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# Manufacturing Characteristics of Cement-Bonded Wood Composite Board as Sound Absorption Type-Noise Barrier*1

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## ABSTRACT

This study was conducted to investigate the performance of sound absorption type-noise barriers manufactured with a combination of wood particles used for particleboard, recycled waste newspaper, and cement. An average density of wood-combined cement board was in the range from 0.83 to 0.96 g/cm$^3$, showing relatively low-density board. Regardless of types of cement bonded board or wooden board, the board with concave holes(凹)-formed surfaces showed greater sound absorption coefficient compared to those of flat surface boards. The board density was not related with those coefficients. Accordingly, it was concluded that concave or deep corrugated surface structure has played an important role in sound absorption for the application of sound absorption type-noise barrier.

*Keywords* : sound absorption type-noise barriers, concave holes(凹)-formed surfaces, sound absorption coefficient

## 1. INTRODUCTION

People are living not only in natural environment but also in diverse artificial environments. Audible sense is the most durable one of five sensible organs of human. Also, the audible sound frequency for human is 20~20,000 Hz and the most sensitive sound frequency is 1,000~5,000 Hz (Kang, 2003). People are more exposed to noisy outdoor conditions with a progress of industrialization. So, it is necessary to minimize noisy environments such as highway, school, apartment and factory, etc. Currently, noise barriers can be classified as interior and exterior types. The proportions of exterior applications such as highway, outskirts of school, and apartment are gradually increasing. These exterior barriers were mainly constructed with aluminium, resin mouldings (acryl or carbohydrates), wood and extruded cement panels. Among these products, cement type barrier is composed of low density and extruded molded types, so called, 'base panel'.

The advantages of cement-bonded wood composite board are light weight, waterproof, vibration, fire, and decay resistant, and also resistant to freeze, thaw, and shock. The reinforcing effect of wood is able to be acquired. There-

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fore, the development of durable noise barrier for interior or exterior applications is feasible.

In domestic market, several types of sound barriers made of aluminum-steel, semi-transparent plastic, and extruded cement board were being sold in order to abate traffic noise at expressways. The functions of sound barrier are mainly to transmit, to absorb, and to reflect noisy sound. The loss in sound transmission is usually measured to evaluate an acoustic effectiveness of sound barrier panels.

Boothby *et al.* (2001) investigated acoustic effectiveness, public acceptance and structural requirements of various designs and types of sound barriers from measurements of cement-bonded composite panel, precast concrete, plywood and glued-laminated panels etc. Hong (1996, 1998) also reported that a sound absorption performance improved with laying atmospheric stadium in wood-based panel. In addition, Kang and Park (2001) reported acoustic performances of wood and wood-based panels by resonance sound absorption, which showed an increase in the sound absorption coefficients by forming concave holes on particleboard than in flat boards. Cha (1976) mentioned that the material or structure of sound absorption is basically classified into three kinds of multi-porous, membraneous and resonator types. In the latter type, when sound hits the cavity-formed resonator, the air vibrates seriously in neighborhood of resonance frequency, and then sound energy is consumed as friction heat.

It is known that three primary ways to control traffic noise are 1) by source, 2) by receiver, and 3) by path (FHWA 1994). The path control consists of the approaches which may shield traffic noise or use a sound barrier. The purpose of this study is to fabricate sound absorption type-noise barrier with a combination of wood particles used in domestic particleboard manufacture, recycled waste newspaper, and cement. And its performance was measured to evaluate a feasibility of using cement-bonded wood panels as actual noise barrier.

# 2. MATERIALS and METHODS

## 2.1. Manufacture of Boards

For manufacture of wood combined cement boards, wooden raw material, cement, hardener ($MgCl_2 \cdot 6H_2O$), and water were evenly mixed using a blade-lift type blender. Then they were mat formed into flat-, or concave-shaped boards, and then pressed in cold press overnight following its unloading. Thereafter, boards were set in air-dry condition.

Wooden boards as control were made with application of phenolic resin and conventional hot pressing. For comparison, sawn lumbers of larch, Korean pine and radiata pine were also included. The experimental design for the manufacturing boards was shown as in Table 1. For this study, concave-shaped structure of average dia. 12.6 mm and depth 15 mm of holes on flat type boards was formed to improve sound absorption (Fig. 1, Fig. 2).

## 2.2. Test of Sound Absorption

For this test, 2.9 cm and 10 cm of diameter of cylindrical specimens were prepared according to KS F 2814 (Methods of test for sound absorption of acoustical materials by the tube method) and ASTM E 1050-98 (Standard test method for impedance and absorption of acoustical materials using a tube, two microphones and a digital frequency analysis system). These specimens were cut so that concave hole (凹) can be included. For comparison, flat boards and sawn lumber were prepared at the same size as the cement combined boards.

Two-microphone impedance measurement tube (B&K type 4206) was used to measure sound absorption rate, and the structure of impedance

Table 1. Experimental design of boards manufactured for sound barrier

| Types of specimen | Composition of raw materials | Type of board surface | Notification |
|---|---|---|---|
| Cement-bonded composite board | PB particle | Flat | CWF |
| | | Hole | CWH |
| | Pallet particle | Flat | CPF |
| | | Hole | CPW |
| | Old newspaper fiber | Flat | COF |
| | | Hole | COH |
| | PB particle (37%)+$MgCl_2$ 3% (Wet process) | Flat | CW3 |
| | PB particle (50%), $MgCl_2$ non-addition (Wet process) | Hole | CW4 |
| Wood-based panel | PB particle | Flat | WF |
| | | Hole | WH |
| | Pallet particle | Flat | PF |
| | | Hole | PH |
| | Old newspaper fiber | Flat | OF |
| | | Hole | OH |
| Sawn lumber | Larch | Flat | NAK |
| | Korean pine | Flat | JAT |
| | Radiata pine | Flat | RA |

*Samples were prepared with three replications for each experimental unit.

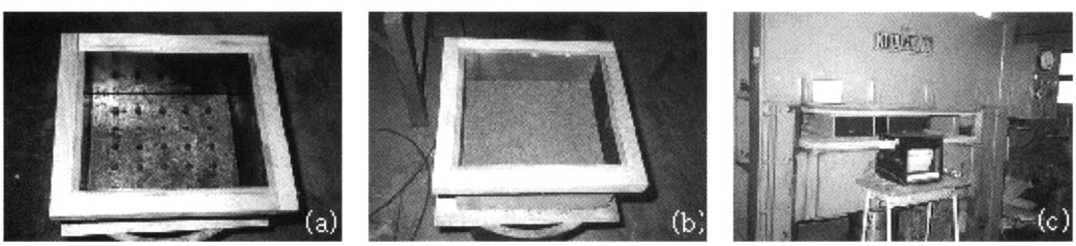



Fig. 1. Forming and pressing for concave hole (凹)-shaped composite board. (a) forming box, (b) prepared mat, and (c) pressing.

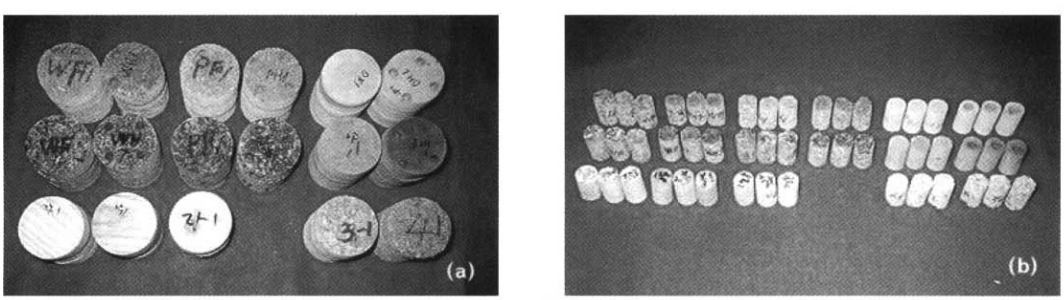



Fig. 2. Board specimens tested for sound barriers. (a) dia. 10 cm, and (b) dia. 2.9 cm.

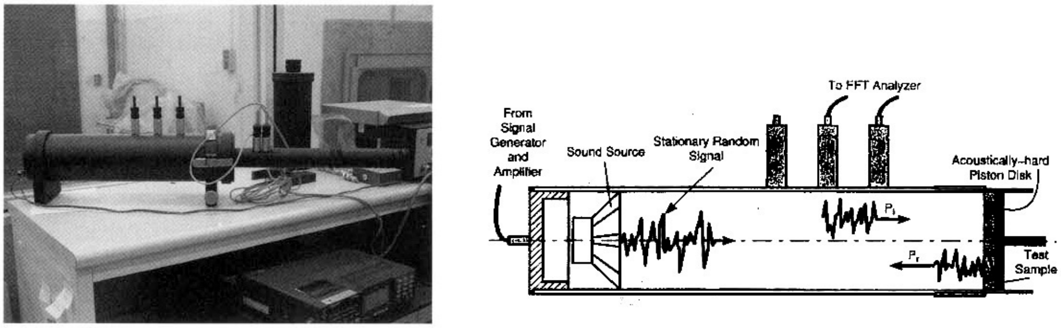



Fig. 3. Two-microphone impedance measurement tube (left side) and cut-away diagram of the impedance measurement tube (right side).

Table 2. Density and compressive strength of cylindrical board specimens for sound barrier

| Types of specimen | Notification of specimens | Type of board surface | Density (g/cm³) 10 cm diameter | Density (g/cm³) 2.9 cm diameter | Density (g/cm³) Mean | Compressive strength (kgf/cm²) |
|---|---|---|---|---|---|---|
| Wood-cement board | CWF | Flat | 0.90 | 0.92 | 0.91 | 39.1 |
| | CWH | Hole | 0.85 | 0.80 | 0.83 (91.2%) | 26.1 |
| | CPF | Flat | 0.92 | 0.92 | 0.92 | 50.3 |
| | CPW | Hole | 0.89 | 0.81 | 0.85 (92.4%) | 16.4 |
| | COF | Flat | 0.98 | 0.94 | 0.96 | 60.7 |
| | COH | Hole | 0.97 | 0.84 | 0.91 (94.8%) | 33.2 |
| | CW3 | Flat | 1.09 | 1.00 | 1.05 | 59.9 |
| | CW4 | Flat | 0.72 | 0.70 | 0.71 | 19.4 |
| Particle/Fiber board | WF | Flat | 0.67 | 0.64 | 0.66 | 285.7 |
| | WH | Hole | 0.62 | 0.57 | 0.60 (90.9%) | 161.0 |
| | PF | Flat | 0.67 | 0.66 | 0.67 | 320.9 |
| | PH | Hole | 0.62 | 0.61 | 0.62 (92.5%) | 186.8 |
| | OF | Flat | 0.53 | 0.55 | 0.54 | 197.0 |
| | OH | Hole | 0.53 | 0.53 | 0.53 (98.1%) | 157.4 |
| Sawn lumber | NAK | Flat | 0.45 | 0.45 | 0.45 | 65.6 |
| | JAT | Flat | 0.52 | 0.53 | 0.53 | 104.2 |
| | RA | Flat | 0.53 | 0.47 | 0.50 | 122.7 |

Note. 1. The contents on notification of specimens are the same as in Table 1.
2. The value in the parenthesis shows the percentage board density of hole-type to flat-type.
3. The compressive strength was measured with dia. 2.9 cm specimen.

tube is shown in Fig. 3. Sound-absorbed side of cylindrical specimen in impedance tube was loaded in the face of speaker. In case of concave shape, it was inserted to put at incident face confronting the sound source. A frequency range for measuring sound absorption rate was from 50 Hz to 6400 Hz. Specimens with 10 cm diameter were tested for testing low frequency

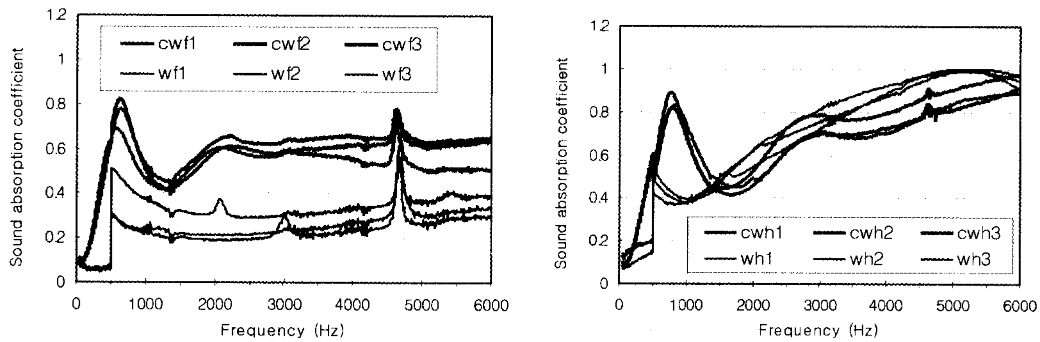



Fig. 4. Sound absorption coefficient of flat type (left side) and hole type (right side) of cement bonded PB and particleboard.

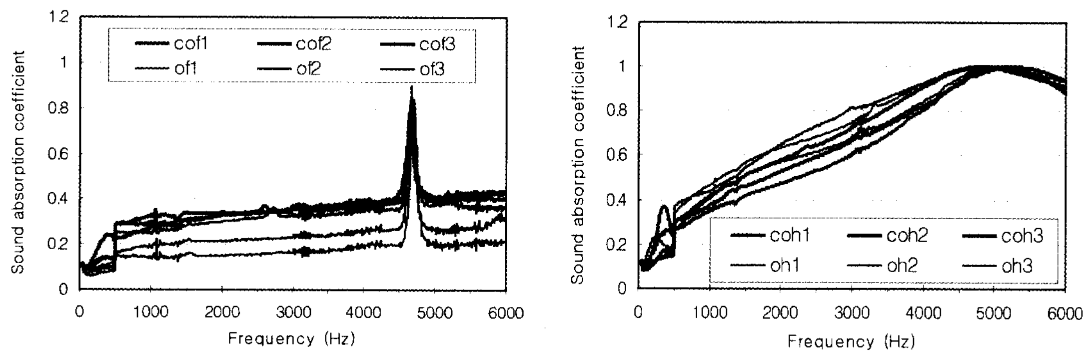



Fig. 5. Sound absorption coefficient of flat type (left side) and hole type (right side) of cement bonded fiberboard and fiberboard.

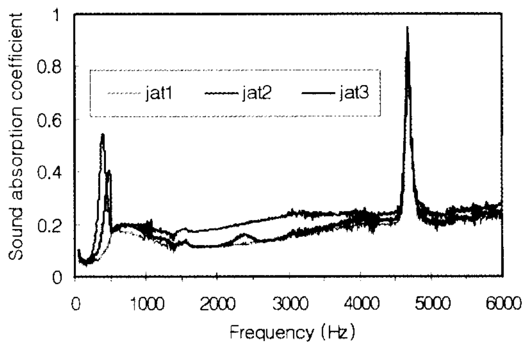
zone (50~500 Hz), while those with 2.9 cm diameter were tested for testing high frequency zone (500~6400 Hz).

# 3. RESULTS and DISCUSSION

## 3.1. Density and Compressive Strength Boards for Sound Absorption

As shown in Table 2, dia. 10 cm and 2.9 cm cylindrical specimens from cement bonded composite boards manufactured by semi-dry process showed an average density ranged from 0.83 to 0.96 g/cm$^3$. Concave 凹 (hole) type, which had lower densities than those of flat type and cement boards mixed with waste newspaper fiber had the highest density. Wooden boards showed a density range from 0.53 to 0.67 g/cm$^3$. As compared with cement bonded composite boards, wooden board mixed with waste newspaper fiber also gave lower density. Sawn softwood lumber showed a density ranged from 0.45 to 0.53 g/cm$^3$.

The compressive strength of cylindrical specimen (dia. 2.9 cm) in perpendicular direction to board surface was relatively low because one piece of concave shape was included. So concave types were lower in strength than flat types. Specimens under compressive stress showed gradual strain slip phenomenon until the displacement of 20 mm in sawn lumber, particleboard (PB), and MDF occur. However, there was not an abrupt failure phenomenon. The slope of sharp resistive strength in sawn lumber



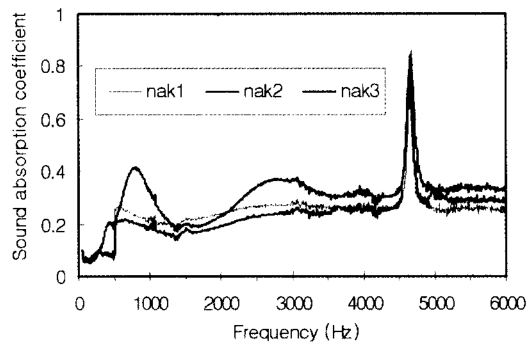




Fig. 6. Sound absorption coefficient of sawn lumber (flat type).
[Korean pine (left side), Larch (right side)]

* In the above graphs, the peaks from 4500 to 5000 Hz in Fig. 4 and Fig. 6 are believed to be due to intrinsic characteristics of impedance tube which was used.

appeared within displacement 2 mm, while wooden boards formed mild slopes.

The difference of compressive strengths between flat type and concave type fiberboards was relatively small when it was compared with that of PB. Load bearing behaviour of each fiberboard had similar trend. However, these primary differences were due to greater transverse compressive strength of wood and wooden boards because of wood-fiber orientation.

## 3.2. Sound Absorption Coefficients of Boards

The sound absorption coefficients of cement-bonded wood composite boards showed about 0.6 to 0.8 through all frequency zones with low density and 5 cm thick board types. However, concave hole-formed board exerted superior sound absorbtion ability with a rate of approximate 1.0. On the other hand, wooden board of flat type showed less sound absorption coefficient below about 0.5, while sound absorbtion of concave type increased as it moves to high frequency zone. This result indicated that sound absorption coefficient reaches about 1 in the frequency from 4000 to 6000 Hz. Sawn softwood lumber was similiar to flat type-wooden board in respect of sound absorption status and rate.

Thus, it was suggested that the degree of sound absorption rate of noise barrier materials could be affected by surface status rather than by its density. These results showed that the concave hole on board surface had better sound absorption (Fig. 4 to Fig. 6).

# 4. CONCLUSION

Wood particles being used for particleboard production and recycled wood-fibers of newspaper were mixed with cement to manufacture sound absorption type noise barrier panel and their performance was evaluated. The results showed that an average density of cement board was relatively low with the range of 0.83～0.96 g/cm$^3$. Its compressive strength was lower than that of lumber and wood-based panel. The sound absorption ability was greatly improved with the concave hole(凹) structures for all board types, and was not related with board density. The results of this study also suggested that the manufacture and development of sound absorption noise barrier panels with concave hole structure at surfaces and the required strength could be feasible by compressive forming method.

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