（様式課程博士３）

学 位 論 文 の 要 旨

専　攻　名	工学専攻	ふりがな 氏　　名	シワット ラワンワデク Siwat Lawanwadeekul
学位論文題目	Sound absorption measurement using the ensemble averaging technique targeted to thermal-acoustic clay brick development		

The study uses the ensemble averaging method with a pressure-velocity sensor; the EA_{pu} method targets thermal-acoustic clay brick development. Under the three objectives of the study were to:

1. Find the optimum condition for thermal-acoustic clay bricks production and cost analysis.
2. Find the appropriate condition of ensemble averaging technique with a pressure-velocity sensor for porous clay bricks.
3. Compare sound characteristics between the standard method and the ensemble averaging technique with a pressure-velocity sensor.

The first objective was the production part. The experiment started by using four different sizes of charcoal—large, medium, small, and fine, with average particle sizes 2, 1, 0.5, and 0.4 mm, respectively, added to raw clay with various amounts from 0 to 30 wt% for creating porous clay bricks. The extruded brick samples were then fired at 900–1100°C, before testing multiple properties. The results revealed that the fired clay bricks' mechanical properties improved with increasing firing temperature due to the mullite phase formation. However, the mechanical properties rapidly deteriorated when the ratio and size of the charcoal increased. In terms of the physical and mechanical properties, 15 wt% of small charcoal and firing temperature of 1100°C were the optimal conditions for manufacturing clay bricks that satisfy the Thai Industrial Standard.

By contrast, the clay bricks that use large and high percentage charcoal with firing temperature at 1100°C afforded low thermal conductivity and a higher sound absorption coefficient due to the resulting bricks' more porous nature. The regression analyses demonstrated that the physical properties were correlated with the other properties, a correlation value higher than 0.80. Moreover, cost research presented that added charcoal 15wt% cost increases only 0.03 THB/piece and presented low thermal conductivity and a higher sound absorption coefficient than traditional clay bricks. Also, added charcoal 30wt% can reduce cost 0.05 THB/piece.

The second objective selected the 30 wt% of large charcoal and firing temperature of 1100°C to reproduce and measured the sound absorption coefficient using the EA_{pu} method. The investigated factors focused on the influence of sample size, measurement position, material properties, and surface condition of the samples. The validation revealed that the EA_{pu} method is applicable for the measurement of porous clay bricks and found that 10 cm^2 but 30 cm^2 or larger samples give better results and low standard deviation. The optimum measurement position was approximately 1 cm around the center of the sample. Sound absorption coefficients measured at places far away from the center were higher because of the gap effect. At over 1000 Hz, the sound absorption coefficient showed a clear difference because of the physical property and was confirmed by the regression analysis. At around 1500 Hz, the surface condition affects the sound absorption coefficient.

The third objective used an impedance tube method as a standard for comparison with the EA_{pu} method. The sample still reproduces from clay bricks that use large and high percentage charcoal with firing temperature at 1100°C. The results indicate that both measurement methods are precise measurements because they were low standard deviations. The different samples presented slightly dissimilar data depend on the physical properties of each sample. In the frequency region between 100 and 400 Hz, results found that the sound absorption coefficient considerably good agreement in sound absorption coefficient values measured by both methods. However, the differences between both became moderate at a frequency above 800 Hz. The sound absorption coefficient measured by the tube method was always higher than that of the EA_{pu} method. In some samples, the tube method's imaginary parts crossed the zero line. They became positive because resonance occurs in this frequency. However, the phenomenon is not found in the EA_{pu} method, indicating that the EA method reduces the interference effect caused by the sample's edges and surface normal impedance.

【623 文字（語）】

（注）和文 2,000 字又は英文 800 語以内　　続紙　有☐　無☑

（様式課程博士８）

学位論文審査結果の要旨

専　　　　攻	工学専攻環境工学コース	氏　　　名	Siwat Lawanwadeekul
論　文　題　目	Development of thermal-acoustic clay bricks for use in Thailand		
主　　　　査	富来　礼次		
審　査　委　員	大鶴　徹		
審　査　委　員	大谷　俊浩		
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審査結果の要旨（1000 字以内）

本研究は，タイ国の住環境改善を行うための “thermal- acoustic clay bricks”開発を目指し，吸音特性や断熱性に影響を与える空隙構造を変化させる手段として木炭を利用して試製したレンガを用い，その音響特性を簡易かつ精度良く把握する手法を明らかにするための検討を行っている。

まず，4 つの異なるサイズ（large (2 mm)，medium (1 mm)，small (0.5 mm)，fine (0.4 mm)）の木炭を用い，木炭の混和量を 0～30 wt%，焼成温度を 900～1100 °C で変化させて製造した材の物性（密度，空隙率，吸水率，熱伝導率）および強度を測定するとともに，吸音特性については音圧―速度（pu）センサーを使用したアンサンブル平均化手法（EA_{pu} 法）を既往の研究に基づいて適用し測定している。その結果，木炭のサイズが大きく，その混和量が多いほど，熱伝導率は低く，吸音率は高くなるものの，強度は小さくなる傾向を示したが，焼成温度を高くすることで強度は高くなることを明らかにしている。続いて，材を開発する途中での測定を考慮し，測定サンプルの寸法，測定位置，材の表面状態と得られる吸音特性の関係について明らかにしている。最後に， EA_{pu} 法による測定値と既存の代表的な音響特性測定手法である音響管法の測定値とを比較し，音響管法による吸音率は EA_{pu} 法による吸音率よりも高くなるものの，両者とも測定結果は 0.04 未満の標準偏差となり，材を開発する途中での EA_{pu} 法による測定が妥当であることを明らかにしている。

以上の研究成果は，材を開発する途中での EA_{pu} 法による音響特性の把握の有用性を示すとともに，より安定した測定を実施するための条件や測定値の信頼性に関するデータも明らかにしており高く評価される。また，本審査会やオンラインで実施された公聴会における質問に対しても的確な受け答えと説明がなされた。よって，本論文は博士(工学)の学位に値するものと認められる。一方，本審査会において研究成果に対しより適切なタイトルへ変更するよう参考意見が出され，” Sound absorption measurement using the ensemble averaging technique targeted to thermal-acoustic clay brick development”への変更が最終審査会で認められた。(1000 文字)