Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI:10.21474/IJAR01/6928
DOI URL: http://dx.doi.org/10.21474/IJAR01/6928

RESEARCH ARTICLE

ANALYSIS OF LAPINDO MUD UTILIZATION AND STEEL SLAG AS A MIXTURE STABILIZATION OF CLAY.

Gati Sri Utami[1] and Untung Usada[2].
1. Department of Civil Engineering, Adhi Tama Institute of Technology Surabaya, Indonesia.
2. Nahdlatul Ulama Sidoarjo of Univercity, Indonesia.

Manuscript Info

Manuscript History

Received: 13 February 2018
Final Accepted: 15 March 2018
Published: April 2018

Keywords:-
Clay, Sidoarjo Mud, Steel Slag, Research, Experimental.

Abstract

Sidoarjo mud is a mud that comes out from the earth's belly that continues to spurt until now, and steel slag is a waste of steel manufacturing industry. Based on previous research Sidoarjo mud can be used as cement replacement material in concrete mixture because it contains silicate (SiO_2). According to Puslitbang road and Bridge, Department of Public Works, steel slag aggregate has a high hardness cause steel slag either as pavement material.
This study aims to know the effect of sidoarjo mud addition and steel slag to the characteristic of plasticity and the carrying capacity of clay.
This research uses experimental method, which is an analysis based on laboratory test results, including Atterberg Limit test, Standart Proctor, Unconfined, Direct Shear, Swelling, and CBR. The soil samples come from the area around Kertajaya Indah Highway, mud from Sidoarjo, and steel slag from PT. Hanil Jaya Steel Sidoarjo. Mixed mud using concentrations of 5%, 10%, and 15%, and steel slag of 10%, 20%, and 30%.
The results showed the original soil Liquid limit: 59%, Plasticity Index: 33.67%, Swelling: 3.54%, γd: 1.27 grams/cm³, qu: 0.778 kg/cm², and CBR: 3.145%, into the category of high plastic clay soil, medium swelling, very tenuous density, medium compressive strength, and bad category CBR. After addition of 15% mud and 30% steel slag, Liquid limit: 35%, Plasticity Index: 19.49%, Swelling: 0.27%, γd: 1.6 gram/cm³, qu: 2.013 kg/cm², and CBR: 8.21%, in the category of low plasticity clays, low swelling, medium density, very strong press strength, and CBR category is quite good. The addition of maximum sludge 15% and minimum 30% steel slag is effectively used as additional material for clay soil stabilization, since it can decrease the plasticity and increase the carrying capacity of soil.

Introduction:-

D. Harjito (2014) more than 640 hectares of productive land in Sidoarjo have been submerged in volcanic Sidoarjo mud eruption, but the eruption still continues. Mud has a semi-crystalline original form, containing a lot of silica and aluminum oxide, with the total amount of SiO_2, Al_2O_3 and Fe_2O_3 more than 85%, the composition is almost similar to the content of semen. Wherein the silica allows it to be used as a cement replacement material but within a certain tolerance content. [1].

The mud function is to increase the cohesion between the particles so that the bonding of the particles becomes denser. The addition of Sidoarjo mud on the soil is expected to have an impact on clay particle so that it behaves close to the sand or silt, due to particle clumping. Mixing the soil with Sidoarjo mud will be able to enlarge the size of clay particles that were initially very small and smooth.

Corresponding Author:- Gati Sri Utami.
Address:- Department of Civil Engineering, Adhi Tama Institute of Technology Surabaya, Indonesia.

Research Aristianto , NGK . Made Anom Wiryasa , I Wayan Sudarsana 2009 Lapindo mud containing chemicals silicate mineral (SiO_2) which is higher than the cement and lime (CaO) . The content of silicate can serve as filler material while the content of lime as binder between the particles . Based on the content of the Lapindo mud used as, a cement substitute material , in the manufacture of concrete . Research results Lapindo mud , can be used as a mixture of materials , manufacturing of solid concrete. [2][3]

Gati Sri Urami (2015) so in general it can be said that the levels of Lapindo mud more than 50 % effective in stabilizing the clay in Sumenep area to reduce the potential for development , while raising the level of Lapindo mud carrying capacity is a maximum of 40% Sidoarjo mud.[4]

Slag is a high blast furnace residue by the steel smelting industry, one of which is a waste of slag that physically resembles a rough aggregate. In steel smelting, iron ore or scrap metal is liquefied with a combination of limestone, dolomite or lime. Steel making started by removing the impurity ions of steel, including aluminum, silicon and phosphorus. The removal of those impurity ions requires the calcium present in the limestone. A mixture of calcium, aluminum, silicon, and phosphorus forms a slag that reacts at a temperature of 1600 ^{o}C and forming a liquid, when the liquid is cooled there will be crystals, it can be used as a cement mixture and can be used instead of aggregate.[5]

The slag material has been declared free of Hazardous and Toxic Material, according to The Federal Register Vol. 45 no. 98 in 1980, has been tested for slag material by standard EPA method, which states non-hazardous, non-flammable, has a pH 7.9 (not corrosive), is not reactive and toxic. Based on pH measurements indicates that the slag is in basic condition, due to the presence of metal oxides that react with water.[5]

Puslitbang Jalan dan Jembatan, Dep PU. (2011) aggregate steel slag has a high hardness coupled with the non porous nature it causes the slag aggregate for both pavement material. [5]

Nurani, Gati and Novi (2014) that the steel slag can be used as a pavement filler material, the more steel slag ash will increase the stability value, to an optimum limit of 4% with a stability value of 2379.52kg, but the stability value tends to decrease when steel slag ash content reaches 5% to 2081.87kg. The value of flexibility increases with the increase of steel slag grade, the increase occurs to the optimum limit of 4% with 5.2% bitumen content. The durability of the mixture is based on the VIM value, the durability value decreases with the addition of steel slag grade to the asphalt concrete mixture, which is ideal in 3% steel slag ash with 4.7% asphalt content. It can be concluded that the ideal steel slag ash content of 3% with the optimum asphalt content of 5.95%. [6]

Table 1:-Chemical Content Test

No	Content	Percentage
1	Aluminium (Al)	3,76 %
2	Ferric oxide (Fe_2O_3)	19,18 %
3	Phosphor (P)	0,07 %
4	Chrome (Cr)	0,08 %
5	Manganese (Mn)	1,11 %
6	Nikel (Ni)	0,01 %
7	Zinc oxide (ZnO)	1,58 %
8	Lead (Pb)	0,30 %
9	Copper (Cu)	0,12 %

Souce: PT. Hanil Jaya Steel, 2011[6]

Methods:-

The soil samples come from the area around Kertajaya Indah Highway, mud from Sidoarjo, and steel slag from PT. Hanil Jaya Steel Sidoarjo. Mixed mud using concentrations of 5%, 10%, and 15%, and steel slag of 10%, 20%, and 30%..

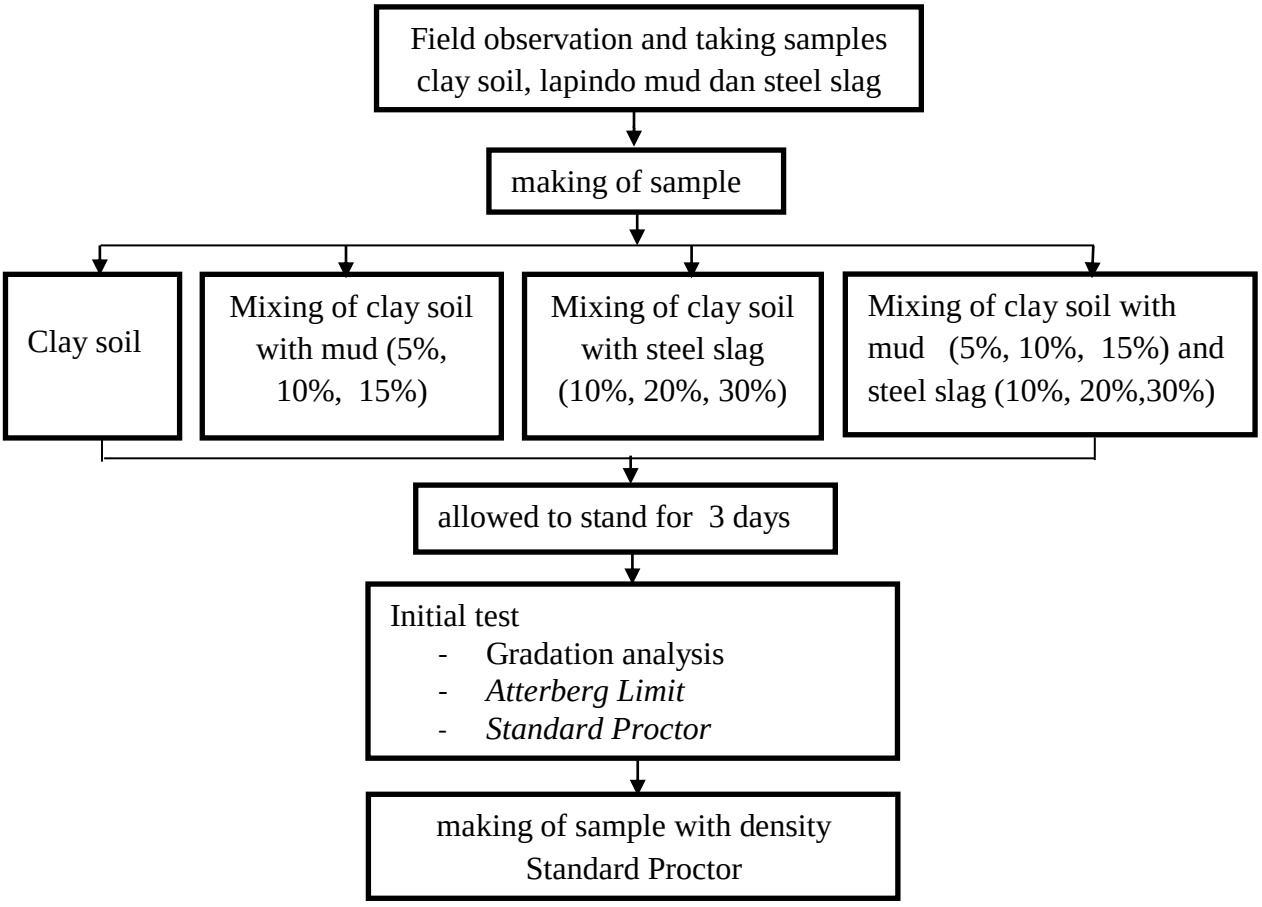
Initial test:-

1. Gradation analysis of grain to determine soil type based on grain size
2. Atterberg limit to determine the soil shrink characteristic based on the value of liquit limit (LL) and plasticity index (IP)
3. Standard Proctor to determine the level of soil density based on dry weight volume value (γd) and optimum water content (ωoptimum)

Advanced testing with sample density Standard Proctor, including:-

1. CBR Laboratory to determine the carrying capacity of the soil as a pavement base soil based on CBR value
2. Direct Shear to determine the soil shear strength based on the shear stress value (τ), cohession (C) and friction angle (ϕ)
3. Unconfined Compression to know the carrying capacity of the soil withstand the vertical force directly based on the carrying capacity limit value (qu)
4. Free swelling to know the characteristic of soil growth if water content increases based on swelling value.

Calculation and analysis of test result data based on standardization of physical and mechanical characteristic as origin soil, then take a conclusion.



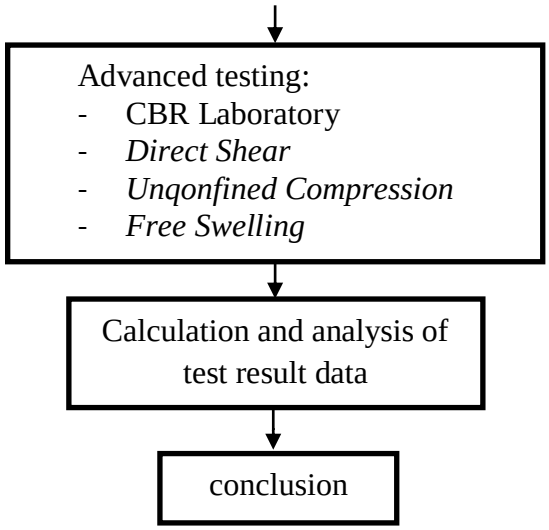


Figure-1;-Flowchart of the research

Result And Discussion:-

Physics Characteristic:-

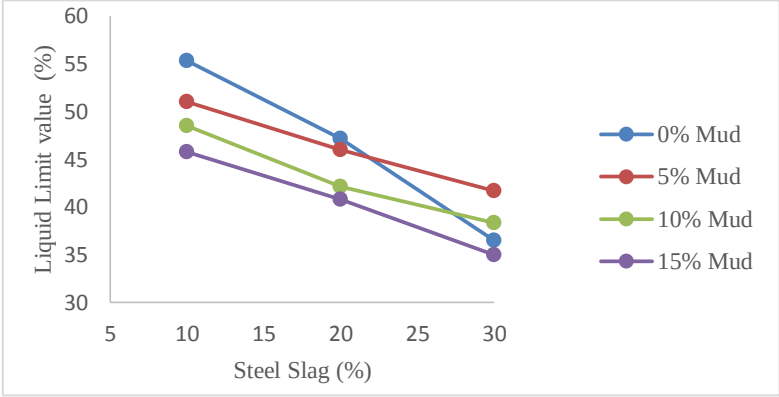


Figure 2:-Corelation between Liquid Limit value with% steel slag for various% mud [7,8,9]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can decrease the number of liquid limits.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% slag steel concentrations also decrease the number of liquid limits.
3. The most significant decrease occurred in a mixture of steel slag without mud Sidoarjo.
4. The most decrease in liquid limits occurred in natural soil + 15% mud + 30% steel slag concentration.

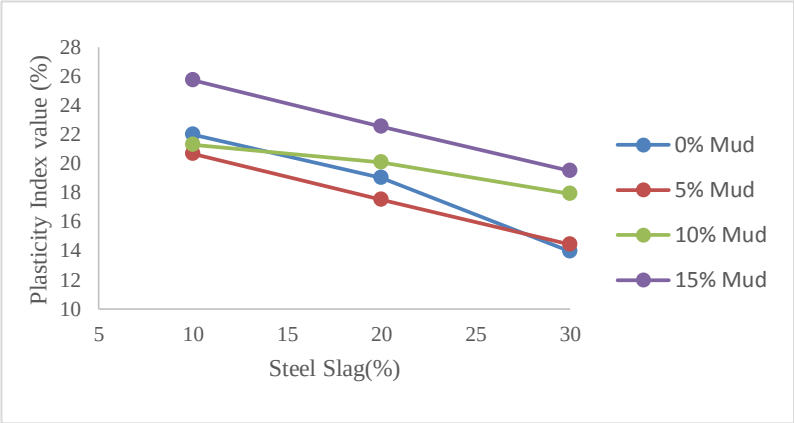


Figure 3:-Corelation between the of Plasticity index value with % steel slag for various % mud [6,7,8]

1. Addition of steel slag on soil with 0%, 5%, 10%, and 15% mud concentration can decrease the plasticity index.
2. Addition of Sidoarjo mud on soils with 10%, 20%, and 30% steel slag concentrations increased the plasticity index.
3. The most decrease in plasticity index number occurred in the mixed concentration of "original soil + 30% steel slag", plasticity index showed 13.95%.

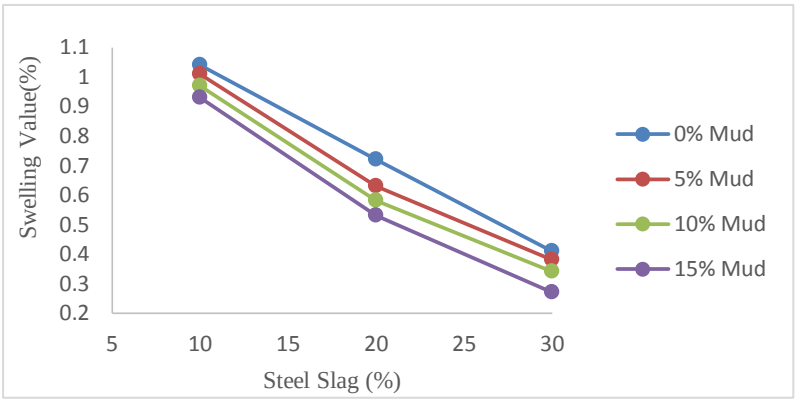


Figure 4:-Corelation between swelling value and % steel slag for various % mud [7,8,9]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can decrease the percentage of swelling.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% slag of steel can also reduce the percentage of swelling.
3. The most decrease in swelling rate occurred in the original soil mixed concentration + 15% mud + 30% steel slag, total swelling showed 0.27%

Mechanics Characteristic:-

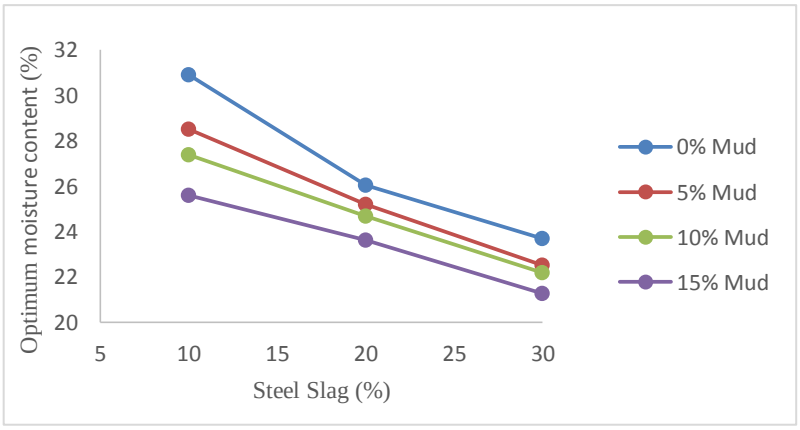


Figure 5:-Corelation between optimum moisture content with % steel slag for various % mud [4,7,8]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can decrease the optimum moisture content.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% slag steel concentrations is also able to decrease the optimum moisture content.
3. The most decrease of water content (W opt) occurred at original soil mix concentration + mud 15% + 30% steel slag, optimum moisture content (W opt) showed 21.27%

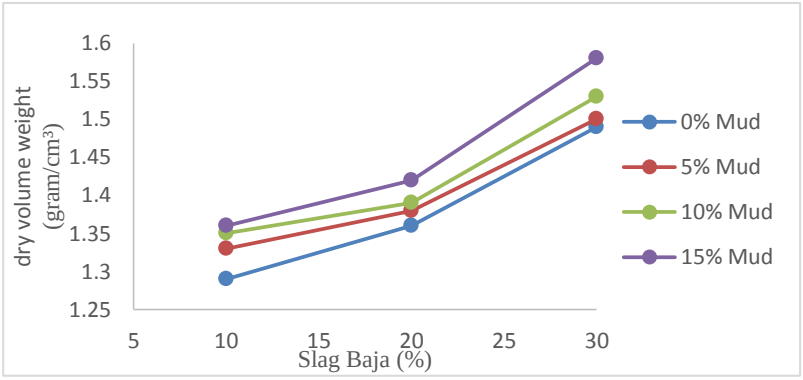


Figure 6:-Corelation between dry volume weight and % steel slag for various % mud [4,7,8]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can increase the dry volume weight (γd).
2. Addition of Sidoarjo mud to soils with 10%, 20%, and 30% steel slag concentrations is also able to increase the dry volume weight (γd).
3. The most increase of dry soil weight (γd) occurred in the original soil mix concentration + 15%mud + 30% steel slag, the dry volume weight (γd) showed 1.6 gram/cm³.

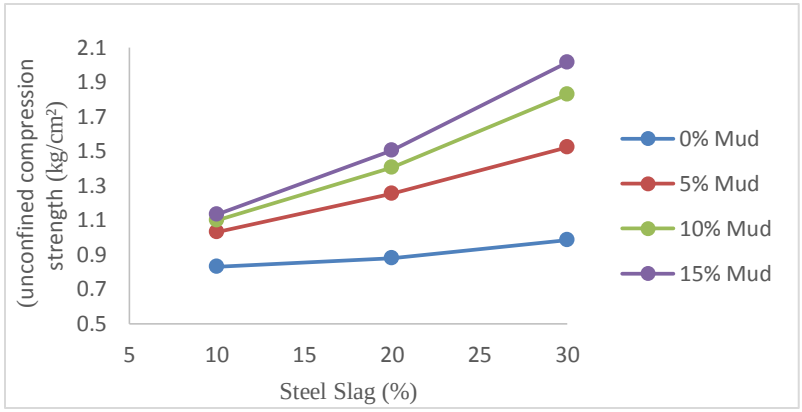


Figure 7:- Corealation between unconfined compression strength with % steel slag for various % mud [4,7,8]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can increase the value of qu.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% steel slag concentration is also able to increase the value of qu.
3. The most increase of qu value occurred at the concentration of the original soil mixture + 15% mud + 30% steel slag, qu value showed 2,013 kg/cm²

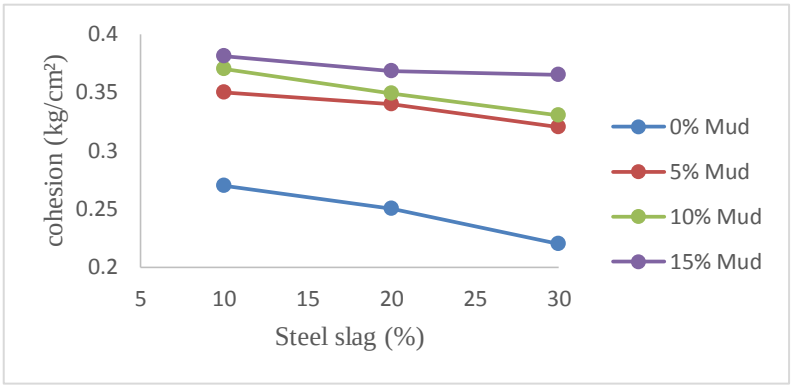


Figure 8:-Corelation between cohesion with % steel slag for various % mud [4,7,8]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can decrease the value of cohesion.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% steel slag can increase the value of cohesion.

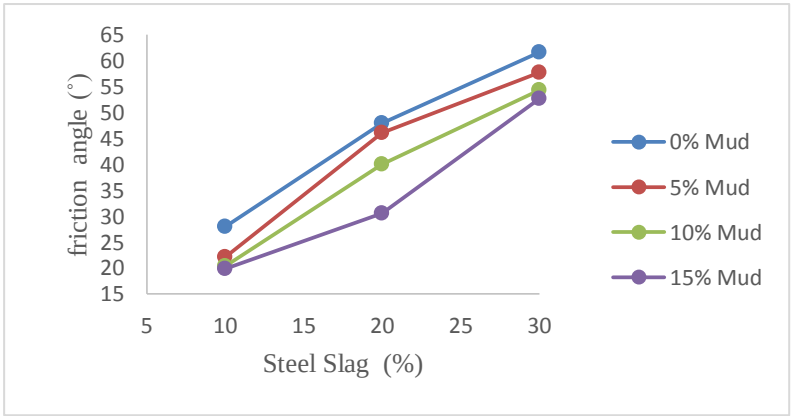


Figure 9:-Corelation between friction angle with % steel slag for various % mud [4,7,8]

1. Addition of steel slag to the soil with 0%, 5%, 10%, and 15% mud concentration can increase the magnitude of the friction angle.
2. Addition of Sidoarjo mud to soil with 10%, 20%, and 30% slag steel concentrations can decrease the magnitude of the friction angle.

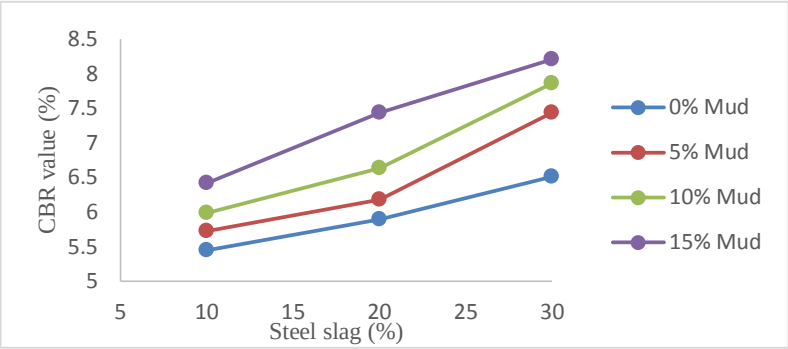


Figure 10:-Corelation between CBR value with % steel slag for various % mud [4,7,8]

1. Addition of steel slag to soil with 0%, 5%, 10%, and 15% mud concentration can increase the CBR value.
2. Addition of Sidoarjo mud on soils with 10%, 20%, and 30% steel slag concentration is also able to increase the value of CBR.
3. The most increase of CBR value occurred at the concentration of mixture of "original soil + 15%mud + 30% steel slag", CBR showed 8.21%.

Table 2:-Result of identification for the original soil mixture + 15% mud + 30% steel slag as base soil [9,10,11]

	Test	Result	Category	
Phisics	LL (%)	35	<50	Low
	IP (%)	19.49	10-20	Medium
	Swelling (%)	0.27	0-1,5	Low
Mechanics	γd (gram/cm³)	1.6	1,6-1,8	Medium
	qu (kg/cm²)	2.013	2- 4	Very tough
	CBR (%)	8.21	7-20	Medium

Conclusion:-

Based on the analysis of the results of data calculations on laboratory tests can be concluded several things as follows:

1. Clay soil taken on Kertajaya Indah Highway Surabaya, Liquid limit value: 59%, Plasticity Index: 33.67%, Swelling: 3.54%, γd: 1.27 gram/cm³, qu: 0.778 kg/cm², and CBR: 3.145%. The original soil belongs to the category of high plasticity clay, medium swelling, very poor density, medium compression strength, and bad category CBR.
2. Addition of Sidoarjo mud up to 15% and 30% steel slag on clay stabilization Liquid limit value: 35%, decreased by 40.68%; Plasticity Index: 19.49%, decreased by 42.11%; Swelling: 0.27%, decreased by 92.37%; Dry volume weight (γd): 1.6 grams / cm³, increased by 24.4%; Unconfined compression strength (qu): 2.013 kg/cm², an increase of 158.7%; and CBR: 8.21%, an increase of 161%.
3. The soil belongs to the category of low plasticity, low swelling, sufficient density, very hard press strength, and CBR category is quite good.
4. Addition of maximum mud 15% and minimum 30% steel slag is effectively used as additional material of clay stabilization, because it can decrease plasticity and increase soil carrying capacity.

References:-

1. D. Harjito, 2014, Exploring The Potentials of Sidoarjo Volcanic Mud as Construction Matrials, Proseding seminar internasional (ICESTI), Bali.
2. Aristianto, 2006, Preliminary Examination of Sidoarjo Heat Mud For Ceramic Products, Ceramic Big hall, Bandung.
3. Ngk. Made Anom Wiryasa, I. Wayan Sudarsana, 2009, Utilization of Lapindo Mud As Cement Substitution Material in Preparation of Concrete Structured Bricks, Scientific Journal of Civil Engineering vol. 13, Civil Engineering Faculty of Engineering Udayana University, Bali
4. G. S. Utami, 2015, Mud Utilization Of Lapindo As Soil Stabilization Materials That Contain Salt Clay, ARPN Journal , Pakistan
5. G.Gunawan, P. D. Oetojo, N. Kusminingrum, T. Rahmawati, and Leksminingsih, 2011, Utilization of Steel Slag for Eco-Friendly Road Technology, Puslitbang road and Bridge, Department of Public Works, Bandung, 1st edtion December 2011.
6. Nurani, Gati, Novi, 2014, Characteristics of Asphalt Concrete Mixture (AC-WC) with Addition of Steel Slag Ash as Replacement Filler, Civil Engineering Journal UPN Kern, Vol. 4, Edition 1 May 2014
7. G. S. Utami, 2014, Clay Soil Stabilisasi With Lime Effek The Value CBR and Swelling, ARPN journal Pakistan.
8. G. S. Utami, 2014, Decreasing the Plastisitas Index and Incresing the CBR Rate of the Subgrade Using the Mixture of Lime and Sand, ARPN journal, Pakistan.
9. Ingles, O.G and Metcalf, J.B., 1972, Soil Stabilization Principles and Practice, Butterworths Pty. Limited, Melbourne.
10. H. C. Hardiyatmo, 2010, Soil Stabilization for Highway Pavement,Yogyakarta: Gadjah Mada University Press.
11. Anonim, 2003, Annual Book of ASTM Standards, section 4, Volume 04 08, ASTM International Barr Harbor Drive, West Conshohocken, PA 19428-2959.