CHICKEN FEATHER: AN ALTERNATIVE OF ACOUSTICAL MATERIALS

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Researchers' contributions on green materials development for sound insulation are increasingly in demand, including the abundant wasted chicken feathers. This study examines possibility of chicken feathers (CF) as an alternative acoustical material through understanding of its sound absorption characteristics. Common absorptive material glass wool (GW) applies as counterpart in measurements. Clean and dried CF is compacted in mesh prior to absorption coefficient measurement. Acoustical measurements by EA method were applied on typical thickness CF specimen of 48 and 60 kg/cm3 mesh densities. Specimen respond of absorption coefficient are relatively increase throughout frequency ranges of 100 - 1600 Hz, reaching maximum 0.99 at frequency 1600 Hz, 950 Hz, and 650 Hz for CF thickness 25, 50 and 75 mm, respectively. Measurement confirmation on glass wool (GW) specimen was resulted in comparable results. Flow resistivity test is applied for empirical model confirmation, resulted in diverged phenomenon and improperly fix to Miki's model as the common empirical model of fibrous acoustic materials. More measurements with variation on specimen densities should validate the possibility of chicken feathers as potential alternative of acoustical materials.

Keywords: chicken feathers, absorption coefficient characteristics

1. Introduction

This study is presented as updated report of the preliminary research on identification of chicken feather as alternative material for acoustical insulation [1]. Poultry products are always in demand and continuously increase for the protein, leaving abundant waste of feathers. This side product does not have enough utilization except for common traditional ways. There are well known utilizations of chicken feather products such as pillow fillers, feather dusters, and handicrafts. Later, this waste took attention of many researchers for its physical characteristic developments through scientific and technological approaches. Some studies on advanced utilization of chicken feathers were reported in academic publications [2–5]. These researches ranged from keratin extraction, as bio gas resources, to its potential for bio-based composite materials [6–11]. Specific to acoustical material, its applications has not enough records [12]. Hence, it is a necessity to understand the acoustical characteristics of chicken feathers, whether it is appropriate or not for acoustical material.

Comfort ability issue in building architecture consist of three main fields, i.e. lighting, thermal and acoustic. In field of noise prevention on architectural building and interior, there are some reports for alternative acoustic materials and structures possibilities instead of the common glass wool noise insulation [13–16]. The first identification on acoustic material feasibility for noise insulation purpose is by measurement of absorption coefficient through varies of known techniques using set of acoustical measurement devices [17–19]. Due to wide application on noise insulation purposes in building acoustic interiors, standard industrial glass wool is commonly referred as experiment counterparts.

Still many factors to consider before chicken feathers resolves as alternative of acoustic insulation material, including production cost, operational lifespan, performance in severe humidity or climate and other sustainability issues. However, main consideration for analysis is the characteristic of sound absorption coefficient. Another confirmation for acoustical behaviour of fibrous material parameters is by application of Ensemble Averaged (EA method) and measurement of static air flow resistivity. EA method should produces raw acoustical characteristics of specimen while the flow resistivity test intended to examine specimen response to incident acoustic pulse in simple and efficient way, including assumption of mathematical models of Miki's[20], [21] .

This study would provide new reference in the field of architectural acoustics material, giving new information about feasible solution for noise prevention by this green and abundant material. The application of recycled chicken feathers as noise insulation material should give additional option for more acoustically comfortable buildings.

2. Experimental set up

Comparison method experiments are performed by estimation of experiment results deviation to the reference counterpart. Here, varies of chicken feather (CF) specimen are compared with identical dimensions of glass wool (GW) as references. Measurements were continued by common analysis in acoustical fields, especially on absorption coefficient characteristics. Systematic deviations based on behaviour differences were observed among measurements, determines level of specimen performance and feasibility for acoustical material insulation. In addition, for more clarity on results, comparisons of measurements were presented in simplified graphics of appropriate statistical calculations.

Thirty pieces of chicken feather (CF) specimen compacted inside cylindrical and square meshes varied in thickness and density. 25, 50, and 75 millimetres thicknesses by 48 and 60 kg/cm^3 densities, shown in Fig 2. Only the clean, soft and healthy feathers are used, from parts of chicken skin but the wings and tail. Before application, preparation of CF includes thoroughly wash by liquid soap, rinsing, a whole night soak in bleach and disinfectant solutions, then exposed to direct sunlight for two days , shown in Fig 1. The stages are aimed to expel pathogenic microorganism, bacteria, fungi and virus while dried feathers will ensure its durability and effective lifetime.

(a) (b) (c)

Figure 1: Cleaning process: (a) Chicken feather separation process (b) Washing and soaking with soap and disinfectant solution (c) dried under direct sunlight

(a) (b) (c)

(d) (e) (f)

Figure 2: Specimen preparation process: (a) Plastic mesh (b) Sewing machine (c) Mesh-compacted CF (d) Clean and dry CF (e) Varied in thickness and density (f) Glass wool (GW)

Measurements of acoustical performance identified by level of absorption coefficients, conducted in Acoustics workshop, Science and Technology Laboratory, Faculty of Engineering of Hasanuddin University, performed in anechoic room to maintain quiet environment while measurement progressed. There are ten samples for each variation of sample thickness, all compacted in a same density. Measurements applied to analyse the sound absorption coefficient based on material thickness. The data collection based on sound waves recorded inside impedance tube in form of absorption coefficients values. There are 801 frequencies within range of 100 Hz-1.6 kHz applied for analysis and comparisons.

Determination of absorption coefficients using two microphones attached on impedance tube B&K 4206. As shown in Fig 3, the tube measures acoustic parameters of small specimen by the reflected sounds inside the tube. Specimen attached at one end of the tube, and sound source at the other end, where two microphones are placed in between (inline or face-to-face configuration). Amplified sound is forwarded into the impedance tubes which the reflections are captured by two

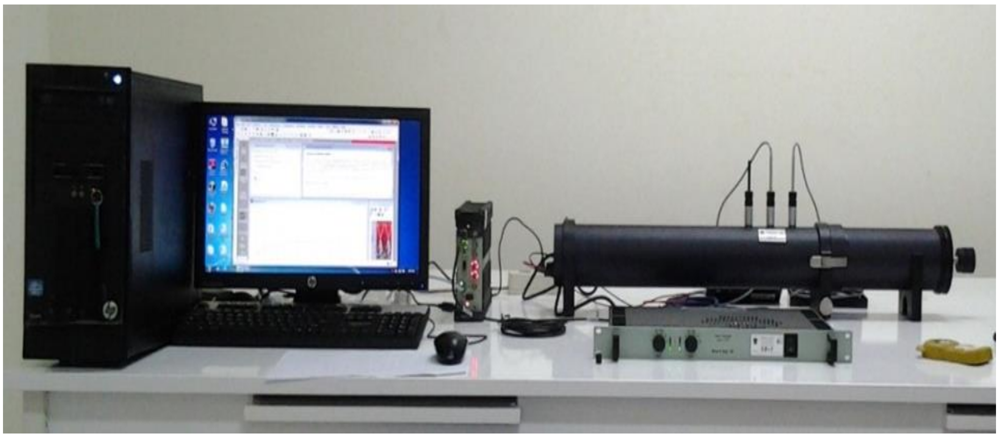

Figure 3: Absorption coefficients measurement with impedance tube

microphones and subsequently recorded and processed using PULSE Labshop software version 16.1

Empirical approach confirming Miki's model is performed through flow resistivity measurement in acoustical laboratory of Kanzai University, Japan, where the set up can be seen in Fig 4. Following measurement by impedance tube, measurement of EA-method were also applied in environmental acoustic laboratory of Kobe University with measurement set up presented in Fig 5 and Table 1.

Figure 4: Flow resistivity measurement set up

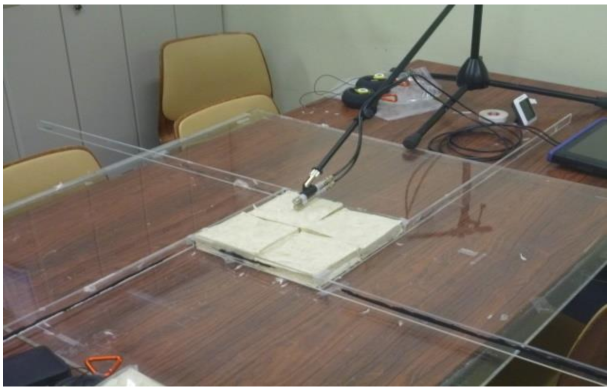

Figure 5: CF measurement by EA-method

Table 1: Measurement set up of EA method

EA method setup	
Material-mic distance	15 mm
Mic-mic distance	15 mm
FFT setup:	
Upper-limit Freq, Hz	5 kHz
Frequency resolution, Hz	3.125 Hz
Time Window	Hanning
Averaging	Linear 150 times

3. Results and Discussions

3.1 Absorption Coefficients of Chicken Feathers (CF)

The impedance tube measurement of CF pictured in Fig 6, while as comparison, glass wool (GW) with similar thickness showed in Fig 7. Glass wool (GW) is commonly used as reference in measurement of sound absorption materials due to its vast applications and referred in many studies [17]–[19]. Specimen of 25 mm thick, 48 kg/m^3 density (written as CF25), specimen with absorption

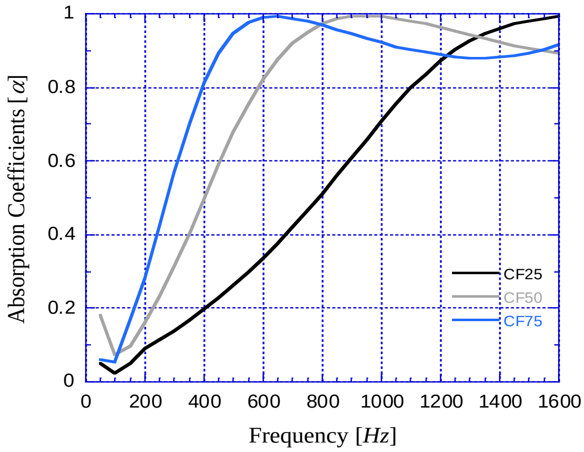

Figure 6. Absorption coefficients of CF25, CF50, and CF75

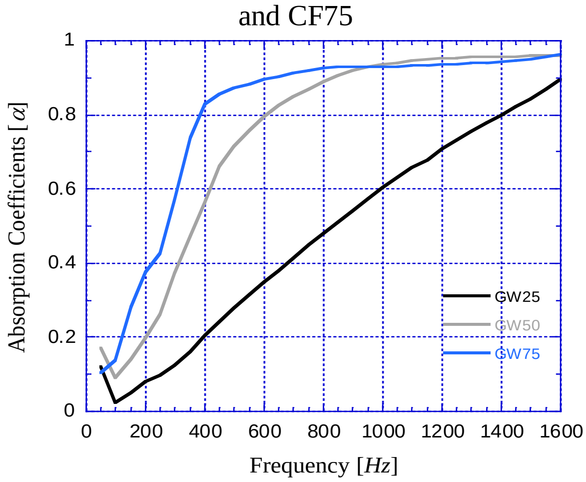

Figure 7: Absorption coefficients of GW25, GW50, and GW75

coefficients deviated by 0.07 at frequency 800 Hz were omitted for data processing and measurement. Averaging value of five specimens then reports absorption coefficient characteristics of CF25. It continuously increases from low to high frequency, reaching maximum 0.99 at frequency 1600 Hz.

Next, measurement of 10 CF specimens 50 mm thickness (CF50) resulted in similar deviation 0.07 at frequency 450 Hz, and then omitted. The remaining 6 specimens leaved for data processing of averaging values. CF50 give the highest 0.99 absorption coefficient at intermediate frequencies of 946 Hz. From this point, by higher frequencies (>1000 Hz), the absorption coefficient declined to 0.89 at frequency 1600 Hz.

Lastly, measurement of CF specimen of 75 mm thickness (CF75), also deviated by 0.07 at frequency 1,400 Hz, which is then excluded from averaging process. The average calculation on remaining nine specimens resulted in highest absorption coefficient 0.99 at frequency 638 Hz. The absorption coefficients start to decrease and reach the lowest 0.88 at frequency 1,342 Hz, then back to 0.91 at a frequency 1600 Hz.

In general, absorption coefficient characteristics of GW and CF are comparable at lower frequencies (< 500 Hz) depends on thickness, while for intermediate frequencies (500-1000 Hz) absorption coefficient of CF are relatively higher than GW. During high frequencies (> 1000 Hz) both materials started to behave differently depending on specimen thickness. For thickness 25 mm, absorption coefficient of CF continue to perform higher than GW, but for thickness 50 and 75 mm, GW start to performed slightly better compare to its counterpart.

3.2 Flow Resistivity

The measurements of flow resistivity on CF applied on 25, 50 and 75 mm thicknesses of two specimen density 48 and 60 kg/cm^3. Measurements resulted in strange behaviors, for both density flow resistivity were fluctuated by the increasing specimen thickness. Its porosity, tortuosity and factor ratio of pore shape are uniquely performed compared to other of porous materials. It diverges from assumption of Delany-Bazley models including the new empirical Miki models [20], [21]. As shown in Table 2, the proportional average of flow resistivity and specimen density by 814 and 991 Ns/m^4 for 48 and 60 kg/m^3 CF, respectively, are logically explained by mechanical material compression. However, instead of limited two density specimens, more density variations and proper statistical approach in future experiment should explain more on this flow resistivity characteristic.

Table 2: Flow resistivity of chicken feather

48kg/m^3	25mm	50mm	75mm	
Spec 1	1004	1109	439	
Spec 2	797	752	740	
Spec 3	440	1512	536	Total Average
Avg	747	1124	572	**814** [Ns/m^4]

60kg/m^3	25mm	50mm	75mm	
Spec 1	1444	986	1100	
Spec 2	524	666	1339	
Spec 3	891	817	1154	Total Average
Avg	953	823	1198	**991** [Ns/m^4]

3.3 Absorption Coefficients of Chicken Feather by EA-Method

Absorption coefficient (α) of CF is also measured by EA method as comparison to the previous impedance tube method. By this method, after 200 Hz, absorption coefficient of CF75 continue to raise until reach the maximum value 0.99 within intermediate frequency ranges of 750 Hz then slightly decreased after 800 Hz and kept above 0.83 until high frequency ranges (> 1000 Hz). This agrees with previous impedance tube measurement, including for the thinner specimen CF25.

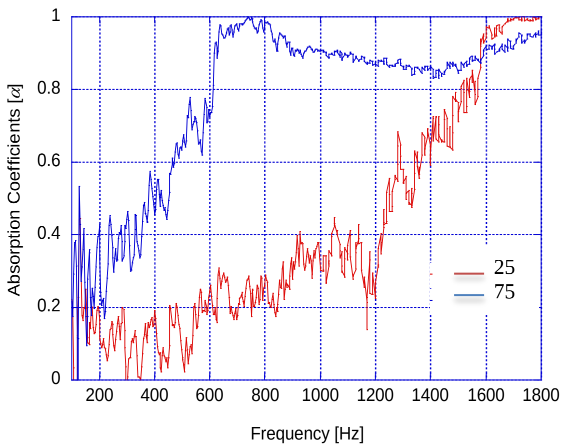

Figure 8: Absorption coefficient of Chicken Feather measured by EA method

3.4 Conclusions

Application of impedance tube measurement for CF absorption coefficient within frequency range of 100 Hz-1600 Hz resulted in maximum value of 0.99 at frequency 1,600 Hz, 946 Hz and 638 Hz for sample CF25, CF50 and CF75, respectively. The thickness of sample affects the absorption coefficient level where the increasing thickness of material resulted in higher absorption coefficient at lower frequencies. This phenomenon confirms by EA method, performed in separate location with typical specimen dimensions. Regardless of other factors, study shows the absorption coefficients of CF were comparable to absorption coefficient of GW, and performed better in certain frequencies. Even though, more experiments and statistical approaches are required on varies of CF density to ensure flow resistivity characteristics and applicability of empirical models with respect to porosity, tortuosity and pore shape factor ratio. The measurement results indicate prospect of chicken feathers as alternative for acoustical material application.

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