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# POLYESTER APPAREL CUTTING WASTE AS SOUND INSULATION MATERIAL

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**Abstract**. *This study developed an insulation structure using waste from apparel cutting and examined its sound insulation capabilities. Shredded polyester apparel cuttings served as the primary material for this structure. Results indicate that the insulation made from apparel waste exhibits superior sound absorption properties compared to conventional sound and thermal insulators. The average sound absorption ranged from 54.7% to 74.7% across frequencies from 250 to 2000 Hz. This research proposes a method to reduce environmental pollution by repurposing polyester apparel waste for insulation in roofs and internal walls.*

**Key words**: *apparel cutting waste, sound insulation*

## 1. Introduction

Traditionally, textiles in buildings primarily serve aesthetic purposes but also offer various functional advantages. Decorative textile materials such as carpets, curtains, upholstery, and textile wall coverings play a significant role in the acoustic conditioning of spaces. Additionally, textile materials, being porous, are commonly utilized as sound insulators and absorbers in building construction, with non-woven textiles being the preferred structure for this purpose. Numerous studies by researchers including Shoshani and Yakubov [1, 2, 6], Shoshani and Wilding [3], Shoshani and Rosenhouse [4], and Lou et al. [5], have investigated the acoustic properties of non-woven fabrics. Similarly, research on woven [7, 8, 9] and knitted fabrics [10, 11] has also been conducted. Garai and Pompoli [12], as well as Narang [13], focused on studying the sound absorption coefficient of polyester fiber materials concerning mass density and sample thickness values.

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However, few studies have explored the use of textile waste for insulation purposes. While research has examined the thermal insulation properties of textiles [14, 15] and their potential as sound-absorbing materials [5], there is a notable gap in addressing textile waste specifically for insulation applications. Generally, textiles with a loose structure, such as knits, are preferred for recycling due to lower energy consumption and the effort required to return them to fibrous form compared to woven fabrics. Whether virgin or recycled, the effectiveness of sound absorption materials depends on their porous structure and thickness.

Today, pressing environmental concerns stem from the escalating global production and consumption of textiles, generating significant volumes of textile waste worldwide. Therefore, finding innovative ways to reuse textile waste not only offers environmental benefits but also promotes sustainability and economic efficiency. This research endeavors to develop a novel insulation structure using waste from woven polyester apparel cuttings and assess its sound insulation properties.

## 2. EXPERIMENTAL

### 2.1. Materials

Polyester fabric cuttings were used as raw material for designing a new insulation structure. The characteristics of fabrics used for the preparation of samples A, C, and D are shown in Table 1. Differences among the three fabrics arise from mass, structural characteristics and fibre content. Sample B obtained from knitted polyester fabric in a partly fibrous form was used for comparison.

Table 1 Polyester fabric characteristics

| Fabric | A | C | D |
|---|---|---|---|
| Thickness (mm) | 0.16 | 1.2 | 1.6 |
| Cv (%) | 2.17 | 1.80 | 1.38 |
| Mass per unit area ($g/m^2$) | 92 | 245 | 272 |
| Cv (%) | 3.13 | 1.16 | 1.38 |
| Warp density ($cm^{-1}$) | 74 | 37 | 44 |
| Weft density ($cm^{-1}$) | 45 | 25 | 28 |
| Warp count (tex) | 7.4 | 36 | 36 |
| Weft count (tex) | 7.4 | 36 | 36 |
| Fiber content (%) | 100 PES | 100 PES | 95/5 PES/Lycra |

To prepare the fabric cuttings for the insulation structure they were additionally shredded in different sizes using a cutting machine with rotational knives, as given in Table 2. Subsequently, the shreddings were used as filler in casings made of 100% polypropylene non-woven fabric. To be comparable to commercially available insulation materials the designed sample thickness was 100mm. The insolation structure was secured by stitching with 4 seams along its length and width distanced by 15 cm. A total of ten samples, of which nine samples with different degrees of shredded fabric and one sample with a partially fibrous structure were prepared.

**Table 2** Sample characteristics and preparation

| Sample | Type of material | Fabric form | ρ (g/m$^3$) |
|---|---|---|---|
| $A_1$ | cutting waste | partially cut, pieces with different size | 215.6 |
| $A_2$ | cutting waste | cut into small pieces with different size | 209.1 |
| $A_3$ | cutting waste | in original form without preparation | 226.4 |
| $A_4$ | cutting waste | in original form without preparation | 249.4 |
| B | knitted fabric partially fibrous | mechanical recycling | 127.0 |
| $C_1$ | cutting waste | cut, pieces' average dimensions 6x4cm | 249.4 |
| $C_2$ | cutting waste | cut, pieces' average dimensions 8x4cm | 265.4 |
| D | cutting waste | cut, pieces' average dimensions 8x4cm | 173.9 |
| ABC | cutting waste -fabric A | A- cut, pieces with different size | 164.3 |
| | knitted fabric partially fibrous -fabric B | B- knitted fabric partially fibrous | |
| | cutting waste -fabric C | C-cut, pieces' average dimensions 6x4cm | |
| ABD | cutting waste -fabric A | A- cut, pieces with different size | 163.0 |
| | knitted fabric partially fibrous -fabric B | B- knitted fabric partially fibrous | |
| | cutting waste -fabric D | D- cut, pieces' average dimensions 8x4cm | |

### 2.2. Methods

As the obtained sample dimensions were not suitable for standard sound absorption tests, a modified testing procedure based on the impendence tube technique was used. The procedure used a sound generator (KYE Systems Corp Multimedia hi-fi speaker system sp-diameter), microphone (A4 mi-10), GoldWave computer software for transmitted sound recording and filtering, and OriginPro 8.5.1 software for analyzing the recorded sound. The sound signals were generated for 30s on frequencies of 125, 250, 500, 1000, 2000, and 4000Hz, i.e. 5s on each frequency. Three tests for each of the samples were conducted. The recorded sound was filtered using Gold Wave software on each of the 6 frequencies, with a cutoff frequency of ±5%. The same procedure was conducted for a referent sample, using air as a sound transmission medium. The amplitudes of the sound signal on each frequency for each sample were recorded.

## 3. Results and Discussion

To calculate the sound absorption coefficient (α) the difference in amplitude of the sample sound absorption and the referent sound absorption was used:

$$\alpha = 100 - \frac{b}{c} \cdot 100(\%) \quad (1)$$

where:

b – amplitude of the output sound waves of the insulation structure

c – referent amplitude of the output sound waves

The results for the sound absorption coefficients of the samples are given in Table 3, whereas the resulting sound absorption curves in Figure 1.

In order to obtain a single figure rating the noise reduction coefficient (NRC) defined as the arithmetic average of sound absorption coefficients at 250, 500, 1000, and 2000Hz was calculated for the samples, Table 3.

**Table 3** Sound absorption characteristics of samples

| Sample | α (%) | | | | | | NRC (%) |
|---|---|---|---|---|---|---|---|
| | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | |
| $A_1$ | 22.52 | 41.36 | 68.94 | 85.56 | 80.99 | 70.33 | 69.21 |
| $A_2$ | 11.89 | 23.69 | 69.45 | 81.45 | 95.43 | 73.99 | 67.51 |
| $A_3$ | 29.37 | 44.62 | 67.57 | 77.83 | 68.27 | 56.07 | 64.57 |
| $A_4$ | 34.95 | 55.01 | 84.16 | 84.78 | 67.78 | 56.07 | 72.93 |
| B | 30.09 | 41.53 | 63.00 | 91.50 | 85.05 | 62.81 | 70.27 |
| $C_1$ | 14.05 | 41.28 | 70.40 | 77.97 | 70.99 | 71.68 | 65.16 |
| $C_2$ | 32.07 | 57.72 | 71.36 | 75.70 | 72.59 | 53.76 | 69.34 |
| D | 13.33 | 42.20 | 46.74 | 78.89 | 50.99 | 88.25 | 54.71 |
| ABC | 16.22 | 50.60 | 64.25 | 69.90 | 91.98 | 86.71 | 69.18 |
| ABD | 36.76 | 50.02 | 76.93 | 82.75 | 89.38 | 61.27 | 74.77 |

All samples show increasing sound absorption with the increase in frequency. For the lowest measured frequency of 125Hz, the sound absorption is minor, ranging from 11.89% to 34.95%. At mid frequencies (500, 1000 Hz) an increase of sound absorption can be seen, achieving the maximum values at 1000Hz for most of the samples, ranging from 69,9% to 91.5%. The high frequencies show a trend of decreasing sound absorption.

The obtained insulation structures exhibit sound absorption properties typical of fibrous materials. The sound absorption curves of all samples show the same trend with maximum absorption achieved at the interval of 1000Hz to 2000Hz. Improved absorption at higher frequencies is typical of porous structures, as they function through the mechanism of dissipative absorption which is particularly efficient at high frequencies.

Sound insulators function by blocking the transmission of airborne sound, thus any gaps in the structure allow sound to “leak”, in just the same ways that water can pass through seemingly insignificant holes. Therefore, the more homogenous the textile structures the better their sound insulation properties should be. As homogeneity is easily achieved in structures containing materials in partially fibrous form, such as sample B, in comparison to those made of fabric cuttings, structure B should theoretically have better sound absorption properties. However, the variation coefficient of NRC for the tested samples is 7,3% indicating that all obtained structures, regardless of the preparation method, have comparatively similar sound absorption properties. In other words, when taking into account the human perception of sounds the difference in sound insulation provided by the various samples is negligible. The achieved sound absorption with NRC ranging from 54,71% to 74,77% is comparable to commercially used insulators, such as glass wool (NRC=66,3% for thickness of 50mm and density of 50g/m3), stone wool (NRC=63,8% for thickness of 50mm and density of 80g/m3) or polystyrene (NRC=51,8% for thickness of 50mm and density of 28g/m3) [16].

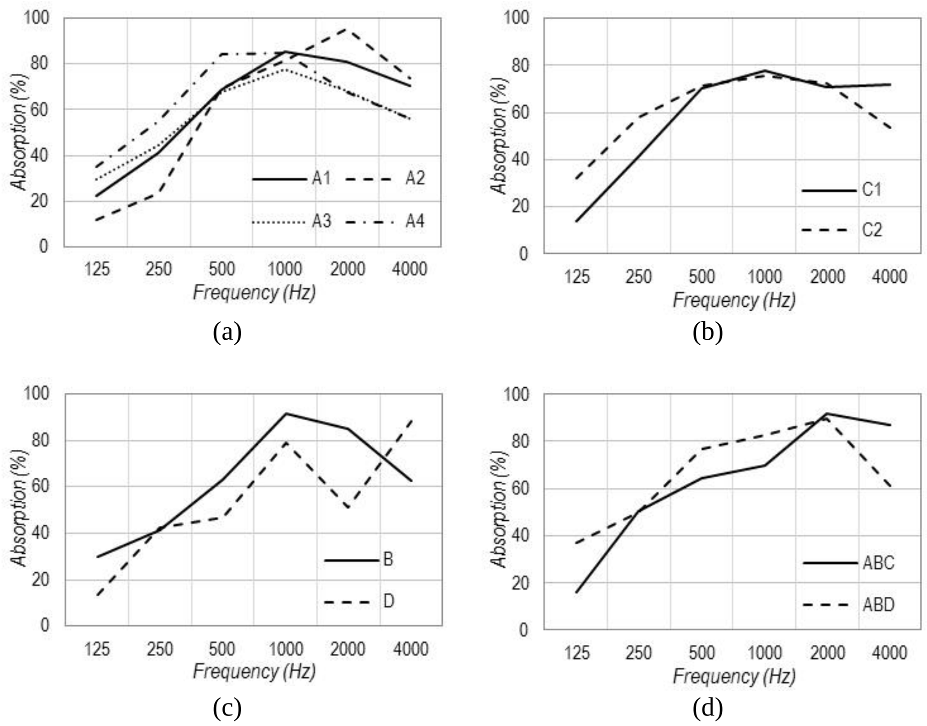


**Fig. 1** Absorption curves for samples (a)A, (b) C, (c) B and D, (d) ABC and ABD

## 4. CONCLUSION

Sustainability in textiles continues to drive innovative research and development. The research presented in this paper focuses on analyzing the sound insulation properties of a new insulation structure made from polyester apparel cutting waste. The noise reduction coefficient of this structure is comparable to commercially used building insulators for both thermal and sound insulation purposes. Utilizing textile waste as insulation offers environmental, sustainable, and economic benefits due to its ready availability and cost-effective production process. However, its application is currently limited to internal walls and roofing constructions.

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