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Economic Feasibility of Acoustical Panels of Natural Materials

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ABSTRACT: In forging industry all equipment creates impact noise, more than 90 dBA which is higher than OSHA and WHO norms. This occupational noise level is hazardous to human health. In this research various methods of noise controlling has been studied along with the cost effectiveness of the sound absorbing materials prepared by using natural / agriculture waste material such as Hyacinth, Coconut coir Dust and Maize with cement and adhesive as binding materials. The specimens were prepared with 75 mm Diameter PVC tube of 12.5 mm and 25 mm thickness with material combinations to various proportions and particle size. Noise reduction coefficient of these specimens was tested in impedance tube (**ISO 10534-2.**) The basic costs required for manufacturing the particle boards from each material combination and its installation is calculated by rate analysis.

KEYWORDS: Noise control techniques, Sustainable Material, Enclosures

I.INTRODUCTION

Noise is unwanted sound judged to be unpleasant, loud or disruptive to hearing. It is most destructive environment. Due to noise pollution the workers facing various health effects such as speech communication interference, loss of productivity, hearing impairment and other physiological and psychological effects. Exposure to noise above 85dB for long time is harmful.

Industrial development is at an accelerating rate. Economy of nation is totally dependent on industrial development. In and around Kolhapur forging industry and casting industry are in phenomenal point. In the forging industry there is purely impact of the heavy hammers which are falling from some height on the steel. This impact causes huge amount of shocks and vibrations. These vibrations create noise which 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 unbearable what is called noise. This noise produced at these industries consistency throughout the day and the workers and officers are exposed to this type of noise. This noise not only creates pollution but also hamper the brain functioning of the human being. This type of noise is like a slow poisoning. It is continuously acting the workers may not be 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 forging industry because Forging is traditionally considered as the back bone of manufacturing industry. It is a major input to the sectors which support 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 variety of raw materials like Carbon steel, alloy steel, stainless steel, super alloy, titanium, aluminium and so forth.

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II. NEW SUSTAINABLE SOUND ABSORBING MATERIALS

As for natural materials, the less treated they are, the higher they perform in energy saving; native materials have to be preferred to reduce transport energy. Moreover, natural fibres have negative impacts. There is a great variety of natural fibers proposed for acoustical applications such as Hyacinth, Maize, Coconut Coir Dust, etc. Further study can be carried out with the help of the sound absorption of material combinations of Hyacinth, Maize and coconut coir with cement and adhesive as a bonding material.

III. RESEARCH STRATEGY USED

This study is focused on the effect of natural sound absorbents on their Noise Reduction Coefficients which were examined with Impedance Tube Method. The sound absorption of material combinations of Hyacinth, Maize and coconut coir were measured using standard test method (ISO 10534-2). Test specimens were prepared by combination of these materials with cement and adhesive for superior coverage. At each stage of testing accurate sound levels were measured using calibrated sound level meter. Test specimens were tested for noise reduction at centre of octave band frequencies.

The testing was performed to investigate the effect of particle size, mix proportion and specimen thickness on noise reduction coefficient. Noise reduction coefficients were calculated for various material combinations and most effective material combinations were checked for their techno-economic feasibility.

IV. EXPERIMENTS AND RESULTS

Natural sound absorbing material has many benefits, such as less cost, availability and renewable are used to noise control in many situations. As it is necessary to recommend the sustainable product, it is essential to look into natural and agricultural waste to find alternative materials. Hence in this dissertation attempt is made to use fibrous and porous kinds of sound absorbent materials. These materials were selected by studying their important physical properties like fiber type, fiber size, porosity, material thickness, density and airflow resistance etc. which can increase sound absorption^[6].

The sound absorptive materials selected for noise control are given below:

1. Hyacinth
2. Coconut Coir Dust
3. Maize

a) Specimen Preparation Methodology:

Specimens with circular shape were prepared by mixing each material combination separately with cement and wood grip at different proportions. The plastic mould of PVC pipe ring (1000 gauge) was used to cast all specimens. 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 1:1, 1.5:1 for cement: [material combination] and 0.5:1, 1:1 for wood grip: [material combination] were used to cast specimens.

Particle sizes were selected in two categories as given below:

- i. 1.18mm < Ps < 2.36mm and
- ii. 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.

b) Experimental Setup:

Three standardized best known methods for measurement of noise reduction coefficient are reverberation chamber method described in the standards ISO 354, and two impedance tube methods that are described in standards

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Vol. 8, Issue 5, May 2019

ISO 10534-1 and ISO 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.

Experiment set up is developed similar to the impedance tube system. The Impedance tube method usually gives accurate measurement for sound absorption coefficients and the impedance according to the standard of ISO 10534-2.

c) Criteria for Selection of Effective Material Combinations:

As per Environment (Protection) Act, 1986 as amended in 2002, ambient noise standard limit is 75dB during day and 70 dB night time for industrial area. In the case study of forging industry noise levels are increased up to 100 dB, which are too much exceeded beyond the accepted limit. To bring these noise levels to the ambient noise standards at least 30% noise reduction is required and hence the base line at 0.3 NRC is selected in order to choose the most efficient and effective material for its technical feasibility. Depending upon the selection criteria, most effective material combinations for abating the noise found as in Table No.1

Table No. 1: Showing performance of selected material combinations for NRC at octave band center frequencies. From selected material combinations, best three material combinations are found technically feasible as showing appreciable noise reduction at low, moderate and high frequencies are as tabulated below:

Table No. 1: Obtained most effective Material Combinations for Noise Reduction

Sr. No.	Material Combination	Mix Proportion	Particle Size 'mm'	Thickness 'mm'
1.	Cement: Hyacinth: Maize	1:0.5:0.5	0.6-1.18	25
2.	Cement: Hyacinth: Coconut Coir Dust	1:0.5:0.5	0.6-1.18	25
3.	Adhesive: Hyacinth: Maize	0.5:0.5:0.5	0.6-1.18	25
4.	Adhesive: Hyacinth: Coconut Coir Dust	0.5:0.5:0.5	0.6-1.18	25
5.	Cement: Adhesive: Hyacinth: Maize	0.5:0.5:0.5:0.5	0.6-1.18	25
6.	Cement: Adhesive: Hyacinth: Coconut Coir Dust	0.5:0.5:0.5:0.5	0.6-1.18	25

V. COST EFFECTIVENESS

1. New sustainable sound absorbing materials

The estimated costs of alternatives for noise control measure are summarized below:

Table No. 2: Cost analysis of most effective Material Combinations for Noise Reduction

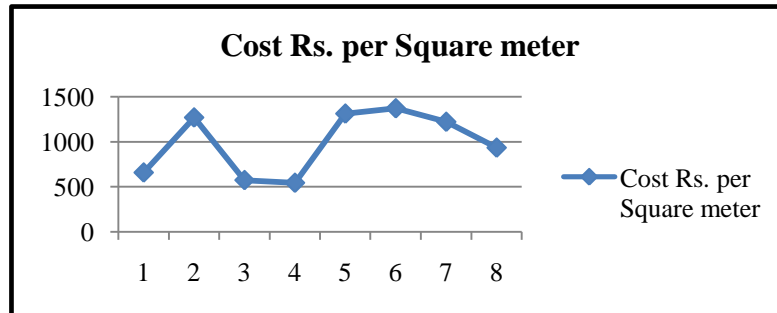
Alternative	Material Combination for Particle Board (25 mm Thick)	Cost Rs. per Square meter
1.	Cement: Hyacinth: Maize = 1:0.5:0.5	575
2.	Cement: Hyacinth: Coconut coir = 1:0.5:0.5	545
3.	Adhesive: Hyacinth: Maize = 0.5:0.5:0.5	1313
4.	Adhesive: Hyacinth: Coconut coir = 0.5:0.5:0.5	1372
5.	Cement: Adhesive: Hyacinth: Maize = 0.5:0.5:0.5:0.5	1222
6.	Cement: Adhesive: Hyacinth: Coconut coir = 0.5:0.5:0.5:0.5	935

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Vol. 8, Issue 5, May 2019



Graph 1: Chart Showing Economic Feasibility of Five Alternatives

From Graph 1, Particle Boards of Cement: Hyacinth: Coconut coir = 1:0.5:0.5 found most economical and Particle Boards of Cement: Adhesive: Hyacinth: Coconut coir=0.5:0.5:0.5:0.5 having highest NRC with found more compact and durable.

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 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 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.

Table No. 3: Summary of Techno-economic Feasibility

Sr. No.	Alternative	NRC at Frequencies		Cost in Rs per Sq.m
		0.375 kHz	0.4 kHz	
1	Cement: Hyacinth: Maize = 1:0.5:0.5	0.32	0.35	575
2	Cement: Hyacinth: Coconut coir = 1:0.5:0.5	0.36	0.41	545
3	Adhesive: Hyacinth: Maize = 0.5:0.5:0.5	0.31	0.35	1313
4	Adhesive: Hyacinth: Coconut coir = 0.5:0.5:0.5	0.30	0.35	1372
5	Cement: Adhesive: Hyacinth: Maize = 0.5:0.5:0.5:0.5	0.34	0.40	1222
6	Cement: Adhesive: Hyacinth: Coconut coir = 0.5:0.5:0.5:0.5	0.38	0.42	935

VI.CONCLUSION

The cost effectiveness of various controlling techniques is studied such as enclosure to the noise sources, Landscape feature natural sound absorbents. The cost of sound absorbing materials prepared with natural/agriculture waste like Hyacinth, Coconut Coir Dust and Maize with cement and adhesive as a bonding material.

The basic costs required for manufacturing the particle boards from each material combination and its installation is calculated by rate analysis. From analysis, the cost of material combination of Cement: Hyacinth: Coconut Coir Dust is observed Rs. 545/- Sq. m. and found more economical. Particle Boards of Cement: Adhesive: Hyacinth: Coconut coir=0.5:0.5:0.5:0.5 having highest NRC was found more compact and durable and cost of this particle board is Rs. 935/- After comparing both the combinations along with their cost and handling of actual material Cement: Adhesive: Hyacinth: Coconut Coir is recommended. Also the Noise reduction property of the Cement: Adhesive: Hyacinth: Coconut Coir material combination is observed better than other material combinations. NRC values obtained at

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forging industry frequency ranges are 0.38 and 0.42 and noise levels can be brought to 62 dB and 58 dB at frequencies 0.375 and 0.4 kHz respectively.

These six material combinations have been found more efficient at mid and high frequency ranges, and suitable for the other industries where the machines are operated at mid and high frequency ranges.

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