A Resource Survey of Lateritic Soils and Impact Evaluation toward Community Members Living Nearby the Excavation Pits

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Abstract**—**The objectives of the research are to find the basic engineering properties of lateritic soil and to predict the impact on community members who live nearby the excavation pits in the area of Amphur Pak Thor, Ratchaburi Province in the western area of Thailand. The research was conducted by collecting soil samples from four excavation pits for basic engineering properties, testing and collecting questionnaire data from 120 community members who live nearby the excavation pits, and applying statistical analysis. The results found that the basic engineering properties of lateritic soil can be classified into silt soil type which is cohesionless as the loess or collapsible soil which is not suitable to be used for a pavement structure for commuting highway because it could lead to structural and functional failure in the long run. In terms of opinion from community members toward the impact, the highest impact was on the dust from excavation activities. The prediction from the logistic regression in terms of impact on community members was at 84.32 which can be adapted and applied onto other areas with the same context as a guideline for risk prevention and risk communication since it could impact the infrastructures and also impact the health of community members.

Keywords**—**Lateritic soil, excavation pits, engineering properties, impact on community members

I. INTRODUCTION

LATERITIC soil is natural resource where its basic physical and chemical properties are not suitable for agricultural activities. On the other hands, the lateritic soil is a basic necessity for economic development of Thailand for both government and private sectors as a material for highway construction or as a material for landfill and also a material for construction of public facilities. The necessity of lateritic soil generates a high demand of the material in construction industry because of its composition as a skeletal soil which is suitable for engineering activities such as a material for landfill and as a base and subbase materials for a highway construction. With excessive pressure under proper moisture content, the lateritic soil can bare a high weight with less destruction. The misuse of lateritic soil without control under engineering standard could lead to a shortage and depletion of lateritic soil [1], [2].

The availability of lateritic soil was estimated to be around 68,765 km^2 or 13.4 percent of the total area of Thailand [3]. The Minister of Natural Resources and Environment suggested that lateritic soil from 10 provinces in central part of Thailand such as Chainat, Nakornnayok, Nakhonsawan, Lopburi, Supanburi, Saraburi, Kanjanaburi, Uthaithani, Petchaburi and Ratchaburi meets the standard for utilization. Area of lateritic soil in Ratchaburi was 76.46 km^2 or 10.29% of total area of the province. The abundant of lateritic soil caused legal and illegal business of soil excavation [1]. The transportation of lateritic soil was conducted by using a big truck and the soil was usually carried through community area. Some lateritic soil companies run their businesses 24 hour a day. This non-stop operation could impact community not only on air pollution but also on transportation, noise, and waste water. From the issues mentioned previously, researcher initiated research question about basic engineering properties of lateritic soil and the impact from excavation activity on community members who live nearby the excavation pits in order to prevent and communicate the possible risk that could affect the construction of basic infrastructure and public health of the residents with the objective to find the basic engineering properties of lateritic soil and predict the impact on community members who live nearby the excavation pits.

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II. METHODOLOGY

Soil samples were collected from lateritic soil excavation pits with the dept at 7-10 meters in the area of Pak Thor in Ratchaburi province for basic engineering properties laboratory examination. Questionnaires about impact from excavation activity were collected from community members who live nearby the excavation pits under following methodology

A. The Focused Research Area

Four focused lateritic soil excavation pits were in Amphur Pak Thor, Ratchaburi province where all of them were legally granted the permission and the owners of excavation pit grant the approval for sample collection. Those were excavation pits A, B, C and D as shown in Fig. 1.

The criteria for selecting sample were on 1.1) The area of excavation site which must be large enough to be captured on Google Map Engine 1.2) Accessibility which must be easy and safely accessible 1.3) Possessed a legit permission under the regulation of lateritic soil excavation business.

B. Tools and Analysis

Samples were collected from the sites for basic engineering properties examination to investigate Atterberg's limits value and specific gravity of soil.

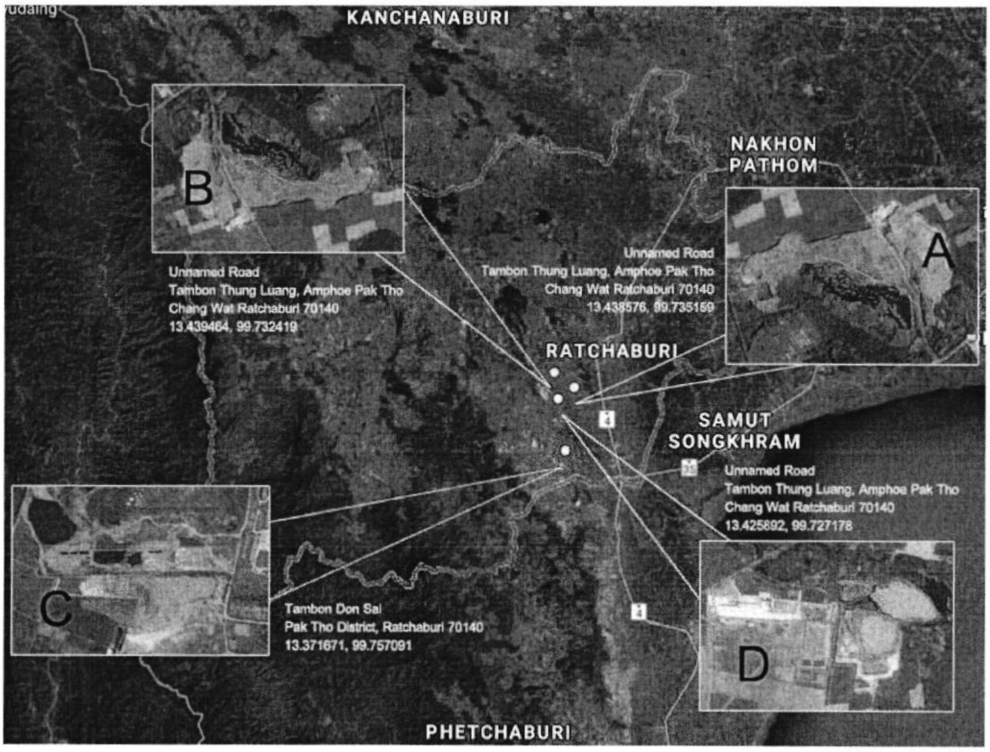

Fig. 1 The location of excavation pit A, B, C and D displayed with Google Map Engine

Questionnaires were selected as a tool to collect data from 120 community members who live in focused area. Questionnaires contain six parts which were;

Part 1. General information from respondents who live in the area of excavation pits

Part 2. Basic information on health and environment problem

Part 3. Impact factors of environment and health problem from community members who live in the area of excavation pits.

Part 4. Source of information and frequency on getting to know environment and health problems

Part 5. Impact from excavation activity on community members who live nearby the excavation pits

Part 6. Recommended solution for Environmental problem from Lateritic soil excavation

Questionnaire data from community members who were impacted from excavation activity were processed under five levels of Likert's scales which can be summarized as the below criteria

- Average score 4.21 – 5.00 = Strongly agree
- Average score 3.41 – 4.20 = Very agree
- Average score 2.61 – 3.40 = Moderately agree
- Average score 1.81 – 2.60 = Disagree
- Average score 1.00 – 1.81 = Strongly disagree

The questionnaire was composed in cooperation with specialists who validated, reviewed, and made suggestions on the contents of the questionnaire including Index of Conformity (IOC). Questionnaires were used to collect data from sample groups by using convenient sampling selection from 120 community members who live nearby the excavation pits. Data were processed by using descriptive statistical and Logistic Regression analysis.

C. Data Analysis

Data collected from questionnaires were collected and analyzed by;

- Descriptive method which is a general description of collective data and laboratory examination and also includes a detail description of general data from community members who were impacted from environment pollution, impacted factors of pollution issue, source and frequency of pollution realization from respondents.

Data then were processed by using SPSS for Windows version 22 and were reported as descriptive statistics as below

1) Frequency and mean score were assigned to evaluate the generic personal information of participants and reported in percentage.
2) Logistic Regression Analysis [4] is an analysis to identify the correlation between response variable and explanatory variable ($\geq$ 1variables). The response variable is a categorical variable which can predict the group value from Logistic Regression equation under event probability. The Logistic Regression can be classified as

2.1) Dependent variable which can occur into two groups (binary Logistic Regression) such as y = 1 for focused event and y = 0 for non focused event

2.2) Dependent variable which can occur more than two groups or multinomial regression

In this study, dependent variable can occur more than two values as a group who has an impact (y=1) and the group who has no impact from excavation pits (y=0). The predictable equation obtained from Logistic Regression Analysis will explain the probability of the event as

$$P_y = \frac{\exp(\beta_0 + \beta_1 x_1 + ... + \beta_p x_p)}{1 + \exp(\beta_0 + \beta_1 x_1 + ... + \beta_p x_p)} \quad (1)$$

For non-focused event

$$\text{Odds} = \frac{P_y}{1 - P_y} \quad (2)$$

Odds values or odds ratios represent how many times the event could probably occur in comparison to not likely to occur. Event could occur if odd ratio is > 1

Applied Logarithm into (2) to get ln (Odds) = $\frac{P_y}{1 - P_y}$

Rearrange to be in the form of Linear Model as

$$\log(\frac{P_y}{1 - P_y}) = \beta_0 + \beta_1 x_1 + ... + \beta_p x_p \quad (3)$$

The Logistic Regression Analysis process

Step 1. Select explanatory variable that could have relationship with response variable (chance to be impacted from the excavation) where explanatory variables were gender, occupation, period living nearby the excavation pits, education background, opinion from respondents toward the transportation falling dust, opinion from community members toward increasing problems of dust and noise from excavation activity.

Step 2. Generate the Logistic Regression Equation by estimating coefficient β_0, β_1, β_2,..., β_p by b_0, b_1,..., b_p from maximum Likelihood method which is a repeated calculation to get the closest parameter and get Logistic Regression Equation as below

$$\log(\frac{P_y}{1 - P_y}) = b_0 + b_1 x_1 + ... + b_p x_p \quad (4)$$

From (4), the coefficient can be interpreted as

- If $b_1 > 0$, $\exp(b_1) > 1$= Increasing odd value (higher chance of occurrence)
- If $b_1 < 0$, $\exp(b_1) < 1$= Decreasing odd value (lesser chance of occurrence)
- If $b_1 = 0$, $\exp(b_1) = 1$= Stable odd value (equal chance of occurrence)

Step 3. Selection of Response variable by using forward stepwise likelihood by considering likelihood ratio or the change in -2 Likelihood Ratio (-2LL). Decreasing -2LL indicates that explanatory variable must exist in the equation.

Step 4. Model's coefficient hypothesis test

Test the non-zero coefficient hypothesis by applying Wald statistics with Wald Statistics Chi Square distribution which is a second power of ratio between coefficient and standard deviation of such coefficient.

Step 5. Validating conditions of Logistic Regression Analysis

Verifying Goodness of Fit of the model by using Hosmer – Lemeshow test which based on Chi square statistic test

$$\chi^2 = \sum_{i=1}^{10} \frac{(O - E)^2}{E_i}$$

by following hypothesis

- H_o = Suitable model
- H_1 = Not suitable model

Step 6. Verifying result of the group prediction by using classification table

III. Result, Conclusion and Discussion

A. Part1 Result of Basic Engineering Property Analysis of Lateritic Soil from Focused Area

Lateritic soil was examined in laboratory to compare with basic standard property of Lateritic soil in Thailand and Khonkean's Loess soil, and the result showed that the average Liquid Limit (L.L.) of Lateritic soil from four focused excavation pits was at 17.76%, average plastic index was 5.70%, and average specific gravity of soil was 2.9% as shown in Table I.

TABLE I
COMPARISON OF BASIC PROPERTIES BETWEEN LATERITIC SOIL FROM FOCUSED AREA AND GENERAL PROPERTY OF LATERITIC SOIL IN THAILAND AND KHONKEAN'S LOESS SOIL

Basic Properties and Standard Test Method	Selected Area Soils	Lateritic Soils [7]	Khon Kaen Loess [8]	Subbase Materials [9]
Liquid Limit, L.L. (%) [5]	18.76	18 - 97	16	< 35
Plastic Index, P.I. (%) [5]	4.54	N.P. - 51	3	4 - 11
Specific Gravity, G.S. [6]	2.62	2.59 – 3.20	2.6	-

From the data in Table I, lateritic soil from focused area was in compliance with the other lateritic soil from other 57 excavation pits in Thailand [7] and also in compliance with the standard material for subbase construction from Department of Highways [9] where L.L. value must be less than 35% and P.I. must be between 4-11%, but it is found that the property of the sample soil was similar to the property of Khon kean's loess soil. The loess soil is a delicate sand sediment carried to composition site by wind with its cohesionless property [8]. However, according to suggestion from Jotisankasa et al. [10], the loess soil is not suitable for construction of infrastructure and subbase construction since losses is capable to bare higher weight during its dry stage but will rapidly loss baring property when wet, which could discourage the economic development on construction of infrastructure in both private and government sectors.

B. Part 2 The Prediction of Impact Existence from Community Members who Live Nearby the Excavation Pits in Focused Area

General information of respondents (such as gender, age, education level, occupation, time living nearby the excavation pits), along with basic knowledge of environment and health problem, impact factors on environment and health from residing nearby the excavation pits from 120 members was analyzed and it was found that the majority of respondents were female at 69 respondents or 57.5% with average age between 18-25 years old or 23.3%. Highest education level was at primary school of 51 respondents or 42.5%. Those were daily workers at 29 respondents or 24.2% and have been resided nearby the excavation pits for more than 30 years at 48 respondents or 40%. The analysis of questionnaire about environment and health impact showed that air pollution was the most impact issue among 87 respondents or 72.5% followed by impact from soil transportation for 44 respondents or 36.7%, noise pollution were 24 respondents or 20% and the least impact was water pollution of three respondents or 25%

The Logistic Regression Analysis was applied to analyze the impact from living nearby the excavation pits (y) against other impact factors such as gender of respondents (X_1), occupation (X_2), time period living nearby the excavation pits (X_3), education level (X_4), level of opinion from community members on falling dirts from soil transportation (X_6) and level of opinion from community members on increasing problems from dust and noise from soil excavation (X_7).

TABLE II
RESULT FROM MODEL AND DATA CONFORMITY ANALYSIS

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
82.431	0.397	0.570

Table II showed the results from model and data conformity analysis by using Nagelkerke R square value = 0.570. The explanatory variables or impact factors are able to predict the existence of the impact at 57%.

TABLE III
THE ANALYSIS OF GOODNESS OF FIT OF THE MODEL

Chi-Square	Df	Sig
3.375	8	0.909

TABLE IV
THE EXPLANATORY VARIABLE THAT IMPACT THE LIVING NEARBY THE SOIL EXCAVATION PITS

	Variables	B	S.E.	Wald	Df.	Sig.	Exp(B)
X_3	Period of Living	1.116	0.432	6.677	1	0.010	3.053
X_4	Education	1.081	0.438	6.082	1	0.014	2.947
X_5	Opinion 1	2.128	0.969	4.826	1	0.028	4.557
X_6	Opinion 2	1.650	0.560	8.678	1	0.003	5.207
X_7	Opinion 3	1.239	0.511	5.872	1	0.015	3.290
	Constant	-4.028	2.460	2.680	1	0.102	0.018

Table III showed the result of the analysis of the Goodness of Fit of the model by using Hosmer and Lemeshow. The Chi square was 3.375 with significant value at 0.909 which implied that the model was suitable within significant level at 0.05.

Result from Table IV revealed that the impact factors toward community members who live nearby soil excavation pits were;

- Period of living nearby the soil excavation pits which the longer period will increase the impact by 3.05 times
- Increasing level of education background will increase the impact by 2.95 times.
- Increasing level of opinion from respondents toward living nearby the excavation area will cause environment and health issue will increase the impact by 4.56 times.
- Increasing level of opinion from respondents toward falling dirt from soil transportation will impact other factors at 5.21 times.
- Increasing level of opinion from respondents toward dust and noise from soil excavation will impact other factors at 3.29 times.

The relationship of those impact factors can be explained by the following Logistic Regression equation.

$$\log\left(\frac{P_y}{1-P_y}\right) = -4.028 + 1.116X_3 - 0.920X_4 + 1.1516X_5 + 1.650X_6 - 1.236X_7$$

where X_3 represents the period living nearby the soil excavation activity, X_4 represents the education level, X_5 represents opinion level toward excavation caused environment and health problems, X_6 represents the opinion level toward falling dirt from transportation, X_7 represents the opinion level toward increasing problem on problem from dust and noise from excavation.

TABLE V
GROUP CLASSIFICATION PREDICTION

Observed	Predicted		Percentage Correct
	Impact		
	Yes	No	
Impact			
Yes	21	13	6.8
No	6	80	93.0
	Overall Percentage		84.32

From Table V, prediction result of logistic regression analysis on classifying impacted group found that the impact toward members who lived nearby the studied excavation pits, by using logistic regression analysis, provided the model accuracy at 84.32% and can be derived into opportunity prediction equation of impact on members who live nearby the excavation pit as below

$$\log\left(\frac{P_y}{1-P_y}\right) = -4.028 + 1.116X_3 + 1.081X_4 + 2.128X_5 + 1.650X_6 + 1.239X_7$$

The result from the study can be applied as a guideline for the other areas with similar circumstance in order to predict the probability on impact occurrences toward community members as a guideline to protect and communicate the risk that impact public health. The result analysis shows that dust was the most concern factor which is a part of air pollution that impact air and living quality especially for those who live nearby the excavation pots because its property as a small particle size. The particulate matter which is smaller than 10 micron (PM10) is small enough to penetrate into human respiration cells and can cause loss in life to human [11]. This is in correspondent with report from WHO [12] which stated that air pollution is one of the most severe risk that impact global public health and cause dead to 7 million lives annually. The mentioned issues can be minimized if there were guideline to protect and communicate the risk from particulate matter problem from lateritic excavation activities especially can minimize public health problems. The outcome from the study can alleviate the economic issue since it could save medical expense as well.

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