บันทึกข้อความ

ส่วนราชการ.............คณะเทคโนโลยีอุตสาหกรรม..

ที่.................................. **วันที่**.....๒๙ พฤศจิกายน ๒๕๖๑...............

เรื่อง รายงานผลการไปประชุม/การอบรม/การสัมมนา/การศึกษาดูงาน

เรียน คณบดี

ตามคำสั่ง/หนังสือ/บันทึกข้อความ ที่.... ๒๔๙๖/๒๕๖๑......... ลงวันที่.......๕ กันยายน ๒๕๖๑...ให้ข้าพเจ้า........โชติกาญจน์ ราชกรม... พร้อมด้วย........-. เดินทางไป~~ประชุม/การอบรม~~/การสัมมนา/~~การศึกษาดูงาน~~ที่.... Meitetsu Grand Hotel...เมืองนาโกย่า ประเทศญี่ปุ่น......เรื่อง.......... การจัดประชุมสัมมนาวิชาการ Conference on Science, Engineering and Environment (SEE-NAGOYA ๒๐๑๘)......ระหว่างวันที่... ๑๑..เดือน.พฤศจิกายน..พ.ศ. .. ๒๕๖๑.. ถึงวันที่.... ๑๕....เดือน...พฤศจิกายน....พ.ศ. ๒๕๖๑..จัดโดย.........The GEOMATE Internationtional Society................รวมเป็นเวลา.............๕..............วัน

☑ อนุมัติให้ใช้งบประมาณ เป็นค่าใช้จ่ายในการเดินทางไปราชการครั้งนี้ จำนวน..๓๐,๐๐๐...บาท (.............สามหมื่นบาทถ้วน...................)

☐ ไม่ใช้งบประมาณ

☐ ใช้งบประมาณส่วนตัว

บัดนี้ การปฏิบัติหน้าที่ราชการที่ได้รับมอบหมายได้เสร็จเรียบร้อยแล้ว ข้าพเจ้าขอรายงานผลการไปประชุม/การอบรม/การสัมมนา/การศึกษาดูงาน ดังต่อไปนี้

การจัดประชุมสัมมนาวิชาการ Conference on Science, Engineering and Environment (SEE-NAGOYA ๒๐๑๘) ซึ่งจัดเป็นครั้งที่ ๔ ในรูปแบบภาคบรรยาย (Oral) ด้านนวัตกรรมวัสดุก่อสร้าง การพัฒนาเทคโนโลยีวัสดุก่อสร้างสีเขียว คอนกรีตและโครงสร้างในอนาคต โดยมีการสัมมนาวิชาการด้านนวัตกรรมวัสดุก่อสร้าง การพัฒนาคอนกรีตสำหรับงานถนน การพัฒนาวัสดุชั้นพื้นทางด้วยวัสดุผสมเพิ่มรูปแบบต่างๆ ซึ่งข้าพเจ้าได้นำเสนอผลงานทางวิชาการในงานนำเสนอรูปแบบภาคบรรยาย (Oral) เรื่อง The use of bottom ash to improve the strength of poor subbase lateritic soil in road construction ซึ่งเป็นการพัฒนาดินลูกรังซึ่งเป็นชั้นดินพื้นทางที่มีความคงทนต่ำ และมีค่ากำลังรับแรงแบกทานของดิน (Unconfined compressive strength) ที่ต่ำกว่ามาตรฐานชั้นรองพื้นทางให้มีการพัฒนากำลังรับแรงที่ดีขึ้น ด้วยวัสดุที่เป็นผลพลอยได้จากการผลิตเชิงอุตสาหกรรม

ข้าพเจ้า จะนำความรู้ ความสามารถ ประสบการณ์ ทักษะ หรืออื่นๆ ที่ได้รับในการไปประชุม การอบรม/การสัมมนา/การศึกษาดูงานในครั้งนี้ มาเพื่อพัฒนางานของหน่วยงาน ดังนี้

การพัฒนาการเรียนการสอน / การพัฒนาปฏิบัติงาน สามารถนำความรู้ที่ได้จากการสัมมนา มาถ่ายทอดความรู้ด้านนวัตกรรมวัสดุก่อสร้าง งานวิจัยด้านวัสดุก่อสร้างชนิดใหม่ๆ แนวโน้มการพัฒนาวัสดุก่อสร้าง ในวิชาวัสดุก่อสร้าง ซึ่งเป็นการเพิ่มองค์ความรู้นักศึกษา การสร้างแนวคิดใหม่ๆ ในการสร้างนวัตกรรมวัสดุเพื่อการอนุรักษ์สิ่งแวดล้อมมากขึ้น

การพัฒนาตนเอง สามารถนำความรู้ที่ได้จากการสัมมนา มาต่อยอดงานวิจัยด้านวัสดุก่อสร้าง โดยเฉพาะวัสดุก่อสร้างเพื่อการอนุรักษ์สิ่งแวดล้อม และนวัตกรรมวัสดุก่อสร้างใหม่ๆ

เอกสารที่ได้รับจากการไปราชการ/การอบรมสัมมนา/การศึกษาดูงาน มีดังต่อไปนี้ คือ

เอกสารประกอบงาน Conference on Science, Engineering and Environment (SEE-NAGOYA ๒๐๑๘)

การเผยแพร่ความรู้ ประสบการณ์ ทักษะ และอื่นๆ แก่ผู้ที่เกี่ยวข้อง คือ

การต่อยอดงานวิจัยด้านวัสดุก่อสร้าง โดยเฉพาะวัสดุก่อสร้างเพื่อการอนุรักษ์สิ่งแวดล้อม และนวัตกรรมวัสดุก่อสร้าง

จึงเรียนมาเพื่อโปรดทราบและพิจารณาดำเนินการต่อไป

ลงชื่อ..ผู้รายงาน

(...โชติกาญจน์ ราชกรม...)

ตำแหน่ง อาจารย์

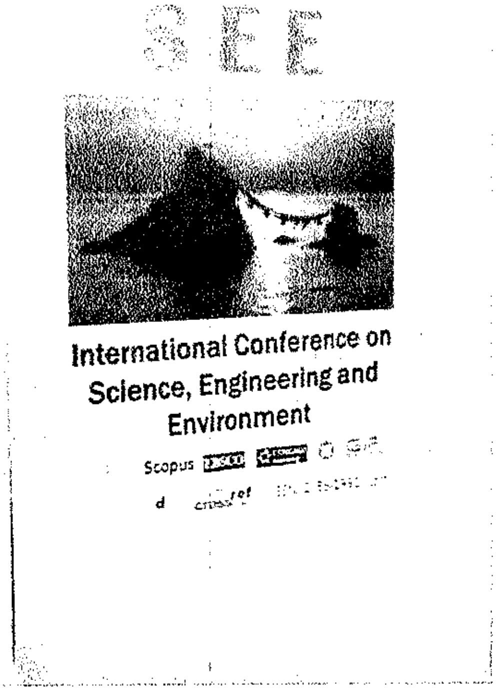
ความคิดเห็นของหัวหน้าหน่วยงาน

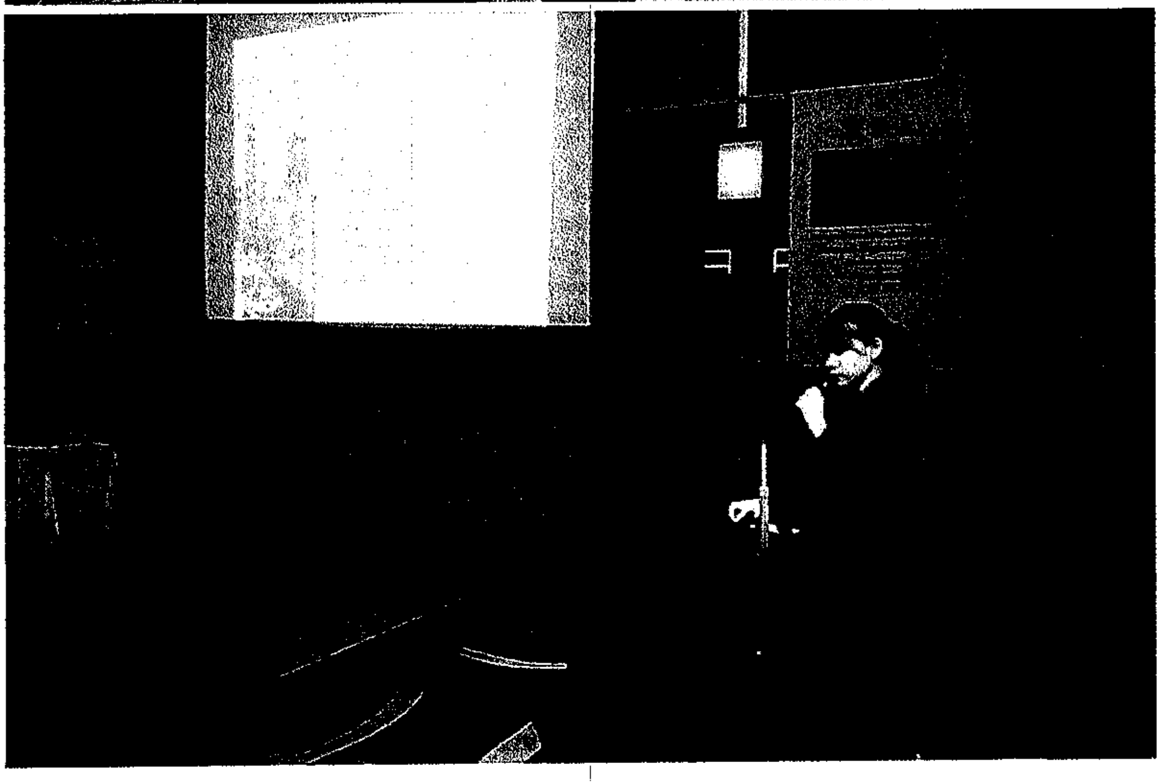
ลงชื่อ..

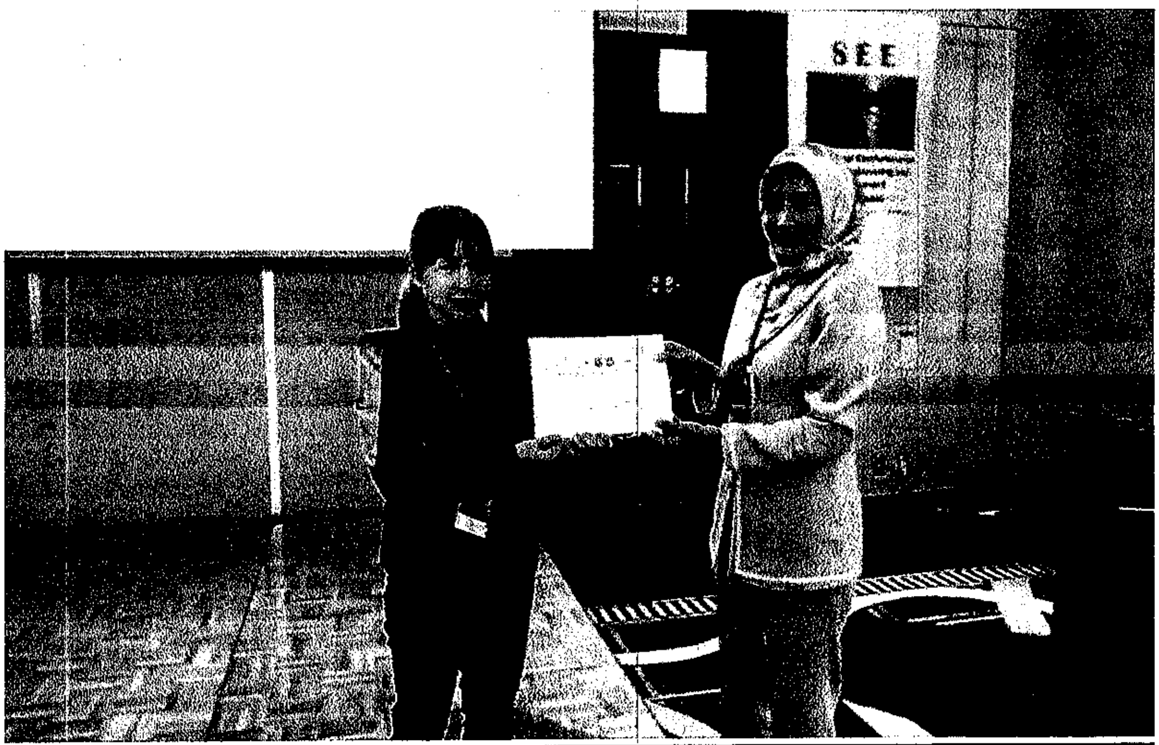
รองศาสตราจารย์ ดร.เบญจลักษณ์ เมืองมีศรี

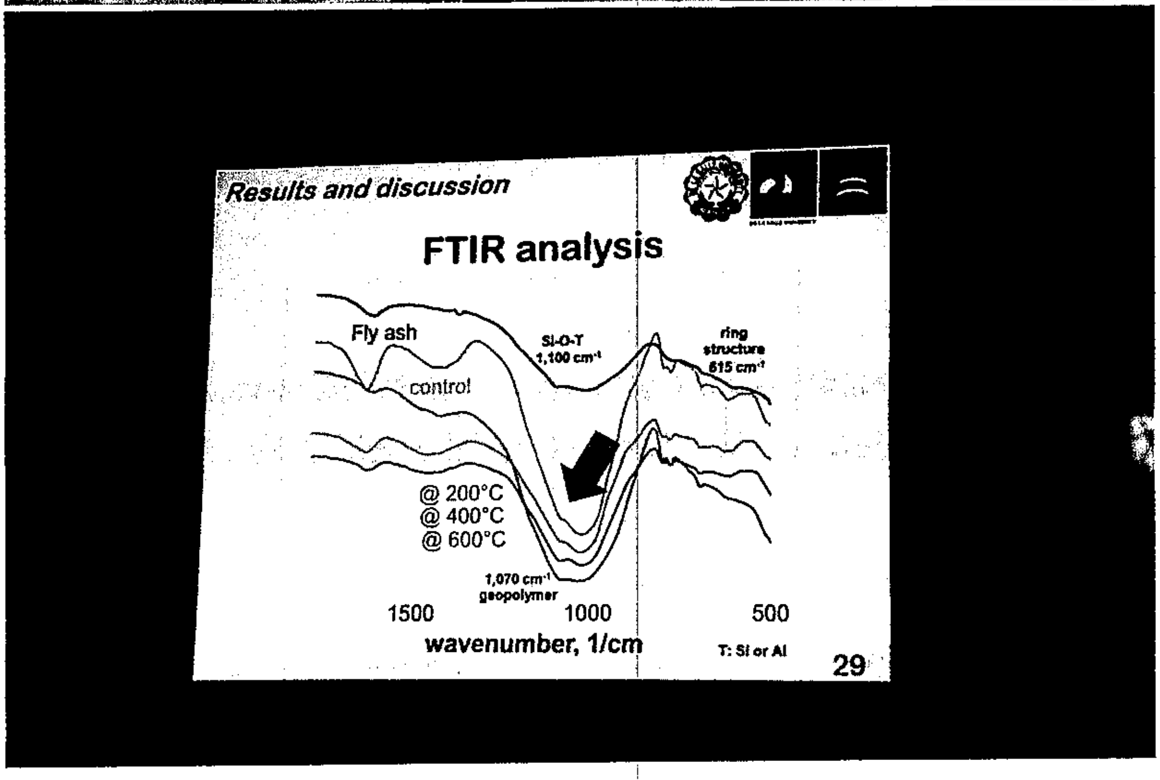
ตำแหน่ง คณบดีคณะเทคโนโลยีอุตสาหกรรม

๑. ภาพประกอบการเข้าร่วมกิจกรรม








Results and discussion
FTIR analysis
Fly ash
control
Si-O-T
1,100 cm-1
ring
structure
615 cm-1
@ 200°C
@ 400°C
@ 600°C
1,070 cm-1
geopolymer
1500
1000
500
wavenumber, 1/cm
T: Si or Al
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หมายเหตุ ๑. แนบสำเนาประกาศนียบัตร หนังสือสำคัญ หรือหนังสือรับรองการเข้ารับการฝึกอบรม สัมมนา/ประชุมทางวิชาการและเอกสารที่เกี่ยวข้องกับการฝึกอบรม/สัมมนา/ประชุมทางวิชาการ ไปกับรายงานฉบับนี้ด้วย

๒. ส่งรายงานพร้อมทั้งเอกสารที่เกี่ยวข้องให้คณบดี **ภายใน ๗ วัน** หลังสิ้นสุดการฝึกอบรม, ศึกษาหรือดูงาน, ประชุมเชิงปฏิบัติการหรือการสัมมนา

๓. กรณีไปนำเสนอผลงานวิจัย/ผลงานวิชาการ หรือการได้รับการตีพิมพ์ในวารสารต่างๆ ขอให้จัดส่งไฟล์งาน (Proceeding จากการตีพิมพ์, วารสาร/ปก, เนื้อหาในส่วนตีพิมพ์ มายัง e-mail: kannika.sroy@vru.ac.th)

PROCEEDINGS OF FOURTH INTERNATIONAL CONFERENCE – SEE 2018
SCIENCE, ENGINEERING & ENVIRONMENT NAGOYA, JAPAN 12-14 NOVEMBER, 2018

Science, Engineering and Environment

Edited by

Prof. Zakaria Hossain
Graduate School of Bioresources
Mie University, Japan

Dr. Jim Shiau
School of Civil Engineering and Surveying
University of Southern Queensland, Australia

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Preface

On behalf of the SEE 2018 Organizing Committee, it is our great pleasure to welcome you to the Fourth International Conference on Science, Engineering & Environment, held at the Meitetsu New Grand Hotel, Nagoya,, Japan organized in conjunction with Mie University Research Center for Environmental Load Reduction, The GEOMATE International Society, Useful Plant Spread Society, Glorious International, AOI Engineering, HOJUN, JCK, CosmoWinds and Beppu Construction, Japan.

The conference covers three major themes with many specific themes including:

Engineering	Science	Environment
· Environmental Engineering · Chemical Engineering · Civil and Structural Engineering · Computer Software Web Engineering · Electrical and Electronic Engineering · Energy and Thermal Engineering · Aerospace Engineering · Agricultural Engineering · Biological Engineering and Sciences · Biological Systems Engineering · Biomedical and Genetic Engineering · Bioprocess and Food Engineering · Geotechnical Engineering · Industrial and Process Engineering · Manufacturing Engineering · Mechanical and Vehicle Engineering · Materials and Nano Engineering · Nuclear Engineering · Petroleum and Power Engineering · Forest Industry Engineering	· Environmental Sciences · Chemistry and Chemical Sciences · Fisheries and Aquaculture Sciences · Astronomy and Space Sciences · Atmospheric Sciences · Botany and Biological Sciences · Genetics and Bacteriology · Forestry Sciences · Geological Sciences · Materials Science and Mineralogy · Statistics and Mathematics · Microbiology and Medical Sciences · Meteorology and Palaeo Ecology · Pharmacology · Physics and Physical Sciences · Plant Sciences and Systems Biology · Psychology and Systems Biology · Zoology and Veterinary Sciences	· Environmental Technology · Recycle Solid Wastes · Environmental dynamics · Meteorology and Hydrology · Atmospheric and Geophysics · Physical oceanography · Bio-engineering · Environmental sustainability · Resource management · Modelling and decision support tools · Institutional development · Suspended and biological processes · Anaerobic and Process modelling · Modelling and numerical prediction · Interaction between pollutants · Water treatment residuals · Quality of drinking water · Distribution systems on potable water · Reuse of reclaimed waters

As expected, this year we have received many submissions from different countries all over the world. The technical papers were selected from the vast number of contributions submitted after a review of the abstracts. The final papers in the proceedings have been peer reviewed rigorously and revised as necessary by the authors. It relies on the solid cooperation of numerous people to organize a conference of this size. Hence, we appreciate everyone who support as well as participate in the joint conferences.

Last but not least, we would like to express our gratitude to all the authors, session chairs, reviewers, participants, institutions and companies for their contribution to SEE 2018. We hope you enjoy the conference and find this experience inspiring and helpful in your professional field. We look forward to seeing you at our upcoming conference next year.

Best regards,

Prof. Dr. Zakaria Hossain, Chairman

Dr. Jim Shiau, USQ, Australia (Assistant to Chairman)

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E-mail: conference@geomate.org
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THE USE OF BOTTOM ASH TO IMPROVE THE STRENGTH OF POOR SUBBASE LATERITIC SOIL IN ROAD CONSTRUCTION

Chotikan Ratchakrom[1]
[1]Faculty of Civil Engineering Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage, Thailand

ABSTRACT

This research investigates the use of bottom ash to improve the unconfined compressive strength of poor subbase. Lateritic soil that used in test represented weak subbase soil in road construction. This research performed on lateritic soil mixed with cement 1-1.5%, kaolin 0.5-1% and the different percentages of bottom ash was between 2-8% by weight of soil. The unconfined compressive strength of the soil improvement tends to increase with an increase in the amount of bottom ash. However, the unconfined compressive strength of the samples slightly increased when the amount of bottom ash was exceeded 6%. The results demonstrated bottom ash can develop the early strength of soil. As shown in the results of soil mixed with cement 1.5%, kaolin 1%, and bottom ash 6-8% can be developed the strength near the soil mixed with cement 3% in 7 days. Moreover, the addition 6% of bottom ash and 0.5% of kaolin in the soil samples mixed with cement 1.5% can be increased the compressive strength 87% of the samples without bottom ash and kaolin. The required strength of subbase improvement should more than 689 kPa at the curing time 7 days. The results demonstrated the strength of soil mixed with 1.5% cement, 0.5% kaolin and 4-8% bottom ash was higher than the required strength. Therefore, bottom ash can develop the strength of poor subbase and reduced the utilized amount of cement to improve the strength of soil.

Keywords: Lateritic soil, Bottom ash, Compressive strength, Kaolin, Subbase

INTRODUCTION

The lateritic soil has been used in road construction of Thailand and developing in the rural area. The subbase of road constructions was constructed by lateritic soil. However, it's become the realize problem of lateritic soil. This is because the poor lateritic soil is low compressive strength and poor durability. Therefore, the bearing capacity of poor subbase was lower than the minimum strength requirement for road construction. Subsequently, the rain infiltration or the water inundates the subbase can be causing the road damage. [1], [2]. This problem represents to emphasis for improvement in engineering properties of lateritic soil such as compressive strength, durability, and permeability [2].

The most commonly used additive for soil stabilization is ordinary Portland cement. To build a subbase with cement stabilized ash alone is not yet common, but this is one of the high volume ash application being promoted by ash producers [3]. The use of ash or the pozzolanic materials combined with cement to improve the strength of soil can be reduced the cost of the soil stabilization. Therefore, this study investigated on the use of bottom ash, which is the by-product from Mae Moh power plant to improve the strength of poor subbase.

Ash removed from the base of the furnace is termed bottom ash [3]. Bottom ash (BA) is a solid waste available in Mae Moh power plant in the north of Thailand is about 0.8 million tons and is disposed of a landfill near the power plant [4]. It is coarser than fly ash, ranging in size from fine sand to gravel [3]. Bottom ash is larger in size and very irregular, containing pores and cavities [5]. Ground to a proper fineness, bottom ash can be used as a pozzolan that produces relative strength [6]. The chemical compositions of bottom ash were 39.3% SiO_2, 21.3% Al_2O_3, Fe_2O_3, 2.1% K_2O, 16.5% CaO, 1.0% Na_2O and 1.4% loss on ignition. The bottom ash has increased pozzolanic activity and used to partially replace Portland cement. The utilization of bottom ash as a cementitious a partial replacement of cement is possible [4].

Bottom ash serves well as structural fill and construction [3]. A variety of research on the mobilization of coal bottom ash for use as the cementitious material has been utilized. The bottom ash has increased the pozzolanic activity [7], [8]. Therefore, many types of research have been used the bottom ash as fine aggregate in concrete [9], asphaltic [10]. On the other hand, the bottom ash can involve clay minerals and increases the value of supporting capacity of the clay and increasing the compressive strength value [11].

This paper investigated the use of bottom ash combined with cement which a partial replacement by kaolin to improve the strength of the poor quality of soils. There are many of additive that has been tested the effect to develop the engineering properties of lateritic soil. In order to reduce costs by replacing some cementations stabilizers with non-cementations additives [12, 13, 14]. Kaolin soil is a mineral of soil, which some of these noncement additives. In chemical terms, kaolin has many cementing materials consists of SiO_2, Al_2O_3, and Fe_2O_3. These elements can improvement bonding, durability and stabilization of soil. [15].

The objective of this paper is investigating the use of bottom ash to improve the strength of poor subbase. In order to increase the strength of subbase higher than the required strength which suggested by the Thailand Department of highways. The unconfined compressive strength of the soil improvement should be more than 689 kPa.

MATERIALS AND METHODS

The lateritic soil which has poor quality was used in the experiment. The strength of the soil samples was less than the required strength which suggested by the Thailand department of highways. The soil samples were conducted on Atterberg limits and sieve analysis test to determine the properties and classification of the samples. Portland cement type 1, kaolin and bottom ash were mixed in the soil samples to improve the strength. Kaolin obtained from Lampang province of Thailand. Bottom ash obtained from Mae Moh power plant in Lampang province of Thailand as shown in Fig. 1.

The maximum size of bottom ash mixed with the soil samples was 4.75 mm. All admixture stored in plastic bags to maintain their dry condition. The soil samples were mixed with cement, kaolin and bottom ash in the ratio accordance with Table 1. The mixture code in group A represented the soil samples mixed with cement 1.5-3% by weight of the soil samples. The mixture code in group B represented the soil samples mixed with cement 1%, kaolin 1% and the different percentages of bottom ash 2-8% by weight of soil. The mixture code in group C represented the soil samples mixed with cement 1.5%, kaolin 0.5% and the different percentages of bottom ash 2-8% by weight of soil.

The difference between the mixture in group B and C is the percentage of Portland cement and kaolin. The combination of cement and kaolin in the mixture of B and C samples was 2% by weight of the soil samples. However, the amount of cement in the mixture group B was less than group C 0.5%.

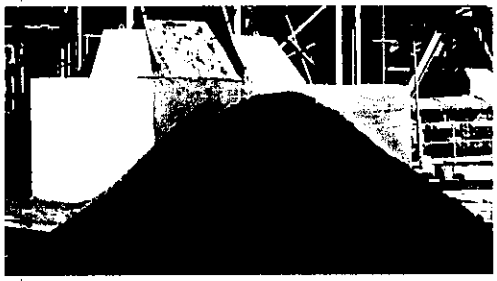

Fig.1 Bottom ash obtained from Mae Moh power plant.

The soil samples mixed with cement, kaolin and bottom ash, according to Table 1 were conducted in modified compaction tests and unconfined compression tests.

Table 1. The mixture ratio of admixture mixed with the soil samples.

Mixture Code	Cement (%)	Kaolin (%)	Bottom Ash (%)
A1	1.5	-	-
A2	2	-	-
A3	3	-	-
B1	1	1	2
B2	1	1	4
B3	1	1	6
B4	1	1	8
C1	1.5	0.5	2
C2	1.5	0.5	4
C3	1.5	0.5	6
C4	1.5	0.5	8

Note: The amount of cement, kaolin and bottom ash mixed with soil is percent by weight of soil.

The modified Proctor compaction tests on the samples in each mixture were conducted in accordance with AASHTO T180. This test is intended to be used to determine the maximum dry density and optimum moisture content in each mixture of the samples. The samples were manually compacted in five equal layers using the modified compaction effort.

Unconfined compression tests are intended to be used to determine the compressive strength of the samples. Unconfined compression tests were conducted in accordance with AASHTO T 208. The soil samples mixed with cement, kaolin and bottom ash in the ratio according to Table 1 were used in this test. The samples mixed with water at the optimum moisture content (OMC) for each mixture which obtained the values from the modified compaction tests. The samples were compacted in five equal layers using modified compaction effort. After completing the compaction process, each sample was extruded from the compaction mold and was then cured in the plastic bag until tested. The specimens were cured in the in the plastic bag for 3, 7 and 14 days. Following the curing process, the samples were soaked in water for 2 hours and then compressed the samples by the compression machine. The results represented by the influence of bottom ash on the strength of soil improvement. However, the Thailand Department of highways suggested that the unconfined compressive strength of subbase improvement should be more than 689 kPa at the curing time 7 days. Therefore, the optimum bottom ash content to improve the strength of soil can be defined by the test results.

RESULTS AND DISCUSSIONS

The Engineering Properties of Lateritic Soil

The soil samples were conducted on Atterberg limits, sieve analysis test, and modified compaction tests to determine the engineering properties of the soil samples. Liquid limit, plastic limit, and plasticity index of the soil samples were 27%, 17%, and 10% respectively. Fig. 2 shows the particle size distribution of the soil samples in this study. However, according to the AASHTO classification system, the soil samples were in A-2-4. The gradation of soil samples is excellent to good for subgrade materials when considered on the general subgrade rating of AASHTO. Moreover, the results of modified compaction tests demonstrated the maximum dry density of the soil samples was approximately 1940 kg/m^3 and optimum moisture content was 9.9%.

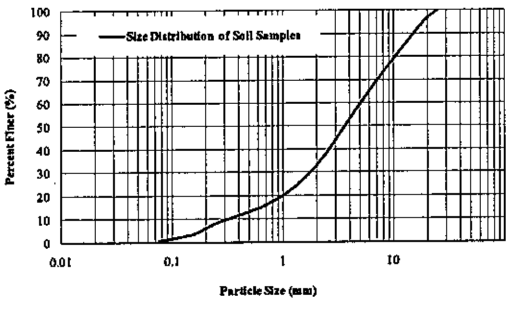

Fig. 2 Particle size distribution of the soil samples used in the test.

Maximum Dry Density and Optimum Moisture Content

The modified compaction tests were conducted on soil samples mixed with cement, kaolin and bottom ash in a ratio accordance with Table 1. The results of compacted soil samples mixed with cement 1.5%-3% as shown in Fig. 3. The results showed the dry density of the samples mixed with cement was slightly different from the samples without cement. The maximum dry density of the samples A1, A2 and A3 was 1957 kg/m^3, 1959 kg/m^3, and 1946 kg/m^3 respectively. The optimum moisture content of the samples A1, A2 and A3 were 9.7%, 9.8%, and 10.2% respectively.

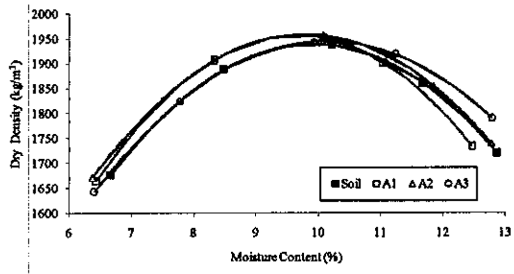

Fig. 3 Dry density and moisture content relationship of the soil improvement by cement.

The results of soil samples mixed with cement, kaolin and bottom ash shown in Fig. 4 and Fig. 5. The results in Fig. 4 illustrates dry density and moisture content of the samples in group B. The maximum dry density of the samples B1, B2, B3 and B4 was 1945 kg/m^3, 1961 kg/m^3, 1954 kg/m^3 and 1966 kg/m^3 respectively. The optimum moisture content of the samples B1, B2, B3, and B4 was 9.8%, 9.9%, 9.9% and 11.1% respectively.

Dry density and moisture content of the samples in group C illustrated in Fig. 5. The maximum dry density of the samples C1, C2, C3 and C4 was 1960 kg/m^3, 1942 kg/m^3, 1938 kg/m^3 and 1940 kg/m^3 respectively. The optimum moisture content of the samples C1, C2, C3, and C4 was 9.8%, 10.4%, 10.0% and 10.0% respectively. The results demonstrated a slight difference of maximum dry density and optimum moisture content of the samples for each mixture. The maximum dry density of the samples in each mixture was between 1940-1960 kg/m^3. Therefore, bottom ash adding in the soil samples is less effect on the maximum dry density of soil.

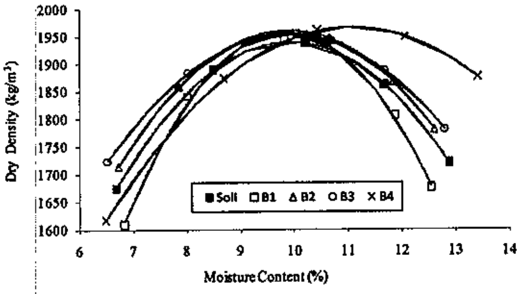

Fig. 4 Dry density and moisture content relationship of the soil improvement in group B.

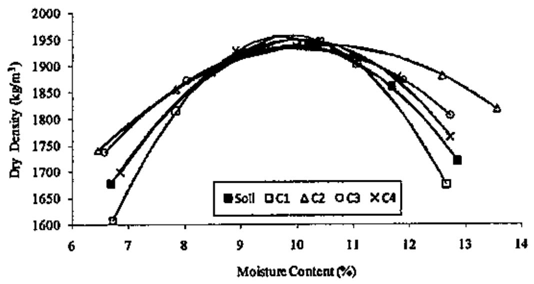

Fig. 5 Dry density and moisture content relationship of the soil improvement in group C.

Unconfined Compressive Strength

The average unconfined compressive strength values of the soil improvement for each mixture are as plotted in Fig. 6.

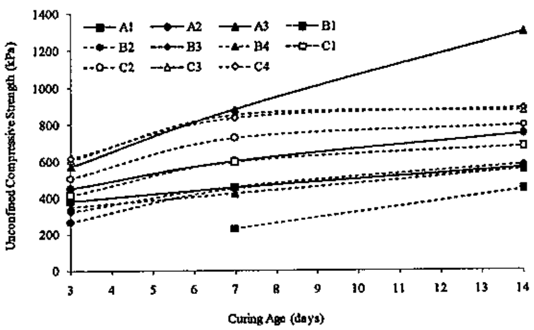

Fig. 6 Unconfined compressive strength of the soil improvement for each mixture.

The results demonstrated the soil samples mixed with 3% of cement gave the highest strength in 14 days. The strength of A3 samples was 1302 kPa in curing time 14 days. The strength of C3 and C4 samples in the curing 14 days was lower than A3 approximately 415 kPa. However, the early strength of C3 and C4 samples was near A3 in the curing time 3 and 7 days. Although, C3 and C4 samples contain Portland cement only 50% of A3. The results can be suggested that bottom ash mixed with soil developed the early compressive strength of soil. This is due to the composition of bottom ash obtained from Mae Moh power plant were 21.3% Al_2O_3 and 13.5% Fe_2O_3 [4] which Al_2O_3 and Fe_2O_3 in the bottom ash can be developed the early strength of the samples. However, the strength of A3 is more than C3 and C4 in the curing time14 days. This is because the cement content in A3 samples was higher than C3 and C4 and the later strength is controlled mainly by calcium silicate hydrate.

Consideration on A1 samples and the samples in group C which contain the same amount of cement in the samples at 1.5% by weight of soil. The results demonstrated the strength of the samples in group C which contained kaolin 0.5% and bottom ash 2%-8% was higher than A1 samples. Moreover, the strength of the samples tends to increase with an increase in the amount of bottom ash. The compressive strength of C3 and C4 samples was near in the curing time 3-14 days. The compressive strength of the samples C3 and C4 increased approximately 87% and 84% respectively of A1 samples in curing time 7 days. However, the strength of C3 and C4 samples in curing time 14 days was higher than A1 samples approximately 55%. Moreover, B2, B3, and B4 samples represented the unconfined compressive strength near A1 samples. Although, the samples in group B contain the amount of cement was less than the A1 samples 0.5% by weight of soil. Therefore, this result demonstrated that bottom ash can be reduced the utilized amount of cement to improve the strength of soil. The influence of bottom ash on the compressive strength of soil shown in Fig. 7 and Fig. 8.

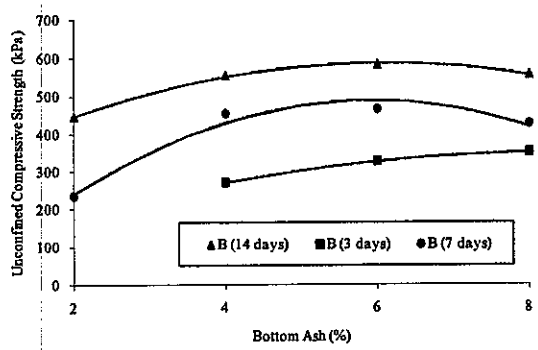

Fig. 7 The influence of bottom ash on the compressive strength of soil mixed with the admixture in group B.

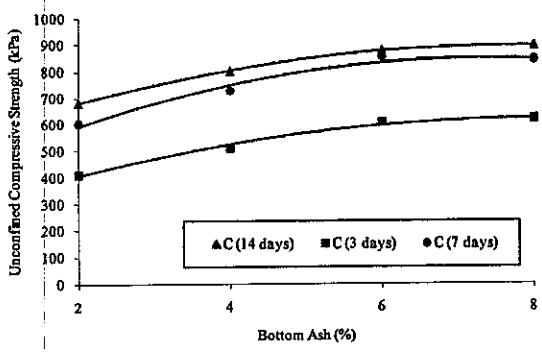

Fig. 8 The influence of bottom ash on the compressive strength of soil mixed with the admixture in group C.

The results demonstrated the strength of soil improvement tends to increase with an increase in the amount of bottom ash. The unconfined compressive strength was rapidly increasing when bottom ash contains in the samples 2 to 6%. However, the samples which contain bottom ash 6% and 8% shown the similar value of the unconfined compressive strength. Therefore, this result can suggest the optimum content of bottom ash used to improve the strength of soil.

Nevertheless, the soil samples mixed with cement 1%, kaolin 1% and bottom ash 2% in curing time 3 days represented breakdown of the samples' after soaked in the water for 2 hours. This is because the amount of cementitious materials is not enough to react. However, the increased amount of cement or bottom ash in the samples can increase the strength of soil and durability of the samples.

The required unconfined compressive strength of subbase improvement which suggested by the Thailand Department of highways should be more than 689 kPa at the curing time 7 days. Fig.9 demonstrated the unconfined compressive strength of soil mixed with an admixture of each mixture at the curing time 7 days. The samples which passed the minimum strength requirement consisted of the samples A3, C2, C3, and C4. The unconfined compressive strength value of the samples A3, C2, C3, and C4 was 889 kPa, 729 kPa, 854 kPa and 838 kPa respectively. Therefore, the samples mixed with cement at 1.5%, kaolin 0.5%, and bottom 4-8% can develop the strength of poor subbase higher than the minimum required strength. However, the soil samples mixed with admixture in group B cannot develop the strength higher than the minimum strength requirement. This is because the amount of cement in the mixture is not enough to increase the strength of soil.

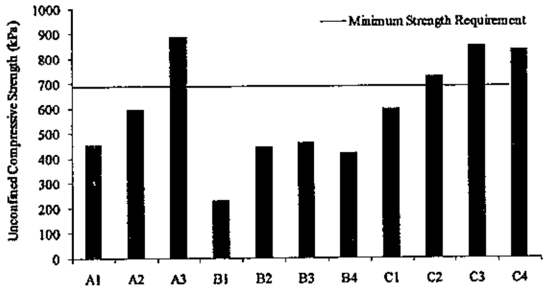

Fig. 9 Unconfined compressive strength of soil mixed with an admixture for each mixture in 7 days curing time

Although the A1 samples have the amount of cement same as C2, C3, and C4, the A1 samples cannot develop the strength of soil higher than the minimum required. However, C2, C3, and C4 samples can be developed the strength was higher than the minimum requirement. This result can be demonstrated that bottom ash can develop the strength of soil from the samples without bottom ash. Therefore, bottom ash mixed with the soil samples can be reduced the utilized amount of cement to improve the strength of soil.

CONCLUSION

Based on the experimental test obtained in this study, the following conclusion was made:

1. Bottom ash can increase the unconfined compressive strength of poor subbase. The optimum bottom ash content mixed in soil is 6% by weight of soil.

2. Bottom ash can develop the early strength of soil. The strength of the samples which contain bottom ash was higher than the samples without bottom ash approximately 84% in curing time 7 days.

3. The strength requirement which suggested by the Thailand Department of highways is 689 kPa in curing time 7 days. The soil samples mixed with cement 1.5%, kaolin 0.5%, and bottom ash 4 to 8% can be developed the unconfined compressive strength more than the strength required.

4. The strength of soil mixed with cement 1.5%, kaolin 0.5% and bottom ash 6 to 8% is equivalent to the soil mixed with cement 3% in curing time 7 days. The unconfined compressive strength was approximately 850 kPa. Therefore, bottom ash mixed in the soil samples can be reduced the utilized amount of cement to improve the strength of soil.

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