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EFFECT OF BORAX ON SETTING TIME OF GEOPOLYMER CONCRETE BASED ON FLY ASH TYPE C

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ABSTRACT
Geopolymer concrete is a new type of concrete that does not use cement as a binder at all. In addition to replacing cement, the use of fly ash in concrete can reduce coal emissions from many coal-fired power plants. However, geopolymer concrete has drawbacks, one of which is that it has a setting time that tends to be too fast. Therefore, this study aims to determine the effect of adding borax on the hardening time and compressive strength of geopolymer concrete. With the addition of 1%, 3%, 5%, and 10% borax. The ratio of activator Na_2SiO_3 and NaOH is used 2.5:1 with a molarity of 10M NaOH. Variations in the addition of borax during mixing include 1%, 3%, 5% and 10% by weight of fly ash. The test results showed that the higher the borax content added, the longer the setting time. The longest final setting time was achieved in geopolymer concrete with the addition of 10% borax for 480 minutes.

Keywords: Geopolymer concrete, setting time, borax.

INTRODUCTION

Geopolymer concrete is a new type of concrete that does not use cement as a binder. Because it contains the chemical elements Si and Al, fly ash is one of the materials used to produce geopolymer concrete (Salain et al., 2020). In addition to replacing cement, fly ash in concrete can reduce coal emissions from many coal-fired power plants.

Despite its many advantages, geopolymer concrete has drawbacks. One of them is having a setting time that tends to be too fast.

Therefore, this study aims to determine the effect of adding borax on the geopolymer concrete's hardening time and compressive strength. It adds borax to fly ash type C concrete for PLTU PT. Cirebon Power with alkaline activator Na_2SiO_3 and NaOH. The addition of borax is to slow down the setting time.

LITERATURE REVIEW

Geopolymer

Geopolymer concrete contains large amounts of alumina and silicon oxide from organic or inorganic materials (Joseph Davidovits, 1994). Geopolymer concrete is a new form of concrete that does not contain cement. In the inorganic polymerization process (geopolymer) developed by French scientists (Salain et al, 2020), materials containing aluminum (Al) and silicon dioxide (Si) are used as perfect cement substitutes. According to J. Davidovits (1991), the geopolymer concrete polymer process is a chemical reaction between alkali and Si-Al, which produces a consistent Si-O-Al-O structural bond. Because fly ash contains the chemical elements Si and Al, it is one of the materials used in the production of geopolymer concrete.

Fly Ash

Fly ash is ash in powder form made from other coals burned in PLTU. The composition of fly ash mainly consists of

silicate dioxide (SiO2), aluminum (Al2O3), iron (Fe2O3), calcium (CaO), and limited amounts of magnesium, potassium, sodium, titanium, and sulfur (Kusnan, 2019).

Based on the ACI Manual of concrete practice 1993 Part I 226.3R-3), fly ash has three types:

1. Type C
2. Type F
3. Type N

The study uses type C fly ash because it has CaO > 10%, while class F has CaO < 10%.

Alkali Activator

The ratio of sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solutions used is 2.5: 1. The molarity used is 10M. Solvents are prepared separately and allowed to stand for 24 hours before mixing. Alkaline activator solvent is in the process of geopolymerization of geopolymer concrete.

Borax

Na2B4O7.5H2O is the scientific name for borax, which is sodium tetraborate pentahydrate. At normal temperature and pressure, it will form odorless white crystals and remains stable (Wardana, 2021). In this study, borax is added to geopolymer concrete because the material is easy to obtain, and from an economic point of view, the price is affordable. In the previous research, the addition of borax to geopolymer concrete can also increase the setting time.

Borax is a compound that can be added to geopolymer concrete as an additive (Purwantoro et al., 2016). Increasing the addition of borax can lengthen the setting time. The more borax added, the longer the binding time will be (Antoni et al., 2016).

Vicat

The setting time test uses the Vicat tool. The setting time is divided into two parts, the initial setting time and the final setting time. The time required for cement to mix with water from a plastic state to become non-plastic and for cement to mix with water from a plastic state to harden are called the initial setting time and the final setting time. Each cement paste cannot be loaded by either its weight or external loads when it reaches final hardness at the bond ends (Muhammad et al., n.d. 2021).

RESEARCH METHOD

This research refers to SNI 03-6827-2002. The Vicat testing is performed at Universitas Trisakti's Concrete Laboratory.

RESEARCH RESULTS

Material Requirements for Vicat Testing

The need for Vicat testing according to the proportions used can be seen in Table 1.

Table 1: Material Requirements for Vicat

Ket.	Material (gr)			
	Boraks	*Fly Ash*	Na_2SiO_3	NaOH
BGOB	0	300	149.4	43.2
BG1B	3	297	147.906	42.77
BG3B	9	291	144.918	41.9
BG5B	15	285	141.93	41.04
BG10B	30	270	134.46	38.88

Ket. = Info
Boraks = Borax

Information:

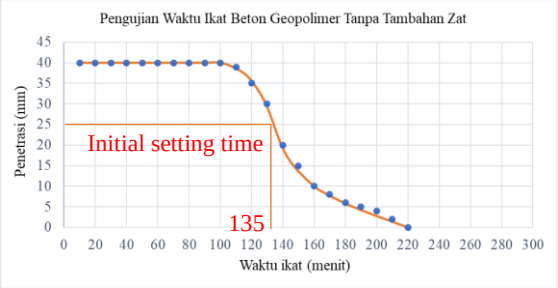
- BG0B = Geopolymer concrete without any borax addition
- BG1B = Geopolymer concrete with the addition of 1% borax
- BG3B = Geopolymer concrete with the addition of 3% borax

- BG5B = Geopolymer concrete with the addition of 5% borax
- BG10B = Geopolymer concrete with the addition of 10% borax

Vicat BG0B Testing

Vicat testing was performed on geopolymer paste without additives using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste without additives was at minute 135, and the final setting time was at minute 220.

Geopolymer Concrete Setting Time Testing without any additive

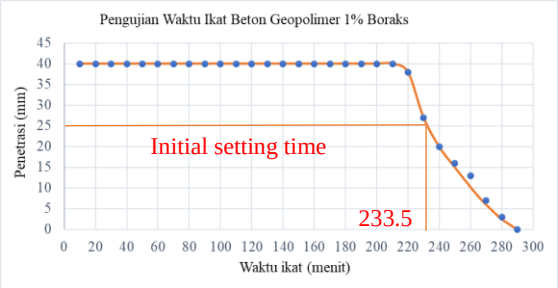


Penetration (mm)
Setting time (minute)
Figure 1. BG0B Setting time graphic

Vicat BG1B Testing

The Vicat test was performed on geopolymer paste with 1% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 1% borax was at minute 233.5, and the final setting time was at minute 290.

Geopolymer Concrete Setting Time Testing with 1% borax

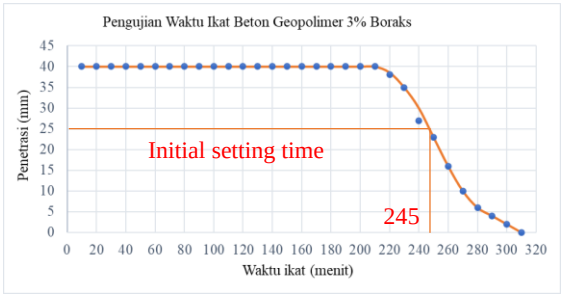


Penetration (mm)
Setting time (minute)
Figure 2. BG1B Setting time graphic

Vicat BG3B Testing

The Vicat test was performed on geopolymer paste with 3% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 3% borax was at minute 245, and the final setting time was at minute 310.

Geopolymer Concrete Setting Time Testing with 3% borax

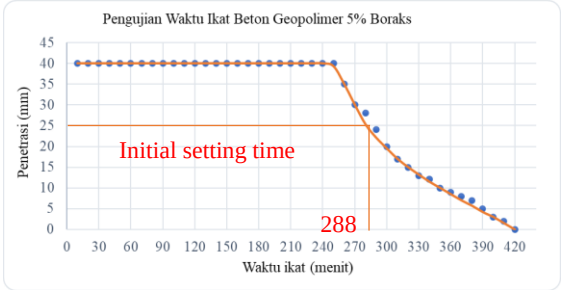


Penetration (mm)
Setting time (minute)
Figure 3. BG3B Setting time graphic

Vicat BG5B Testing

The Vicat test was performed on geopolymer paste with 5% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 5% borax was at minute 288, and the final setting time was at minute 420.

Geopolymer Concrete Setting Time Testing with 5% borax

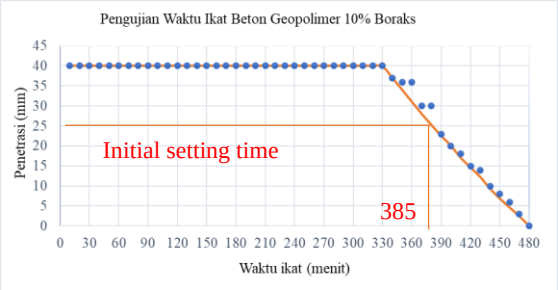


Penetration (mm)
Setting time (minute)
Figure 4. BG5B Setting time graphic

Vicat BG10B Testing

The Vicat test was performed on geopolymer paste with 10% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 10% borax was at minute 385, and the final setting time was at minute 480.

Geopolymer Concrete Setting Time Testing with 10% borax



Penetration (mm)
Setting time (minute)
Figure 5. BG10B Setting time graphic

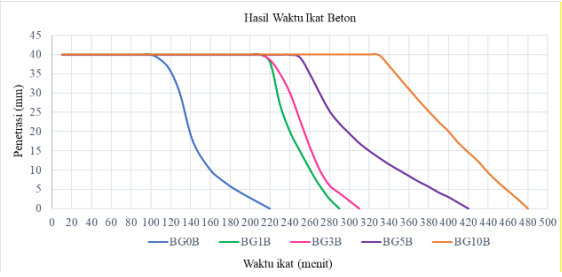
Vicat Testing Result

The results of the setting time of geopolymer concrete based on type C fly ash are as follows:

Table 2: Concrete Vicat testing result

Info.	Setting Time (minute)
BGOB	220
BG1B	290
BG3B	310
BG5B	420
BG10B	480

Concrete Setting Time Result



Penetration (mm)
Setting time (minute)
Figure 6. Concrete's setting time graphic

Figure 1 shows that borax addition to geopolymer concrete will slow down the hardening time of the concrete. The more the use of borax, the longer the hardening time of the concrete.

In this study, the longest setting time was the BG10B variation or the addition of 10% borax by weight of fly ash, which was 480 minutes. According to previous research, borax addition can prolong the setting time. The more borax was added, the longer the setting time was needed (Antoni et al., 2016)

CONCLUSION

1. Geopolymer concrete without additives has the fastest setting time among the other variations, which is 220 minutes.
2. The more borax was added, the longer the concrete setting time was needed.
3. The addition of borax to geopolymer concrete can slow down the setting time of concrete. The longest setting time is with 10% borax, which is 480 minutes.

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2. Type F
3. Type N

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The ratio of sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solutions used is 2.5: 1. The molarity used is 10M. Solvents are prepared separately and allowed to stand for 24 hours before mixing. Alkaline activator solvent is in the process of geopolymerization of geopolymer concrete.

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BG5B	15	285	141.93	41.04
BG10B	30	270	134.46	38.88

Ket. = Info
Boraks = Borax

Information:

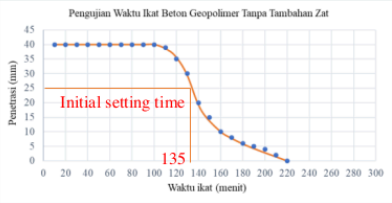
- BG0B = Geopolymer concrete without any borax addition
- BG1B = Geopolymer concrete with the addition of 1% borax
- BG3B = Geopolymer concrete with the addition of 3% borax

- BG5B = Geopolymer concrete with the addition of 5% borax
- BG10B = Geopolymer concrete with the addition of 10% borax

Vicat BG0B Testing

Vicat testing was performed on geopolymer paste without additives using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste without additives was at minute 135, and the final setting time was at minute 220.

Geopolymer Concrete Setting Time
Testing without any additive

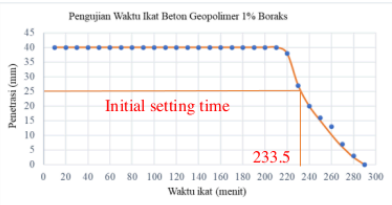


Penetration (mm)
Setting time (minute)
Figure 1. BG0B Setting time graphic

Vicat BG1B Testing

The Vicat test was performed on geopolymer paste with 1% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 1% borax was at minute 233.5, and the final setting time was at minute 290.

Geopolymer Concrete Setting Time
Testing with 1% borax

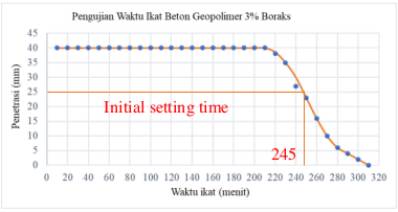


Penetration (mm)
Setting time (minute)
Figure 2. BG1B Setting time graphic

Vicat BG3B Testing

The Vicat test was performed on geopolymer paste with 3% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 3% borax was at minute 245, and the final setting time was at minute 310.

Geopolymer Concrete Setting Time
Testing with 3% borax

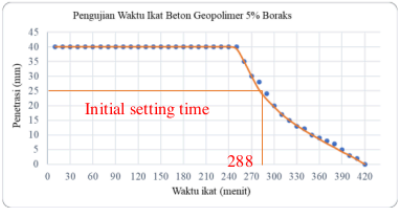


Penetration (mm)
Setting time (minute)
Figure 3. BG3B Setting time graphic

Vicat BG5B Testing

The Vicat test was performed on geopolymer paste with 5% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 5% borax was at minute 288, and the final setting time was at minute 420.

Geopolymer Concrete Setting Time
Testing with 5% borax

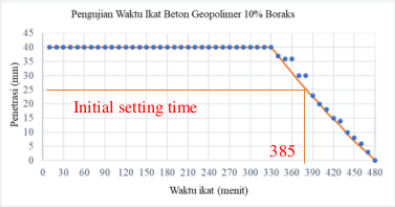


Penetration (mm)
Setting time (minute)
Figure 4. BG5B Setting time graphic

Vicat BG10B Testing

The Vicat test was performed on geopolymer paste with 10% borax using the Vicat tool. The initial setting time (decreased to 25 mm) of geopolymer paste with 10% borax was at minute 385, and the final setting time was at minute 480.

Geopolymer Concrete Setting Time Testing with 10% borax



Penetration (mm)
Setting time (minute)
Figure 5. BG10B Setting time graphic

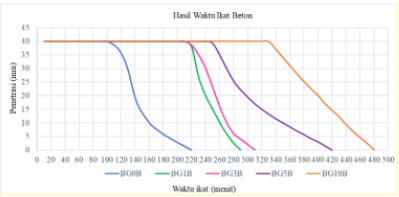
Vicat Testing Result

The results of the setting time of geopolymer concrete based on type C fly ash are as follows:

Table 2: Concrete Vicat testing result

Info.	Setting Time (minute)
BGOB	220
BG1B	290
BG3B	310
BG5B	420
BG10B	480

Concrete Setting Time Result



Penetration (mm)
Setting time (minute)
Figure 6. Concrete's setting time graphic

Figure 1 shows that borax addition to geopolymer concrete will slow down the hardening time of the concrete. The more the use of borax, the longer the hardening time of the concrete.

In this study, the longest setting time was the BG10B variation or the addition of 10% borax by weight of fly ash, which was 480 minutes. According to previous research, borax addition can prolong the setting time. The more borax was added, the longer the setting time was needed (Antoni et al., 2016)

CONCLUSION

1. Geopolymer concrete without additives has the fastest setting time among the other variations, which is 220 minutes.
2. The more borax was added, the longer the concrete setting time was needed.
3. The addition of borax to geopolymer concrete can slow down the setting time of concrete. The longest setting time is with 10% borax, which is 480 minutes.

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