บันทึกข้อความ
 sürรษฎร์ หน่วยสนับสนุนการวิจัยและบริการ คณะวิศวกรรมศาสตร์ มหาวิทยาลัยอุบลราชธานี โทร. 3319 ที่ ศร 0529.8.13/814 วันที่ 11 ตุลาคม 2559
เรื่อง การใช้เมทากาลิสอบบังคับในการเปรียบเทียบลวดลายบนผิวโลหะในต่างประเทศ
เรียน รองคณบดีฝ่ายวิจัยและบริการวิชาการ

ตามที่เจ้าหน้าที่ ดร.ธิดิการน์ บุญชู เดินทางส่งเจ้าหน้าที่บริษัทงานทั่วไป ได้รับการตอบรับในการนําเสนอผลงานวิจัย เรื่อง Application of Metakaolin from Northeast in Thailand used as Binder in Casting Process of Rice Polishing Cylinder ในการประชุมวิชาการระดับนานาชาติ 19th International Conference on Industrial Engineering and Technology ระหว่างวันที่ 26 – 27 มกราคม 2560 ณ ประเทศอสเตรเลีย นั้น

ดังนั้น เพื่อให้การนําเสนอผลงานวิจัยเป็นไปด้วยความเรียบร้อย จึงขอทราบมีอนุมัติหนังสือสนับสนุนเพื่อนําเสนอผลงานวิจัยกล่าว เจ้าหน้าที่จ่ายเงิน 40,000 บาท (สี่หมื่นบาทถ้วน) โดยมีค่าใช้จ่ายในการนําเสนอผลงาน หัวสิน 81,880 บาท (แปดหมื่นหนึ่งพันแปดImaginea8บาทถ้วน) ดังนี้

1. ค่าลงทะเบียน 400 ยูโร 16,000 บาท
2. ค่าค่าพาหนะระหว่างประเทศ (ไป-กลับ: กรุงเทพฯ-ออสเตรเลีย) 36,000 บาท
3. ค่าค่าพาหนะในต่างประเทศ 4,500 บาท
4. ค่าค่าพาหนะภายในประเทศ (ไป-กลับ: อุบลราชธานี-กรุงเทพฯ) 1,500 บาท
5. ค่าค่าฝึกดินทาง (VISA) 3,000 บาท
6. ค่าค่าพักในต่างประเทศ 12,000 บาท
7. ค่าเบี้ยเลี้ยงในต่างประเทศ (2,100 บาท x 4 วัน) 8,400 บาท
8. ค่าเบี้ยเลี้ยงภายในประเทศ (240 บาท x 2 วัน) 480 บาท

ทั้งนี้ ข้าพเจ้าขอรับรองว่าผลงานเรื่องดังกล่าว ไม่เป็นส่วนหนึ่งของผลงานระดับบันทิศกิจและของอนุมัติหนังสือสนับสนุนตามค่าใช้จ่ายจริงไม่มีเกิน 40,000 บาท (สี่หมื่นบาทถ้วน)

จึงเรียนมาเพื่อโปรดพิจารณา

[ลายเซ็น]
(ดร.ธิดิการน์ บุญชู)
เจ้าหน้าที่บริการงานทั่วไป

ลงนามในวันที่ 12 มี.ค. 59
Dr. Thitikan Boonkang  
Ubon Ratchathani University  
Thailand

Herewith, the international scientific committee is happy to inform you that the peer-reviewed draft paper code 17AT010125 entitled (Application of Metakaolin from Northeast of Thailand Used as Binder in Casting Process of Rice Polishing Cylinder by Thitikan Boonkang) has been accepted for oral presentation as well as inclusion in the conference proceedings of the ICIET 2017 : 19th International Conference on Industrial Engineering and Technology to be held in Innsbruck, Austria during January, 26-27, 2017. The high-impact conference papers will also be considered for publication in the special journal issues at http://waset.org/Publications.

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International Scientific Committee  
ICIET 2017 : Innsbruck, Austria  
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Application of Metakaolin from Northeast in Thailand used as Binder in Casting Process of Rice Polishing Cylinder

T. Boonkang, C. Santhaweesuk, N. Pianthong, P. Neeramon, A. Phimhlo, S. Bangphan

Abstract—The objective of this research was to apply metakaolin from northeast of Thailand as a binder in the casting process of rice polishing cylinder in replacement of the imported calcined magnesite cement and to reduce the production cost of the cylinder. Metakaolin from 3 different regions, Udon Thani, Nakhon Phanom and Ubon Ratchathani were obtained. The design of experiment analysis using the MINITAB Release 14 based on the compressive strength and tensile strength testing was conducted. According to the analysis results, it was found the optimal proportion were calcined magnesite cement: metakaolin from Udon Thani, Nakhon Phanom and Ubon Ratchathani equal to 63:37, 71:29 and 100:0, respectively. When using the optimal proportion to cast and tested the rice milling, it was found Udon Thani metakaolin cylinder has efficiency better than Nakhon Phanom metakaolin cylinder by statistically significant at 0.05 that the average broken rice percent were 32.52 and 38.29. While the average wear rate both have not statistically significant at 0.05 were 7.27 and 6.53 g/hr respectively.

Keywords—Metakaolin, Binder, Rice Polishing Cylinder

I. INTRODUCTION

In the past until to present, a rice milling machine has agriculture base machinery that important for Thai agriculturist. The agriculturist brought a small rice milling machine which capacity as 1-2 ton/day to use increasing in the present because it has convenient and fastness for rice mill in family. Normally, a small rice milling machine has different follow with locality. It separated two types were vertical axle and horizontal axle. The agriculturist used generally as horizontal axis which driven by electric motors because it was low price and easy purchased locally. However, rice quality depends on several factors such as grain shape, size, moisture and process of shelling and polishing [1]. The process of rice polishing is an important step and the quality of milled rice has broken rice percentage will be more or less depends on the quality of rice polishing cylinder [2-4]. Normally, the rice polishing cylinder has two composite materials were abrasive material and binder material [5]. The abrasive material has emery grain and silicon carbide. The binder material has calcined magnesium cement and magnesium chloride.

In present, calcined magnesite cement was imported from abroad around 5,268 tons/year which valued average 89 million baht per year [6]. Therefore, to decrease this material from abroad. It has idea to apply pozzolan materials in domestic which is a waste of the agricultural such as rice husk ash, bagasse ash and metakaolin mixed with calcined magnesite cement to reduce production cost and to improve casting process [7-10]. Research of pozzolan materials with rice polishing cylinder was research by T. Boonkang and et.al [11] has applied pozzolan material used as binder in the casting process of rice polishing cylinder. This research has selected a natural pozzolan materials were rice husk ash, bagasse ash from northeast zone and metakaolin from north zone in Thailand. These pozzolan materials were replaced calcined magnesite cement that imported in the ratio as 40 percent. The result of suitable proportion was rice husk ash: bagasse ash: metakaolin as 15 : 25 : 60. When applied this proportion to cast the rice polishing cylinder, it found average broken rice percent as 19.88 and average wear rate as 4.43 g/hr. The rice polishing cylinder from imported binder has average broken rice percent as 23.98 and average wear rate as 7.02 g/hr. So, the pozzolan rice polishing cylinder has rice mill effective better than import binder rice polishing cylinder. For this research, metakaolin was replaced maximum of pozzolan material. Therefore, it has idea to apply metakaolin from northeast for replacement which affect the reduction cost.

The research review about metakaolin such as J.T. Ding and et.al [12] studied the effects of metakaolin and silica fume to the properties of concrete. It replaced cement at 0, 5, 10 and 15 percent and found the concrete which mixed metakaolin has the ability to work better than concrete which mixed silica fume due to hardness increasing. Optimal ratio of metakaolin that replaced at 15 percent. It has the compressive strength more than other proportion. L.Courard and et.al [13] studied the durability of concrete replacement by metakaolin. This research used metakaolin was replaced at 5-20 percent by studied chemical property and behavior. When immersed in chloride and sulfate, It takes more than 100 days were a mixture of mortar with metakaolin reduces
the rate of diffusion of chloride and sulfate. The suitable proportion which replaced around 10-15 percent. H.M. Khater [14] studied the influence of metakaolin resistance to magnesium chloride of concrete mortar. The proportion of metakaolin was replaced on rate 0, 5, 10, 15, 20, 25 and 30 percent by heating at 820 °C around 2 hours. The testing was found the ability of magnesium chloride was increased allow by quantity of metakaolin which increasing. Optimal ratio of metakaolin at 25 percent has maximum compressive strength. From the research above, it found metakaolin can be replaced cement. Therefore, in order to develop the pozzolan rice polishing cylinder [11]. If we find metakaolin from northeast to study for development used as binder. It will increase the value of metakaolin in northeast and reduce transportation costs due to the management of pozzolan binder material from same source. In addition, it has affect to the reduction cost of rice polishing cylinder and decrease calcined magnisite cement from abroad. It has reasonable for this research.

II. METHOD EXPERIMENTAL PROCEDURE

A. Method

Material preparation and equipment in the experimental

1) Control factors were metakaolin and calcined magnisite cement. Metakaolin was burned at 800 °C around 6 hours. After that, it was mashed and screened by the sieve size 325 that allow by standard ASTM C618.

2) Metakolin was tested from 3 sources were Udon Thani, Nakhon Phanom, Ubon Ratchathani.

3) The formulation was casted specimen and rice polishing cylinder have proportion of abrasive material: binder material as 5:1 and tested rice milling efficiency with horizontal axle rice mill machine which popular in the local.

4) Rice for testing was Jasmine Rice 105 allow by industrial standard 888-2532 and rice must checked moisture and cleaned to remove scrap. The rice milling for analysis factors to use rice in rate as 20 kg per one treatment.

5) Using Minitab Release 14.00 program for evaluation and design of experiment by Mixture Design function to analysis and responses surface method to investigate suitable proportion of metakaolin.

B. Design of Experiment

In the experiment has separated 2 methods as below

1) The study which suitable proportion of metakaolin material by response two important sections were compressive strength and tensile strength. Then, it used suitable proportion to cast rice polishing cylinder.

2) Comparison of rice mill efficiency testing from each metakaolin cylinders and compared testing with rice polishing cylinder which used import binder by the same ratio was binder material: abrasive material as 5:1. The response has 2 sections were broken rice percent and wear rate.

The factor which studied was metakaolin from Udon Thani, Nakhon Phanom and Ubon Ratchathani. When use Minitab program for design of experiment by mixture design, it found 5 formulas for each metakaolin sources allow by Table I.

<table>
<thead>
<tr>
<th>TABLE I</th>
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<tbody>
<tr>
<td>PROPORTION OF METAKAOLIN FROM DOE</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
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</tbody>
</table>

Minitab Release 14.00 program has Response Optimizer function to find suitable value of the factors which has the best value of experiment. The researcher has chosen to use desirability function to determine the suitable factor. In this step must be to set the scope of the responses were lower level, target, upper level, weight of response and the importance of response. In this research, it used weight and significance of response was 1 due to focus the response near reach target and it must be within certain limits. When analysed the data by Response Optimizer was suitable value, the scope of response in terms of compression strength and tensile strength to set up the target as average compressive strength and tensile strength of original binder in present [3]. The compressive strength average as 23 MPa with the lower level as 20 MPa and upper level as 26 MPa. The tensile strength average as 4 MPa with the lower level as 3 MPa and upper level as 5 MPa.

When brought the data from testing result of compressive strength and tensile strength from each sources were evaluated, It found suitable proportion of Udon Thani metakaolin was calcined magnisite cement at 0.6296 : metakaolin at 0.3704 allow by Fig. 1 or around percent 63 : 37. The target of compressive strength was 23 MPa and tensile strength was 4 MPa. This proportion responded the compressive strength results as 23 MPa and the satisfaction as 1. In terms of tensile strength response results as 3.9927 MPa and the satisfaction as 0.99274. The total satisfaction as 0.99636 which near reach 1 was set and can be used.
Optimal D

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<tr>
<th>Hi</th>
<th>Cur</th>
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<tbody>
<tr>
<td>1.0</td>
<td>0.6296</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hi</th>
<th>Cur</th>
<th>Lo</th>
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<tbody>
<tr>
<td>1.0</td>
<td>0.3704</td>
<td>0.0</td>
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<table>
<thead>
<tr>
<th>Compress</th>
<th>Targ: 23.0</th>
<th>y = 23.0000</th>
<th>d = 1.0000</th>
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<tbody>
<tr>
<td>Tensile</td>
<td>Targ: 4.0</td>
<td>y = 3.9927</td>
<td>d = 0.99274</td>
</tr>
</tbody>
</table>

Fig. 1 Suitable proportion of Udon Thani metakaolin

Evaluation result of Nakhon Phanom was found suitable proportion as calcined magnisite cement at 0.7110 : metakaolin at 0.2890 allow by Fig.2 or around percent 71 : 29. This proportion responded the compressive strength results as 22.7363 MPa and the satisfaction as 0.91211. In terms of tensile strength response results as 4.2718 Mpa and the satisfaction as 0.72824. The total satisfaction as 0.72824 which near reach 1 was set and can be used.

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<th>Hi</th>
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<tr>
<td>1.0</td>
<td>0.7110</td>
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<th>Hi</th>
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<td>1.0</td>
<td>0.2890</td>
<td>0.0</td>
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</table>

Fig.2 Suitable proportion of Nakhon Phanom metakaolin

Evaluation result of Ubon Ratchathani was found suitable proportion as calcined magnisite cement at 1 : metakaolin at 0 allow by Fig.3 or around percent 100 : 0. This proportion responded the compressive strength results as 23.6331 MPa and the satisfaction as 0.78895. In terms of tensile strength response results as 3.9066 MPa and the satisfaction as 0.90562. The total satisfaction as 0.84528 which near reach 1. However, the proportion Ubon Ratchathani metakaolin has none. So, there has not casted rice polishing cylinder from this material.

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<td>0.0</td>
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Compress | Targ: 23.0 | y = 23.6331 | d = 0.78895 |
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<tbody>
<tr>
<td>Tensile</td>
<td>Targ: 4.0</td>
<td>y = 3.90568</td>
<td>d = 0.90562</td>
</tr>
</tbody>
</table>

Fig.3 Suitable proportion of Ubon Rathathani metakaolin

Result testing of rice mill efficiency

Comparison of rice mill efficiency has 2 sections were broken rice percent from rice milling and wear rate by function of T-Test for analysis and evaluation of two group samples at the significance level of 0.05. The casting of rice polishing cylinder has Udon Thani metakaolin cylinder and Nakhon Phanom metakaolin cylinder for 3 pcs per type. When compared broken rice percent, it was found average broken rice percent of Udon Thani metakaolin cylinder as 32.52 that lower than Nakhon Phanom metakaolin cylinder which has average broken rice percent as 38.30 allow by Fig.4.

Two-sample T-Test for UD Cylinder vs NP Cylinder

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>UD Cylinder</td>
<td>9</td>
<td>32.52</td>
<td>1.56</td>
</tr>
<tr>
<td>NP Cylinder</td>
<td>9</td>
<td>38.30</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Estimate for difference: -5.77778
95% CI for difference: (-7.61501, -3.94054)
T-Test of difference = 0 (vs not =): T-Value = -6.74
P-Value = 0.000 DF = 14

Fig.4 Average broken rice percentage comparison

When compared wear rate between two types cylinder, it found average wear rate of Udon Thani metakaolin cylinder as 7.271 g/hr that higher than Nakhon Phanom metakaolin cylinder which has average wear rate as 6.526 g/hr allow by Fig.5.

Two-sample T-Test for UD Cylinder vs NP Cylinder

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>UD Cylinder</td>
<td>9</td>
<td>7.48</td>
<td>1.87</td>
</tr>
<tr>
<td>NP Cylinder</td>
<td>9</td>
<td>6.52</td>
<td>1.54</td>
</tr>
</tbody>
</table>

Estimate for difference: 0.96000
95% CI for difference: (-0.761171, 2.681171)
T-Test of difference = 0 (vs not =): T-Value = 1.19
P-Value = 0.253 DF = 15

Fig.5 Average wear rate comparison
From the evaluation of rice mill efficiency between rice polishing cylinder that used import binder with rice polishing cylinder that used metakaolin from Udon Thani and Nakhon Phanom showed in TABLE II.

<table>
<thead>
<tr>
<th>TABLE II</th>
<th>EFFICIENCY EVALUATION OF RICE POLISHING CYLINDER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detail</td>
<td>Nakhon Phanom Rice Polishing Cylinder</td>
</tr>
<tr>
<td>Average broken rice percent</td>
<td>38.30</td>
</tr>
<tr>
<td>Average rice mill time per rice 20 kg</td>
<td>43</td>
</tr>
<tr>
<td>Average wear rate</td>
<td>6.53</td>
</tr>
<tr>
<td>Average mill rice percent</td>
<td>67.5</td>
</tr>
<tr>
<td>Cost of material (baht)</td>
<td>988</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

1) When brought metakaolin from three sources were Udon Thani, Nakhon Phanom and Ubon Ratchathani for casting and testing by experimental of compressive strength and tensile strength, it found the optimal formulas were calcined magnesite cement: metakaolin from Udon Thani, Nakhon Phanom and Ubon Ratchathani equal to 63: 37, 71: 29 and 100: 0. So, we selected metakaolin from Udon Thani. Nakhon Phanom to cast cylinder because it has proportion for replacement.

2) The optimal proportion was casted and tested the rice milling, it found Udon Thani metakaolin cylinder has efficiency better than Nakhon Phanom metakaolin cylinder by statistically significant at 0.05 that is the average broken rice percent were 32.52 and 38.29. While the average wear rate both have not statistically significant at 0.05 were 7.27 and 6.53 g/hr respectively.

3) The cost of metakaolin cylinder was decreased not so much. However when considering the overall to import cement from abroad, it found metakaolin from northeast can be replaced around 30-40 percent which affect the reduction of import cement around 27 - 36 million baht per year.

4) Metakaolin from Ubon Ratchathani should improve by replacement with pozzolan materials were rice husk ash and bagasse ash. This material to improve the compressive strength and tensile strength increasing. It will affect the replacement ratio has increased and bring waste material from the agricultural to ensure maximum benefit.

ACKNOWLEDGMENT

Thanks to Ubon Ratchathani University (UBU) for support research budget and Faculty of Engineering (UBU) for support research equipment. In addition, thanks to Ubon Krungthaiikonlakan Company that supports technician to cast rice polishing cylinder. Thanks to sub-district administration organization Nonthong (Udon Thani) and Srisongkram (Nakhon Phanom) to support metakaolin for experimental.

REFERENCES

Conference Aims and Objectives

The ICET 2017: 19th International Conference on Industrial Engineering and Technology aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Industrial Engineering and Technology. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Industrial Engineering and Technology.

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All honorable authors are kindly encouraged to contribute to and help shape the conference through submissions of their research abstracts, papers and e-posters. Also, high quality research contributions describing original and unpublished results of conceptual, constructive, empirical, experimental, or theoretical work in all areas of Industrial Engineering and Technology are cordially invited for presentation at the conference. The conference solicits contributions of abstracts, papers and e-posters that address themes and topics of the conference, including figures, tables and references of novel research materials. WASET

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   M. N. Moschakis, V. V. Dafopoulos, I. G. Andritsos, E. S. Karapidakis, J. M. Prousaldis

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Noor Azlina Mohd Saleh, Salmiah Kasolang, Ahmad Jaffar

7) Green Lean TOM Practices in Malaysian Automotive Companies
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Suleman Obeidat, Adnan Bashir, Wisam Abu Jadayil

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10) Integration Process of Industrial Design and Engineering Design
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12) Aspects to Motivate users of a Design Engineering Wiki to Share their Knowledge
Regine W. Vroom, Lysanne E. Vossen, Aneel M. Geers