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Acoustical and Mechanical Properties of Environmental Friendly Acoustic Panel Made from Pumice Waste with Polyester Binder

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Abstract: Comfortable working room is essential for environment of factory, hotel, office and privacy. Sound absorber material is very important to absorb voice/sound, so it will decrease the intensity of sound resonance to ear then, it will create comfortable room for the user. Development of waste-based sound absorber such as pumice which has porous structure, light and easily obtained from the waste of sifting process with <10 mm has characteristic of big opportunity to be used as acoustic material of wall covering. This study will review the feasibility of pumice panel (polyester and pumice) in absorbing sound so, it can be applied as acoustic wall. The purpose of this study is to determine transmission loss, impact strength and flexibility of the composite panel of pumice with real size for room application. Research material was pumice particle sized 3, 5 and 10 mm with weight fraction of 40, 60 and 80% for every size of the pumice particle. Materials for composite making process and treatment are aquades, polyester of Yukalac 157 BQTN, hardener of MEKPO and Glycerin. Specimen test of the composite was made by using Hand lay-up technique. It was found that highest sound absorption was the composite with weight fraction 60% and 3 mm size particle with result 35% transmission loss on 1500 Hz sound frequency. Meanwhile, the result on 2500-4000 Hz was obtained on composite with 40% of 3 mm pumice particle. The highest impact strength was obtained on composite of 80% composition of pumice and particle sized 10 mm. The highest bending strength (1.480 MPa) occurred on weight fraction 40% with particle size 10 mm of composite.

Key words: Pumice waste, composite, transmission loss, impact, bending, mechanical

INTRODUCTION

Comfortable working room is essential for environment of factory, hotel, office and privacy. Sound absorber material is very important to absorb voice/sound so, it will decrease the intensity of sound resonance to ear then, it will create comfortable room for the user.

Sound absorber material is a panel, resonator and porous material (Lee and Joo, 2003). The available sound absorber material used porous material such as glass wool and rock wool but they can be harmful for health if their fibres are inhaled and can cause skin irritation (D'Alessandro and Pispola, 2005).

Development of sound absorber with some wastes and fibres has been developed to improve the use of these materials. Some researches about sound absorber have been conducted by Lee and Joo (2003), who developed sound absorber from bamboo and recycling polyester fibres, respectively. Sound absorber development of some natural fibers for building acoustic material has been studied by Kumar.

Pumice has porous structure which has the same characteristic with the existing sound absorber material (Karabulut and Caliskan, 2013). Pumice is a natural rock as the result of effusive volcanic activity containing foam made of glass-walled bubble and usually called as silicate volcanic glass rocks. Pumices are black, light grey and white. The characteristics of this rock are porous structure, easy to find and cheap but fragile. Pumice is easy to find in Indonesia, especially in Lombok Island which are mostly exported and used as the mixture of building material. The abundant pumice waste comes from the result of pumice sieve of unused pumice, since the size does not fulfil the criteria of packaging to be marketed (aggregate size of pumice waste

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<10 mm). The abundant pumice waste becomes economical consideration to engineer this rock become useful material. The porous pumice waste is very likely to be acoustic material of covering wall. This research reviewed the appropriateness of combining two different materials in order to absorb sound so, it can be applied as acoustic wall.

In the 1st year of this research, it was found that optimum characteristic score of the composite with percentage of particle weight fraction 40, 60 and 80% with particle size 3, 5 and 10 mm with input frequency 400, 600, 800, 1000, 1200 and 1500 Hz that is the coefficient of sound absorption of pumice composite increased slowly from frequency 400 until 800 Hz and then decline on frequency 1000 and 1200 Hz and then raising drastically on input frequency 1500 Hz. For frequency 1500 Hz on the particle composite sized 3 mm with particle weight fraction 60% it was gained the highest sound absorption coefficient that was 0.39. Therefore, on frequency 1500 Hz the tested composite is able to absorb sound well α >0.15 based on ISO 11654.

The activity in 2nd year is that the composite was managed into real panel size which is tested to know its transmission loss. Besides that, the endurance of the acoustic panel is tested as well. Research material is pumice particle sized 3, 5 and 10 mm with weight fraction 40, 60 and 80% with polyester as the binder. This panel composite material is made with hand lay-up method.

MATERIALS AND METHODS

The specimen is made by Press Hand Lay-Up technique. Sound testing machine of transmission loss (impedance tube standing wave method). The material used as matrix is Unsaturated Polyester Resin (UPRs) of Yukalac 157 BQTN with MEKPO hardener. The hardener as well as the sound transmission loss component is the pumice particle sized 3, 5 and 10 mm with weight fraction variation 40, 60 and 80% for every pumice size, the mixture designation shown in Table 1.

Transmission loss test of specimen sound is done with panel size 300×300 mm (Fig. 1) on transmission loss test device as in Fig. 2. Mechanical tests are impact test and bending test.

Table 1: Designations of mixtures

Mix. designation	Pumice dimensions (mm in dia)	Weight fraction of pumice (%)
3-40	3	40
3-60	3	60
3-80	3	80
5-40	5	40
5-60	5	60
5-80	5	80
10-40	10	40
10-60	10	60
10-80	10	80

Fig. 1: Picture of pumice composite fraction sized 3 mm and weight fraction 60%

Fig. 2: Transmission loss test device

RESULTS AND DISCUSSION

The result of transmission loss: Transmission Loss (TL) is a parameter of material to absorb or isolate sound in this study is shown by decibel (dB). Figure 3 and 4 show the result of TL testing for pumice panel in many pumice particle sizes (3, 5 and 10 mm) with weight fraction variation 40, 60 and 80%. Research finding shows that on low frequency of 500 Hz the TL value tend to increase then in frequency 1000 Hz tend to have the lowest TL due to the acoustic excitation and the panel response characteristic matching in this frequency (Moore and Lyon, 1991; Wang *et al*., 2005) and then increases again on frequency 1500 Hz for almost all panel

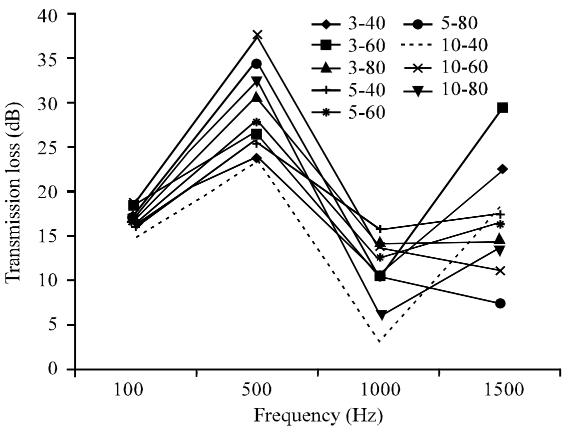

Fig. 3: Graphic of frequency relation (~1500 Hz) with transmission loss (dB)

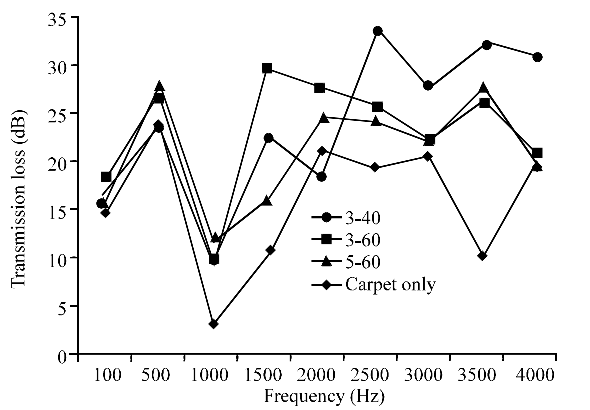

Fig. 5: Comparison of transmission loss (dB) from some pumice composite with carpet only

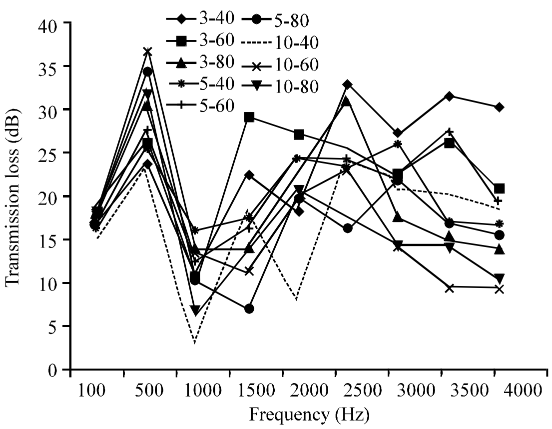

Fig. 4: Graphic of frequency relation (~4000 Hz) with transmission loss (dB)

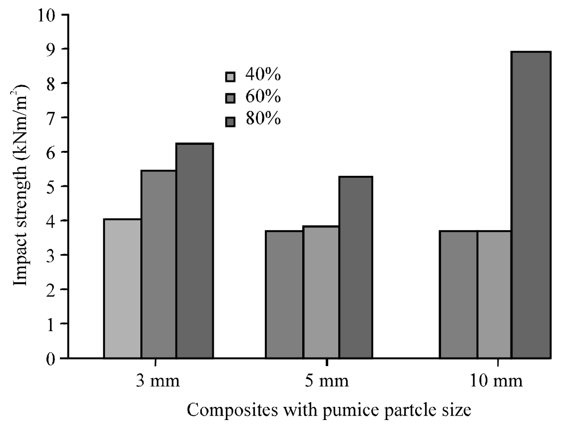

Fig. 6: The relation of pumice particle size of composite and impact strength (kNm/m^2)

types such as Fig. 3. The acoustic panel which has the best sound absorption capacity on frequency 1500 Hz (it is shown by highest TL value) that is panel 3-60 (pumice particle size 3 mm with weight fraction 60%). It is because the pumice solidity is spread equally on the composite surface by 40% of pumice weight fraction in which not all surface is covered by pumice as it is with 80% because there are too many pumice so, many of them are detached and the resin surface looks so, there is sound reflection from both of composites in which causing lower capability of sound absorption. Comparing to pumice particle composite of 5 and 10 mm because the size is bigger, so the gaps among the particles are bigger and the resin looks from the surface which means the sound is reflected as the consequence the absorption capability is lower.

For higher frequency from 1500 Hz which is shown by Fig. 4. The TL of every composition does not show certain trend and the graphic looks randomly. However, it looks that composition of 3 mm pumice particle and 40% pumice weight fraction shows highest TL on frequency 4000 Hz (Fig. 5).

Comparison of pumice composite from some the best composition with carpet, it was found that the average of transmission loss is higher than using carpet only which means pumice composite has better sound absorption than carpet only.

The result of composite panel impact: Based on Table 2 and Fig. 6, it can be seen the relation of pumice particle size and weight fraction upon impact strength of polyester-pumice composite. On weight fraction 40% it can be seen that the highest impact strength is on particle size 3 mm (composite 3-40) with value 4.05 kNm/m^2 and the lowest impact strength is on specimen of particle size 10 mm (composite 10-40) with value 3.68 kNm/m^2. On

Table 2: Data of impact strength

	Weight fraction (%)		
Particle size	40	60	80
3 mm	3.84615	5.97474	5.45455
	3.80952	7.18954	6.66667
	3.66972	5.24476	6.15385
	4.71476	4.54545	8.19672
	4.21053	4.87013	5.14403
Average	4.05014	5.56492	6.32316
5 mm	3.44828	3.96040	6.28592
	3.57143	3.90320	5.53622
	4.12371	4.53515	4.73821
	4.00000	3.84615	4.66853
	3.73832	3.38983	5.74713
Average	3.77635	3.92695	5.39520
10 mm	3.92157	3.90244	9.97009
	3.84615	3.84615	8.39034
	3.61991	3.68664	9.73304
	4.03551	3.41880	8.25593
	2.97030	3.77358	8.96516
Average	3.67869	3.72552	9.06291

weight fraction 60% it can be seen the highest impact strength is on particle size 3 mm (composite 3-60) with value 5.56 kNm/m^2 and the lowest impact strength is on specimen particle size 10 mm (composite 10-60) with value 3.72 kNm/m^2. On weight fraction 80% it can be seen that the highest impact strength is on particle size 10 mm (composite 10-80) with value 9.06 kNm/m^2 and the lowest impact strength is on specimen particle size 5 mm (composite 5-80) with impact strength 5.39 kNm/m^2. From all of these composites, it can be seen that the highest impact strength is on composite with particle size 10 mm with weight fraction 80%, it is because bigger particle size will strengthen the material, so based on the function of pumice as reinforcement, the existing fracture within the composite is a brittle fracture because the characteristic of pumice and polyester as thermoset polymer have brittle characteristic, therefore, the fracture is more than 2 fractures. If compared the fracture seen from the SEM photographs, the number of polyester is much more found in composite 10-40 (Fig. 7) and Polymer is fewer in composite 10-80 (Fig. 8). The form of fracture in both composite types are the same, brittle but composite 10-40 has more brittles than composite 10-80 which means that the polymer has more brittle characteristic than the pumice.

Bending strength: Figure 9 shows that composite bending strength with variation of weight fraction and particle size is various or cannot be seen in general tendency. However, it can be seen that composite with pumice particle size 10 mm with all weight fraction has the best bending strength. The highest bending strength from all composite data is gained in weight fraction 40%. It proves that composite with pumice weight fraction 40% which means the polymer is more than the composite with weight fraction composition 60 and 80% which finally made the composite stiff.

(a)
(b)

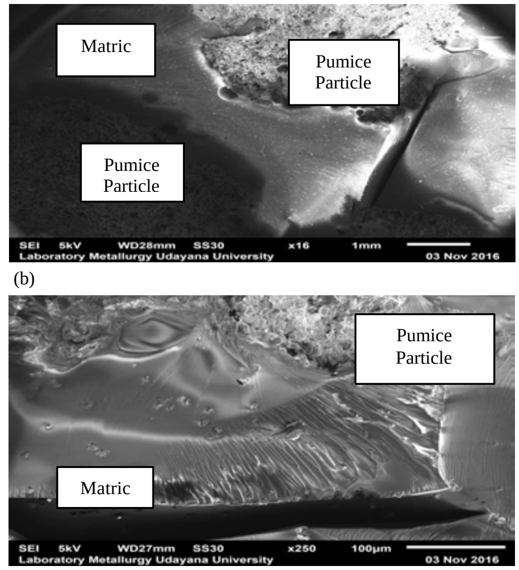

Fig. 7: SEM photographs of composite with pumice particle size 10 mm with weight fraction 40%; a) magnification 16x and b) 250x

(a)
(b)

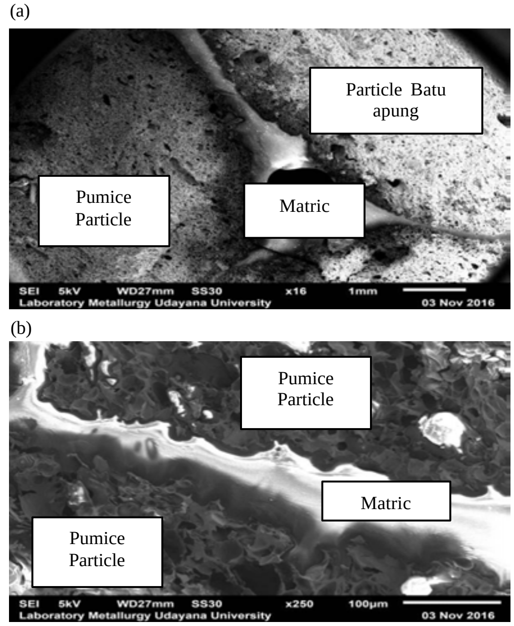

Fig. 8: SEM photographs of composite with pumice particle size 10 mm with weight fraction 80%; a) magnification 16x and b) 250x

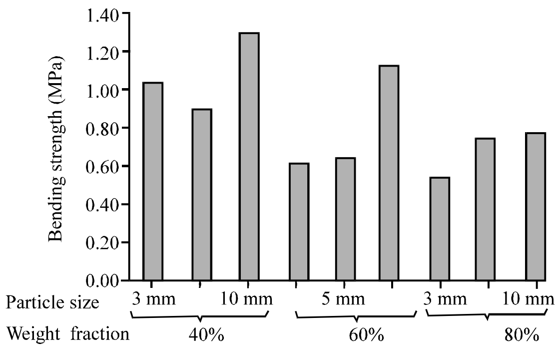

Fig. 9: Graphic of relation of pumice particle size and weight fraction upon bending strength (MPa)

CONCLUSION

The highest capacity of sound absorption occur in composite with weight fraction 60% and particle size 3 mm with transmission loss 35% on frequency 1500 Hz. Meanwhile, on frequency 2500-4000 Hz the highest capacity occur in 40% pumice composition with particle size 3 mm. The highest impact strength on composite with 80% pumice composition and particle size 10 mm. The highest bending strength occurs in weight fraction composition 40% with particle size 10 mm with value 1.480 MPa.

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REFERENCES

D'Alessandro, F. and G. Pispola, 2005. Sound absorption properties of sustainable fibrous materials in an enhanced reverberation room. Proceedings of the International Conference on Inter-Noise and Noise-Con Congress and Exposition on Noise Control Engineering, August 7-10, 2005, Institute of Noise Control Engineering, USA., pp: 2209-2218.

Karabulut, S. and M. Caliskan, 2013. Development of an ecological, smooth, unperforated sound absorptive material. Proceedings of the 2013 International Conference on Meetings on Acoustics (ICA) Vol. 19, June 2-7, 2013, Acoustical Society of America, Barnstable, Massachusetts, pp: 1-7.

Lee, Y. and C. Joo, 2003. Sound absorption properties of recycled polyester fibrous assembly absorbers. AUTEX Res. J., 3: 78-84.

Moore, J.A. and R.H. Lyon, 1991. Sound transmission loss characteristics of sandwich panel constructions. J. Acoust. Soc. Am., 89: 777-791.

Wang, T., V.S. Sokolinsky, S. Rajaram and S.R. Nutt, 2005. Assessment of sandwich models for the prediction of sound transmission loss in unidirectional sandwich panels. Appl. Acoust., 66: 245-262.