing.

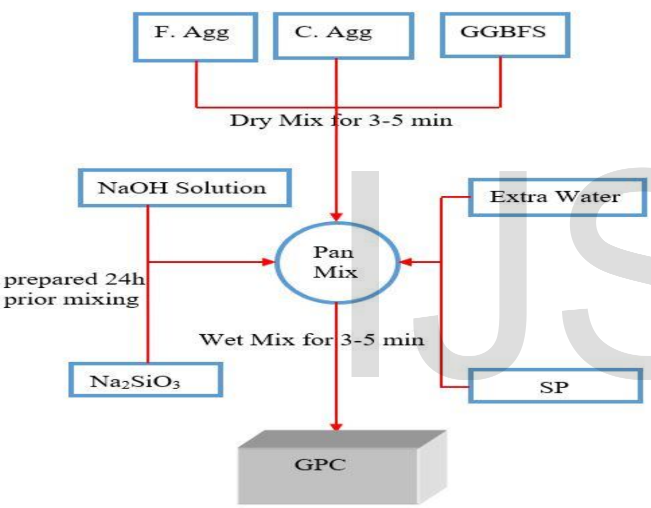


Figure 1: Mixing Process of Geopolymer Concrete.

3.4 Testing methods

The workability [15], of samples was investigated using slump test according to ASTM C143, Slump test was conducted to determine workability of AAS, where vertical difference between the top of the mould and the displaced original center of the top surface of the specimen was measured as the slump value [16]. The initial and final setting time of AAS samples was determined by the penetration resistance test according to ASTM C 403 [17]. Slump losses was conducted to determine the decrease in workability of AAS over time. Measure the internal heat was conducted to determine the heat resulted from Geopolymerization process.

4 RESULTS AND DISCUSSION

4.1 workability.

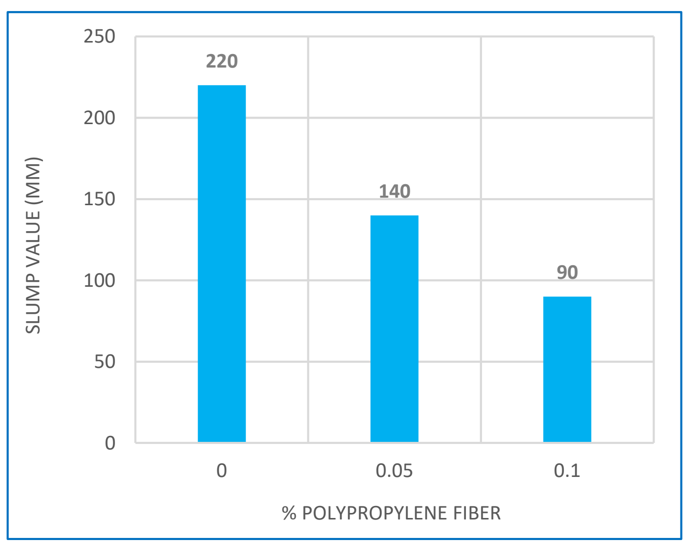
4.1.1 Slump

To express the workability of all mixes, shows the Slump test was used figurer 2, In Table4, shows the slump value of the three mixes (GPC2, GPC5, GPC8), were prepared with PPF volume ratios of 0%, 0.05%, and 0.1%. These relatively low fiber dosages were retained to reduce friction between fibers and aggregates, the slump value of AAS with constant slag content with/ without fiber content, the presence of fiber reduces slump of concrete. In absence fibers of mix GPC2, the slump value is high (220mm), in presence of fiber for mix (GPC8) 0.05%, The slump decreased 36%. with increase PPF 0.1%, as in mix (GPC5), the slump decreased 59%.

Figure 2: The performed slump test.

The presence of fibers does not have a significant effect on the time of slump losses shows in Figure 3. occurs reduction in time of slump losses from 30 min to 26min, 25min sequentially, approximate 13% to 16%.

Figure 3: Effect of PPF on Slump.



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4.1.2 Slump loss

Slump loss of traditional concrete as a result of the hydration process, concrete will loss consistency and stiffen as time elapsed, water in the concrete mix is consumed by the hydration process to produce hydration products such as ettringite and calcium silica hydrate. In geopolymer concrete slump loss as a result of the temperature resulting from the polymerization process, figure 4, shows slump loss of control mix (GPC2) in absence of PPF.

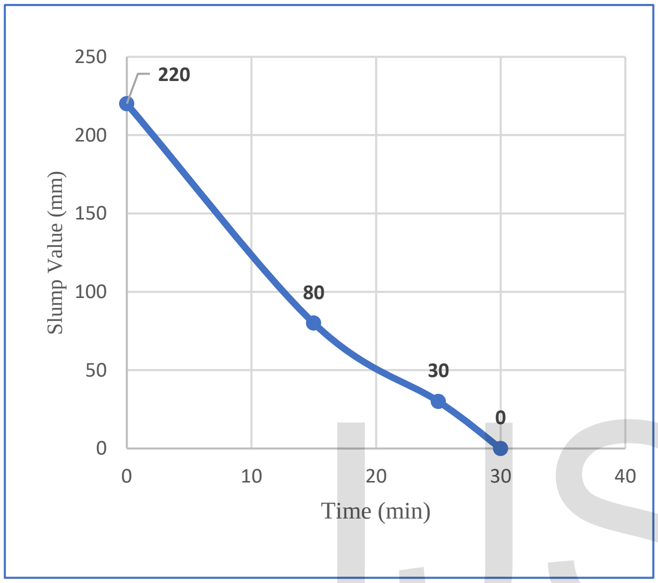

figure 4: Slump loss of 0.00%PPF.

figure 5, figure 6, the effect of the presence of polypropylene fiber on slump loss, at 0.05% and 0.1% occurred reduction of the initial slump value over time gradual.

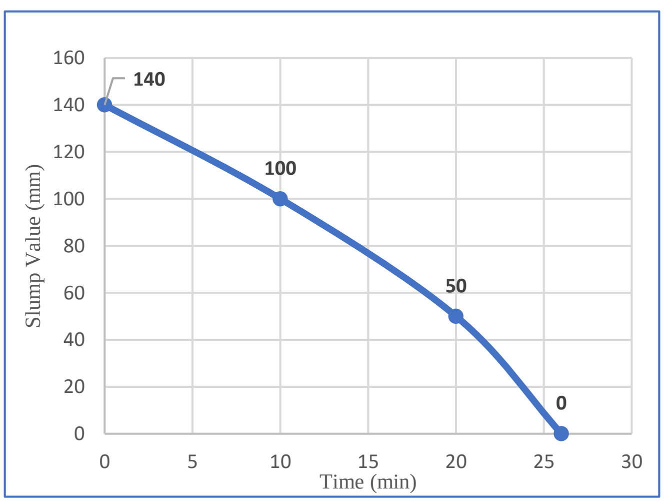

figure 5: slump loss of 0.05%PPF.

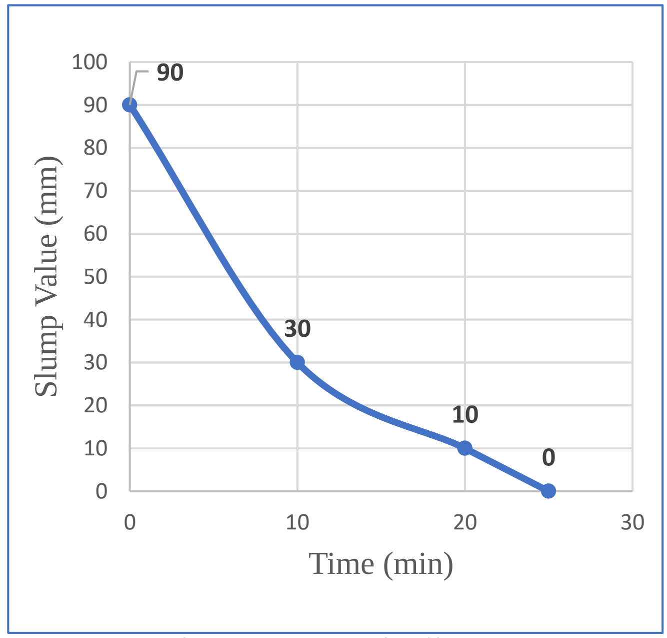

figure 6: slump loss of 0.1%PPF.

Figure 7, figure 8, slump loss of mixes in presence of superplasticizer constant dose 2% and polypropylene fiber 0.05% and 0.1%, no effect of PPF in presence of SP on workability.

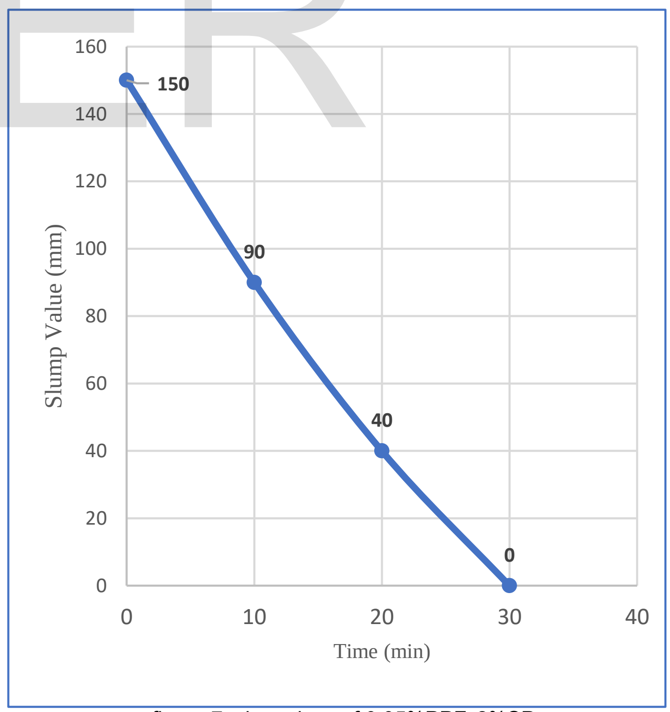

figure 7: slump loss of 0.05%PPF, 2%SP.

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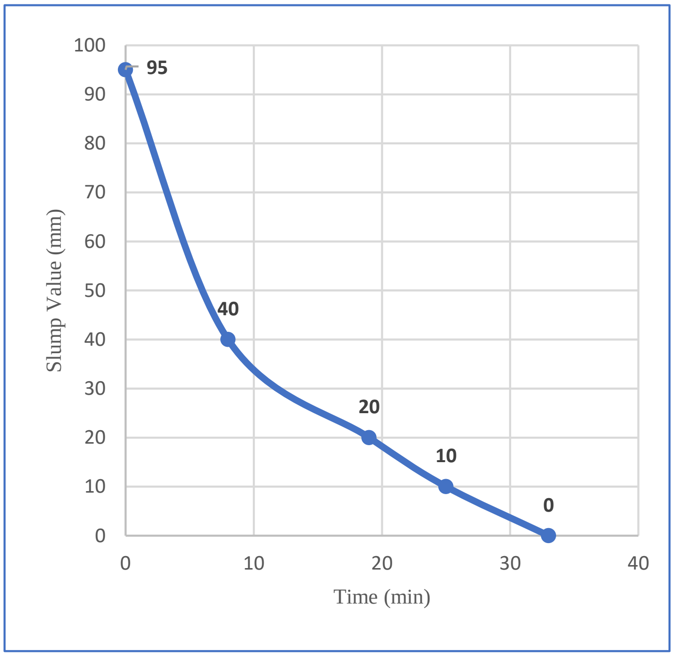

figure 8: slump loss of 0.1 %PPF, 2% SP.

figure 9, shows the initial setting time and time for slump loss [18], in absence of PPF and SP for sample GPC2, in presence 0.05%, 0.1% PPF for samples GPC5, GPC8 and in presence 0.05%, 0.1%PPF, in addition to 2% SP, notice that the concrete reaches initial setting time at approximately the same time that needed to slump loss.

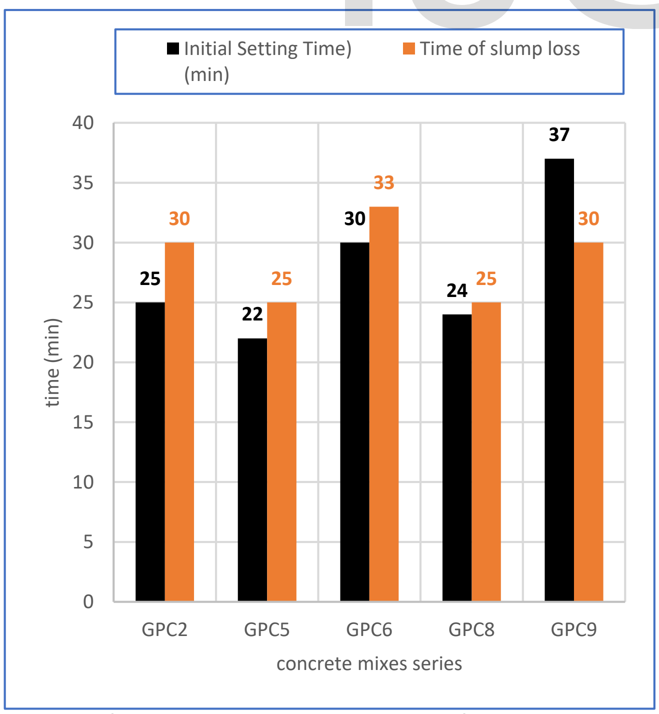

figure 9: initial setting time and time of slump loss.

4.2 Setting time

Setting time is an important property of concrete. Depending on the degree of hardened, divided into two parts: (a)initial setting time, (b) final setting time ASTM C403 the initial and final setting times determined as shows in figure 10, the time when the penetration resistance is 3.5 MPa and 27.6 MPa, respectively, figure11, shows mould of setting time test and initial, final setting time of control sample 25min, 94 min respectively.

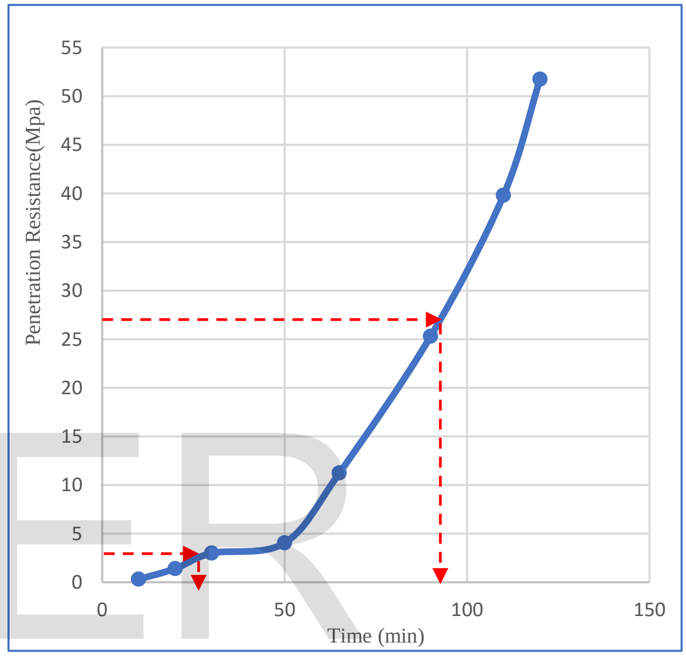

Figure 10: Performed setting time test of control.

Figure 11: mould of Setting Time Test.

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Figure 12, shows the effect of polypropylene fiber on setting time of samples (GPC2, GPC5, GPC8), based on results, the presence of polypropylene fibers at 0.05% and 0.1% low affect the initial setting time, but it has a noticeable effect on the final setting time. at 0.05% fibers, there was a decrease in the final setting time of approximately 11% for sample (GPC8), at 0.1% fibers, there was a decrease in the final setting time of approximately 17% for sample (GPC5).

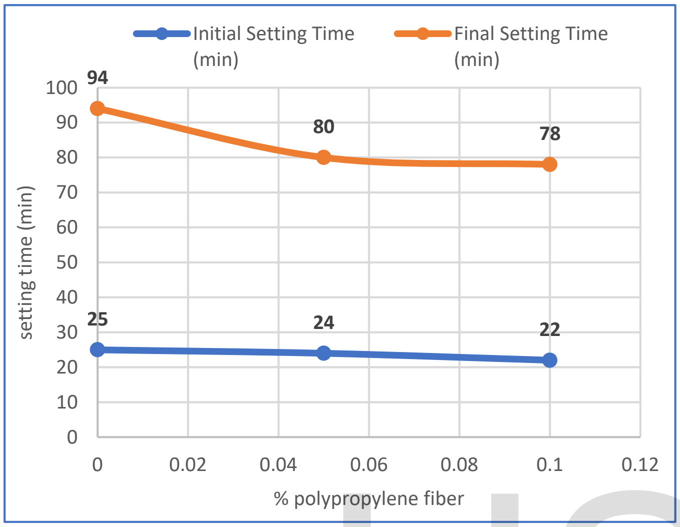

Figure 12: Effect of PPF on Setting Time.

5. Conclusions

The main objective of this study is to evaluate the effects of polypropylene fibers on the fresh properties of geopolymer concrete. Based on the experimental results, the main conclusions can be drawn as follows:

- The presence of polypropylene fiber in concrete mixes Affects either decrease or increase on fresh properties, these changes vary in increase and decrease manner depending on the feature we are studying.
- Presence of polypropylene fibers, decreased the workability of geopolymer concrete.
- use of polypropylene fibers, no effect on the initial setting time, but it significantly affects the final setting time.
- Polypropylene fibers reduce the time required to slump loss of concrete.

5. RECOMMENDATIONS FOR FURTHER

This research was limited on studying one type of binder and fiber., Therefore, the study must be applied to different types of by-product materials as well as fibers to study the extent of their effect on the fresh properties of geopolymer concrete in addition to other variables such as the type of alkaline activator used and its concentration.

ACKNOWLEDGEMENTS

The authors would like to thank all the members of properties and testing of materials laboratory for their help in experimental work.

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