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Recommendation of Natural Materials for Industrial Noise Attenuation

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Abstract:- Industrial growth in India generates major noise pollution which becomes a serious environmental issue. An excessive noise level in the industries can contribute to poor occupational health such as noise-induced hearing loss; decrease the performance of workers and affecting productivity. To enhance workplace environment there is a need to find out harmless and effective noise control methods. the research work is carried out to explore the use of natural materials (agricultural wastes) for noise reduction for industrial structure. For specimens mold was used having 75 mm diameter and 25 mm high. These molds were cast using materials viz; Hyacinth, Maize, and coconut coir dust. Cement/Adhesive and Hyacinth was mixed with one material from the rest of the materials at a ratio of 1:0.5:0.5 and 1.5:0.5:0.5 with the addition of water. The experimental set up of impendence tube with function generator, speaker and sound level meter is used for calculations of Noise Reduction Coefficient of a specimen prepared for octave band center frequency. Effectiveness of the natural material to control industrial noise is discussed in this paper.

Keywords:- *Hyacinth, Noise Reduction Coefficient, Impedance Tube.*

I. INTRODUCTION

Industrial development is at an accelerating rate. The economy of the nation is totally dependent on industrial development. In Kolhapur and around forging industry and casting industry is in phenomenal point. In the forging industry, there is a pure impact of the heavy hammers which are falling from some height on the steel. This impact causes a huge amount of shocks and vibrations. These vibrations create what is called sound. Sound can be described as a disturbance which passes through a medium in the form of longitudinal waves from a source to a receiver. It causes a sensation of hearing. Sound is essential from the architectural point of view however sound beyond some tolerance becomes what is called noise. This noise which is produced at these industries consistent throughout the day and the workers and officers are exposed to this type of noise. These noises not only create pollution but also hamper the brain functioning of the human being. This type of noise is like slow poisoning. It is continuously acting the workers may not understand but during the span of the time, they have major health, mental as well as physical problems.

Due to the noise problem, we cannot avoid the forging industry because Forging is traditionally considered as the backbone of the manufacturing industry. It is a major input to the sectors which support the economic growth of the nation, such as, Automobile, Industrial Machinery, Power, Construction & Mining Equipment, Railways, and General Engineering. The Indian forging industry is well recognized globally for its technical capabilities. Indian forging industry has a capability to forge a variety of raw materials like Carbon steel, alloy steel, stainless steel, superalloy, titanium, aluminu
m and so forth.

Effective noise control has become an important topic because of its various direct and indirect impacts of noise on productivity as well as the health of the worker. Traditional noise control techniques mainly include insulating, absorbing, vibration isolation and damping. However, they have their own limitations. Advanced techniques such as barrier walls, duct silencers, acoustical wall panel, soundproof curtains, and sound enclosures for industrial machinery are available in order to minimize the noise, although these techniques are expensive. It is also observed from practical applications, most sound absorbing materials are synthetic but they induce health risks to lungs and eyes while their processing due to that, sensitive individuals were severely affected [6]. There is currently much interest in developing eco-friendly and sustainable absorbers either from natural agricultural wastes or recycled. With the help of these materials, the building can be constructed where noise can be controlled more effectively in an economical way

In a previous study by N.S.Shinde et al, (2015) investigated noise reduction properties of Salvinia dust, Durian Peel, Coconut Coir, with cement [4]. They have found that the Noise Reduction Coefficient (NRC) is greater for the specimens with large particles than that for the specimens with small particles. Further, they have found that NRC increases with increasing the specimen thickness.

In the current study materials like Hyacinth, Maize and coconut coir dust are studied for their noise reduction properties. Hyacinth was selected due to their high availability. It grows in slow-moving water bodies such as lake lakes, ponds, streams, rivers, etc. Due to the rapid growth rate of Hyacinth, surfaces of ponds, reservoirs, and lakes are covered by floating plants. As the texture of Hyacinth consists of fiber, an attempt has been made to utilize it in the manufacturing of noise reduction product.

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II. OBJECTIVES

The objectives of the current research study are

- To study and utilize Hyacinth, Maize, coconut coir dust with cement/ adhesive as noise reduction material.
- To investigate the effectiveness of material combinations for noise reduction properties.

III. RESEARCH METHODOLOGY

Research Methodology includes preparation of the specimen, development of experimental set-up and laboratory experiments.

A. Specimen Preparation Methodology

Specimens with circular shape were prepared by mixing cement and hyacinth with one material from maize and coconut coir dust at different mix proportions. Diameter and thickness of the specimen were 12.5 mm and 25mm, respectively. The plastic mold (gauge 1000 PVC pipe ring) that was used to cast all specimens is shown in Figure 1.

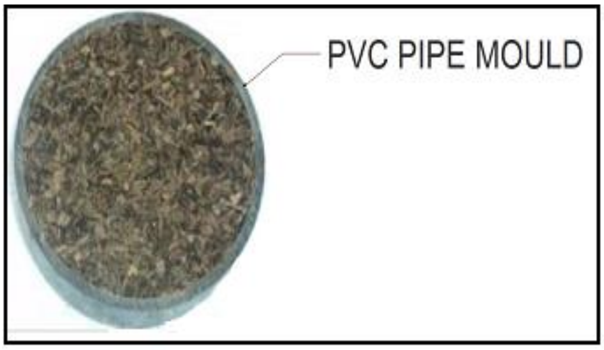

Fig 1:- Specimen Used for Noise Testing

Specimens with circular shape were prepared by mixing each material combination separately with cement and adhesive at different proportions. The diameter of the specimen was kept 75 mm for each. Thicknesses were kept 12.5mm and 25mm for each mix proportion and material combination. Different mix proportions as 1:0.5:0.5 and 1.5:0.5:0.5 were used to cast specimens. Particle sizes were selected in two categories as given below:

- 1.18mm < Ps < 2.36mm and
- 0.6mm < Ps < 1.18mm

Sieve analysis tests were conducted according to IS 2720 (Part IV) – 1985 to obtain the fraction of mentioned particle sizes from selected materials. Specimens with these particle sizes were cast to investigate the effect of particle size on noise reduction property of developed specimens. These specimens were kept in the laboratory for one-week hardening. Various material combinations and their mix proportions used to cast the specimens in the study are presented in table 1.

Material Combination with its Nomenclature	**Mix Proportion (on a weight basis)**	**Particle Size (mm) Ps**	**Specimen Thickness (mm)**	
Cement: Hyacinth: Maize **(C:H: M)**	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1.5: 0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
Cement : Hyacinth: Coconut Coir **(C:H:CC)**	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1.5: 0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
Adhesive : Hyacinth: Maize **(A:H:M)**	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1.5: 0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
Adhesive : Hyacinth: Coconut Coir **(A:H:CC)**	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1.5: 0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
Cement : Adhesive Hyacinth: Maize: **(C:A:H:M)**	0.5:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
Cement: Adhesive : yacinth:: Coconut Coir **(C:A:H:CC)**	0.5:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25
	1:0.5:0.5	1.18<Ps<2.36	12.5	25
		0.6 <Ps< 1.18	12.5	25

Table 1:- Details of Specimens Prepared for Testing

B. Development of Experimental Set Up

Three standardized best-known methods for measurement of noise reduction coefficient are reverberation chamber method described in the standards IS 354, and two impedance tube methods that are described in standards IS10534-1 and IS 10534-2. Over the time impedance tube has been proved to be more viable as compared to other methods mentioned above as it is relatively easily constructed, portable, it has low cost, and it provides fast results.

The experiment set up is developed similar to the impedance tube system. The Impedance tube method usually gives an accurate measurement for sound absorption coefficients and the impedance according to the standard of IS 10534-2. The developed experimental set up is described with the following points.

- *Apparatus and Equipment:*

Function generator model specification Caddo 4061, 3 MHz function- pulse generator with 40 MHz frequency counter was used as a sound generator by providing frequency input at each octave band center frequencies from 31.5 Hz to 16 KHz.

One standard stereo speaker, Pyramid 4080 with frequency response 60 to 20,000 hertz and 250-watt power rating was purchased, so that high-intensity sound is generated inside the tube.

In the standards (IS 10534-2), the tube material was not specified but it is strongly recommended that the tube must be sufficiently rigid to avoid transmission of noise into the tube from outside and vibration excitation by the sound source or from background sources (e.g. doors closing). IS 10534-2 recommends the wall thickness should be 5% of the tube diameter and the length of the tube at least 10 - 15 times the tube diameter. Thus, in the current study, SWR pipe is used as a propagation tube with the fulfillment of above-stated recommendations.

Noise level meter (model: SL- 4010) with calibration certificate is purchased from the market is used to measure noise levels.

Thus the experimental set up consisted of speaker at one end, propagation tube, and noise level meter which is interposed the specimen as shown in below Fig. 2

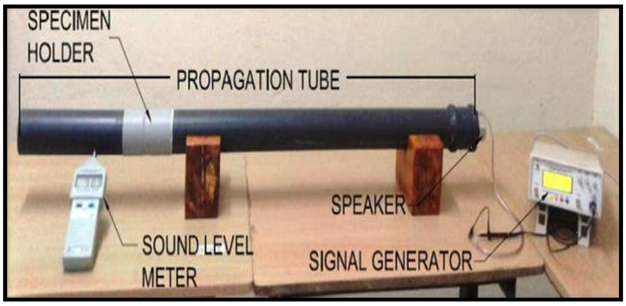

Fig 2:- Impedance Tube System for Sound Absorption Measurement

C. Experimental Work:

The main objective of the test is to find out the sound absorbed by the specimen and determining the Noise Reduction Coefficient (NRC). Noise Reduction Coefficient is used to quantify the effect of noise reduction at each octave band center frequency. NRC can be determined as the ratio between noise reductions due to the specimens to the incident noise level without placing the specimen.

$$\text{Noise Reduction Coefficient} = \frac{\text{The intensity of reduced Noise (dB)}}{\text{Intensity of incident Noise (dB)}}$$

Here, the Noise reduction is the difference between the noise level measurements without placing the specimen (A in dB) and with placing the specimen (‘B’ in dB) is given by equation (2)

IV. RESULT AND DISCUSSION

From Observations and Calculations of Noise Reduction Coefficient, it is observed that NRC values increased for the higher specimen thickness, mix proportion, and small particle size. Investigated effects on the material combinations observed for effective noise reduction are as shown in Table. 2.

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Materials	**Mix Proportion**	**Particle Size ‘mm’**	**Thickness ‘mm’**	**Octave Band Centre Frequencies (Hz)**								
				63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	**16000**
				Noise Reduction Coefficients (dB)								
C:H:M	1:0.5:0.5	0.6 <Ps< 1.18	25	0.32	0.17	0.25	0.40	0.33	0.27	0.42	0.47	0.52
C:H:CC	1:0.5:0.5	0.6 <Ps< 1.18	25	0.42	0.29	0.29	0.46	0.42	0.39	0.44	0.49	0.53
C:A:H:M	0.5:0.5:0.5:0.5	0.6 <Ps< 1.18	25	0.35	0.23	0.26	0.45	0.40	0.36	0.47	0.51	0.49
C:A:H:CC	0.5:0.5:0.5:0.5	0.6 <Ps< 1.18	25	0.38	0.24	0.28	0.45	0.40	0.36	0.47	0.51	0.49

Table 2:- Materials Combinations Found Effective for Noise Reduction

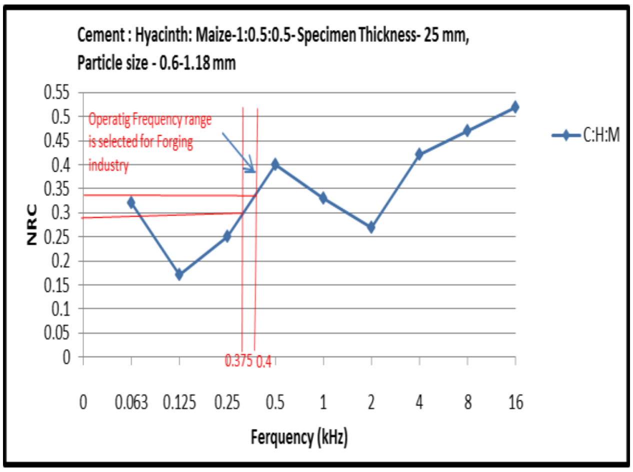

Fig 3:- Graph of Cement: Hyacinth: Maize

Fig. 3 shows the noise reduction coefficients for the material combination Cement: Hyacinth: Maize (1:0.5:0.5) having specimen thickness 25mm and a particle size between 0.6mm - 1.18mm. In the frequency range of 0.375 - 0.4 kHz the NRC is increased from 0.32 to 0.35 i.e. the selected material performs well at mentioned frequency range and it reduces noise up to 35%. The noise level of 100 dB is effectively brought to 68 dB and 65 dB at frequencies 0.4 kHz and 0.375 kHz respectively in the forging industry workplace. Also, the material combination gives the best results at moderate frequency range (i.e. 0.2 – 2.0 KHz) and NRC is increased up to 0.40 at frequency 0.5 kHz. In the low-frequency range (0.125- 0.2 kHz) NRC value varies from 0.18 to 0.28 and performs well.

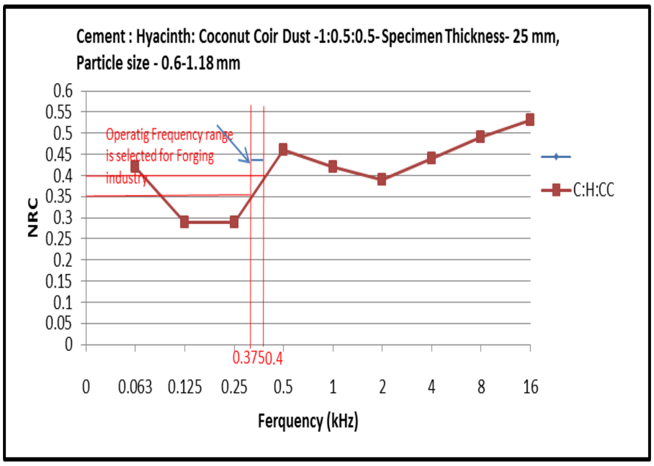

Fig 4:- Graph of Cement: Hyacinth: Coconut Coir Dust

Fig. 4 shows the noise reduction coefficients for the material combination Cement: Hyacinth: Coconut Coir Dust (1.0:0:0.5:0.5) having specimen thickness 25mm and a particle size between 0.6mm - 1.18mm. In the frequency range of 0.375 - 0.4 kHz the NRC is increased from 0.36 to 0.41 i.e. the selected material performs well at mentioned frequency range and it reduces noise up to 41%. The noise level of 100 dB is effectively brought to 64 dB and 59 dB at frequency 0.4 kHz and 0.375 kHz respectively in the forging industry workplace. NRC increases up to 0.46 at the frequency of 0.5 kHz, hence the material performs well in the moderate and higher frequency ranges. NRC value at the frequency 0.125 kHz is 0.28 which shows material performance is poor in lower frequency.

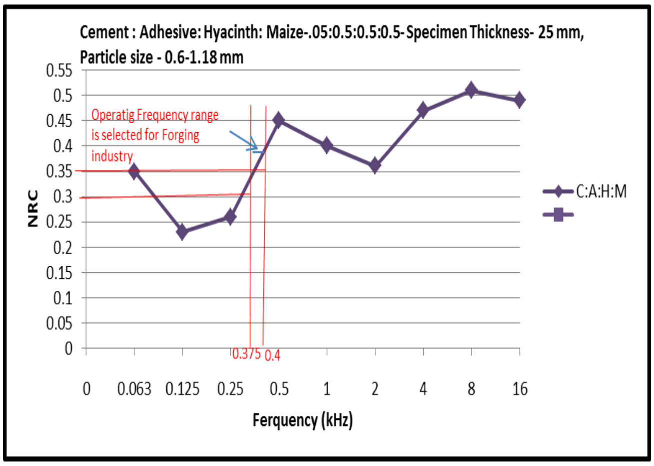

Fig 5:- Graph of Cement: Adhesive: Hyacinth: Maize

Fig. 5 shows the noise reduction coefficients for the material combination Cement: Adhesive: Hyacinth: Maize (0.5:0.5:0.5:0.5) having specimen thickness 25mm and a particle size between 0.6 mm – 1.18 mm. In the frequency range of 0.375 - 0.4 kHz the NRC is increased from 0.34 to 0.40 i.e. the selected material performs well at mentioned frequency range and it reduces noise up to 40 %. The noise level of 100 dB is effectively brought to 58 dB and 63 dB at frequency 0.4 kHz and 0.375 kHz respectively in the forging industry workplace. NRC increases up to 0.45 at the frequency of 0.5 kHz and 0.51 at 8 kHz, hence the material performs very well in the moderate and higher frequency ranges.

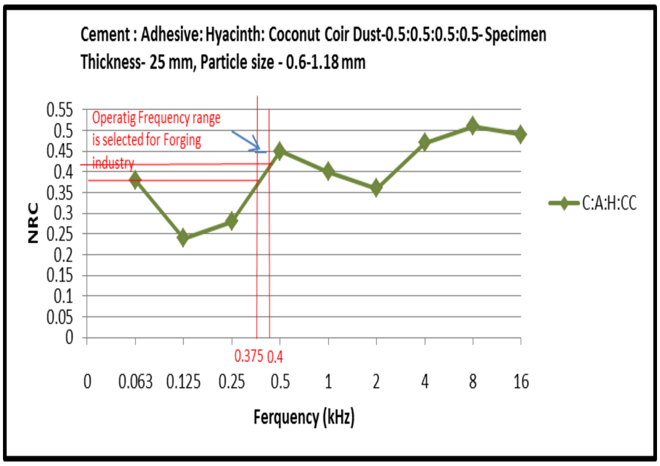

Fig 6:- Graph of Cement: Adhesive: Hyacinth: Coconut Coir Dust

Fig. 6 shows the noise reduction coefficients for the material combination Cement: Adhesive: Hyacinth: Coconut Coir Dust (1.5:0.5:0.5) having specimen thickness 25mm and a particle size between 0.6 mm – 1.18 mm. At the frequency of 0.375 kHz, the NRC is 0.38 and at frequency 0.4 kHz it is 0.42. The noise level of 100 dB is effectively brought to 58 dB at frequency 0.4 kHz in the forging industry workplace. NRC increases up to 0.45 at the frequency of 4 kHz and 0.51 at 8 kHz, hence the material performs very well in the moderate and higher frequency ranges.

V. CONCLUSION

The Noise reduction property of the Cement: Adhesive: Hyacinth, Maize, Coconut coir dust material combination is observed better than other material combinations. NRC values obtained at different frequency ranges (low, medium and high) found better than other material combinations and high noise levels of 100 dB can be brought to the permissible acceptable limit of ambient noise standards both during day and night time. As selected materials are easily available with low cost, hence the overall efficiency at workplaces environment in industrial construction can be easily improved with the application of these materials. From the analysis, it is clearly seen that the overall efficiency is better hence, it is recommended that this material is more suitable. However, the durability and strength of the product should be further investigated.

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REFERENCES

[1]. Aitbar Ali Abbasi, Hussain Bux Marri, And Murlidhar Nebhwani, ‘Industrial Noise Pollution and its Impacts on Workers in the Textile-Based Cottage Industries: An Empirical Study' Mehran University Research Journal Of Engineering & Technology, Volume 30, NO. 1, January 2011 [ISSN 0254-7821]

[2]. Amelia Trematerra*, Mezzero Antonio, Gino Iannace, ‘Use of Green Material for Acoustic Correction inside Rooms’, Journal of Sustainable Architecture and Civil Engineering, ISSN 2029–9990, 2013. No. 3(4),http://dx.doi.org/10.5755/j01.sace.3.4.4708

[3]. Azimi M, ‘Noise Reduction in Buildings Using Sound Absorbing Materials’ Journal of Architectural Engineering Technology DOI: 10.4172/2168-9717.1000198

[4]. N.S.Shinde, M.B.Kumthekar “Natural Materials for Effective Noise Control Measures in Industrial Construction”.

[5]. Azuma PUTRA, Fazlin Abd KHAIR, Mohd Jailani Mohd Nor, ‘Utilizing Hollow-Structured Bamboo as Natural Sound Absorber’, Archives of Acoustics Vol. 40, No. 4, pp. 601–608 (2015), Copyright c 2015 by PAN – IPPTDOI: 10.1515/aoa-2015-0060

[6]. Francesco Asdrubali, ‘Survey on the Acoustical Properties of New Sustainable Materials for Noise Control’, Euronoise 2006, Tampere, Finland

[7]. Gabriela Cristina Candido da Silva, Maria Alzira de Araujo Nunes, Renato Vilela Lopes, and Antonio Boson Almeida, (2013), Faculty of University of Brasil, "design and construction of a low-cost impedance tube for sound absorption coefficients measurements", 22nd International Congress of Mechanical Engineering, ISSN 2176-5480. pp. 105-115.

[8]. Mohammad Hosseini Fouladi, Masomeh Ghassem, Md. Ayub, Mohd Jailani Mohd Nor, ‘Implementation of coir fiber as acoustic absorber material’ Article in Noise & Vibration Worldwide, October 2011, DOI: 10.1260/0957-4565.42.9.11

[9]. Qinying Zhang(a), Linxuan Zhao(a), Hainan Cui, ‘Investigation of the noise reduction provided by vegetation belt in different design styles', Buenos Aires – 5 to 9 September 2016, Acoustics for the 21st Century… Proceedings of the 22nd International Congress on Acoustics.