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Experimental Investigation into Sound Transmission Loss through Concrete Containing Recycled Rubber

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ABSTRACT: With the development of urbanism and the airports, construction of highways around cities, noise pollution caused by the traffic of vehicles, landing and take-off the airplane has become one of the most harmful effects on the habitats around the highways and urban areas. In order to prevent these damaging effects, or in other words, for reducing the transmission of the noises from streets to the residential buildings, sound absorbing materials can be used around the highways. A number of 4 mixture designs have been investigated in this study in order to reduce sound transmission through concrete, including control sample and 3 mixture designs of recycled rubber with sizes of 1–3 mm. The rubber has been used as a replacement of 5, 10, and 15 percent of sand. First, 7, 14 and 28-day strengths of concrete have been measured and then, sound transmission losses through the samples have been measured at the range of 63 to 6300 Hz by using impedance tube of the transfer function. The results indicate a reduction in the transmission of sound in samples containing rubber at high-frequency ranges, showing the effectiveness of this type of concrete usage in airports and freeways.

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1- Introduction

Sound pollution is one of the most harmful factors in the home, work environments, and even in the streets. This harmful factor is the most common physical hazard threatening people's health. Today, in spite of industrial development, exposure to excessive permissible sound is still one of the most hazardous health problems threatening the residents of urban areas and industrial workers in the world [1]. When sound waves encounter a solid hardboard, in addition to reflecting and absorbing waves, some of the waves pass through the surface. So when it is said that an element is a great sound absorbent, this does not mean that the element is a good sound separator or insulator and the harder the separator is, the lower the sound transmission1 would be. Researchers have conducted several studies on the loss of sound transmission from materials from the year 1990 to 2016 [1, 5, and 7]. Using materials that reduce the transmission of sound in private, public and industrial spaces can play a very important role in controlling sound inside buildings. The measuring of the loss of sound transmission through the materials is evaluated by two measurement methods. The first method is to evaluate the sound transmission class and the second method is to calculate the transmission loss by using the impedance tube [2- 4].

2- Methodology

2- 1- Mix design

Generally in this study 4 mixing designs were examined, which included one control sample and three mixing designs containing fine-grained waste rubber crumb aggregates with dimensions of 1 to 3 mm. The rubber crumbs have replaced 5%, 10% and 15% of the sand's weight. In order to investigate the compressive strength of concrete, 3 samples of 150 × 150 mm2 for 7 days old, 3 samples for 14 days and 3 samples for 28 days old were prepared. In order to reach better compatibility, super-plasticizer was used, and in all designs, the concrete consistency was 10 ± 50 mm [6].

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2- 2- Calculating the sound transmission loss

In order to conduct this test, samples of 100 mm in diameter and 50 in height, as well as specimens of 30 mm in diameter and 50 m in height were produced. To calculate the transducer loss according to the E2611 standard, the SW422 + SW477 model impedance tube made by BSWA Company is used. Some advantages of using the impedance tube are its high accuracy, no need for sample preparation in large dimension and volumes, the possibility to compare with the research of other people in other parts of the world and the possibility of accurate calibration, and the greatest disadvantage of using this device is indicated at the time of preparation of some samples which requires a very precise mold design.

3- Results

The compressive strength of the samples has been investigated to determine the feasibility of this type of concrete for using as road or wall separators and construction blades. By increasing the number of rubber crumbs, we will see a further decrease in the concrete's resistance. With replacing 5% of rubber crumbs with sand, a compressive strength decrease of 12.5% was achieved and with increasing the amount of

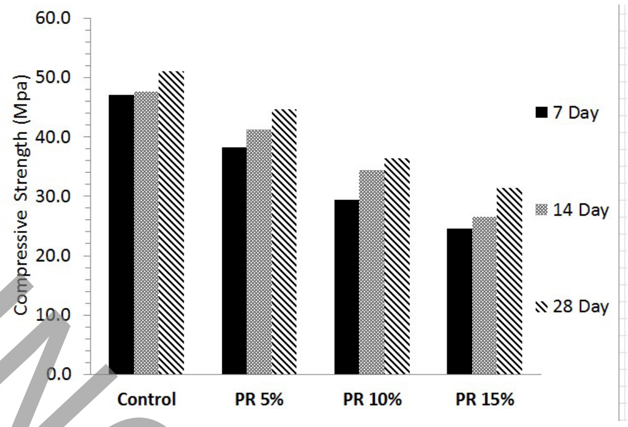

Figure 1. The compressive strength of samples containing fine-grained rubber.

replacement percentage, the compressive strength in the sample containing the rubber crude reduced from 15.4% to 38.4%. The reason for the loss of resistance in rubber-containing samples is that rubber crumb is a substitute the stone materials and on the other hand, the presence of rubber in concrete causes a complete lack of adhesion in materials. The failure of the samples shows that the samples bear a high compressive load after failure and have a lot of deformation without being collapsed. The sample does not collapse after failure and can be reloaded with fewer loads. This behavior reflects the high energy absorption of rubber-coated concrete. After conducting tests with the impedance tube, according to Figs. 2 to 4 which comparatively analyze the transducer loss of the control sample and the sample containing the rubber crumbs, it is observed that the fine-grained rubbers that have replaced sand have a significant effect on reducing the transmission of sound. The most harmful effects of noise pollution on human body occur in the frequency range of 4000 to 20,000 Hz, so this frequency range has the most important role in reducing the voice transmissions in the frequency range [8]. According to the conducted tests, the more fine-grained rubbers replace sand, the greater the sound transmission loss is. The sample that contains 15% more fine-grained rubber had a noticeable reduction in the range of 2000 Hz to 6300 Hz compared to other samples. In fact, with the increase in the presence of rubber crumbs in concrete, the sound transmission loss will increase.

4- Conclusion

By replacing sand with rubber crumbs the sound transmission decreases in concrete. Although this replacement improves the acoustic qualities of the concrete, due to the properties of the rubber and also the lack of adhesion to the concrete mix, it reduces the compressive strength as in the sample with 15% replacement where the sample has the highest sound loss, the compressive strength was reduced by more than 38%. The degree of transmission loss even with the use of rubber in concrete is not the same at all frequency ranges and concrete is not able to equally reduce the transmission of sound at all frequencies to the same extent. In general, it can be concluded that substituting sand with rubber crumbs in values of 5% and 10% has desirable effects on low frequencies and an increase in substitution of more than 10% has significant effects on high frequencies. Considering the good performance of this type of concrete at high frequencies and also due to their acceptable resistance, it is possible to use this type of concrete in the waiting rooms of airports and in the freeways.

5- Conclusion

By replacing sand with rubber crumbs the sound transmission decreases in concrete. Although this replacement improves the acoustic qualities of the concrete, due to the properties of the rubber and also the lack of adhesion to the concrete mix, it reduces the compressive strength as in the sample with 15% replacement where the sample has the highest sound loss, the compressive strength was reduced by more than 38%. The degree of transmission loss even with the use of rubber in concrete is not the same at all frequency ranges and concrete is not able to equally reduce the transmission of sound at all frequencies to the same extent. In general, it can be concluded that substituting sand with rubber crumbs in values of 5% and

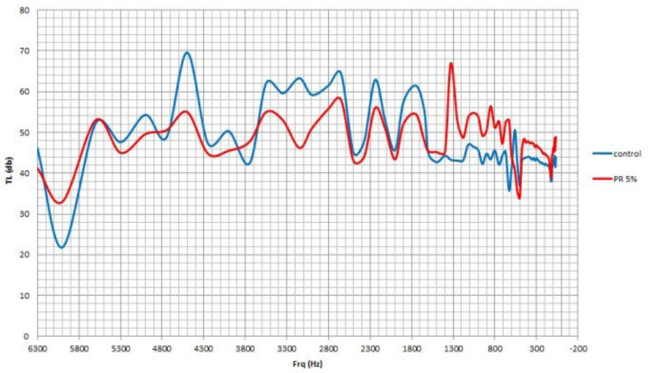

Figure 2. Sound transmission loss from concrete containing fine-grained rubber with 5% replacement.

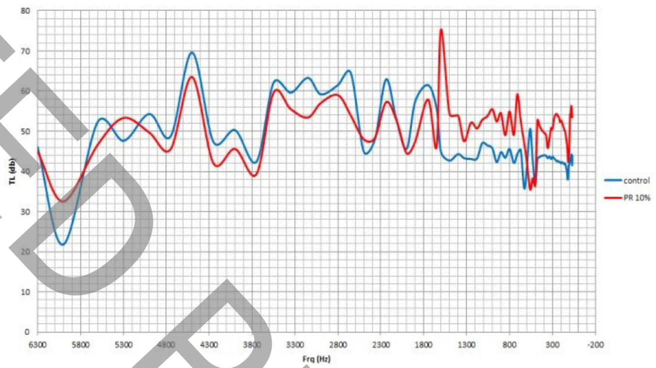

Figure 3. Sound transmission loss from concrete containing fine-grained rubber with 10% replacement .

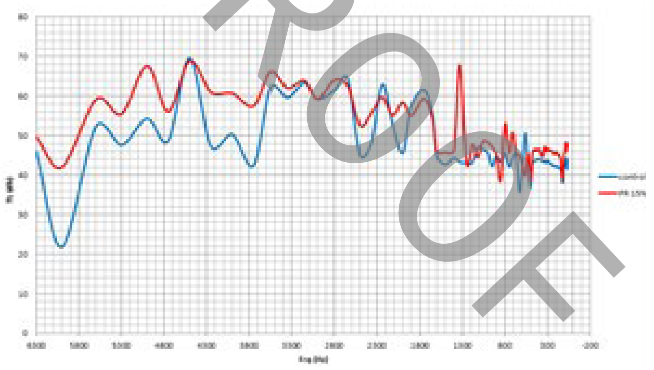

Figure 4. Sound transmission loss from concrete containing fine-grained rubber with 15% replacement.

10% has desirable effects on low frequencies and an increase in substitution of more than 10% has significant effects on high frequencies. Considering the good performance of this type of concrete at high frequencies and also due to their acceptable resistance, it is possible to use this type of concrete in the waiting rooms of airports and in the freeways.

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