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THE EFFECT OF EPOXY RESIN AND CEMENT ON SOIL AND PILE INTERFACE FRICTION IN DIRECT SHEAR

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The foundation is an underground construction that functions to deliver loads to the ground. The foundation is used in unfavorable soil conditions where hard soils are found to be very deep. In Supporting the load above it, the pile foundation behavior relies on end bearing, friction resistance and combined end bearing and friction resistance. There are several factors that influence the behavior of the pile in supporting the load, namely the type of soil and the method of mounting the pile (put or drilled). At the piles that are located on cohesive soil and the bearing capacity is less profitable, the pile behavior relies on pile friction resistance. As for the pile mounting method in cohesive soils, it will usually result in a rise in ground level around the pile, followed by soil consolidation. To minimize the increase in surrounding soil, the drill is made first, and the precast pile is inserted into the drill hole without being fixed. In the implementation of the drilling method, the diameter of the hole is made larger than the diameter of the pile, so there is no bond between the pile and the surrounding soil. To fill the empty part of the drill hole, additional material is needed which is binding to the surrounding soil. This additional material is expected to be able to produce a pile resistance friction force against vertical loads. Additives used as ingredients added to this study are epoxy and cement resins which aim to increase friction resistance. This study examines the increase in friction resistance values on the soil and pile interfaces using direct shear. The test results show that the highest friction resistance values occur in the mixture with the proportion of soil: epoxy: cement is 62.5%: 25%: 12.5% with addition of 220 ml of water which is 1.1 kg / cm2 at 7 days curing time.

Key words: Epoxy resin, Interface, Friction resistence

INTRODUCTION

The foundation is an underground construction that functions to distribute loads to the soil. Deep foundation is used in unfavorable soil conditions where hard soils are found to be very deep. In Supported the load above it, the pile foundation behavior relies on end bearing, friction resistance and combined end bearing and friction resistance. There are several factors that influence the behavior of the pile in supporting the load, namely the type of soil and the method of pile installation (put or drilled). At the piles are located on cohesive soil and the bearing capacity is less profitable, the pile behavior relies on pile friction resistance. As for the pile installation method in cohesive soils, it will usually result in a rise in ground level around the pile, followed by soil consolidation. To minimize the increase in surrounding soil, the drill is made first, and the pile is inserted into the bore hole without being fixed. In drilling, the diameter of the hole is made larger than the diameter of the pile, so there is no bond between the pile and the surrounding soil. To fill the empty part of the drill hole, additional material is needed which is binding to the surrounding soil. This additional material is expected to be able to produce a pile resistance friction (side friction) against vertical loads. Additives used as ingredients added to this study are epoxy and cement resins which aim to increase friction resistance. The main objective of this study was to determine the composition of the optimum mixture of soil paste, cement, and epoxy which functioned as a binder between the pile and soil and the time of the liquid phase. The experiment was carried out by observing the paste mixture which has a fixed soil, cement and epoxy composition with the addition of different water. Where the trial and error method is used to determine the addition of water needed. Observations were made on the paste mixture that was made. Observation of friction resistance (side friction) values on soil and pile interfaces is carried out on a laboratory scale using the Direct Shear Test. The direct shear test is very popular for the laboratory testing of soils owing to its simplicity. The shear force is measured with a bearing ring or a load cell that is attached to the upper shear box. A frictional force is generated at the attachment point when the upper shear box tends to move up/downward due to the volume change of the soil (sheared sample).

EPOXY REACTION TO A MIXTURE OF SOIL-CEMENT PASTE

Epoxy is a copolymer formed from two different chemicals, called resins and hardener. The resin itself consists of a short chain monomer or polymer with a group of epoxides at both ends. The most common epoxy resin is the reaction between epichlorohydrin and bisphenol-A. While hardener consists of polyamine monomers, for example Triethylenetetramine (Teta). When these two compounds are mixed (epoxy and hardener resin), the amine group reacts with the group of epoxides, so that the resulting polymer is so stiff and strong.

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The polymerization process is called "curing". Epoxy mixture basically tends to harden gradually and has a rather flexible texture and has good stickiness. Therefore, the epoxy mixture has the opportunity to be used as additional material in geotechnical engineering. Anagnostopoulus (2015), explained that in particular the experimental results showed a malfunction of epoxy resin in a mixture of clay soil with water. In his research the value of the strength of the paste was tested by adding water content even though water itself could adversely affect the development of paste strength, where the reduced initial strength might be due to the amount of water stored in the hydrophilic part of epoxy resin which inhibits the development of strength to a certain time limit. the chemical reaction between hardener and mixture that causes the development of strength.

To reduce the adverse effects caused by water on the paste mixture, cement is used as an ingredient that can consume large amounts of water due to pozzolanic reactions, this results in a reaction between epoxy resin and hardener which causes the mixture to increase strength. In addition, the presence of cement in the mixture causes an increase in alkalinity, which acts as a catalyst in the reaction between epoxy resin and hardener in the formation of cross-linked polymer structures.

FACTOR AFFECTING SOIL STRENGTH

Generally there are several factors which affects the soil and pile interface friction in the field,among others, soil properties (number of pores, size granules and distributions), type of soil, moisture content and type of load and level. Shear strength testing usually done in two levels, namely, with normal stress and administration shear stress until failure occurs until maximum shear stress is reached. According to Sosrodarsono 1987, Factors that influence decreasing soil shear strength :

1. Composition, geology structure and geometry of the field. Composition, material conditions can be weak (weak) on increasing water content. This occurs in clay soils more consolidated and highly consolidatedmore and organic clay soils.
2. Chemical / physical reactions:
   - Hydration of clay minerals such as absorption water by clay minerals so moisture content increases. This is usually followed with decreasing cohesion prices, for example Montmorillonite clay.
   - Depreciation of clay caused drying can cause cracks shrink so that the ground shear strength decreases andgiving a chance for water to flow in into it.
   - Erosion by water in clay soil "Dispersive" causes pore which decreases the soil shear strength.

Changes to the loading system include Because the soil stress decreases conditions more consolidated clay soil layers and highly consolidated ones previously it was burdened with a layer above itthen the top layer is excavated(discarded), can cause it to occur change in load on the clay layer causing reduced ground shear strength

RESEARCH METHODS

Table 1: Physical and Mechanical Properties of Soil

No	Physical and Mechanical Properties	Result
1	Specific gravity (Gs)	2,42
2	Water content (w)	53,24 %
3	Liquid limit (LL)	44,04 %
4	Plasticity limit (PL)	33,14 %
5	Plasticity index (PI)	10.91 %
6	Shrinkage limit (SL)	39.82 %
7	Dry unit weight (γd)	1,243 g/cm^3
8	Maximum Dry Density (MDD)	1,309 g/cm^3
9	Optimum moisture content (wopt)	33,02 %
10	Fraksi gravel, %	3,09 %
11	Fraksi sand, %	25,99 %
12	Fraksi silt, %	57,97 %
13	Fraksi clay, %	12,95 %

The soil used in this study were taken from Kedunglo village, Kemiri sub-district, Purworejo district, Yogyakarta. The test results of physical and mechanical properties of soil can be seen in Table 1.

Material Testing

Experimental investigations were carried out to obtain the optimum composition of soil paste, cement, and epoxy which functioned as a binder between the pile and soil along with the liquid phase time to observe the paste mixture which has a fixed soil, cement, and epoxy composition with the addition of different water. Where the trial and error method is used to determine the addition of water needed. With a comparison composition of soil, epoxy resin and cement is presented in the Table Composition of the mixture of soil paste, cement, and epoxy

The first stage before test is preparation of pile concrete material and soil (shown in Figure 1). Second stage is make a sample consisting of a mixture of soil, epoxy resin and cement is placed between soil and concrete samples. the scematic of sample is presented in Figure 2.

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The next stage is the main testing phase, namely the soil shear test, soil and pile interface friction using direct shear. The purpose of this test is to get friction values on the soil and pile interfaces with the addition of epoxy resin and cement. The first step in shear resistance test is soil samples test without a mixture of epoxy and cement. This aims to find out the shear resistance held by the soil without any reinforcement. The next step is to examine the soil and pile interface friction to obtain a large shear force that can be resisted by the soil mixture, epoxy and cement with several variations of the addition of water are presented in Table 2. From the results of research using Direct shear produces the maximum force value that can be held by soil and pile and after adding a mixture of soil, epoxy and cement. This maximum force value is called P max. At the time of testing, the P max value is obtained from the relationship data between the stresses and strains of each mixture at each confining stress of 1 kg/cm^2, 2 kg/cm^2 and 4 kg/cm^2. P_{max} value can be known when horizontal dial reading on the slide tool shows a constant or decreasing value. From the results of the shear test it does not only produce P max values, but also Undrained Cohesion or Cu values. Assuming the shear angle (θ) is zero, the shear stress value (σ) is the same as the value of Cu.

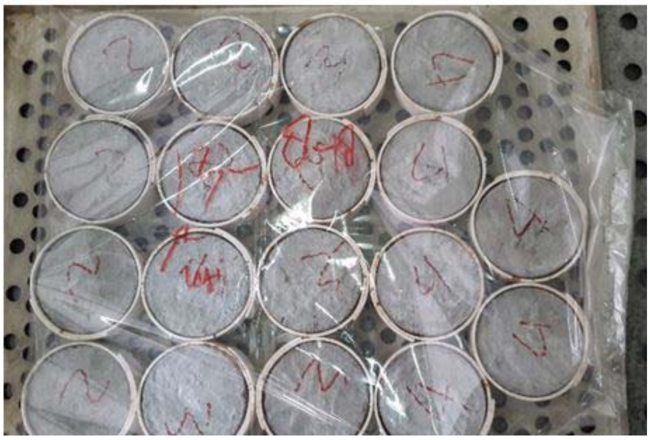

Figure 1: Preparation of Concrete Sample

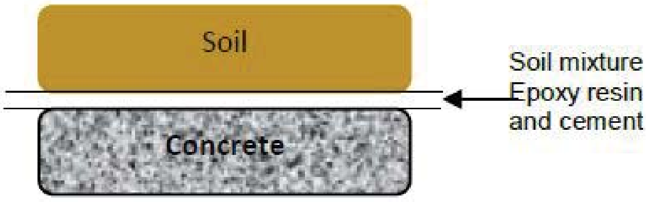

Figure 2: Schematic of laboratory sample to simulate soil and pile interface friction

Table 2: Composition of the mixture of soil paste, cement, and epoxy

Sample number	Comparison of epoxy composition	Paste composition			Addition of water (ml)
	Resin: *hardener*	Soil (gr)	Cement (gr)	Epoxy (gr)	
1	2 : 1	200	40	80	200
2	2 : 1	200	40	80	210
3	2 : 1	200	40	80	220
4	2 : 1	200	40	80	230

RESULTS AND DISCUSSION

The results of the study using Direct Shear get maximum force value that can be held by soil and pile without treatment and after adding a mixture of soil, epoxy and cement. This maximum force value is called P max. in addition to the P max value, the sliding test also obtained Undrained or Cu Cohesion values. Assuming the shear angle (θ) is zero, the shear stress value (τ) is the same as the value of Cu. Soil-pile interface value and The value of friction resistance in each mixture is presented in Figure 3, Figure 4 and Figure 5.

The value of soil-pile interface shown in figure 3 is 0.180 kg/cm^2. The results of this study presented in Figure 6 show that the increase in the friction resistance value tends to increasing water and the maximum value occurs in the mixture with the addition of 220 ml of water. In general there are several factors that affect friction resistance in the field, including soil conditions (pore number, grain size and shape), soil type, moisture content and type of load and level. Increasing the value of soil friction resistance on the soil and pile interfaces due to the bonding factor between soil, epoxy and cement causes flocculation-agglomeration events that produce a larger soil mass, thus increasing the area of contact between granules. The greater the area of contact between granules, the greater the frictional force that occurs in the contact area between soil grains which means the friction coefficient value and the soil friction resistance increase. Bonding time also affects the value of friction resistance shown in Figure 6 and Figure 7, which is 60%.

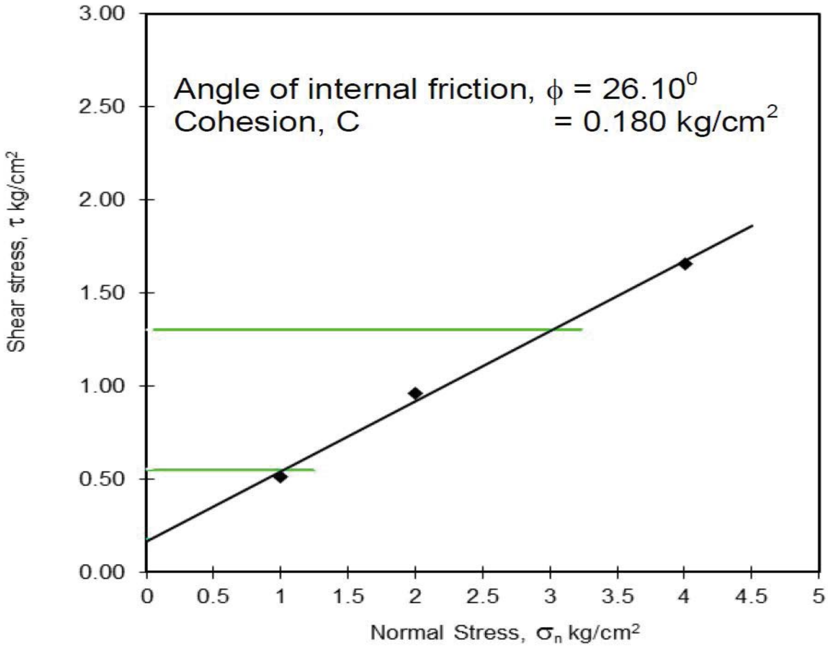

Figure 3: The soil– pile friction resistence

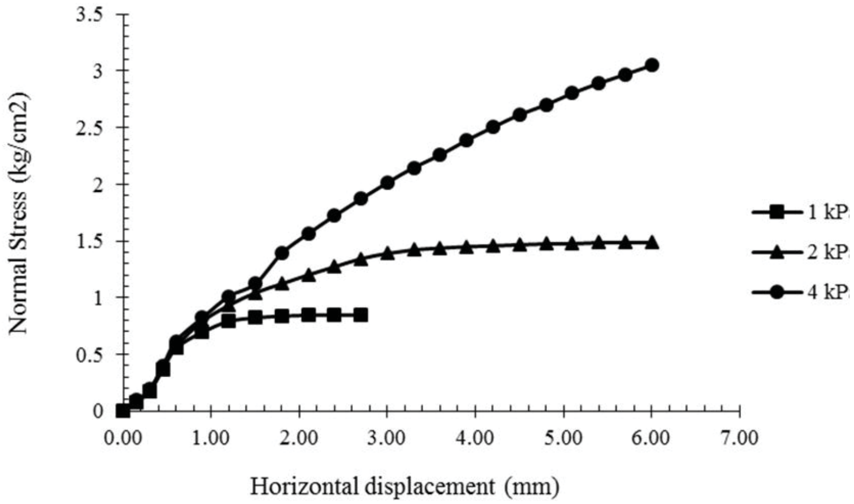

Figure 4: Stress and strain soil mixture 1 with 3 day curing periode from direct shear test

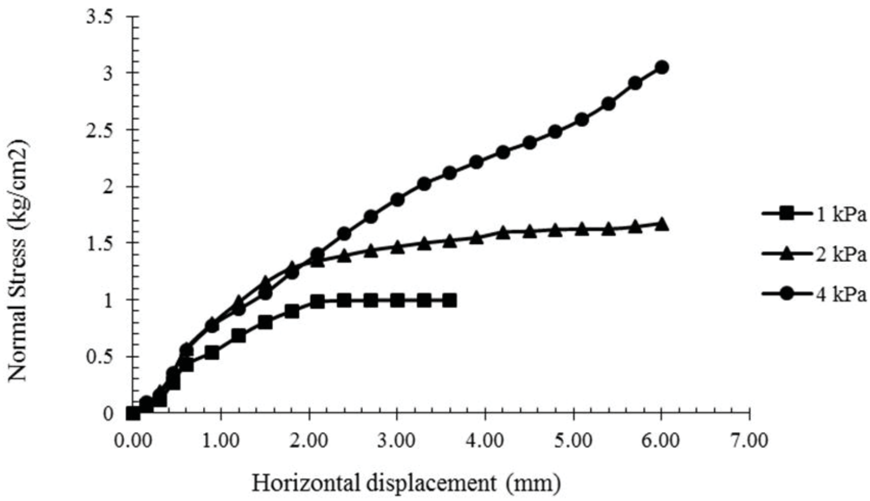

Figure 5: Stress and strain soil mixture 1 with 7 day curing periode from direct shear test

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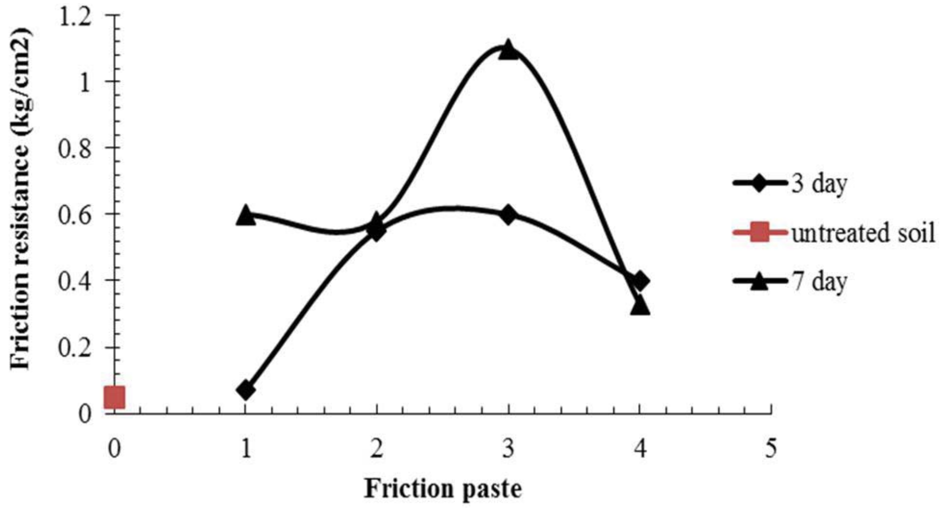

Figure 6: Value of soil-pile friction resistance for each mixture for 3 and 7 days curing period

CONCLUSION

The result of shear resistivity testing interface between soil A-7-5, piles and soil mixtures, epoxy and cement carried out in the laboratory using Direct shear shows that the increase in friction resistance values tends to increase with increasing water and maximum values occur in the mixture with the addition of water 220 ml of 0.65 kg/cm^2 for 3 days curing and 1.1 kg/cm^2 for 7 days ripening. This is due to the bonding factor between soil, epoxy and cement which causes agglomeration-flocculation events which produce a larger mass of soil, thus increasing the area of contact between granules. The greater the field of contact between granules, the greater the frictional force that occurs in the contact area between soil grains, which means that the friction coefficient and soil friction resistance increase.

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