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Effect of Mineralogical and Physical Characteristic of Pozzolanic Binders on Enhancing Strength in Soil Improvement Work Abstract. Various binders such as pozzolanic binder already known for its ability on enhancing the physical characteristic on concrete or soil stabilization. Pozzolanic reaction requires several primary factors to provide maximum improvement on physical characteristic.

This research is aimed to identify the effect of the origin characteristics (physical and mineralogical) of pozzolanic binder on increasing the strength on engineering properties in soil improvement work. Two type of fly ashes are utilized in this study with different types of physical and mineralogical characteristic. Laser Granulometric test, and mineralogical test are realized to identify the characteristics of each fly ash utilized.

To determine the effect of the binder addition (with different characteristics), several tests are performed such as unconfined compressive test, tensile strength test are realized to identify the effect of fly ash addition. The results show that binder with higher SiO2, Fe2O3 and Al2O3 content produces higher strength. 1. Introduction Utilization of alternative binders already realized in the last 20 years in concrete or stabilization work.

Pozzolanic binder is one of the binders that known to increase the performance of concrete. Besides as a mixture in concrete, pozzolanic binders already utilized in soil improvement work. Silitonga e[1][2] in his works stabilized a waste dredged sediment from Port using Fly ash. The fly ash utilized in this research is a waste from local coal mine.

The result shows that the fly ash addition increase the unconfined compressive strength of the stabilized soil compared to sample without any fly ash content. Research done by Becquart et al [3] shows that the sample mixed with bottom ash increase the engineering properties. Due to its pozzolanic reaction, the strength provided during the pozzolanic reaction occurs is very significant compared to others sample.

Besides fly ash as a pozzolanic reaction, Silica Fume is commonly used as binder in concrete. Several studies already realized using Silica Fume in concrete and soil stabilization work. Pfeifer et al [4] realized a research to investigate the pozzolanic reaction using Silica Fume.

The Silica Fume is known for its fine particle size distribution, this fine particle size improves its ability as a filler and promotes the pozzolanic reaction. Previous research by Wang et al [5][6][7], the research working on stabilization of waste sediment in France. This study trying to identify the deformation of dredged sediment stabilized with hydraulic binders and fly ash.

The unconfined compressive test is realized to determine the effect of fly ash. The result shows that the fly ash addition improves the engineering properties of sample. A study realized by Silitonga [8],using two type fly ashes, due to its source location, each fly ash has different mineralogical characteristics.

The result from this work describes that the fly ash with more SiO_2 and Al_2O_3 produces higher unconfined compressive strength, especially after 28 days of curing ages. Park in his research.[9], working on reuse of coal ash in United State. The research realized with several types of coal ash and investigates the capability of each coal ash, so that the reuse of each coal ash can meet the ideal application domain. Jeong et al [10] trying to identify the pozzolanic reaction process during the various temperature on its influence on enhancing strength of the sample.

This study stated that the strength development increase with the increase of the temperature. 2. Materials and Methods 2.1. Materials The research is realized using two type of fly ash. Each type of fly ash is collected from different coal mining. Fly ash type one (CV-1) is taken from southern France and fly ash type 2 (CV-2) is taken from the center of France.

Several tests are realized to identify the characteristics of fly ash used in this study. The sediment is taken from Port de Cherbourg, France. The sediment is a waste sediment from dredging work. The waste sediment is taken from 5 different sampling in Port de Cherbourg, these locations are PDC-1, PDC-2, PDC-3, PDC-4 and PDC5.

The hydraulic binder used (cement and lime) is the common type that normally utilized in soil improvement work. 2.2. Initial Characteristics 2.2.1. Particle Size. Particle size distribution has the most important effect on strength gained in concrete. This increase strength gained in concrete is provide by the fine particle size distribution of fly ash.

To determine the particle size of fly ash utilized in this study, the Laser Granulometric Diffractometer is utilized. The choice of this machine is because the fine particle size of fly ash, only with laser granulometric diffractometer the particle size less than 2 μm can be identified. The result of Particle size test is shown in table 1. Table 1. Particle size distribution of binders Parameters PDC-1 PDC-2 PDC-3 PDC-4 CV-1 CV-2 D50(μm) 8.4 10.2

7,6 9,6 12 17,5 <2 μm (%) 1.7 2.9 3.3 1.9 16.4 7.40 2 à 63 μm (%) 76.4 72.9 77.8 79.8 80 89 > 63 μm (%) 21.9 24.2 18.9 18,4 3.5 3.80 The result of particle size test for waste sediment of port de Cherbourg shown in Table 1. From table 1, we can observe the similarity of particle size distribution of sediment of Port de Cherbourg is very high, this result represents the homogeneity of the sediment utilized in this study. The result of particle size of two type of fly ash shows that the particle size of fly ash is finer than waste sediment.

The particle size of fly ash is considered coarser than particle size of fly ash that commonly utilized in concrete work. From the result we can observe that CV-1 has finer particle size than CV-2. Fly ash type 1 (CV-1) has two times greater percentage of sediment with size < 2 μm compared to fly ash type 2 (CV-2).

From this result we can assume that fly ash type 1 (CV-1) will be reactive than fly ash type 2 (CV-2), and will provide more strength than CV-2. 2.2.2. Mineralogical Characteristic. The mineralogical test is realized to determine the amount of element content in the binders used (fly ash) in this study. According to Silitonga [11] in his research stated that the amount of SiO2, Fe2O3 and Al2O3 plays an important role on enhancing the engineering performance of the stabilized soil The mineralogy of fly ash is presented in Table 2. The result shows that CV-1 has more SiO2, Fe2O3 and Al2O3 t than CV-2.

On the other hand, CV2 possess higher percentage of CaOfree than CV-1. Silitonga[12] stated in His work that, CaOfree has an important effect on pozzolanic reaction, CaOfree promotes the pozzolanic reaction to produce C-S-H and C-A-H. Table 3. Mineralogical Characteristic of fly ash (CV-1 and CV-2) Name SiO2 (%) Fe2O3 (%) Al2O3 (%) MgO (%) CaOtotal (%) CaOfree (%) SO3 (%) CV-1 47.3 7.09 21.63 3.32 8.52 0.9 4.02 CV-2 20.3 1.91 11.7 1.07 35.3 13.3 17.1 2.2.3. Methods. After dredging process, the waste sediment is disposed in special treatment area.

This area is especially designed to conserve waste material, so that the waste material contaminated will be well conserved and will not spreads the pollutants in to the environ. The water content (w) of waste sediment is very high, with the help of high temperature the dewatering process occurs and decrease the water content. After the water content reach in to the level where it can be treated then the stabilization process can be started. 2.2.4.

Formulation The composition of mix admixture is defined according to the goal of this research, which is to identify the effect of physical and mineralogical characteristic of binder to enhance the strength. Sample with cv-1 and cv-2 content can help to identified the influence of different type of fly ash in the sample Table 3. Formulation of mix admixture Name Sand Cement Lime CV-1 CV-2 (%) (%) (%) (%) (%) US - - - - - 5510CV-1 15 5 5 10 - 5515CV-1 15 5 5 15 - 5520CV-1 15 5 5 20 - 5510CV-2 15 5 5 - 10 5515CV-2 15 5 5 - 15 5515CV-2 15 5 5 - 20 CMT 15% 8 5 x x Several formulations with various percentage of fly ash is composed to determine the effect of percentage of fly ash.

The sample only compose by cement (CMT) is realized as a reference, this sample allow us to compared this sample with other samples with fly ash addition, so that it can be determined the effect of fly ash addition in the sample. 3. Result and Analysis 3.1.1. Unconfined Compressive Strength (UCS) The most utilized test in concrete and soil improvement work is Unconfined Compressive Strength (UCS).

This test is to determine the strength of the sample. The result of the UCS is presented in Table 4. As shown in table 4, the test is realized 5 different age of curing (7, 14, 28, 56, and 90 days). Sample US (Untreated Sediment) at 7 days of curing age cannot be determine because the sample is to weak to measure.

At 90 days of curing age, the value of UCS of sample US only reached 0.79 MPa. The minimum UCS value for road construction is 1MPa (28 days). This result shows that the waste sediment without any treatment is not compatible to be used as material in road construction work. Sample with fly ash type 1 (CV-1). With 10 % of fly ash (5510CV-1), 15% (5515CV-1) and 20% (5510CV-1) did not show any remarkable UCS value at 7 days of curing age.

A 14 days and 28 days the evolution of the strength increase started to be more important, the different on UCS value becomes more important with the age of curing age. This is because at teen age curing age, the Pozzolanic reaction of fly ash is still not reach its maximum reaction Table 4. Result of UCS Name 7 days (MPa) 14 days (MPa) 28 days (MPa) 56 days (MPa) 90 days (MPa) US - 0.61 0.74 0.72 0.79 5510CV1 0.77 0.85 1.16 1.38 1.76 5515CV-1 0.73 0.84 1.15 1.59 2.1 5520CV-1 0.66 0.79 1.19 1.42 1.99 5510CV2 0.62 0.7 1.12 1,38 1.78 5515CV-2 0.71 0.81 0.99 1.53 1.88 5520CV-2 0.59 0.73 1.11 1.7 1.98 CMT 0.82 0.97 1.24 1.3 1.33 At teen age curing age (7-14 days) sample only with cement content shows the highest UCs value (0.82MPa), Cement hydration is a very quick to started.

As soon as water introduce in to the admixture, the cement hydration directly starts and produces CSH and CAH, which plays an important role on providing the strength of the sample. In the other hand pozzolanic reaction of fly ash need extra time to reacts. At teen age curing age, the role of fly ash that provide extra strength is as a filler.

Due to its fine particle size, fly ash can fill the empty space in the sample microstructure. This role makes the sample become more solid and automatically increase the strength. The sample with highest percentage of fly ash type 1 (20%), 5520CV-1 shows a highest UCS value at 28 days of curing age.

All the samples with fly ash type 1 (CV-1) show the higher UCS value at every percentag(10%, 15% and 20%). This confirms the theori on role of particle size on enhancing strength development. From the particle size of point of view the CV-1 possess finer particle size than CV-2, thus it assumed that CV-1 is more reactif and will provides higher strength than sample with CV-2.

This result confirms the role of particle size on enhancing the perform (UCS) and confirms the improtant role of particle size at teen age curing age (7-28 days). At long term curing age (60-90 days) the sample with fly ash type 1 (CV-1) content still shows a highest UCS value among other samples.At this curing age, the sample with 15% of CV-1 (5515CV-1) possess a highest UCS value.Theproblem of excessif content of fly ash might be the main reason why sample with 20% of CV-1 (5520CV-1) does not possess the highest UCS value.After 28 days of curing age, samples with fly ash content, start show an increase of UCS compared to the sample with cement content only (CMT).

The cement hydration normally reach its highest reaction at 28 days, on the other hand pozzolanic reaction starts at 20 days and up untill 90 days if the require factor still available then the pozzolanic reaction can still occurs untill 18- days and even at 360 days of curing age. 3.1.2. Tensile Strength (TS) This test is realized to help to identify the strength development due to the fly ash addition.

The tensile strength test is one of the most common tests realized in road construction work, and because reuse of this waste sediment is as a material in road construction work, that is why the tensile strength test is performed in this research. According to France classification (NF P 98 114) to determine the ability of a material in road construction work, the curing age of the sample is at least at 360 days. Because of the limitation on time in this research, we can assume the value at 90 days.

The result of sample at 90 days of curing age can be using this equation: (1) The result of the tensile strength test is present in table 5. According to the result of tensile strength test in table 5, we can confirm that at 90 days the sample with 15% of fly ash type 2 (5515CV-1) shows a highest Tensile strength (0.67 MPa) and Elastic Modulus (4.17 MPa). This confirms the effect of fly ash addition on the increase of the performance.

This result is similar with the result of unconfined compressive strength (UCS) test result. Table 5. Result of tensile strength test at 90 days of curing age. Name Tensile Strength (MPa) Elastic Modulus (MPa) US - - 5510CV1 0.5 3,3 5515CV-1 0.67 4.17 5520CV-1 0.6 4.12 5510CV2 0.52 4.4 5515CV-2 0.56 4.08 5520CV-2 0.57 4.10 CMT 0.38 1.93 Almost all the samples with fly ash type (CV-2) have lower UCS tensile strength and elastic modulus compared to samples with fly ash type 1 (CV-1).

This result confirmed the advantage of CV-1 than CV-2. As we can observed from the particle size of point of view, fly ash type 1 (CV-1) has finer particle size distribution than fly ash type 2 (CV-2) From the mineralogical test, each type of fly ash has individual advantage, fly ash type 1 (CV-1) has more percentage of SiO2, Fe2O3 and Al2O3 t than fly ash type 2 (CV-2).

on the other hand, fly ash type 2 (CV-2) possess more CaOfree than fly ash type 1 (CV-1). In this tensile strength test we confirmed that a possession of higher percentage of SiO2, Fe2O3 and Al2O3 is more important to increase the performance than possessing the CaOfree. The amount of percentage of the fly ash in this test shows an unremarkable different on strength gained.

The sample with increase percentage of fly ash does not shows an increase of the strength. The tensile strength value almost does not affect on the increase of the amount of fly ash. 4. Conclusion. This main goal of this study is to define the effect of mineralogical and physical characteristics of pozzolanic binder (fly ash) on enhancing the performance.

The physical characteristic on particle size, fly ash type 1 (CV-1) has advantage on its finer particle size compared to fly ash type 2. From the mineralogical point of view CV-1 has more SiO2, Fe2O3 and Al2O3 content than CV-2, on the other hand CV-2 has more

CaOfree than CV-1, these two advantages are known has an important role on promoting and enhancing the pozzolanic reaction.

The Unconfined Compressive Strength Test and Tensile Strength test state that the sample with best performance is sample with fly ash type 1 (CV-1) with percentage 15%-20% of fly ash. The UCS test and Tensile test confirmed that binder with finer particle size has more advantage to enhance the strength performance. The results also confirm that possessing the SiO_2, Fe_2O_3 and Al_2O_3 has more influence on strength gaining process than possessing CaOfree. 5.