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A Implementation Of Highways Traffic Sound Barrier And Analysis Of Solid Metallic Modular Panels

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Abstract- With the development of road construction, traffic noise pollution becomes more and more serious. Sound barrier, an effective and comparatively inexpensive measure of controlling noise, will be developed to some degree. The sound barrier durability is a very complicated problem. It is influenced by structure design, concrete construction and so on.

Keywords- traffic noise, sound barrier, structure design, durability

I. INTRODUCTION

The evolution of human civilization is dependent on industrialization to a large extent and further urbanization of the cities and towns in the country. In India, the urban population is rising at a fast rate (twice) compared to the total population of the world. In the developing world, this growth is extensively spread and heavily concentrated in a few mega cities. The rapid increase in population, particularly in developing countries can be seen as a contrast to the relatively less percentage of available urban space.

It is said that at the beginning of the century four out of the five lived in the countryside, but by the year 2000 it is estimated that at least one-half of the world's population reside in urban areas. Industrial growth along with technological developments in developing countries has lead to the introduction of various technologies to modern life and that has resulted in the increase of unwanted wastes into the environment in solid, liquid and gaseous forms. The deterioration of the 'habitat' conditions which has occurred during the recent decades is described by the general term 'pollution'. Environmental pollution can also be defined as "contamination of the environment by chemical, physical and biological agents that harm both humans and animals or plants".

In both developing and as well as in developed countries the present environmental problems are widespread. These problems can be air, water and noise pollution. When viewed in relation to such obvious forms of pollution, noise pollution may be less obvious but this problem has increased rapidly with time. "Noise in big cities is considered to be the third most hazardous type of pollution, right after air and water pollution" (WHO, 2005). In the recent times, noise problem has increased enormously both in its severity and extent. Crowded cities and towns, with mechanized means of transport, new means of activity and amusement are polluting the atmosphere with their uninterrupted noise. Noise is one of the environmental pollutants, which we encountered, in daily life.

II. NOISE POLLUTION

Noise pollution generally articulated as a sound and its implications on human health. The current development of rapid raise in population leading to an increase in industries, transportation and community activities - all these are the major sources of noise pollution. Noise is a technologically generated problem and doubles every ten years along with social and industrial growth. The geometric progressionwise of noise is ever increasing in urban areas with growth in technology (Vijayalakshmi, 2003). In India, the population is 1.21 billion (Census India, 2011). The important factors resulting in the increase of urban population are the relocation of people from rural to urban areas, expansion of cities with developed infrastructure and so on.. (Banerjee et al., 2008; Omidvari and Nouri, 2009). Indian cities face a lot of noise problem mainly due to transport, ill planning and traffic congestion compared to most of the cities in North America and Europe (Prabat and Nagarnaik, 2007).

Traffic noise pollution research is limited in India when compared to other developed countries. In large cities (urban areas) traffic noise considered as one of the major source of environmental pollution (Jamarah et al., 2006; Murthy et al., 2007 and Omidvari and Nouri. 2009). Road traffic noise is a major problem in developing countries, which is observed, with phenomenal increase in vehicle ownership since 1990s. The increasing growth of two wheeler, three wheelers and car in particular have contributed more to noise pollution and unconditional use of breaks, transient driving pattern and surface gradient of road, leads to traffic congestion especially during peak hours and from this it is clear that traffic congestion and urban city go hand in hand. Poor maintenance of vehicles, speed, traffic volume, stop and go traffic pattern creates more noise when compared to smooth flow can increase vehicular noise pollution. The traffic noise propagation can also be varying due to meteorological (weather) conditions also.

The traffic noise pollution also affects physically as it lowers the property values and decreases the quality of life for the people living in the neighborhood of urban corridors. Most of the important roads and highways are there in residential and commercial areas due to unavailability of land resources or due to lack of finance. Noise is generally measured as sound intensity that is determined in terms of pressure of sound waves in logarithmic scale of decibels dB (A). Equivalent continuous (A-weighted) sound level is defined as the steady sound level which has the same amount of acoustic energy as the fluctuating level for a prescribed period. The road traffic noise calculation of equivalent noise levels (Leq) at a number of residential, commercial and industrial areas during day and night times gives additional general applications e.g. environmental assessment of road schemes, highway design and land use planning apart from knowing about noise regulations and noise pollution manifested itself in an urban environment.

III. NOISE CONTROL

Noise control techniques can be in four fundamental ways to reduce noise: Reducing the noise at the source, blocking the path of noise to receiver, increasing the path length and protecting the receiver and the best method of control are reducing noise levels near the source. Individuals to control vehicular traffic noise can use proper design of highway planning, mufflers, specially designed earmuffs. To establish speed limits, restricting traffic flow and alternate routes for ambulances and heavy vehicles especially with in the city limits are good noise control measures. Mitigation of emitted traffic noise can be effective with non-vehicular noise management strategies like creating awareness to public, providing buffer zones, land use and transport planning and design of new roads, noise barriers and noise walls along roadside.

The recognition of road traffic noise has led to development of many mathematical models to predict noise levels from fundamental variables. To predict noise levels in a satisfactory manner, a mathematical model needs to develop using statistical information. The model should be simple with sufficient data and accurate integration of results to the subjective insight of the noise is very important. Models play a vital role in highway and non-highway design schemes and are used for assessing the existing conditions of traffic noise and noise levels (Givaris and Mohmoodi, 2007; Steele, 2001).

IV. HIGHWAY SOUND BARRIERS

Fortunately, the development of highly-effective and aesthetically-pleasing sound-absorbing noise barriers like the SonaGuard System has proven to be a more effective option than concrete for highway applications. Our SonaGuard system is a good choice for new construction when there are no existing walls along the highway. Not only do these highway noise barriers significantly decrease noise levels for nearby homeowners and businesses, they provide a pleasing visual screen for the unsightly chaos of traffic and road noise.

Fig.1. Highway sound barriers.

1.Highway Sound Barrier Wall Cost

According to The U.S. Department of Transportation and Federal Highway Administration, in 2010, the average cost for highway noise barrier walls per square foot was $32. Although that is the average, actual cost is heavily dependent on the site-specific variables such as wind load or type of application as well as the material being used for noise reduction. For the most realistic cost estimate, consulting with someone who specializes in sound mitigation would be the way to go for the best estimate possible.

Who Pays for Highway Sound Barriers?

There are two different types of projects when it comes to sound barrier walls along a highway.

Those types are Type I and Type II

Type I is when it is new construction and Type II is when the sound barrier is being added to an existing highway.

When funding **Type II**, it must meet certain requirements, such as a certain noise level, in order for The Department of Transportation to provide any type of funding.

Funding is typically only for new construction or road expansion because federal laws and regulations do not require the building of noise barrier walls along existing highways. If state departments decide it is necessary to build sound barrier walls along an existing highway, they are liable for funding and costs (fhwa.dot.gov). noise barriers manufacture (road noise barriers, highway noise barriers, metal noise barrier, polycarbonate noise barriers and sound absorbing noise barrier walls/ panels india by ecotone systems).

Leading Noise barrier, noise barrier manufacturer. Ecotone’s barrier is also known as sound barrier walls, highway noise barriers, Road noise barrier, sound fence panels are built to protect people who live in the settlements and are vulnerable to noise pollution. Loud noise can be devastating to your health. This way, noise barrier manufacturers have a practical solution to cut down such types of unwanted noise. Such types of walls are designed to absorb / Reflect sound. A Sound Fence Panel has a perforated outer material to absorb the noise, and a core of other materials diffuses the sound waves coming it’s way. It is helpful to keep the sound from passing through the panel. Highway traffic is one of the major causes/culprits behind noise pollution. So, it is recommended to use highway noise barriers.

The sound barrier wall is an engineered modular sound panel system designed for high noise reduction of external noise control. The barrier wall is commonly used to control mechanical noise, transport noise, and other disturbing noises, which are generated by chillers, fans, transformers, compressors, etc. Our engineered sound barrier walls are specially designed with environmentally sustainable composite construction that absorbs sound energy and prevents aggressive noise. Modular Sound Barrier manufactured from 18SWG GI sheets galvanized coated perforated sheet modular construction duly covered seven tanks and powder coated, having rock wool as slabs of 100 mm thickness and 64 KG / metric cubic density (specification of rock wool conforming to IS Is) 8183) is. Complete with foundation and support from the floor. A sound control system designed to suppress sound levels up to 15–20 dB maximum at a distance of 1 meter.
Sound inhibition can be used in applications such as:

V. LITERATURE REVIEW

Kinga Szopińska et al.[1] The construction of the highway requires research to indicate whether the new communication route will have a negative impact on the acoustic climate of the neighbouring areas. If the permissible noise level is exceeded, forms of acoustic protection should be introduced. In the last years, the permissible noise levels have been changed which has influenced the selection of noise barriers along highways. For the purpose of this research, the two sections of the Polish A4 highway (A and B) were selected. The aim was to check the possibility of using open databases for the preliminary assessment of exposure to road traffic noise in residential areas along highways. The results confirmed that the changing legal situation led to an inappropriate selection of noise barriers. Their effectiveness in Section A was 90% while in B it amounted for 4% only.

AdaliceFláviaet al.[2] Duarte de Medeiros Road traffic is the main contributor to noise in urban areas. A case of concern is urban highways, due to the intensity of the emitted noise. Acoustic barriers are one of the solutions usually adopted to reduce highway traffic noise in this case. However, they have a negative visual impact on the urban landscape. An underpass could be a solution that provides noise attenuation without introducing aesthetical problems to the urban area. This work investigates the noise attenuation of a highway underpass aiming to confirm its efficiency as a solution for the minimization of traffic noise and explores a variety of scenarios that could influence the noise propagation. Noise measurements and the collection of input data used in noise simulations were conducted at an urban highway located in the city of João Pessoa in Brazil.

The investigation was focused on the highway underpass with an L-shaped top edge, which is acting as a parallel acoustic barrier to an adjacent residential area. In addition, simulations were performed using the software SoundPLAN. Five scenarios were simulated: the actual situation and four scenarios with different depths of the underpass and changes on its edge. It was found that the existing L-shape edge of the underpass is positively influential only at points at the immediate vicinity of the border and resulted in an additional average attenuation of 1.3 dB in this region. However, in general, the average attenuation due to the underpass for the points in the whole acoustic shadow zone was 10.6 dB with the actual L-shape edge, and 13.1 dB from simulations when the L-shaped edge was removed. From simulations involving changing the depth of the underpass, it was observed that there was no linear relationship between attenuation versus depth.

The simulation results showed that adding an L-shape edge with its current length is not efficient regardless of the depth of the underpass. The results thus confirmed the underpass as an effective solution for the mitigation of highway traffic noise and provided additional insight on the role of the depth associated to changes on the geometry of the top of the underpass. Priscila Lopes et al.[3] The high-level highways, where the operating speed is high, are implanted in areas with low population density. However, in some Brazilian regions, the uncontrolled growth of large cities leads to urbanization in their surroundings. As a result, these highways become urban roads, and collective transportation buses use them.

There is a duplicate section of BR-282/SC highway in this scenario, which promotes access to Santa Catarina Island, where a Bus Rapid Transport (BRT) corridor will be implanted. This study aims to evaluate the attraction and rejection factors for the implantation of BRT stations located on the central axis of the highway between the opposing traffic lanes. It was carried out a case study with five stages: choice of the station implantation site, identification of attraction and rejection factors, description of mitigating measures, and elaboration of the design guidelines. A qualitative and quantitative study of the adjacent environment was carried out in the area covered by the station, and the walking conditions were verified. The analysis of the rejection factors related to traffic, pavement, and accessibility included noise pollution, air pollution, thermal discomfort, and access conditions, consideration of the existence of sidewalks and bicycle paths. As a result, the user attraction factors were relative to proximity to the residences and jobs poles and the station's connectivity with the local and marginal routes. On the other hand, rejection factors were related to noise and thermal discomfort, atmospheric pollution, and access characteristics (streets, sidewalks, and commerce). Mitigating measures and the station design to be feasible the Bus Rapid Transport stations attractiveness implanted in the road center were proposed.

Mahdi Rezapouret al.[4] Vehicles in transport sometimes leave the travel lane and encroach onto natural or artificial objects on the roadsides. These types of crashes are called run-off the road crashes, which account for a large proportion of fatalities and severe crashes to vehicle occupants. In the United States, there are about one million such crashes, with roadside features leading to one third of all road fatalities. Traffic barriers could be installed to keep vehicles on the roadways and to prevent vehicles from colliding with obstacles such as trees, boulder, and walls. The installation of traffic barriers would be warranted if the severity of colliding with the barrier would be less severe than colliding with other fix objects on the sides of the roadway. However, injuries and fatalities do occur when vehicle collide with traffic barriers. A comprehensive analysis of traffic barrier features is lacking due to the absence of traffic barrier features data. Previous research has focused on simulation studies or only a general evaluation of traffic barriers, without accounting for different traffic barrier features.

Paola Filigranaet al.[5] Localized variations in traffic volume and speed can influence air pollutant emissions and corresponding concentrations in nearby communities, but most studies have utilized only aggregated traffic activity data. In this study, we compared the estimated influence of highway traffic activity on concentrations of primary oxides of nitrogen (NO_x) and fine particulate matter ($PM_{2.5}$) in communities near highways using a dispersion model informed by highly spatiotemporally-resolved variations of traffic volume and flow compared to the use of Annual Average Daily Traffic (AADT) data at a few locations.

We used two sources of traffic activity data on 500 half-mile roadway segments on the five major highways in the Washington State Puget Sound during 2013. The first consisted of vehicle counts available every half-mile and 5 min; the second was traffic information (e.g., AADT) aggregated across the year and roadway network. Using the Motor Vehicle Emissions Simulator (MOVES) and the Research Line source dispersion model (RLINE), we modeled hourly concentrations of primary NO_x and $PM_{2.5}$ generated by highway traffic at nearly 4000 residences within 1 km of major highways. These concentrations were aggregated to daily and annual average concentrations, which were compared by input data source.

At most locations, concentrations of primary NO_x and $PM_{2.5}$ modeled using the resolved traffic data had similar spatial and temporal distributions to concentrations predicted using the AADT data. However, several areas showed large differences. For example, 25% of residences within 150 m of a highway had concentrations that differed by more than 19% (8 ppb) for NO_x and 32% (0.7 $\mu g/m^3$) for $PM_{2.5}$, and the AADT data consistently predicted lower concentrations than the resolved traffic data. Our findings indicate that temporal and spatial variation in traffic patterns can result in complex spatiotemporal variations of air pollutant concentrations that can be captured with the use of dispersion modeling with the appropriate inputs. The use of spatiotemporally resolved traffic activity data can improve exposure estimates and help reduce exposure measurement error in epidemiological studies, especially in communities near highly congested highways.

Fatma Outayet al.[6] For next-generation smart cities, small UAVs (also known as drones) are vital to incorporate in airspace for advancing the transportation systems. This paper presents a review of recent developments in relation to the application of UAVs in three major domains of transportation, namely; road safety, traffic monitoring and highway infrastructure management. Advances in computer vision algorithms to extract key features from UAV acquired videos and images are discussed along with the discussion on improvements made in traffic flow analysis methods, risk assessment and assistance in accident investigation and damage assessments for bridges and pavements. Additionally, barriers associated with the wide-scale deployment of UAVs technology are identified and countermeasures to overcome these barriers are discussed, along with their implications.

Celia Arenas This paper focuses on developing a highway noise barrier prototype mainly composed of bottom ash from the traditional pulverised coal combustion at semi-industrial scale, following a simple and low-cost manufacturing procedure similar to that used to cast commercial concrete noise barriers. In order to obtain good sound absorption coefficients, a multilayer product was designed, with a porous layer in the incident noise face followed by the finest material in the back layer.

The characterisation of the recycled multilayer product was carried out in accordance with the current European standard for road traffic noise reducing devices and the results have been compared to the specifications stated by the regulations. The acoustic performance has been evaluated by determining the sound absorption coefficient and the airborne sound insulation in a reverberation room. Regarding the non-acoustic performance, the physical (open void ratio, unit weight), mechanical (compressive strength, Young's modulus, flexural strength, fracture energy, indirect tensile strength, characteristic length, impact strength) and fire resistance properties were determined. From the results obtained, bottom ash from traditional pulverised coal combustion can potentially be recycled by manufacturing a multilayer product that complies with the specifications required for road traffic noise reducing devices according to the European standards, and that reaches the same acoustic category as other commercial products used for the same application.

Owain T. Ritchie et al.[7] Previous research into perceptions of autonomous vehicles has largely focused on *a priori* attitudes, with little work on the perception of specific traffic situations, context and driving styles. The present study used three simulator experiments (total N = 150) to examine the combined effects of vehicle speed, lane position, information presentation and traffic context on occupants' levels of satisfaction with autonomous highway journeys. Overall, occupants preferred being in a vehicle that was mostly overtaking compared to being overtaken, regardless of whether the overtaking vehicles were exceeding the speed limit. This finding remained even when occupants were given additional reminders that they themselves were travelling at an appropriate speed (Experiments 1 & 2).

Experiment 3 found that occupants preferred overtaking to being overtaken when following another car, but this preference disappeared when they were following a lorry, suggesting that occupants' sensitivity to position amongst the traffic was partially context dependent. Overall, the findings suggest that journey satisfaction is sensitive to overtaking contexts and the inappropriate behaviour of other drivers (e.g., speeding) can reduce journey satisfaction for occupants in autonomous vehicles that drive within the speed limit, depending on the specific traffic situation. Potential implications for the integration of autonomous vehicles with other traffic and the need for in-vehicle presentation of information are discussed.
Mehdi Shokouhianet al.[8] Exposure to noise generated from traffic has led to significant annoyance and sleep deprivation in people. Continuous exposure to traffic noise can lead to mental instability and reduce the learning rate of children. Many cases of cardiovascular diseases, sleep disturbance, and cognitive impairment have been reported as a result of traffic noise. With increasing population of cars, health problems resulting from traffic noise will continue to increase and it is of utmost priority to abate this noise.

Noise abatement is one of the most effective strategies in reducing noise level for communities close to roadways, although it is also one of the major cost drivers in highway projects to reduce noise. Extensive noise modeling is required to determine the feasibility of abatement choices; however, traffic noise models usually do not interact with highway geometries in selecting optimized noise abatement options. The Traffic Noise Model (TNM) developed by Federal Highway Administration (FHWA) was used to compute highway traffic noise and evaluate the effect of noise abatements. A parametric study was conducted on a total of 23,093 scenarios generated to examine ten major variables influencing roadway noise level. A noise prediction model was developed using multiple regression analysis incorporating parameters such as roadway geometry (horizontal offsets and elevation differences), barrier height, receiver height, traffic volume, roadway section, road-surface material, barrier types, speed and roadway section. This model can be used to examine possible noise mitigation strategies to make the best decision at design stage of a roadway.

Alexis Pinsonnault-Skvareninaet al.[9] The aim of this study was to describe the perception and satisfaction of mitigation measures along the construction site of a major urban highway, and to quantify the relationship between mitigation measures and noise annoyance. A total of 1,409 participants were included in a first socio-acoustic survey in 2018, and 609 in a second survey in 2020. Residents were generally satisfied with most of mitigation measures, although a reduction in their perceived effectiveness was observed in the 2020 survey. The perception of mitigation measures explained between 2.9 and 6.5% of the variance in construction noise annoyance. Traffic management, site surveillance and temporary noise barriers were the most important variables in the statistical models. While some measures are used only by a small proportion of the target population, our results show that implementing comprehensive mitigation measures can help to reduce construction noise annoyance.

Dalei Wang et al.[10] Running vehicles cause disturbances in the surrounding air, which lead to a vehicle-induced aerodynamic load (VIAL) on roadside thin-wall structures. In this study, to reveal the aerodynamic load mechanism on roadside sound barriers subjected to the action of a vehicle-induced airflow, the Computational Fluid Dynamics(CFD) method is used to simulate the airflow around a running vehicle and adjacent to the sound barrier.

First, the reliability of the numerical simulation is verified by comparing it with field tests. Second, using the CFD method, flow fields around the running vehicle with and without a sound barrier are obtained, the wind-pressure distribution is extracted, and the micro-mechanism of the sound barrier's influence on the airflow around the running vehicle is revealed by comparing and analyzing the flow-field distribution characteristics. Thirdly, through parametric studies, the changing rules of the wind-pressure distribution and the VIAL effect of internal force on the sound barrier screen are presented under different conditions, i.e., sound barrier height, vehicle shape, vehicle–barrier separation distance, and sound barrier shape. Then, using the FEM method, the load effect of vehicle-induced airflow on the sound barrier column is revealed. The conclusions improve the understanding of the action mechanisms of the vehicle-induced airflow on roadside sound barriers.

Jianqiang Zhao et al.[11] A highway noise prediction model which considers 20 s continuous equivalent sound level measure as the basic vehicular noise has been developed and is called the L_{eq}(20 s) model. The L_{eq}(20 s) model is believed to provide accurate predictions by measuring the sound level of individual vehicle without assuming the vehicle noise source as a point source. To verify the rationality of L_{eq}(20 s) model, a mathematical derivation was performed based on the Federal Highway Administration (FHWA) traffic noise prediction model in this study. The derivation process indicated two defects in the L_{eq}(20 s) model. One was that given the lack of a revision item for finite length road, the L_{eq}(20 s) model cannot be applied to some special roads, such as in predicting the traffic noise level of a receiving point which is located at the tunnel portal of a highway.

The other was that the L_{eq}(20 s) model had some theoretical deviations from the model of mathematical derivation from the FHWA model. When the speed of a vehicle ranged from 20 km/h to 120 km/h, the deviations ranged from 0.80 dB(A) to 0.13 dB(A). The deviations could be reduced if the constant item of −22.55 dB(A) in the L_{eq}(20 s) model was revised to −22 dB(A). To compare the accuracy of the L_{eq}(20 s) measure with the measure of the mean energy emission level, which was used as the basic vehicular noise in the FHWA model, a series of simultaneous measurements of a 5 s continuous equivalent sound level [L_{eq}(5 s)] and the maximum emission levels of individual vehicles was conducted.

The measurements of L_{eq}(5 s) were compared with the calculations based on the hypothesis of monopole and dipole sources from the maximum emission levels of individual vehicles measured on roadsides. Result indicated that the mean value of measured L_{eq}(5 s) was close to that calculated from the maximum emission level with the hypothesis of monopole source for light vehicles. However, for medium and heavy vehicles, the mean value of measured L_{eq}(5 s) was between the two values calculated from the maximum emission level with the hypothesis of monopole and dipole sources. A mean error of 1.2–1.6 dB(A) was obtained for L_{eq}(5 s) when the mean energy emission level was employed in the FHWA model for medium and heavy vehicles. The accuracy of traffic noise prediction can be improved by considering L_{eq}(20 s) as the basic vehicular noise instead of the mean energy emission level.

DaeSeung Cho et al.[12] A highway traffic noise prediction model has been developed for environmental assessment in South Korea. The model is based on an outdoor sound propagation method and is fully compliant with ISO 9613 and the sound power level (PWL) estimation for a road segment, as suggested in the ASJ Model-1998 that is based on PWLs. Due to that model's selection of two pavement types, such as asphalt or concrete pavement, an unacceptable traffic noise prediction is made in cases where the road surface is different from that on which the model is based. In order to address this problem, several road surface types are categorized, and the PWL of each surface type is determined and modeled by measuring the noise levels obtained from newly developed methods. An evaluation of the traffic noise prediction model using field measurements finds good agreement between predicted and measured noise levels.

DaeSeung Cho et al.[13] In this study, we introduce outdoor sound simulation that is fully compliant with ISO 9613 yet with some complementary methods that enhance its applicability; for example, calculation of sound attenuation due to undulating terrain in octave bands, geometric divergence in the near-field of the source, and short-term wind effects. Using the method, we have carried out highway traffic noise prediction and measurement for 12 sites with representative road shapes and structures. In the prediction, the sound power level for a road segment was estimated by the method suggested in ASJ Model-1998 with experimental corrections to the overall noise level and spectrum. Comparing results between predicted and measured noise levels show good correspondence at direct, diffracted and reflected sound fields within 30m from the center of the near side lane.

Sergey Naidenkoet al.[14] The Russian Far East is a unique location that may be considered a hot spot of biodiversity in Russia. In 2010, a new illuminated highway for high-speed traffic was built on its territory. The aim of this study was to evaluate the impact of this highway on the distribution and activity of various mammalian species. We set up camera traps in five lines near the road and obtained photos of 1372 passes of various animals. In total, 15 species of wild mammals were captured by camera traps. Animals preferred to stay far away from the road. This highway became a serious barrier separating the local populations of ungulates and carnivores. Only domestic animals and Amur wild cat used the underpasses more often than other areas. The distance from the road did not affect the daily activity of the mammals.

David J. Oldham et al.[15] The Boundary Element Method has been employed for a parametric investigation of the performance afforded by highway noise barriers with multi-edge tops and different acoustic treatment. Configurations investigated included single additional edges located on either the source or receiver sides of the barrier and two additional edges located symmetrically on each side of the barrier. The effect of treating the internal faces with a sound absorbing material was also investigated. The parameters investigated included the source to barrier distance, the receiver to barrier distance, the barrier height, the length of the additional edge and the gap between the additional edges and the face of the barrier. The values of each parameter were selected to be those appropriate to a practical installation. The performance of each edge variation was investigated for both reflective and absorptive faces. The relative insertion loss afforded by a given multi-edge configuration was found to be a function of the location of the source, the barrier and the receiver and also the height of the barrier. However, the sensitivity of the relative insertion loss to variations in most parameters was not great. For both reflective and absorptive treatments, the relative insertion loss of most additional edges was found to be only slightly greater on increasing the length of the edge above 0.5 m. Although there was always an increase with increasing gap width over the range of widths investigated gap but the indications were that benefit to be obtained for gap widths in excess of 0.4 m may not be an economic proposition.

For source locations close to the barrier and receiver locations in the far field, as would be appropriate for a highway noise barrier, although the relative insertion loss afforded by a reflective additional edge located on the source side of the barrier is generally low, significant attenuation can be obtained when an absorptive treatment with a high coefficient of absorption at frequencies around 1000 Hz is applied to the device. However, a reflective edge located on the source side of a barrier at very short source to barrier distances and/or high barriers was found to result in a negative value of relative insertion loss and an explanation based upon resonances in the gap between the additional edge and the barrier was postulated. The use of two additional edges located symmetrically either side of a barrier can be a very effective means of improving the performance of a highway noise barrier giving relative insertion loss values that are high and consistent over a large range of parameters for both reflective and absorptive surfaces. However, in the former case the performance can be severely reduced for combinations of short source to barrier distances and/or high barriers.

VI. CONCLUSION

The acoustical science of noise barrier design is based upon treating an airway or railway as a line source. The theory is based upon blockage of sound ray travel toward a particular receptor; however, diffraction of sound must be addressed. Sound waves bend (downward) when they pass an edge, such as the apex of a noise barrier. Barriers that block line of sight of a highway or other source will therefore block more sound.[6] Further complicating matters is the phenomenon of refraction, the bending of sound rays in the presence of an inhomogeneous atmosphere. Wind shear and thermocline produce such in homogeneities. The sound sources modeled must include engine noise, tire noise, and aerodynamic noise, all of which vary by vehicle type and speed. The noise barrier may be constructed on private land, on a public right-of-way, or on other public land. Because sound levels are measured using a logarithmic scale, a reduction of nine decibels is equivalent to elimination of approximately 86 percent of the unwanted sound power.

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