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Influence of Bamboo Pile in The Pile Mattress Bamboo Construction Systems as Reinforcement of Soft Subgrade That Support Embankment Load

Bambang Widodo[a]*

[a] *Department of Civil Engineering, Narotama University, Indonesia*

Abstract

One of the problems that arise in building land transport infrastructure located on soft soil is the making of the road construction. The completion of the road construction issue is carried out by the engineering that the road is safe and stable. Many engineering have to do to handle pile on soft soil, among others, the construction of concrete slab combination of concrete pillars, improved soil embankment with reinforcement material of choice. Infrastructure (2002) provides five methods of solution work which is above the heap of soft soil that has been accepted and applied in Indonesia, are: Replacement Material Counterweight berms, Surcharging, Staged Construction, Use of Lightweight Materials. The title major of the research is Pile Mattress Bamboo Construction Systems as reinforcement of soft subgrade that support embankment load. The main long-term goal of the research is to provide a method of solution that is above the pile of work soft soil complement existing methods, by using the main material of bamboo. Many reasons for the use of bamboo, among others: bamboo available everywhere around the world, including in Indonesia ,. Bamboo in saturated condition is not obsolete, the price is cheaper, its density is less than the density of water so that it has buoyancy, easier and faster in execution [5]. Bamboo is an environmentally friendly material (green building) that is to be able to take advantage of bamboo on a large scale, it can be pursued on a bamboo conservation lands that are less productive, so as to reduce the rate of deforestation and prevent soil erosion, and can contribute to oxygen (O2) and absorb carbon dioxide (CO2) which is a very great good for the environment. Bamboo in the main study used as pile mattress bamboo. The research proposed in this doctoral dissertation research is research on the effects of bamboo pile on pile mattress bamboo construction system to support the embankment with soft subgrade. Bamboo pile on pile mattress bamboo construction system contributes pile load bearing support depending on the distance between pile, number pile in one cluster and depth of pile entering into soft ground.

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Keywords: Soft Soil, Bamboo Pile, Constant Spring, Pile Mattress Bamboo Construction.

1. Introduction

1.1 Background

Soft ground in Indonesia is estimated to cover about 20 million hectares or about 10 percent of Indonesia's total land area (Infrastructure, 2002). Soft soil found in the area around the beach, and many cities in Indonesia is located on the waterfront and most of its territory is essentially soft soil areas with high water surface, as shown in Fig.1. The city is a center of the economy of the area concerned, so that the necessary facilities and infrastructure to support the smooth running of the event. One of the facilities and infrastructure that is needed is a means of land transportation, good highways and railroads.

Urban areas located on soft soil, the means of land transportation must pass through the soft ground. One of the problems that arise in building land transport infrastructure located on soft soil

* Corresponding author. Tel.: 081393939792
E-mail address: bijhe_bw@yahoo.co.id

is the making of the construction of the road. The completion of the road construction issue is done with engineering so that the road is safe and stable.

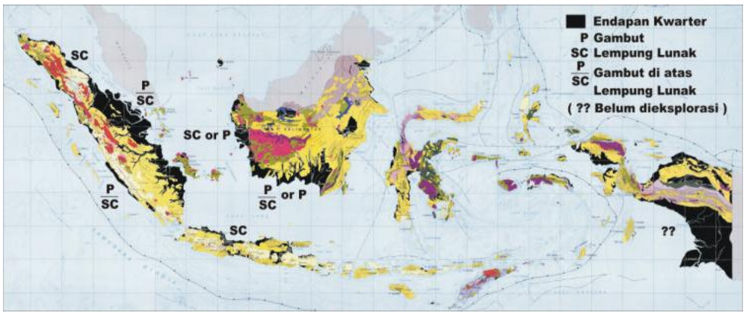

Fig.1. Soft Soil Map in Indonesia [8].

Infrastructure (2002) gives five methods of solution work pile located on soft soil that has been accepted and applied in Indonesia, is Replacement Material, Counterweight berms, addition of Load (Surcharging), Staged Construction, Use of Lightweight Materials.

[5] featuring research full-scale test embankment with reinforcement pile mattress bamboo for toll roads in Tambak Oso, Surabaya (Fig. 2). The study states that embankment with the pile mattress Bamboo system show sufficient stability against slope failure and the failure of the bearing capacity, the actual settlement was also approaching the predicted settlement. Therefore, the pile mattress bamboo system proved reliable as a reinforcement of embankment and can distribute more uniform settlement.

Fig.2. Pile mattress Bamboo for Toll Road Embankment Tambak Oso Surabaya [5].

1.2 Problems and Objectives of Research

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Problems in the construction design of pile mattress bamboo for reinforcement of soft soil is to determine the number of layers of the mattress and the distance of pile associated with the existing soil conditions. At a certain soil conditions, the number of layers of the mattress can be determined if the data rigidity of mattress is known, so is the distance pile can be determined if the data of the ultimate force that causes deformation so that the ground collapses (spring constant) is known. Issues that will be examined is limited to the effect of bamboo pile which is part of the pile mattress construction system in supporting the embankment load. This problem can be solved by the proposed research. The results of the proposed research is pile bamboo spring constants parameters. The parameter is required in numerical analysis with Plaxis 2D. Numerical analysis can determine the influence of the distance of pile on the pile mattress bamboo construction in support of embankment load.

The aim of research in this doctoral dissertation research is part of the main research goals that influence of the cluster distance on the pile mattress bamboo construction. This goal is an integral part of the final goal of primary research (the completion of a dissertation).

2. Theories And Concepts

2.1 Spring Constant

Determination of the spring constant of pile bamboo by [5] which is illustrated in Fig. 3. is as follows: Bamboo is considered to have a diameter of 8 cm. Pile hold ultimate force suit bearing capacity of soft soil that is working on the pile with Equation (1).

$$P_{ult} = K_{ll}.(c_1.h_1 + c_2.h_2 + c_3.h_3 + \ldots c_i.h_i) + 9.A_b.c_i \quad (1)$$

With: kll = average circumference of bamboo; c1, c2, ... ci = cohesion undrained appropriate layers, and h1, h2, .. hi = height of each layer of soil in accordance of pile depth, Ab: sectional area of bamboo pile. The maximum bearing capacity of the soil transferred to the bamboo is expressed in Equation (2).

$$F_{max} = P_{ult} / F_s \quad (2)$$

with: Fs is the safety factor. The amount of ground deformation (δ) so fmax immobilized, assumed $\delta = 0.1xd$, with d is the diameter of the bamboo. The magnitude of the spring constant (k) defined by equation (3).

$$k = F_{max} / \delta \quad (3)$$

Sectional stiffness parameter value (EA) of pile is obtained by taking the value of the modulus of elasticity (E) of bamboo by reference.

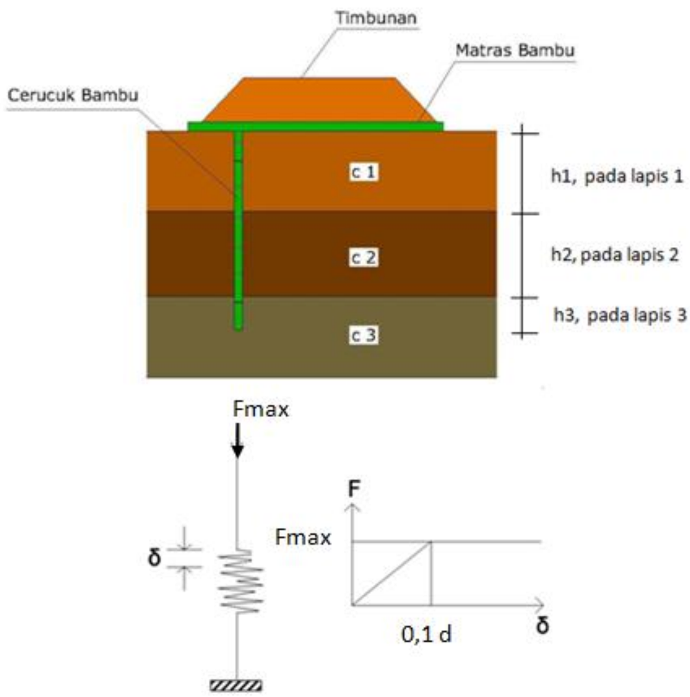

Fig. 3. The determination of Fmax and Spring Stiffness of Bamboo Pile [5].

2.2 Bearing Capacity of Single Pile in Clay

Ultimate bearing capacity (QU) of the pile foundation on clay soil can be expressed by Eq. (4).
$Q_u = \alpha \bar{C}_u . A_s + N_c . C_u . A_b$ .... (4)

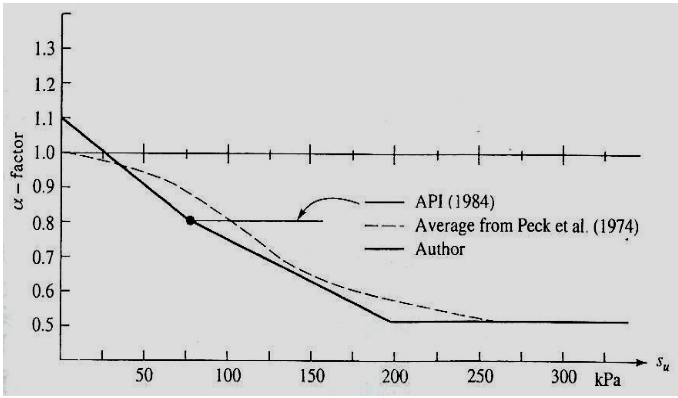

Fig. 4. Relation of Su and Adhesion [2].

with : α = Adhesion factors derived from an empirical relationship with shear strength (Fig. 4.), Cu = average undrained cohesion along the pole blankets, As = area of the pile, Nc = bearing capacity factor (~ 9.0), cu = undrained cohesion base of the pile , Ab = area of base pile.

2.3 Bearing Capacity of Pile Mattress Bamboo on Soft Soil

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Bearing Capacity of pile mattress bamboo soft soil, can be considered as a combination between the carrying beams / plates and piles. The workload on it (q) through the mat first be distributed into piles. Load acting on pile will be retained by the soft soil. Because piles rigidity much greater than the soil that supports it, then the soil will decline to collapse. The amount of support for the soil to collapse (Qu) can be calculated by Equation (4).

Fig. 5. shows that the magnitude of the soil deformation to pile collapsed in general there are two concepts, the first is the concept of capacity with controlled deformation (controlled deformation capacity), PF0.1, and the second is the concept of ultimate capacity, Pu, The first concept states that pile collapse if the amount of deformation of pile has reached 10% of the pile diameter [1].

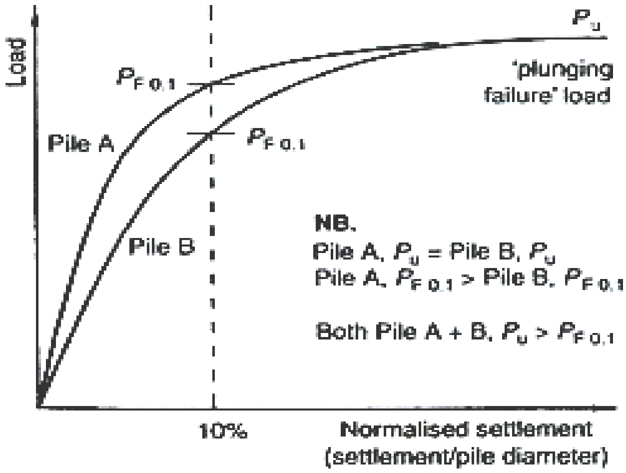

Fig. 5. Definition of Failure Pile [1].

After the soil that supports pile collapse, then the residual loads is supported by the mat (qm). load transfer on the pile mattress bamboo can be illustrated as in Fig. 6. The Load of pile is displayed with Equation (5).

$Q_{tot}=n.Q_{ult}$ …………………………..…………………………..………………………………. (5)

with: Qtot = total load pile, n = number pile per meter length embankment, Qult = ultimate load of pile.

Distributed load received the mat can be written by Equation (6).

$q_m=q-n.Q_{ult}/B$ …………………...………………..……..…..………………...……….……. (6)

with, qm = distributed load which received the mat, q = total distributed load that work on the mat, B = width of the mat.

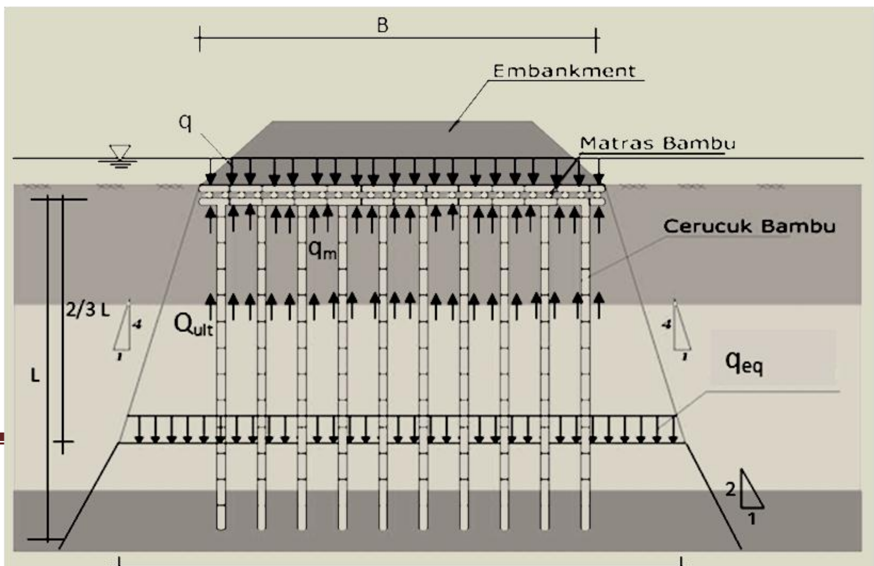

Fig. 6. Load Transfer on Pile Mattress Bamboo System.

Load mat is supplied to the ground with spread 4v : 1h, provide additional stress to the ground by qeq, qeq work at a depth of 2/3 the length of pile, an additional amount of stress in the soil can be written by Equation (7).

$q_{eq}=q_m.B/B1$ ……………………………………………..…………………….…… (7)

3. Subgrade Condition And Materials Testing

4.1 Sub grade Conditions

The location of testing model in the Cilosari village Semarang, Central Java, namely in the double railway track Semarang-Bojonegoro KM: 1,500. Subgrade condition is known by testing Drilling Machines and Test Sondir. Results drill machine and sondir test as shown in Fig. (7).

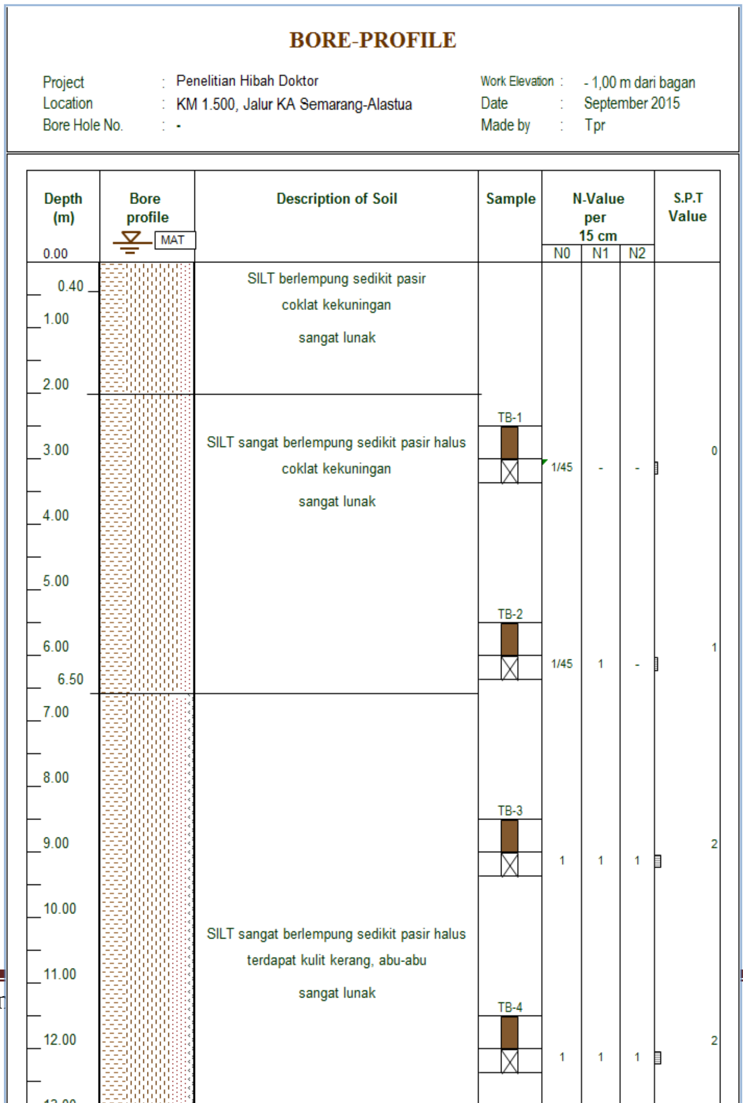

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Fig. 7. The Result of Drill Machine and Sondir Test.

4.2 Material Test

Pile a bamboo tied into a particular cluster with a plastic strip or wire rope. The necessary data of bamboo pile is a cross-section stiffness (AE) cluster and spring constants. Pile of bamboo that are planned in the study were 3 clusters, 4 clusters and 7 clusters, as shown in Fig. 8.

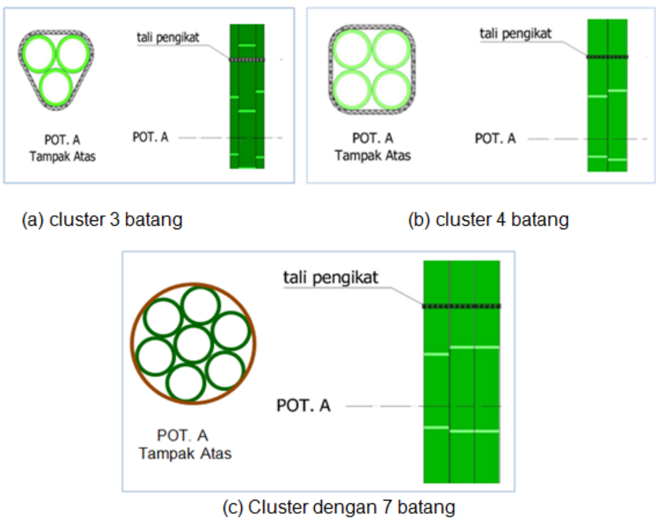

Fig. 8. Arrangement of Bamboo Pile Cluster.

4. Setting Model And Testing Program

4.1 Setting Model

Bamboo pile testing are located in areas of ponds with stagnant water approximately 1.50 meters. Framework is needed to test. Framework for testing shown in Fig. 9(a)., after the framework is completed pile erection as in shown in Fig. 9(b).

Fig. 9. (a) Setting Cluster, (b) Cluster Piling.

Pilling of bamboo into the ground by using a load of 63 kg free falling with the steering pipe. Free fall height of about 100 cm. Value of the pile deformation is recorded on the 30 final blow. Piling done to position the cluster as shown in Fig. 10.

4.2 Testing Program

Testing is done for each clusters as many as 3 trials. Type clusters there are 3 types namely clusters 3, clusters 4, and the clusters 7. Example of position clusters 3 and clusters 7 are ready to be tested is shown in Fig. 10.

The Concept Testing of spring constant is doing add load gradually (Fig. 11.) until the cluster down because the soil is not able to support the load that is given. The main data is recorded is the magnitude of the force applied and the magnitude of the deformation.

Fig. 10. Cluster Ready to Be Tested.

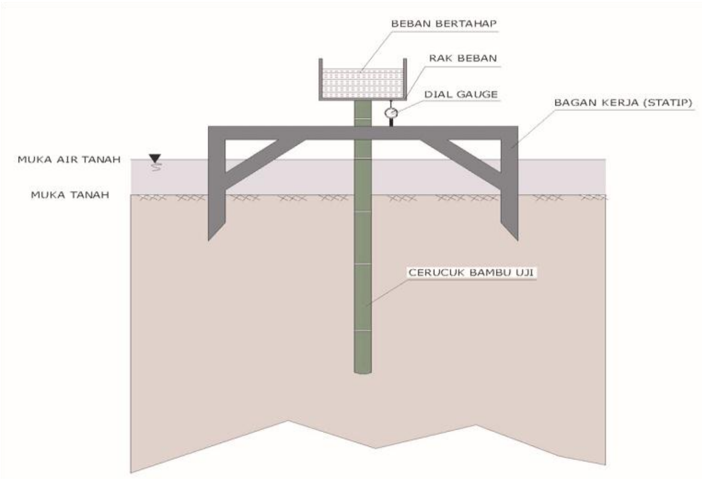

Fig. 11. Set Up Test Constant Spring of Bamboo Pile.

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5. Experimental Data And Analysis

The data of bamboo size and the amount of deformation in the last 30 blows shown in Table 1.

Table 1. Circumferential of Cluster and the Deformation in 30 Last Blow

Type Cluster	Cluster Uji	Keliling cluster (cm)			Keliling rata-rata	Penurunan 30 pukulan terakhir
		ujung	tengah	pangkal		
-	-	cm	cm	cm	cm	cm
cluster 3	1	46	47	48	47	28
	2	45	47	49	47	29
	3	41	43	45	43	34
cluster 4	1	46	48	51	48	19
	2	43	45	48	45	20
	3	49	52	51	51	18
cluster 7	1	64	66	68	66	11
	2	65	67	67	66	12
	3	66	69	73	69	10

Based on data from Table 1., then do the analysis of the influence of the cluster against 30 final blow. The data analysis using a standard external diameter bamboo minimum allowed under the requirements of the job, which is 5 cm. Subsequent analysis using statistical analysis to the data equivalence bamboo on research into bamboo minimum allowed. Then do regression Power in order to obtain the relationship between the cross-sectional area of cluster and equivalent deformation. The analysis is displayed in Table 2.

Table 2. Analysis of Deformation Equivalent

Type Cluster	Cluster Uji	Keliling rata-rata cluster	sisi/jari-2		luas tampang culster terpasang	luas tampang cluster diameter 5cm	Pembanding luas	Penurunan 30 pukulan terakhir	penurunan equivalen	Penurunan equivelent rata-rata
-	-	cm	cm		cm2	cm2	-	cm	cm	cm
cluster 3	1	47	sisi	16	106	43	2.45	28	69	
	2	47	sisi	16	106	43	2.45	29	71	70
	3	43	sisi	14	89	43	2.05	34	70	
cluster 4	1	48	sisi	12	146	100	1.46	19	28	
	2	45	sisi	11	128	100	1.28	20	26	27
	3	51	sisi	13	160	100	1.60	18	29	
cluster 7	1	66	jari-2	11	347	177	1.96	11	22	
	2	66	jari-2	11	350	177	1.98	12	24	22
	3	69	jari-2	11	383	177	2.16	10	22	

Based on data analysis, it can be graphed the relationship between cross-sectional of cluster and equivalent deformation as in show in Fig. 12.

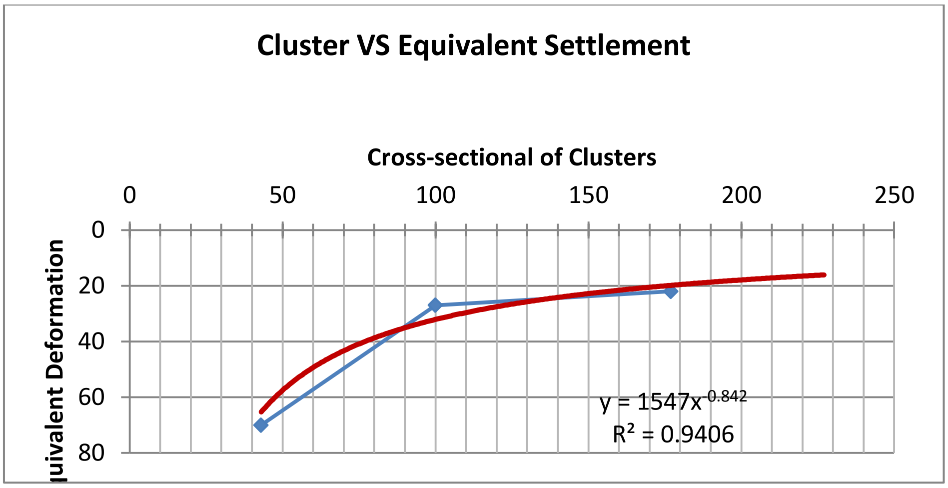

Fig. 12. Graph Relations Cross-sectional of Cluster and Equivalent Deformation.

6. Conclusion

Of the studies that have been done, it can be concluded as follows:

1) Cluster bamboo effect on bamboo mat pile construction system that supports embankment load above the soft subgrade that the more the number of clusters for the same load would be obtained by a smaller decline in the equation: S = 1547 x-0.84 with: S = decrease equivalence and x = area cluster.

2) With the ability to cluster the greater, then that the collapse occurred at the end of the cluster, the high of the embankment to be adjusted or the distance between clusters is enlarged or the length of cluster is reduced so there is no effect foot of the table, which is very dangerous at this construction system.

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