Noise Control in Buildings: Review Paper

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Abstract— This study is aimed at bringing out the salient aspects of building noise control. An analysis has been carried out with respect to the noise transmission as well as the characteristics of noise inside buildings. The key issues on building noise control have been included and discussed. Noise pollution means any sound that is undesired by the recipient. The effect of sound on human depends upon its frequency. Human ear are known to be sensitive to an extremely wide range of intensity varied from 0 to 180 dB. The noise is generated by the human through various ways. In present research article, various sources of noise pollution Planes take off and land, traffic moves along roadways, construction crew repair roads, dogs bark, music blares and sirens sound etc. The measurement of noise, dB scale, equipments used in the measurement of noise levels, impacts of noise, adverse health effects of noise pollution, control of indoor noise, control technologies available for noise pollution and Indian penal codes to prevent noise pollution are the main points of focus of attention. Noise must be controlled and prevented by using various effective techniques at the source itself is today's need. The objective of this work is to know about the various ways of generation of noise, their effects on human, its prevention and control.

Key words: Noise Control, Buildings

I. INTRODUCTION

Noise is a common phenomenon that we encounter in our day to day lives. We are surrounded by various kinds of sounds in the atmosphere. Noise may range from low whisper to loud roaring of thunder. Complete silence cannot be achieved even in the silence zones. More over with the advancement in technology and rapid urbanization, noise levels in our environment are going constantly up. Noise has become one of the major sources of pollution in modern times. It is the major cause of concern in developing as well as developed countries. The ever increasing noise pollution is making environment more and more unpleasant to live. The constant beeping of horns, blaring of loud speakers, music being played on the TV sets has become part and parcel of urban life. This ever increasing noise has ill effects on human, animal and plant life. Its ill effects range from insomnia to cardiovascular diseases. It is responsible for high levels of stress in humans in urban as well as rural areas recent researches have also shown the negative effects of noise on plant growth. Legislations have been passed in many countries to reduce this form of pollution.

A sound wave is typically made up of vibrations at different frequencies. The frequency is basically the number of waves that pass a single point in one second moving at the speed of sound in air. One wave per second is a frequency of one hertz (Hz). A frequency of 1,000hertz is a kilohertz (kHz). Human speech contains frequencies between 200 Hz and 5 kHz, while the human ear can actually hear sound generally between 25 Hz and 13 kHz, a wider range. Frequencies below 20 Hz can be sensed as a vibration, though not audible to most people.

II. NOISE POLLUTION

The word noise is derived from the Latin term nausea. It has been defined as unwanted sound, a potential hazard to health and communication dumped into the environment with regard to the adverse effect it may have on unwilling ears .Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes the sensation of hearing through nerves. Sounds produced by all vibrating bodies are not audible. The frequency limits of audibility are from 20 Hz to 20,000 Hz.

Dasarathy. A, Dr. T.S. Thandavamoorthy et al [7] Observed that the noise level at all locations exceeds the value prescribed by the competent authorities. At the pedestrian locations the noise level is 60 dB to 110 dB. At the railway crossing the noise level is 45 dB to 110 dB range of noise level. Because of high level of noise it is imperative that noise level has to be abated by exercising control at the source. Geetha. M. et al [12] Studied impacts of noise pollution at construction site. From the responses obtained from various company supervisors, workers and engineers, the following points were noted. The first observance made was 55 % of noises are produced only by the major equipments used at site. Heavy machineries contribute 15% of production in noise levels. Due to these types of noises produced 30% of construction laborers and workers are highly affected. Hazel Kiddo Richard, Zulkepli Hj. Ibrahim [14] observed that noise pollution around the educational area can negatively affect the performance of both teachers and students. The noise level should be around the range of 35 dB to 55 dB in the school area. Public school children were tested to determine whether quiet (45-55 dB), average (55-70 dB), and noisy (75-90 dB).

Jar Yuan Pai [15]. During the study analyzed the causes of this excessive noise and used noise reduction methods. The paired t test was performed and the results showed improvement methods were successful. This study found the noise levels reached 98.5–107.5 dB in power generator rooms and air-conditioning facilities, and suggests employees use ear plugs when working in those areas. Dornia Pojani [9]. This study found that noise is a growing concern for residents in Tirana. While it is well known that central area residents experience serious distress due to noise pollution, even more peripheral neighborhoods are affected. However, until recently noise pollution has remained mostly untackled because the overall institutional scheme that deals with noise management issues is redundancies and gaps and a lack of clear functional division among competing authorities and levels. Furthermore, corruption and favoritism are rampant at all government levels. T.S.S. Jayawardana et al [29] While analyzing the noise in a textile factory saw that some of the textile factory equipped with heavy machinery

produces a noise level up to 95 dB, while the national institute of occupational safety and health (NIOSH) recommend that the intensity and time to which workers must be exposed are 85 dB and 8 hours respectively.

III. NOISE CONTROL STRATEGIES IN BUILDINGS

Acoustical design for buildings requires quantitative information about acoustical products, materials and systems so that recommended design criteria can be met. A number of acoustical test procedures are used in the laboratory and in buildings to obtain this kind of information and to verify that the building is performing as the designer intended For most noise control work in buildings, the most important acoustical properties of the materials and systems used for sound reduction through different elements of building like walls, flooring, ceiling and stage arrangement in a building.

Lakavath Ravinder et al [16] It has been observed that a sound insulation of the order of 30 to 35 dB is possible in a given building. The devisable partition is made up of glass wool, laminate of both sides with wooden panels. Initially the SPL drop is faster inside the building and later on drop falls at the rate of 3dB for doubling the distance. The cost of the acoustically divisible partition wall is found to be very high even though it has one advantage of this partition wall seem to be creating acoustically divisible spaces where in one can conduct two programs simultaneously, without any disturbance to each other. DJ Oldham et al [8] a combined experimental and theoretical approach to the interaction of airflow and sound transmission through ventilators for natural ventilation applications is described. A key element of the investigation have been the development of testing facilities capable of measuring the airflow and sound transmission losses for a range of ventilation noise control strategies. A method is proposed for quantifying the acoustic performance of different strategies to enable comparisons and informed decisions to be model leading to the possibility of a design methodology for optimizing the ventilation and acoustical performance of different strategies.

M.Y. A. Perera et al [22] While analyzes the quality of noise and its distribution inside the factory Maximum noise level of some textile machines is as high as 95dB and locating many machines inside a single room causes to increase the cumulative noise level by at least 5dB beyond maximum noise level of a machine. So the noise level inside a textile factory is well above the limits specified by NIOSH and it amounts to be hazardous. Economically viable noise control panels are designed and carry out a pilot implementation in order to prove the effectiveness of the noise control method experimentally. Shiu Keung Tang [27] of natural ventilation-enabling noise control devices for use on the façades of high-rise residential buildings in congested cities. These devices are important for a sustainable urbanized city, as they are supposed to offer good acoustical protection to citizens, allowing for an acceptable level of natural ventilation inside residential units energy for mechanical ventilation can then be saved.

IV. MATERIALS USED FOR NOISE REDUCTION

Various noise reduction techniques ranging from active to passive have been used for the purpose of reduction of noise. Synthetic and natural materials have been used as absorbers for the purpose of noise reduction. These absorbers may either be categorized as panel absorbers or porous absorbers. The noise reduction techniques may range from traditional to innovative.

A. Green & Sustainable Materials for Noise Control in Buildings:

The concept of sustainable building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of green building materials and products represents one important strategy in the design of a building.

Green building materials offer specific benefits to the building owner and building occupants: Reduced maintenance/replacement costs over the life of the building. Energy conservation. Improved occupant health and productivity. Lower costs associated with changing space configurations. Greater design flexibility.

Asdrubali, Francesco [3] investigated on the measurement of sound absorption coefficient of novel sustainable fibrous materials. The fibrous materials have the properties of noise mitigation and building acoustic correction. They also carried out the optimization of reverberation room characteristics in order to quantify the sound absorption properties and to make a comparison with traditional fibrous sound absorbers according to ISO 354 standard. They observed a remarkable influence on the measured absorption coefficients by installing different numbers of diffusers both in terms of mean value and of Standard deviations suspended gypsum board plane diffusers were employed, even in combination with wall diffusers placed at the lower room corners. They observed the dependence of final data on the climatic conditions of the room it was noticed that when temperature and relative humidity gets closer to the limits prescribed by the ISO 354 standard (150C and 30%), the correction for air absorption can strongly influence results mainly at higher frequencies.

B. Noise Reduction through Facades with open Windows

Indoor noise is mainly caused by road and railway traffic, especially in summer time due to open windows. The presence of absorbent ceilings can help to reduce reverberating noise and the global mean acoustic level. The aim of this work is to define an index to evaluate the indoor noise reduction index (NRI) with open window; it is a function of the acoustic absorption coefficient of the room ceiling. It is evaluated by measurements in two reverberating rooms, which simulate the real conditions. In the emission room a noise source reproduces the road and railway noise. In the receiving room a microphone measures the noise level and its spectrum; the ceiling is treated with different absorption materials. A comparison between the values in absence and in presence of different materials and an evaluation of NRI are carried out. Experimental results are generalized and a theoretical expression of NRI is given.

Mitchel ryan et al [20] During the study has determined that no overall noise reduction can be estimated based only on façade construction type and that the noise level difference from outdoors to inside is a result of numerous incident noise and individual room characteristics.

This investigation has ultimately determined that whilst two separate residential dwellings may have the same material construction, they may in fact achieve significantly different noise reductions based on the volume and layout of the room in addition the size of the window in relation to the façade.

C. Building Acoustic Material

Acoustics is a term sometimes used for the science of sound in general. It is more commonly used for the special branch of that science, architectural acoustics, which deals with the construction of enclosed areas so as to enhance the hearing of speech or music. It could as well be regarded as the branch of architecture that deals with the control of sound which showcases the reflective, absorptive properties of sound.

M.Ramesh kumar et al [21] Sustainable building acoustic materials made from either natural or recycled materials are getting popular to reduce the carbon footprint. Most of the natural fibres discussed here are mainly be used for mid and high frequency applications. It is necessary to develop sustainable acoustical materials to control low frequency and impact noise. Since sustainable material development for acoustics is in its infancy, their impact on environmental needs to be evaluated using Life Cycle Assessment techniques.

D. Timber Frame Buildings

Timber framing and "post-and-beam" construction are traditional methods of building with heavy timbers, creating structures using squared-off and carefully fitted and joined timbers with joints secured by large wooden pegs. It is commonplace in wooden buildings from the 19th century and earlier. If the structural frame of load-bearing timber is left exposed on the exterior of the building it may be referred to as half-timbered, and in many cases the infill between timbers will be used for decorative effect.

Hans gerlich [13] New Zealand Building Code requirements (NZBC) The scope of the NZBC requirements is thus narrow and applies only to apartments and the living areas within these. Unlike our neighbours in Australia, New Zealand does not require noise control for temporary accommodation such as hotels, hostels and motels. Building controls in some European countries go even further, requiring minimum levels of noise control between rooms within houses.

E. Sound Insulation

To prevent you from being disturbed by the activity in the next room, whether the room is upstairs or in line, the construction has to prevent sound from being transmitted. This doesn't have to be a massive concrete slab or wall. Soundproofing relates to the overall ability of a building element or building structure to reduce the sound transmission through it. Two types of sound insulation might be referred to – airborne sound insulation and impact sound insulation.

Maaz allah khan et al [17] By increasing wall thickness and isolating one side of the construction from the other is another way to increase the transmission loss of a panel or construction. By decoupling ceilings from the structure and by altering floor finishes impact insulation and airborne insulation can be upgraded. By adding a lightweight concrete topping slab, fiberglass bat insulation, resilient channels and a second layer of gypsum board a base assembly can be upgraded from STC 37 to STC 58 which contains plywood subfloor, joists and gypsum board.

Sandesh G. jharbade et al [24] to increase the transmission loss of a panel or construction, such as a wall, is by increasing its thickness and isolating one side of the construction from the other. This is commonly done by using two panels separated by an air cavity, and is known as a dual panel partition. Doubling the air space width increases the TL by about 5 dB. Usually, the dual panel approach is more effective and lower cost than increasing wall mass.

Shikha choudry et al [3,26] Several natural materials are commonly used as thermal and acoustical insulation in multilayered walls among these flax, coconut, cotton, sheep wool and kenaf mats Their sound and thermal insulation performance are in many cases as good as those of traditional materials many studies have demonstrated that the sound insulation of double-leaf walls with low density animal wool (sheep wool) or heavy vegetal wool (latex-coco) is equal or better than the one of walls with mineral wool or polystyrene of the same thickness (about 69 dB in heavy double walls). Arno Pronk et al [2] in their work have presented water as a sound insulation material. Use of 200mm thick water layer with a membrane can be effective in reducing the noise as much as 100mm concrete wall. Water being cheap can be better alternative to synthetic sound absorbers.

F. Sound Absorption

Room acoustics describes how sound behaves in a space. That means the listener and the sound source are in the same room. If the room has nearly no sound absorbing surfaces (wall, roof and floor), the sound will bounce between the surfaces and it takes a long time before the sound dies out. The listener in this kind of room will then have a problem registering the speaker because he hears both the direct sound and repeated reflected sound waves.

If the surfaces instead are covered with sound absorbing material, the reflected sound will decrease much quicker and the listener will only hear the direct sound. Also, the general sound level in the room will decrease.

Faizan kasmi [15,11} In buildings sound absorbing materials used are rated using Noise Reduction Coefficient (NRC), which is basically a type of average of sound absorption coefficients from 250 Hz to 2 kHz, the primary speech frequency range. From perfectly absorptive (NRC = 1.0) to perfectly reflective (NRC = 0.0) NRC theoretically ranges. The sound absorption options provided on walls and ceilings are possible. Fabric, perforated metal and spaced wood slats are absorptive materials often covered with acoustically transparent surfaces. shweta jain [3,28] Natural fibres are generally good absorbers. The extremely wide variety of natural fibres allows to find a suitable material for almost every absorbing need. Many natural materials as kenaf, flax, sisal, hemp, cork, sheep wool, bamboo or coconut fibres show good absorbing performance and can therefore be used as sound absorbers in room acoustics and noise barriers. Reports the coefficients of absorption as well as the values of Noise Reduction Coefficient (NRC), for some conventional and sustainable materials. The NRC rating is an average of how absorptive is a material at four frequencies (250, 500,

1000 and 2000 Hz) and is here used for a comparison of the various materials.

G. Sound Absorption Coefficient of Four Types Malaysian Wood

Elammaran jayamani et al [10] In this work work has been carried out experimentally to determine the sound absorption coefficient of four types of Malaysian wood. They are Tapang (Koompassia excels), Pulai (Alstonai angustiloba), Selunsor merah (Tristianiopsis beccariana) and Jelutong (Dyera polyphylla). The test was performed using the ASTM E1050-98/ISO 10534-2 (American Society for Testing and Material) standards for the sound absorption coefficient testing. This method is known as impedance tube method (Two-Microphone Method). The absorption coefficient depends on the frequencies. In this study the values of the frequencies used was in the range from 350 Hz to 1000 Hz.

H. Noise Reduction in Buildings using Sound Absorbing Materials

Azimi M [5] Porous materials obtained from synthetic fibers, such as mineral wool or glass wool, are commonly used for thermal insulation and sound absorption, because of their high performance and low cost. Their diffuse-field sound absorption coefficient is very high at midhigh frequencies. On the other hand, they have several cons they can be harmful for human health if their fibers are inhaled, since they can lay down in the lung alveoli, and can cause skin irritation (as stated by the European Council Directive on dangerous substances 67/548/ EEC [9] and subsequent amendments).

A majority of sustainable materials for noise control can be divided into three main categories: Natural materials, recycled materials, Mixed and composited materials. 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.[19]

I. Improved Sound Absorption Properties of Polyurethane Foam Mixed With Textile Waste

Ancuta Elena tiuc et al [1] study on acoustic properties improvement of rigid polyurethane closed-cell foam, by incorporating various quantities of textile waste into the matrix. In order to obtain a homogenous, easy to handle material, an optimal percent of 10-50% textile waste was used. The sound absorption coefficient of the composite materials was measured using an impedance tube. The composite materials obtained have better sound absorption properties compared to rigid polyurethane foam. The noise reduction coefficient (NRC) of the composite material with 40% textile waste and 60% rigid polyurethane foam is twice as high as the 100% rigid polyurethane material.

V. EFFECT OF NOISE POLLUTION

Noise pollution affects both health and behavior. Unwanted sound (noise) can damage psychological health. Noise pollution can cause hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects.

Savale P.A. [25]During the study on the sources of noises determined typical noise levels of various sources with noise level ranging in between 95-104 dB for Gensets, 80 dB for printing press, 96 dB for trains, 90-100 dB for trucks, 90-105 dB for car horns. When humans remain exposed to such high levels of noise for prolonged period of time it results in serious health hazards to them few of them are deafness, nervous breakdown, mental disorder, heart trouble, high blood pressure, dizziness etc. Its general effects on human being are that, it covers disturbance in sleep which lead to other side effects. Marget e. Collins et al [18] the specific effect of the growth of plants subjected to sounds of varying intensity and frequency. Any environmental factor that places a biological system under stress can affect its performance and/or behaviour. The effect of sound on physiology and behaviour of animals and man has been studied by various researchers. However, only a limited amount of detailed information is available on the effect of sound on plant systems.

VI. PASSIVE /ACTIVE NOISE CONTROL

Passive Noise Cancellation is the noise that headphones block out based on the physical design of the earcups. Based on the shape of the headphone earcups and how it fits over the head determines to a large degree how much noise the headphones can block out. This comes in handy when a user is listening to music or whatever desired sounds he wants to listen to. When passive noise cancellation is strong, the user hears less outside unwanted ambient noises and can focus more on the desired sound at hand. This is in comparison to active noise cancellation, which works differently; active noise cancellation is noise cancellation that works through powered electronic circuitry to produce noise cancellation. Passive noise cancellation is all about the physical, or you can say mechanical, design of the earcups.

Active noise control, also known as noise cancellation, or active noise reduction, is a method for reducing unwanted sound by the addition of a second sound specifically designed to cancel the first.

Mario cuesta and pedro cobo [19] The aim of this work was to design and implement a hybrid passive/active system to control the exhaust noise radiated by a small generator. Noise control device requires a combination of passive and active methods. Passive control rises absorption properties of materials to reduce high frequency noise but it becomes expensive in terms of weight and bulk at low frequencies where attenuation must be achieved with active control. Active control is based on the principle of destructive interference between the primary and the secondary sources. Naveen garg et al [23] This study proposes a comprehensive noise abatement programme following the best practicable and economical option (BPEO) for implementation in metro city like Delhi for reducing annoyance and ill effects of traffic noise.It reviews potential applications of noise control barriers and vegetation for reducing road traffic noise and presents a design morphology and decision matrix using TOPSIS (Technique for order preference by similarity to ideal solution) approach for selection of appropriate sound barriers.

Ayman el badawy et al [4] the application of the Herschel-Quincke (HQ) tube concept as a noise reduction device was employed to reduce the noise of an industrial burner-combustor test rig.

A computational technique was developed to design the HQ tube dimensions to control the sound field in such system. Transmission loss predictions from the analytical model were shown to correlate well with experimental data acquired from an extended impedance tube setup, as well as the real test rig Noise propagating in a duct is an undesirable effect of many industrial and residential systems that have airflow. HVAC (Heating, Ventilating, and Air Conditioning) systems, gas-turbine generators, exhaust stacks and turbofan engines are some examples of such noise propagation systems. Barbara tiseo et al [6] during the passive noise control are practical and most effective at mid and high frequencies. On the other hand, active noise control techniques are more efficient at the low frequency range. Combined solutions seem to be the most appropriate key to cover the whole frequency range of frequencies.

In the present study, a description of simulations for both feedback structural and acoustical structural control strategies are illustrated in order to maximize the damping within an acoustic duct by applying a passive foam layer bonded to an "active" surface.

VII. CONCLUSION

There are various techniques that can be employed for the purpose of noise reduction. Various materials can be used as noise absorbers for reducing noise levels. These absorbers may either be used in porous form or panel form. The absorbers used may be either synthetic or natural. It is necessary to develop sustainable material to be used for noise reduction purposes. Various innovative methods like water membrane and green wall should be encouraged as they do not have any harmful on environment. The suitable action will be taken to attenuate the noise levels and controlling pollution. In future, public education, government and NGOs can play significant role in controlling the noise pollution.

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