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THE CONNECTION BETWEEN OVEN CURING DURATION AND COMPRESSIVE STRENGTH ON C-TYPE FLY ASH BASED-GEOPOLYMER MORTAR

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ABSTRACT

Oven curing gives effect to the strength of geopolymer mortar. The geopolymer mortar treated by curing oven with measured duration and temperature. Temperature and term used in the oven curing on the geopolymer mortar. They affect the strength of geopolymer mortar. This study aimed to determine the connection of duration and temperature used in the curing oven to the compressive strength of C-type fly ash based geopolymer mortar. The constituent material of geopolymer mortar is activators, fly ash, and sand - the activator using NaOH and Na_2SiO_3. A comparison of fly ash and sand is 1: 2.75. Comparison NaOH: Na_2SiO_3 is 1: 2 and 10 M NaOH. Oven temperature variations used45ºC, 65ºC, 85ºC, 105ºC, and 125ºC, and differences in the duration of use 20 hours, 10 hours, 8 hours, 6 hours, and 4 hours. The results showed that the connection of temperature and term used in the oven curing of the compressive strength of geopolymer mortar is significant. The relationship between duration and compressive strength has a non-linear polynomial equation negative. The period and temperature optimal for curing C-type Fly Ash based geopolymer mortar is the temperature of 105oC and the duration of 8 hours.

Keyword: mortar, geopolymer, C-Type fly ash, duration, curing.

1. INTRODUCTION

The use of coal as an energy source in the industry produce by-products such as ash in the form of fly ash and bottom ash (bottom ash). Particle size of fly ash is tiny so it is easy flying in the air that causes air pollution, most of the fly ash is not appropriately used or used only as a heap. Hoarding indiscriminate very likely threaten the environment. Besides, the particles of heavy metals they contain soluble and contaminate water sources.

Demand for cement is increasing along with the development of infrastructure that is more to the concrete construction. The main ingredient in the manufacture of concrete is cement. The use of Portland cement in large quantities is not inevitable. In fact, we know that the cement industry produced the greatest emissions from the industrial sector. Emissions of greenhouse gases (carbon dioxide, CO_2) generated by the cement industry comes from the calcination reaction or due to the use of fossil fuels during the production process. The cement manufacturing process will result in emissions of one (1) ton of CO_2 into the atmosphere in every production of 1 ton of Portland cement. Therefore, it has various types of efforts that have been and are being taken to minimize CO_2 emissions. Besides, reduce/avoid the use of cement in concrete by replacing some or all of the cement with a more environmentally friendly material that is fly ash which is a waste burning coal. For that effort to find alternative materials on a concrete tie which is more environmentally friendly as a substitute for Portland cement is the main focus of numerous studies on concrete.
Fly ash is an aluminosilicate material that is pozzolan that can react with $Ca(OH)_2$ which is a by-product of cement hydration reaction. The results of this reaction is a gel pozzolan calcium silicate hydrate (CSH), so if used in conjunction with Portland cement, fly ash then have to wait for the cement hydration reaction. The proportion of normal use of fly ash in concrete is usually capped at 30% (Malhotra 1996). It is to be a limitation in the use of fly ash in large quantities and also became a limitation to reduce dependence on Portland cement. Some research suggests that a material containing silica and alumina (aluminosilicate) has the potential to become the connective material similar to Portland cement when activated with alkali. In this case.

Geopolymer concrete is an environmentally friendly concrete for not using cement as concrete forming material. Geopolymer concrete quality can chek of the strength and resilience. The strength of a mortar/concrete is strongly influenced by the porosity of material as Erniati *et al* (2014, 2015) that the higher the porosity of the lower strength values. Besides the quality of the concrete is also influenced by curing. As Erniati B. (2018) that the value of the concrete strength will drop if without curing.

Geopolymer research by Adams *et al* (2009a, b) to take advantage of the power plant fly ash waste, with the result that the fly ash has good potential as a replacement for portland cement in producing mortar or concrete. Aravindan S., *et al*, 2015 has also been examined geopolymer with the result that the geopolymer concrete using fly ash material higher base strength than the conventional concrete.

Geopolymer mortar research still found strength varies greatly because of the difficulty of compositions and methods of the duration and the curing of the mortar/concrete fly ash geopolymer with a different base. As Erniati *et al* (2018) have examined the mortar using fly ash geopolymer different and using oven curing and curing with temperature room. The results showed that the

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temperature and the type of fly ash greatly affect the strength of geopolymer mortar.

Geopolymer strength depends on the type of fly ash and the activator used. Previous research on geopolymer, use activator Bakharev (2005) and Fernandez-Jimenez and Palomo (2005), manufacture of geopolymer utilizing a combination of sodium silicate and sodium hydroxide produces the best compressive strength.

Geopolimerisasi reaction in the process of formation of geopolymer mortar strongly influenced optimal drying temperature and time to achieve higher power (Adam A and Harianto, 2014; Pradnya K. Jamdade, 2016).

Budh and Warhade (2014) have been conducting research geopolymer mortar with the result that the curing temperature and molarity affect compressive strength. Curing at a temperature of 85ºC at 48 hours showed increased strength geopolymer mortar.

Based on the above, the researchers are interested in examining how the duration and curing of the mortar and fly ash-based geopolymer type C. It is expected that these results will strengthen the national innovation system specially developed material that is environmentally friendly and industry will also be able to use the waste to produce a friendly concrete technology an environment that has a strong strength and endurance in a corrosive environment.

2. RESEARCH METHODS

A. Materials

The preparation of geopolymer mortar samples using several local materials is fly ash, the activator, and the aggregate fines. Fly ash comes from coal-fired power plants in Jenneponto, South Sulawesi.

B. The design

Making geopolymer mortar samples based on SNI 03-6825-2002. Binder used is fly ash. The ratio between fly ash and sand is 1: 2.75. The rate of activators and fly ash is 0.3. The ratio of $Na2SiO3$ and NaOH is 2. NaOH composition using 10 M. Oven temperature variations are use45ºC, 65ºC, 85ºC, 105ºC and 125ºC, and the change in the duration of use is 20 hours, 10 hours, 8 hours, 6 hours, and 4 hours.

C. The experimental

There are several stages of this research, namely the preparation of materials and equipment, the characteristics of the materials used in the manufacture of samples, the design mix of geopolymer mortar mixtures, curing ovens, compressive strength test according to the planned age. Test of compressive strength (MPa) Based on ISO standards. Count of compressive strength (f'c) obtained by the maximum value in Newton (P) and then divided by the value of the sample surface area (mm^2).

3. RESULT AND DISCUSSIONS

A. Characteristics of fine aggregate

The research sample using materials of natural aggregate is fine aggregate from the district Takalar. Testing characteristics of fine aggregate conducted at the Laboratory of Structural and Materials Engineering Faculty of Civil Engineering at Fajar University. The testing of this aggregate refers to the SNI (Indonesian National Standard). The results of the examination of fine aggregate (sand) carried out before the manufacture of the test object can be seen in Table-1.

Table-1. Fines aggregate characteristics.

No.	Checking type	Standard (SNI)	Result
1	Fineness Modulus	1.50 to 3.80	2,54
2	Specific gravity (SG):		
	a. SG Real	1.60 to 3.30	2,54
	b. SG Dry Basis	1.60 to 3.30	2,63
	c. SSD	1.60 to 3.30	2.57
3	Weight Volume:		
	a. Solid condition	1.4 to 1.9 kg / ltr	1.85 kg / ltr
	b. friable condition	1.4 to 1.9 kg / ltr	1.68 kg / ltr
4	Water content	2% - 5%	2.94%
5	Sludge levels	Max. 5%	2.51%
6	Organic Content	<No. 3	No. 1
7	Water absorption	Max. 2%	1.37%

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B. Microstructure fly ash

Observation of the characteristics of fly ash using a microstructure because the size of fly ash is tiny. There are two observations made of compounds that fly ashes with X-Ray Fluorescence (XRF) and Scanning Electron Microscopy (SEM) test equipment. Table-2 shows the chemical content of fly ash.

Table-2. Chemical Content in fly ash by XRF.

No.	Parameter	%
1	SiO_2	46.81
2	CaO	20.23
3	Fe_2O_3	13.84
4	Al_2O_3	13.33
5	SO_3	3.04
6	K_2O	1.30
7	Ti_2O_2	1.20
8	SrO	0.107
9	BAO	0.0363
10	ZrO_2	0.0500
11	Nb_2O_5	0.0106
12	Y_2O_3	0.0079

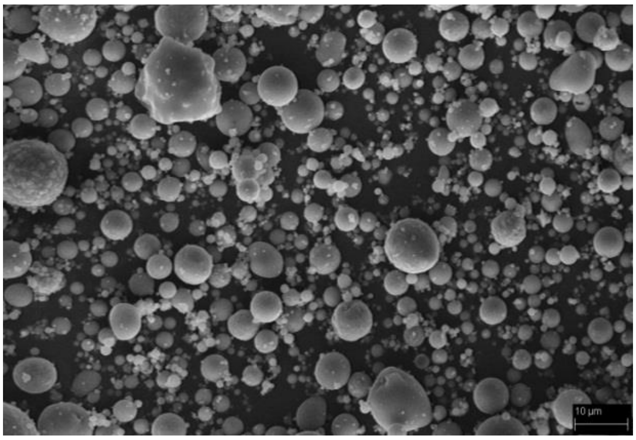

Figure-1. Microstructure of fly ash using a magnification of 2500×by SEM tool.

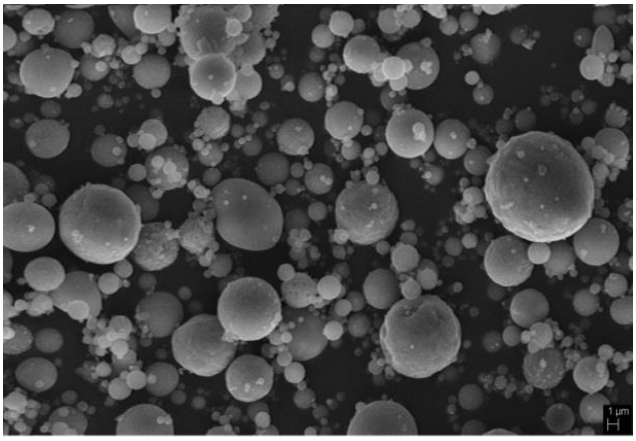

Figure-2. Microstructure of fly ash using a magnification of 5000× by SEM tool.

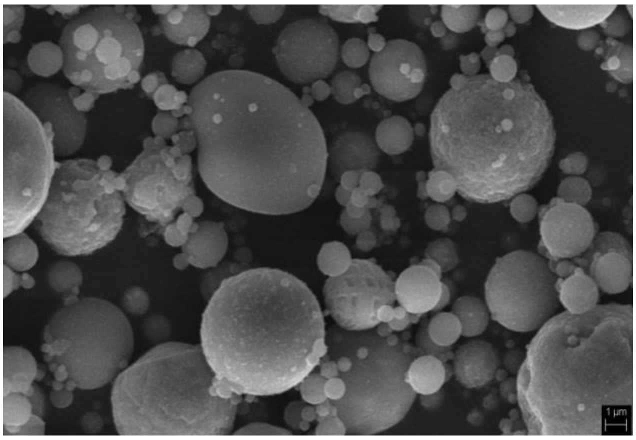

Figure-3. Microstructure of fly ash using a magnification 10.000× by SEM tool.

The results of the analysis of the fly ash microstructure using SEM, which Figure-1; Figure-2; Figure-3 and Figure-4 were described. Figure-1 shows the microstructure of fly ash with the enlargement of 2500x; Figure-2 displays the microstructure of fly ash with the expansion of 5000x, Figure 3 displays the microstructure of fly ash with a magnification of 10.000×, Figure-4 shows the microstructure of fly ash with a magnification of 20.000×

The microstructure of fly ash, as in Figures 1, 2, 3 and 4, shows that the fly ash is round with varying sizes.

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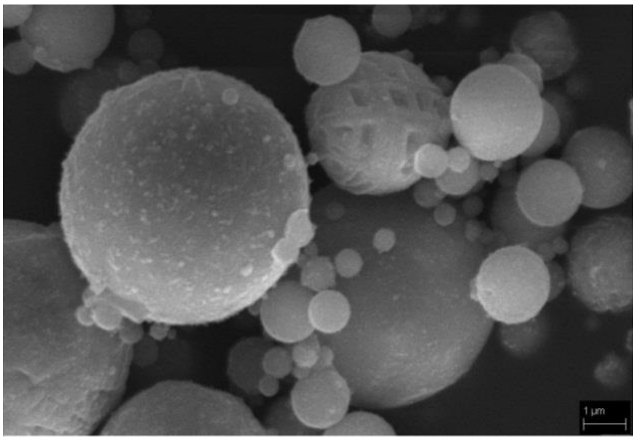

Figure-4. Microstructure of fly ash using a magnification 20.000× by SEM tool.

C. Compressive strength

Mortar compressive strength of geopolymer depends on curing. As shown in Figure-5, Figure-6, Figure-7, Figure-8 and Figure-9 illustrates the connection and the duration of the compressive strength of geopolymer mortar. The connection seems clear that the form of nonlinear equations. Of each variation in temperature, it shows that the higher the duration, the higher the compressive strength value, however, have a duration value optimum value.

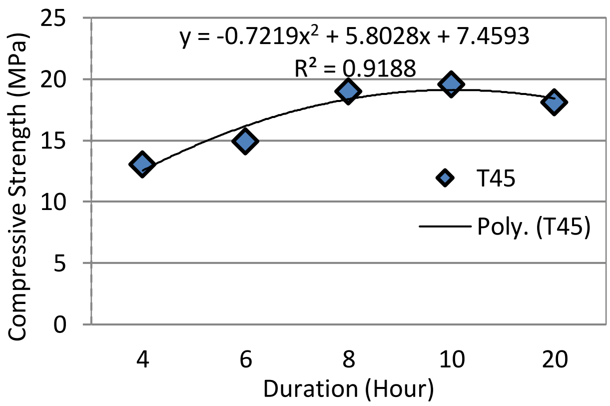

Figure-5. Connection duration (time) curing the Geopolymer Mortar compressive strength value on the age at 45°C.

Figure-5 shows the connection duration (time) curing mortar with the compressive strength of geopolymer on the age at 45°C at 28 days. That connection resulted in a nonlinear connection polynomial equation y = -0.7219x2 + 5.8028x +7.4593 and the value of R^2 = 0.9188. The non-linear equation produces the correlation value is approaching the number 1. Thus Relations duration (time) curing the Geopolymer Mortar compressive strength value on the age at 45°C at 28 days is very significant. Figure 5 also seen that if the duration is over 10 hours, the compressive strength value down.

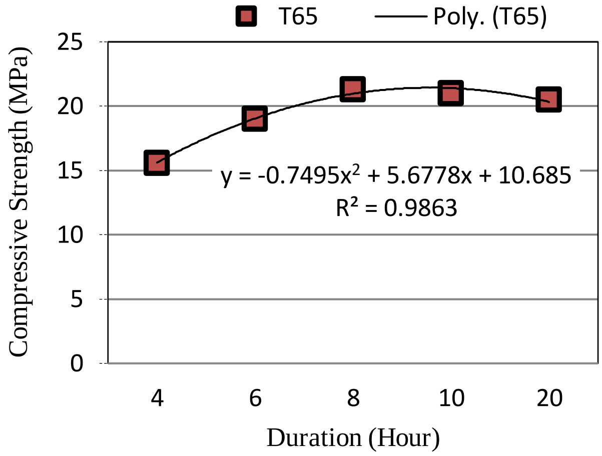

Figure-1. Connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 65°C.

Figure-6 shows the connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at temperatures of 65oC at 28 days. That connection resulted in a nonlinear connection polynomial equation y = -0.7495x2 + 5.6778x + 10 685 and the value of R^2 = 0.9863. The non-linear equation produces the correlation value is approaching the number 1. Thus Relations duration (time) curing with the compressive strength at the age of Geopolymer Mortar at temperatures of 65°C at 28 days is very significant. In Figure 6 can also be seen if a greater duration of 8 hours, then the compressive strength drops.

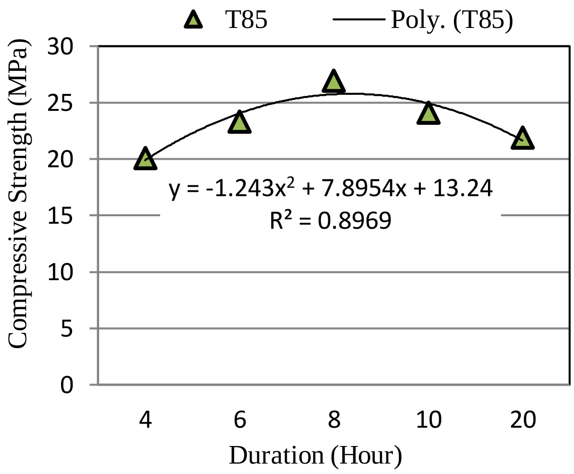

Figure-7. Connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 85°C.

Figure-7 shows the connection Relations duration (time) curing with the compressive strength at the age of Geopolymer Mortar at temperatures of 85°C at 28 days. That connection resulted in a nonlinear connection polynomial equation y = -1.243x2 + 7.8954x + 13.24 and

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the value of R^2 = 0.8969. The non-linear equation produces more than 0.85 correlation values are close to 1. Thus Relations duration (time) curing with the compressive strength at the age of Geopolymer Mortar at temperatures of 85ºC at 28 days is significant. Figure 7 is also seen if a greater duration of 8 hours, then the compressive strength drops.

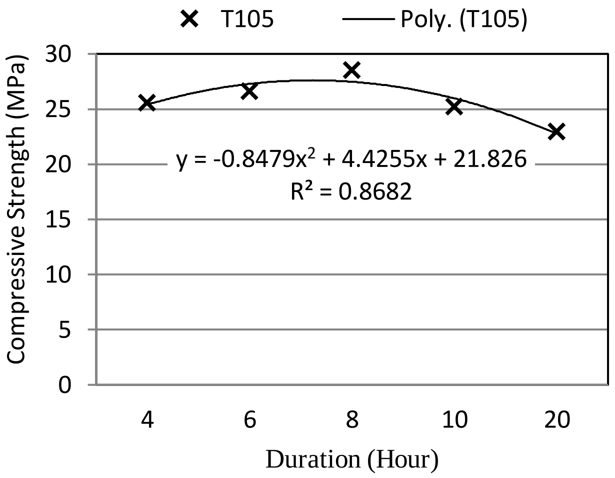

Figure-8. Connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 105ºC.

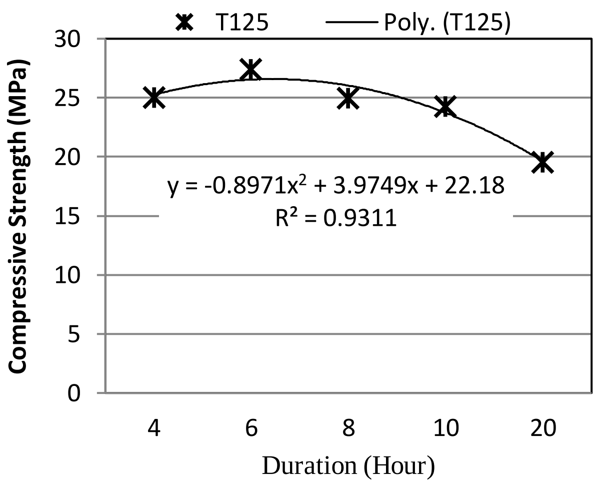

Figure-9. Connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 125ºC.

Figure-8 shows the connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 105ºC at 28 days. That connection resulted in a nonlinear connection polynomial equation y = -0.8479x2 + 4.4255x + 21 826 and the value of R^2 = 0.8682. The non-linear equation produces more than 0.85 correlation values are close to 1. Thus the connection duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 105ºC at 28 days is significant. Figure-8 also seen if a greater duration of 8 hours, then the compressive strength drops.

Figure-9 shows the connection Relations duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 125ºC at 28 days. That connection resulted in a nonlinear connection polynomial equation y = - + 3.9749x + 0.8971x2 22:18 and the value of R^2 = 0.9311. The non-linear equation produces more than 0.85 correlation values are close to 1. Thus Relations duration (time) curing with the compressive strength at the age of Geopolymer Mortar at a temperature of 125ºC at 28 days is significant. Figure 9 is also seen if the duration is greater than 6 hours, then the compressive strength down.

Of the five temperatures (45, 65, 85, 105, and 125)°C used were obtained connection polynomial nonlinear equations and correlation values above 0.85. That means that the relationship of the duration of curing is a very significant geopolymer mortar.

D. Duration and temperature of optimal on geopolymer mortar

Recapitulation of geopolymer mortar compressive strength with temperature variations and different curing it can be seen that the optimal value in Figure-10.

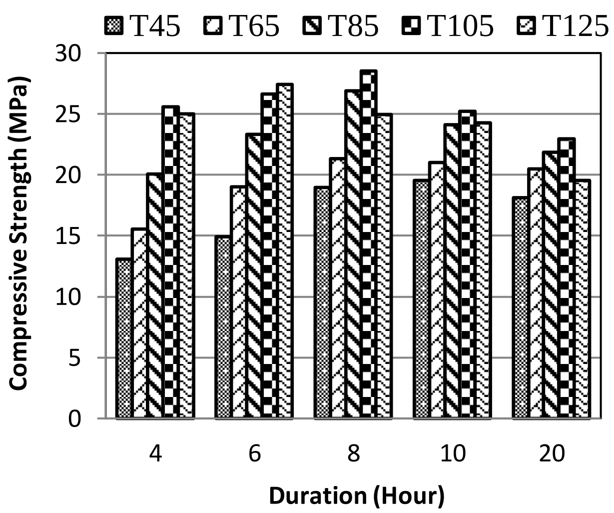

Figure-10. The connection of duration and temperature (time) curing the compressive strength value of Geopolymer Mortar.

Figure-10 shows that the on duration of 4 hours, the compressive strength is highest at 105ºC temperature of 25.57 MPa. Duration curing 6 Hours value, compressive strength is highest at 125ºC temperature of 27.43 MPa. Curing duration of 8 hours, the compressive strength is highest at 105ºC temperature of 28.53 MPa. Duration of 10 hours, the compressive strength is highest at 105ºC temperature of 25.22 MPa. Duration 20 hours, the compressive strength is highest at 105ºC temperature of 22.95 MPa. Thus the optimal duration and temperature for curing the base of geopolymer mortar type C is the temperature of 105ºC and the duration of 8 hours.

Adam A and Harianto (2014), describes in his paper that the results that the highest compressive strengths obtained on duration and temperature of drying 120°C and 20 hours.

In contrast to the results of research Pradnya Jamdade K. (2016), the optimum strength of concrete is achieved at 90°C within duration of between 18-24 hours and a longer curing time increases the polymerization process to produce Geopolymer concrete compressive strength is higher.

4. CONCLUSIONS

The microstructure of type C fly ash has a spherical shape with sizes varying from 0.2 to 12. Fly ash can be used as material geopolymer mortar. The duration and temperature of the geopolymer mortar oven curing have a connection with a significant compressive strength mortar. Connection duration of curing and compressive strength of mortar to form a negative polynomial nonlinear equation. At a temperature of 45ºC, the compressive strength will drop if the duration of which is used for more than 10 hours. At a temperature of 65ºC, the compressive strength will drop if the duration of which is used for more than 8 hours. At a temperature of 85ºC, the compressive strength will drop if the duration of which is used for more than 8 hours. At a temperature of 105ºC, the compressive strength will drop if the duration of which is used for more than 8 hours. At a temperature of 125ºC, the compressive strength will drop if the duration of which is used for more than 6 hours.

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