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# Noise Reduction with Rubberized Concrete: A Review

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***Abstract: In recent years, with the rapid development of the economy and population of India and worldwide, noise pollution and disposal of scrap tyre rubber become a huge environmental problem and affecting human and animal life. In this paper, a review of previous research is made to reduce and control noise transmission with use of end-of-life tyre as coarse aggregate at the different percentage in concrete. As a result, it was found that rubber replaced concrete can be used for noise insulation and has desirable strengths. Benefits of noise reduction with the replacement of rubber waste in every aspect briefly presented in this paper. In conclusion, our research background on noise reduction with rubberized concrete is also explained in details.***
***Keywords: Passive Noise Control, Rubberized Concrete, Scrap Tyre, Recycling, Waste Management***

## I. INTRODUCTION

The urban areas of India have become highly populated in past few decades. In the last decade, it rose by 31.8%. This has led to certain environmental and health issues that also include environmental pollution. Some causes are unavoidable and are required to be followed for the developmental activities.

So, it is not possible to completely avoid them. But, some preventive measures sure can be taken to control and minimize the extent of it.

As per the prevention and Control of Pollution Act implemented in 1981, the noise is termed as an ‘air-pollutant’. It is that unpleasant, distracting and unnecessary sound that ought to be avoided due to its sleep depriving and concentration-lowering impact. The person gets annoyed due to the persistent uneasiness caused by them.

According to the WHO guidelines, for a sound sleep, the noise in that room should not be more than 30dBA. For maintaining concentration in any classroom, it should not exceed 35dBA.

The noise levels more than these limits on a continuous basis, may harm mental as well as physical health on a short term and long term basis. Rubber waste, especially scrap tire waste, is one of the most hardly manageable. Its management and utilization is a very urgent ecological problem of today.

Vast amounts of scrap tires are placed in dumps, where they cause a big danger of fire. During such fires, poisonous smoke is released, and fires are difficult to extinguish.

This causes different environmental problems and forces to permanently seek for new possibilities and ways in the field of management, utilization and recycling of scrap tires.

Rubber waste management may be subdivided into 3 main stages: waste recycling, waste incineration or its storage in specially installed dumps. The environmentalists seek by various legal acts to prohibit the incineration of rubber waste and their burying in solid waste facilities.

The aim of this work is to evaluate the possibilities for the application of different particle scrap-tire rubber waste in noise control in order to tackle two priority environmental problems with one solution i.e. “Control of Noise Pollution with recycling of end-of-life tyre in concrete construction”

## II. CAUSES AND EFFECTS OF NOISE

By definition, noise pollution takes place when there is either excessive amount of noise or an unpleasant sound that causes temporary disruption in the natural balance. Various main causes and effects of noise pollution as follows.

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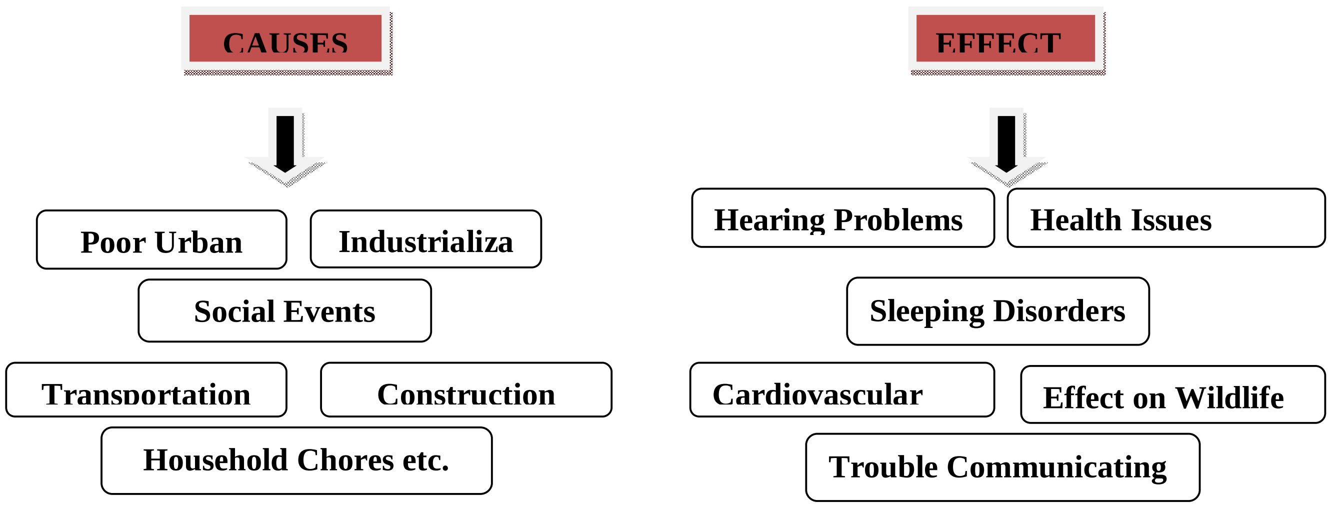
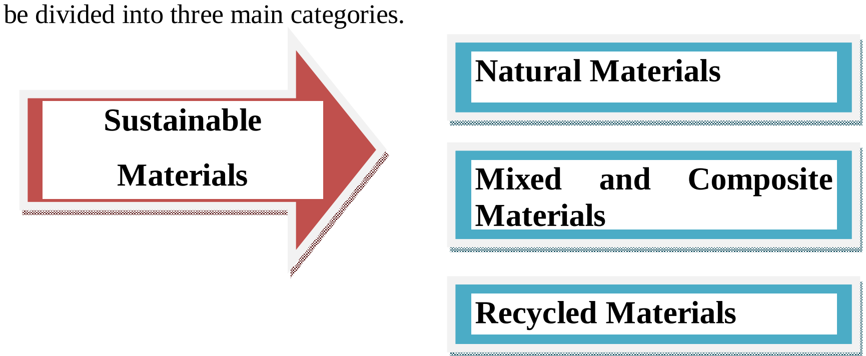



## III.SOUND ABSORBING MATERIALS

Synthetic fibers can be used for thermal insulation and sound absorption, because of their high performance and low cost, porous materials and rubber can be a good alternative for noise cancellation A majority of various sustainable materials for noise control can be divided into three main categories.




There is a great variety of natural fibers which can be used for thermal and acoustical applications. These are commercially available in the form of coconut, kenaf, hemp, mineralized wood fibers. Rubber particles or end-of-life tyre seems good solution for passive noise control.

## IV.RUBBERIZED CONCRETE

Concrete is one the most extensively used construction material all over the world. Many scientists and researchers are in quest for developing alternate construction material that are environment friendly and contribute towards sustainable development. Huge amount of rubber tyres waste is being generated day by day which creates the disposal problem and has many environmental issues. End-of-life tyre cannot be discharge off easily in the surrounding environment as its decomposition takes much time and also produces environmental pollution. If normal conventional concrete ingredients replaced with rubber or waste rubber that term is known as rubberized concrete.

## V. NOISE CONTROL TECHNIQUES

Various measures have been taken by humans to reduce the noise levels. Noise is a mechanical wave, and thus exhibits reflection, refraction, diffraction, absorption etc. The in depth knowledge of these phenomena may help in reducing noise. There are two types of noise control measures in use, they are:

### *A. Active Noise Control*

In this technique, we modifying and canceling sound field by electro-acoustical approaches is called active noise control. There are two methods for active control. First one by utilizing the actuators as an acoustic source to produce completely out of phase signals to eliminate the disturbances and second method is to use flexible and vibro-elastic materials to radiate a sound field interfering with the disturbances and minimize the overall intensity.

### *B. Passive Noise Control*

Passive noise reduction technique refers to those methods that aim to beat down the sound by modifying the environment close to the source. Since no input power is required in such methods, this method is often cheaper than active control, however the performance is limited to mid and high frequencies. Active noise method mainly control and works well for low frequencies.

## VI. LITRATURE REVIEW

1) *Savale P. A et al* paper explores the sources, effects and suggestions for controlling the excessive noise. Automobiles, industries, highway transport, airports, railways and public address system turns out to be major sources of noise pollution. Most of our day-to-day activities, by knowingly or unknowingly every one of us contribute to generate noise pollution. Often neglected, noise pollution adversely affects the human being leading to irritation, loss of concentration, loss of hearing. Efforts shall be made to identify the sources of noise pollution and the reasons for increase of noise levels. Efforts shall be made to reduce the undesired noise levels from noise generating sources [1].
2) *Zulkepli Hj. Et al.* carried out a research on noise pollution at school environment and three schools having distinct ambiences have been taken into consideration. It has been observed that increase in commercial, traffic and other activities around the schools leads to increase in noise pollution in school environment. The research includes the negative impacts to teachers and pupils performance due to noise pollution from traffic, commercial and other activities in the vicinity of school campus. The observations have been made under two categories i.e. by measuring noise rate and by questionnaire. The physical data collection is done by sound level meter for the duration of 8 hours with interval of 5 seconds at several points within school. A graph of Sound pressure level (Decibel) vs time has been presented and noise level range with min. and mod has been obtained. The noise range (in Decibel) for case1, case2 and case3 has been found to be (56-77), (53-72) and (42-59) respectively. The Max of SPL (in Decibel) found are 77, 72 and 59. The Mod of SPL (in Decibel) is 68, 62 and 45. After analyzing and comparing the measured data with the allowable range (35-45), it is found that the noise problem does exist in the case1 and case2. The case 3 has been found suitable for classrooms. The questionnaire survey has been done for case1 as it has poor noise quality and the results revealed that there definitely exists a noise problem with 95% respondents agreeing to it. It is further revealed that 41% of the noise came from students itself, 30% from traffics, 12% from construction, 12% from people passing by, 3% from miscellaneous sources like noise from animals and 2% from shopping activities. Various negative effects observed include disturbance in study/teaching, hearing problem during class, mental stress, difficulty in discussion, one needs to speak louder. And health problems like headache. After the final analysis it has been concluded that only those schools are exposed to noise pollution wherein there are commercial and traffic activities around. It has also recommended building schools away from shops and main roads [2].
3) *M.H.F. De Salisa et al* researched on various strategies that can be implemented for noise control in naturally ventilated buildings include reduced costs, simpler and manageable environment conditions and by reducing the use of mechanical ventilation systems .the buildings constructed should be designed in such a way so that the need mechanical devices are as minimum as possible. Trickle filters and large openings provided do the tricks. The well designed ventilation systems must have 10Pa pressure difference available to drain air through buildings. Location of vent apertures should be away from direct noise paths and screens used should consist of barriers including fences, earth mounds etc. Treatment of apertures, inlets and outlets can be done by using acoustic louvre and providing linings. Hybrid systems have been developed for window inlets and in general, in-duct treatment and various components to use the best attributes of more than one type of treatment for noise reduction Also a number of hybrid treatments and techniques can be implemented if the problematic noise source has strong tonal components. Also reduction in broad band noise such as road traffic noise, reductions can be made in the prominent frequency bands integral barriers used also improves the sound reduction of external walls [3].
4) *T.S.S Jayawaradana et al* analyzed that noise in a textile factory equipped with heavy machinery produce a noise level up to 95dB, while the national institute of occupational safety and health recommended that the intensity and time to which worker must be exposed are 85dB and 8 hours respectively. Developed mathematically node and spectrum to view software were used in his study [4].

5) *Azmi M et al* Observed that, public housing sites are subject to severe noise impact from various sources many recycled materials, such as waste rubber, metal shavings, plastic, textile agglomerates can be used. It can be useful to mix various recycled materials of different grain size to obtain the desired performance [5].
6) *Zhao et al* Reported the sound insulation property of wood/used tire rubber composite panel (WRCP). The results indicated that an increase in the usage of recycled tire rubber crumbs and the dosage of PMDI adhesive could significantly improve the soundproof property of the WRCP [6].
7) *Sarawut et al* During the study, At 20 phr of silica, tensile strength, elongation at break and abrasion resistance of the silane filled master batch composite were superior to those of silane-filled conventional composites. In the presence of Si-69, the master batch composites gave similar damping properties to those of the conventional composites at all silica loadings [7].
8) *Zhou et al* Reported the novel sound absorber, using recycled rubber particles with good attenuation property. Results indicated contribution of recycled rubber to low frequency sound absorption is confirmed. Although more work is required to verify the effect of different rubber particles and composite structure, the results can lead to a novel kind of sound absorption materials with high performance [8].
9) *Krzysztof et al* Presented the application of ground tire rubber (GTR), as potential filler for butyl rubber. The micro structural analysis of a sample containing 30 phr of GTR revealed strong interactions between the butyl rubber matrix and GTR [9].
10) *Zeno Ghizda˘veț and Bianca-Maria Ștefan* study is made to characterize the acoustical behavior of concrete made with crumb rubber waste from sport fields. Concrete mixes with different water to cement ratio (0.45, 0.50 and 0.55) and crumb rubber dosages (0%, 5.0% and 7.5% by weight) were prepared. Properties examined for the nine mixes included compressive strength, apparent density, apparent porosity and acoustic tests. Four additional samples with a modeled intrinsic porosity were subjected to acoustic tests in the frequency range 200–3000 Hz. Some samples with high crumb rubber dosage were selected to study the interaction between crumb rubber wastes and cement matrix. Self-organizing maps (SOM) and Principal Component Analysis (PCA) methods were implemented to generate visual clustering and to find out the correlations between experimental data. It was found that the sound absorption coefficient was above 0.5 for all samples containing rubber, in contrast to the control samples. Some exceptional values of the sound absorption coefficient (of 0.82 and 0.93) has been obtained on samples having a larger number of rubber grains on the surface. Evenness of the sound absorbing coefficient and a quite good values range of 0.6-0.7 – has been obtained by simply producing artificial, macroscopic pores in the composite material. The water/cement ratio ranging from 0.45 to 0.55 induced a decrease in compressive strength of up to 9 MPa. Apparent density decreased with both water/cement ratio and the amount of added rubber (of up to 152 kg/m3) while the apparent porosity experienced an increase of up to 1.8% [10].
11) *Esteban Fraile-Garcia and Javier Ferreiro-Cabello* stated that, the acoustic behavior of building elements made of concrete doped with waste-tire rubber. Three different mixtures were created, with 0%, 10%, and 20% rubberin their composition. Bricks, lattice joists, and hollow blocks were manufactured with each mixture, and three different cells were built and tested against aerial and impact noise. The values of the global acoustic isolation and the reduction of the sound pressure level of impacts were measured. Results proved that highly doped elements are an excellent option to isolate low frequency sounds, whereas intermediate and standard elements constitute a most interesting option to block middle and high frequency sounds. In both cases, the considerable amount of waste-tire rubber recycled could justify the employment of the doped materials for the sake of the environment. With the maximum percentage of rubber I their composition (20%) provide a better response than standard and with 10% for low frequencies upto 1401DP in the case of airborne insulation and 190DB in the case of impact sound insulation. in the first case, the improvement was up to 50% and for second case, this percentage was hardly 15% [11].
12) *Muhammad B. Waris and Nehal N. Ali* investigated possible use of recycled tire in concrete for partial fine aggregate replacement to provide possible solution for tire waste management as well as aggregate resource conservation. Commercially produced tire crumbs of size ranging between 0.80 to 4.0 mm were used for partial replacement of fine aggregates in concrete. Three fractions of 20%, 40% and 60% replacement were considered in addition to a control mix. A lean mix proportion of 1:2:4 with water-cement ratio of 0.50 was used in this study. In the fresh state, workability improved with increase in replacement percentage of tire crumbs. In hardened concrete, the compressive strength, tensile strength and flexural strength decreased with increase in fraction of tire crumbs. The apparent density was only slight changed while voids and water absorption decreased because of increase in workability. The relative values of strength exhibit a linear relationship with replacement ratio. Based on the results, following conclusions may be drawn: Workability of the mix increases with increase in tire rubber content, Compressive strength, tensile strength and flexural strength all decrease as the percentage of tire rubber increased, The apparent density is only slightly decreased; the maximum reduction is almost 10% with the 60% replacement, Increase in workability

lead to reduction in voids and water absorption due to better compaction, but with large replacement fraction of uniformly graded tire rubber the benefit is nullified [12].

13) *Falak O. Abas and Enass A. Abdul Ghafoor* presented of discarded waste tires substituted in to the concrete mix by weight (0%, 10%, 15%, and 20%) respectively. Two types of waste tires are used as (chips and grounded shape) applied at 68 experiments and tested their mechanical, physical and chemical properties with 260 test in order to determine the optimal enhancing replacement ratios of waste tires as (dry density, compressive and flexural strength, performing slump, and toughness indices) at curing ages of (3, 7, 28 and 56 days) for standard and improved concrete mix. The results for tests show a decline in compressive strength of the concrete in other hand an increase in their toughness with good approach properties and reduce the cost of additive materials, also solve a serious problem posed by waste tires. The compressive strength values of all waste tires rubber concrete mixtures have a tendency to decrease below the values for the reference concrete mixtures with the increasing of waste tires rubber ratio at all curing age. This may be attributed to the decrease in the adhesive strength between the surface of the waste tires rubber and cement paste. At 56 days curing ages the concrete mixtures that made of 20% waste tires rubber has the lowest compressive strength, and the decreasing ratio of this mixture below the referent concrete mixture at the same curing age is 35.25% [13].
14) *Ali I. Mohsin and Besma M. Fahad* stated that environmental problem associated with the disposal of waste automobile tires we need to find an environmentally friendly solution. In this research different mixes were prepared with Cement-Sand ratio (1:3) and Water- Cement (0.5). Two sets were prepared by partially or full replacing the sand with crumb rubber to fabricate the rubberized mortar mixtures. The first set include fine crumb rubber with particles size (0.3-1 mm), The second set include coarse crumb rubber with particles size(1.18-2.36 mm). Each set was consist of different percentage of replacing the sand by crumb rubber (10,30,50,100%) by volume. Tests were conducted, including density, Ultrasonic Pulse Velocity, Thermal Conductivity, and measuring Acoustic Impedance. several results obtained including. The full replacement (100%) of sand by crumb rubber was the highest insulation properties(acoustic impedance and thermal conductivity), while it was the lowest in density. addition of recycling rubber decrease the density of mortar, the increase in percentage of recycling rubber cause increase in insulation properties, different particles size of recycling rubber effects on the behaviour of the measuring properties. This will improve the Thermal conductivity and acoustic impedance of mortar by adding recycling rubber, the addition of recycling rubber decrease the density of mortar, the increase in percentage of recycling rubber cause increase in insulation properties, different particles size of recycling rubber effects on the behaviour of the measuring properties [14].
15) *Niall Holmes and Alex Browne* paper presents the acoustic performance of small scale crumb rubber concrete (CRC) panels in terms of the sound absorbance and insulation at low (63, 125, 250 & 500 Hz) and high (1000, 2000, 4000 and 5000 Hz) frequencies. Acoustic tests were conducted with differing levels of fine aggregate replacement with crumb rubber (7.5 and 15%) with four different grades following freezing and heating. Analysis of the workability, compressive strength and density are also presented. The results found that CRC performed well in terms of sound absorbance particularly with higher proportions (15% here) and grades of crumb rubber. As an insulator, the CRC was comparable with plain concrete with only marginal differences observed. Effects of freezing and heating were shown to have no significant influence on the insulation properties. The insulation performance for all concretes was found to improve at high frequencies. The results demonstrate that CRC has potential as an external building cladding to absorb sound around high-rise urban structures but requires full-scale testing on site. This approach offers an environmental friendly solution to the ongoing problem of used tyres. On the basis of the various investigations carried out to assess the acoustic performance of small scale CRC panels the following conclusions have been drawn:

*a)* CRC has been found to be more effective than plain concrete in absorbing sound in low, normal and high temperature environments. Better absorption coefficients were observed for higher rubber replacement levels (15% here) and grades (2-6mm & 10-19mm). This is due to the higher densities of these concretes which is an important factor governing sound absorption behavior.

*b)* CRC performance as an insulator was comparable to plain concrete with marginal differences between both. It has shown here that all concretes perform better as an insulator for higher frequency sound due to the wider surface affected. As with the absorption study, there was no noticeable difference in insulation behaviour in the three environments. However, in conjunction with the improved sound absorbance, the results demonstrate CRC can be effective in reducing noise in urban settings. A minor decrease in the insulation performance of CRC in the elevated temperature was observed on the largest rubber grade (10-19mm) due to some minor cracking on the surface.

c) The workability of the concrete was decreased as the crumb rubber grade and proportion increased and reduced the 'flow ability'. As expected, the compressive strength of the CRC was decreased for every grade and particularly for the higher replacement levels. However, the majority of the CRC did exceed the characteristic strength and previous work has shown that compressive strengths can be maintained provided the replacement level does not exceed 20%. Uneven distribution of the crumb rubber in one sample was found to be due to an inadequate water content and vibration [15].

16) *Kotresh K.M and Mesfin Getahun Belachew* stated that disposal of waste tyres is becoming a major waste management problem in the world. It is estimated that 1.2 billions of waste tyre rubber produced globally per year. It is estimated that 11% of post consumer tyres are exported and 27% are sent to landfill, stockpiled or dumped illegally and only 4% is used for civil engineering projects. Hence efforts have been taken to identify the potential application of waste tyres in civil engineering projects. In this context, our present study aims to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite. According to this paper the tyre recycling factories should supply quality rubber aggregates in 20-10mm, 10-4.75mm and 4.75mm down sizes to be used as cement concrete aggregate. The light unit weight qualities of rubberized concrete may be suitable for architectural application, false facdes, stone baking, interior construction, in building as an earthquake shock wave absorber, where vibration damping is required such as in foundation pads for machinery railway station, where resistance to impact or explosion is required, such as in jersey barrier, railway buffers, bunkers and for trench filling [16].

17) *F.Pacheco Torgal and A. Shasavandi* stated that the volume of tyre rubber wastes is increasing at a fast rate. An estimated 1000 million tyres reach the end of their useful lives every year and 5000 millions more are expected to be discarded in a regular basis by the year 2030. Up to now a small part is recycled and millions of tyres are just stockpiled, land filled or buried. This paper reviews research published on the performance of concrete containing tyre rubber wastes. It discusses the effect of waste treatments, the size of waste particles and the waste replacement volume on the fresh and hardened properties of concrete. Tyre rubber wastes represent a serious environmental issue that needs to be addressed with urgency by the scientific community. Investigations carried out so far reveal that tyre waste concrete is specially recommended for concrete structures located in areas of severe earthquake risk and also for applications submitted to severe dynamic actions like railway sleepers. This material can also be used for non load-bearing purposes such as noise reduction barriers. Investigations about rubber waste concrete show that concrete performance is very dependent on the waste aggregates. Further investigations are needed to clarify for instance which are the characteristics that maximize concrete performance. Nevertheless, future investigations should clarify which treatments can maximize concrete performance being responsible for the lowest environmental impact [17].

18) *Piti Sukontasukkul et al* presented the thermal and sound properties of crumb rubber concrete panel were investigated. The crumb rubber from used tires, produced in a local recycling plant, was used to replace fine aggregate at ratios of 10%, 20% and 30%. Properties such as thermal conductivity, thermal resistivity, heat transfer, conductance value, sound absorption at different frequency and noise reduction were investigated. Results indicated that crumb rubber concrete panel was not only lighter but had higher sound absorption and lower heat transfer properties than the conventional concrete panel.
   a) By replacing conventional fine aggregate with crumb rubber at 10–30%, the unit-weight of concrete can be reduced from 14% up to 28% depending on the type and the content of the crumb rubber.
   b) The CR concrete exhibits superior thermal and sound properties than plain concrete as measured by the decrease in thermal conductivity coefficient (k) and the increase in sound absorption coefficient (a) and noise reduction coefficient (NRC).
   c) Crumb rubber concrete is able to satisfy both requirements from TIS in terms of unit-weight (less than 2000 kg/m3) and values of k (less than allowable ranges of 0.303–0.476 W/m K) [18].

19) *Fotini Kehagia and Sofia Mavridou* stated that rubberized bituminous mixtures could be a good solution for the re-surfacing of any street which is in poor condition, since not only does it reduces noise generation, but it also provides more durable pavements that are less susceptible to the effects of temperature, while maintaining the noise reduction even after 8 months of operation. Consequently, use of EOL Tires in road pavements is highly recommended to be efficiently promoted by the national legislation as well since the whole quantity of stockpiled EOL Tires could be managed in a technical and environmentally friendly way. Addition of tyre rubber particles in bituminous binder provides up to 3dB noise reducing bituminous mixtures and pavements, noise reduction that remains even after months of road section's operation [19].

## VII. CONCLUSION

The main aim of this paper is to determine the effects of end-of-life tyre on noise reduction in rubberized concrete. This paper is a first in the series of papers for the investigation of noise absorption behaviour of rubberized concrete while natural aggregate replacing with scrap tyre rubber in chipped shape. Based on literature review and all investigation following conclusion have been drawn.

*A.* There are various methods available that can be employed to reduce noise pollution under passive noise control. Plenty of materials are available which can be used to reduce the sound transmission. It is very important to find materials which can be sustainable and cheap to utilize and provide a better solution of many problems associated with the environment.

*B.* From the literature review, it was observed that only a few researchers had been made over use of chipped shape scrap rubber as coarse aggregate. So end-of-life tyre in chipped shape can be utilized as coarse aggregate.

*C.* Further, it is brought to light that no literature is available on sound and vibration measurement of the same kind of composites. So there will be a good scope in vibration and sound study of rubberized concrete.

*D.* The aim of our research is to produce rubber replaced concrete by use of scrap tyre rubber and this modified concrete should have properties of sound absorption.

*E.* Studies are focused mainly on mechanical and physical characteristics analysis of rubber replaced concrete mixture in which modified concrete has desirable physical and mechanical characteristic. Scrap tire rubber is used either as an alternative to natural aggregates or as the additive.

*F.* Noise transmission can be prevent by introducing rubber aggregate in conventional concrete.

*G.* It was investigated that waste tyre rubber has properties for sound insulation application. Insulation properties of the waste tyre were significantly affected by the amount of rubber as aggregate and its interfaces within the materials.

## REFERENCES

[1] Savale P. A. 2014 Effect Of Noise Pollution On Human Being : Its Prevention And Control Journal Of Environmental Research And Development Vol. 8 No. 4.
[2] Zulkepli Hj., Ibrahim and Hazel Kiddo Richard. 2000. Noise Pollution at School Environment Located in Residential Area. Jurnal kejuruteraan awam (journal of civil engineering), Vol. 12 NO.2.
[3] M.H.F. De Salisa. 2002. Noise control strategies for naturally ventilated buildings. Building and Environment 37 471–484.
[4] T.S.S Jayawaradana. 2014. Analysis and Control of Noise in a Textile Factory. International Journal And Scientific And Research Publication, Volume 4, Issue 12.
[5] Azmi M. 2017. Noise Reduction in Buildings Using Sound Absorbing Materials. Journal of Architectural and Engineering Technology, Azimi, J Archit Eng Tech 6:198.
[6] Zhao. 2010. Composites Science And Technology. Elsevier. Vol. 70, pp2033–2038.
[7] Sarawut. 2011. Olymer Testing. Elsevier, Vol. 30, pp. 515–526.
[8] Zhou. 2007. Journal of Sound and Vibration. Elsevier, 304 400–406.
[9] Krzysztof. 2014. Iranian Polym er Journal. Springer, Vol. 23, pp. 185–194.
[10] Ghizd ve and Zeno. 2017. Sound Absorbing Materials Made by Embedding Crumb Rubber Waste in a Concrete Matrix. Construction and Building Materials, 124: 755–63.
[11] Fraile-Garcia, Esteban, Javier Ferreiro-Cabello, Beatriz Defez, and Guillermo Peris-Fajanes. 2016. "Acoustic Behavior of Hollow Blocks and Bricks Made of Concrete Doped Withwaste-Tire Rubber. Materials, 9(12): 1–12.
[12] Waris, Muhammad B., Nehal N. Ali, and Khalifa S. Al-Jabri. 2016. "Use of Recycled Tire in Concrete for Partial Aggregate Replacement. International Journal of Structural and Civil Engineering Research, 5(4): 273–76.
[13] Abas, Falak O, Enass A Abdul Ghafoor, Mohammed U Abass, and Talib Kamil Abd. 2015. Re Use of Waste Tires Rubber As Fine Aggregate Replacement in, 4(3): 110–20
[14] Mohsin, Ali I, and Besma M Fahad. 2015. Improve the Acoustic Impedance and Thermal Conductivity of Mortar by Adding Recycled Rubber, 5: 9–16.
[15] Holmes, Niall, Alex Browne, and Christopher Montague. 2014. Acoustic Properties of Concrete Panels with Crumb Rubber as a Fine Aggregate Replacement. Construction and Building Materials, 73: 195–204.
[16] Motresh, K M, and Mesfin Getahun Belachew. 2014. "Study On Waste Tyre Rubber As Concrete Aggregates." 436(3): 433–36.
[17] Torgal, F Pacheco, A Shasavandi, and S Jalali. 2011. "Tyre Rubber Wastes Based Concrete: A Review." WASTES: Solutions, Treatments and Opportunities: 1st international confreance.
[18] Sukontasukkul, Piti. 2009. Use of Crumb Rubber to Improve Thermal and Sound Properties of Pre-Cast Concrete Panel. Construction and Building Materials 23(2): 1084–92.
[19] Fotini Kehagia and Sofia Mavridou. 2014 Noise Reduction in Pavement Made of Rubberized Bituminous Top Layer. Open Journal of Civil Engineering, 4, 198-208