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Prediction of Traffic Noise in Kwang-ju City (Trunk Roads and Access Roads)

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ABSTRACT

도로교통소음은 많은 지역에 산재해 있으며, 특히 주도로변에 거주하는 사람들에게는 환경과 관련하여 매우 중요하다. 도로교통으로부터 소음수준을 계산하는데 몇가지 다른 방법들이 이용되고 있다. 이 방법들은 계산방법과 그래프식 그리고 컴퓨터 모델링 기술 등이다.교통과 교통소음의 영향으로부터 소음을 계산하는 간단한 기술인 예측 방법을 여기에 나타내었다. 이 TNS(Traffic Noise Screening) 방법은 서로 다른 도로유형에 대한 일련의 도로교통소음레벨의 예측그래프로 전개된 것이다. 이 그래프는 Federal Highway Administration(FHWA) STAMINA2.0을 이용하여 다양한 시나리오에 대한 소음 예측모델을 계산한 결과를 기초로하였다. TNS에 도로의 기하학적 형태, 교통량, 주행속도 그리고 도로중앙선의 거리등의 데이터를 입력시킨다.

TNS그래프는 소음영향과 연관된 교통소음예측에서 사용하는 경우 교통소음레벨의 계산을 쉽게 한다. 이 TNS 방법은 STAMINA2.0과 같은 상세 모델링을 대신하지는 못하지만 상세 모델링을 필요로 할 때 도움을 주는 도구이다. 만약 소음계산들이 중요하거나 또는 시나리오가 보다 복잡하고 부가된다면 보다 상세한 모델링이 수행되어져 스크린 결과들이 나타난다.

Introduction

In the midst of environmental concerns today, noise tends to be the forgotten pollutant. Typically, noise is an issue of importance in any community where a noise emission becomes the focus of local concern. Noise intrusion can interfere with many aspects of our environment, such as speech and telephone conversations. It has been found to decrease childrens learning skills. Exposure to excessive noise can also result in hearing loss.[1,2] Traffic noise is ubiquitous in communities and is a growing concern for local receptors (residences, churches, schools, etc.). In response to this concern, noise analysis are performed to estimate impacts from traffic and to assess mitigation techniques, such as the use of noise barriers. The available methods for noise prediction and analysis are numerous and include computational, graphical and computer modeling techniques. A noise prediction methodology, which is a simplified approach for estimating noise impacts from traffic,[3] has been presented.

This Traffic Noise Screening procedure utilizes graphical representations of traffic volume and roadway geometry that are based on the computerized FHWA STAMINA2.0 noise prediction model.[4] Graphs have been developed for several general scenarios by making certain assumptions. It would be impractical to develop graphical solutions for all the many possible conditions that can exist and be modeled to with STAMINA2.0. However, the TNS procedure is intended to help determine if more detailed noise analysis (such as with STAMINA2.0) are warranted. Careful judgment should be exercised in applying this graphical procedure to specific situations. The user should be familiar with basic noise analysis techniques and with the STAMINA2.0 computer modeling procedure.

This TNS procedure can be used for predicting traffic noise impacts on new development near

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existing roadways or on receptors (residences, churches, schools, etc.) located near existing roadways. In addition, more detailed noise modeling and/or monitoring may be required. Background noise or contributions from other sources are not included in the noise levels predicted from the TNS graphs. If available, this information can be combined (using appropriate computations for combining noise levels) with traffic noise levels estimated from the TNS graphs.

Background

Different means are available in estimating noise levels resulting from traffic. Three methods discussed here are the TNS Manual Method using monographs, HUD Noise Assessment Guidelines, and the STAMINA2.0 noise prediction computer model.

FHWA's Highway Traffic Noise Prediction Manual Method

The FHWA Traffic Noise Prediction Model Manual Method consists of equations that have been reduced to one monograph.[5] This approach can be used for hard or soft sites and uses information on separate traffic volumes for autos and light trucks, medium and heavy-duty trucks, vehicle travel speed, and receptor distance. This approach can be useful when a quick estimate is needed, but is subject to reduced accuracy and precision associated with the monograph and several assumptions. An Leq (L equivalent) of 67 dB(A) is the FHWA for evaluating traffic related noise impacts on sensitive receptors.[6] The Leq noise level descriptor is the continuous dB(A) level that would have produced the same or equivalent sound energy during the same time as the actual varying noise history. The Leq noise descriptor is one of the most widely used. Table 1 presents a summary of the ministry of environment republic of korea criteria for noise abatement.[7]

HUD Noise Assessment Guideline

The ministry of Environment Republic of Korea of Housing and Urban Development (HUD) has guidelines for assessing the exposure of housing sites during present and future noise conditions.[7] The approach is simplified for use by persons with little technical training in noise assessment. This method consists of graphs and a number of tables of correction factors. Adjustments can be made for stop-and-go traffic, and for speeds ranging from 40 to 100 km/h. Average daily traffic (24 hour) volumes are used as input. Noise sources addressed are roadways, aircraft and railroads. The degree of acceptability of the noise environment at a site is determined by the outdoor day-night average sound level (Ldn). The Ldn is the 24 hour equivalent continuous level in dB(A), with 10dB added to nighttime (10:00PM to 6:00AM) noise levels. The HUD guide for assessing the impacts of predicted noise levels suggests that Ldn values less than 65dB are acceptable.

Measurement

The environmental noise in Kwang-ju was measured by the municipal Office of Kwang-ju during the daytime in the summer of 1999. Five hundred and nine points were chosen as measurement points distributed uniformly in the city area, about 170km^2, the center of which coincided with the center of Kwang-ju. The positioning of buildings required additional measurement points. The median levels, L50, were measured at intervals of 500 seconds using microphones placed 1.2m above ground. The sampling rate was once per second. One hundred values of noise level at each mesurement point were analyzed to obtain the median level, L50. As the traffic volumes in the measurement periods were relatively stable compared to those of rush hour or midnight, the measurement sample length of 500 seconds was adequate. Traffic flow volumes along the trunk roads were also measured at the same time.

Approach

The FHWA's STAMINA2.0 noise prediction model was used to represent different scenarios consisting of various combinations of inputs. The results of the modeling were used to prepare a series of TNS graphs for predicting noise levels from different roadway configurations. Diagrams of the three roadway configurations considered are presented in Figures 1, 2, and 3 for a two-lane roadway, a four-lane highway, and a six-lane divided highway, respectively. Various traffic volumes, receptor distances, and travel speeds are presented on each TNS graph. Peak hour traffic data (for traffic volume and travel speed) are used. Estimated noise levels are hourly Leqs generated by STAMINA2.0.

The amount of noise due to traffic roadways depends on the roadway configuration, total traffic volume, vehicle travel speed, and distance of the receptor from the roadway.

The vehicle mix (i.e., percentage of automobiles and medium and heavy duty trucks) also affects traffic noise levels. Various methods in the STAMINA2.0 modeling are discussed below.

Roadway Configuration. Three roadway configurations were considered in representing three typical classes of roadways; two-lane roadway, four-lane roadway, and six-lane divided roadway (Figures 1, 2, and 3, respectively). The roadway segments are assumed to be flat, straight, and continuous. Traffic is free-flowing. The terrain between the road and the receptor is assumed to be a flat grassy surface (soft site), free of obstructions.

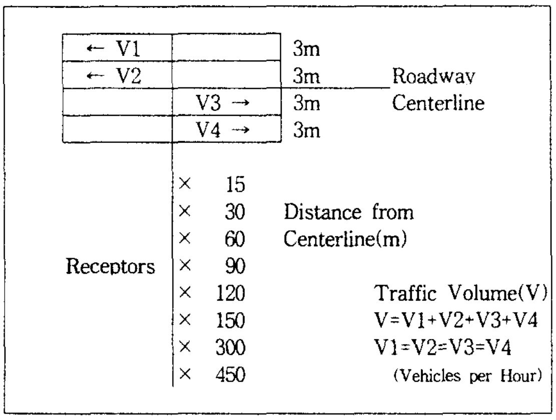

Figure 2. Four-lane Roadway Configuration.

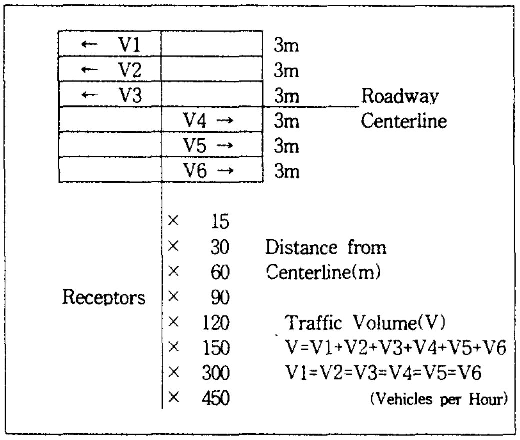

Figure 3. Six-lane Roadway Configuration.

The roadways are assumed to have lane widths of 3 m. Infinite roadway lengths (at least 700 m) are assumed in each direction from the receptor line. A TNS graph is presented for each of the three roadways considered (Figures 4, 5 and 6).

Traffic volumes. Various peak hour traffic volumes were used to develop the TNS graphs. The total peak hour traffic volume is presented on the X-axis and is the total hourly volume of the entire roadway. The total traffic volume is assumed to be distributed equally in each travel lane. The range of traffic volumes used are considered to be typical for each roadway type.[9]

When the hourly traffic volume approaches and exceeds the roadway capacity, it tends to reduce the average travel speed. This may result in lower noise levels than would be expected with the increased volume. As speed is reduced, engine and tire noises are also reduced. However, due to noise from acceleration and deceleration, stop-and-go traffic generally results in higher noise levels than traffic traveling at a slow but consistent speed.

Vehicle Travel Speed. Three typical vehicle travel speeds were used; 55, 70 and 90 km/h. These were considered to be constant and the same for each travel lane. Scales for each of the three speeds are presented on the Y-axes of the TNS graphs.

Receptor Distance. The orientations and distances of receptor points located on a line perpendicular to the roadway are shown in Figures 1, 2 and 3. Distances to receptor points shown on the graphs are measured from the center line of the roadway. The receptor points are at five feet above the roadway elevation to represent the typical position of the human ear.

Vehicle Mix. Vehicles are classified into three categories for purposes of noise analysis.

The first category is cars and light trucks; the second is medium-duty-trucks that have one rear axle with four tires; the third is heavy-duty trucks that have two or more rear axles. The scenarios presented assume a vehicle mix of 100% autos and light trucks.

The use of this simplified approach when screening traffic noise that involves medium-or heavy duty truck traffic should include an adjustment to Leq values obtained from Figures 4, 5 and 6. The adjustment factor to be used would depend upon the type and percentage of trucks in the vehicle mix. The U.S. Environmental Protection Agency suggests a peak hour vehicle mix of 96% autos and light dutytrucks, and 4% medium and heavy duty trucks.[10] FHWA equations for calculating reference mean energy emission rates for automobiles and medium and heavy duty trucks indicate the need for an adjustment of approximately 5dB for 4% medium and heavy duty trucks.[11,12] The user should employ careful judgment in applying adjustment factors to scenarios where the vehicle mix differs from 100% automobiles and light trucks.

Traffic Noise Screening Procedure

Use of the TNS procedure is described below:

Step 1. Establish roadway scenario.

Identify the following information, describing the roadway scenario to be evaluated:

Roadway configuration: (Refer to Diagrams)

· Two-lane roadway: Figure 1

· Four-lane roadway: Figure 2

· Six-lane divided roadway: Figure 3

Total traffic volume: (peak hour traffic, vehicles per hour, sum of all lanes)

· Average vehicle travel speed (55, 70, 90 km/h)

· Receptor distance from roadway centerline (m)

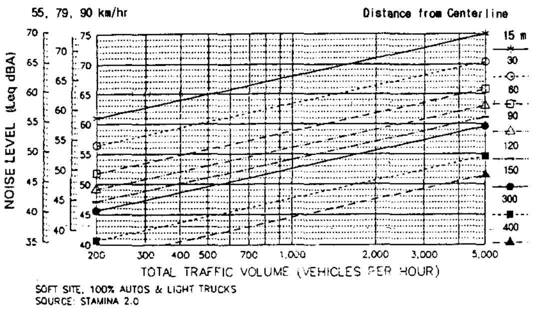

Figure 4. Traffic Noise Levels [Leq dB(A)] of two-lane Roadway.

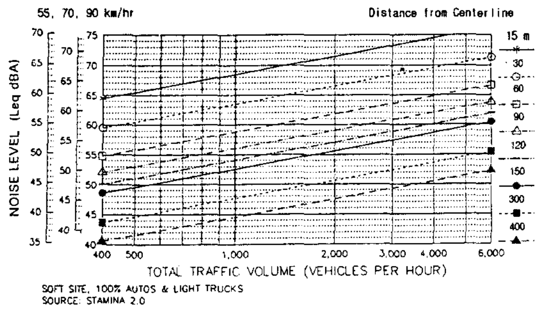

Figure 5. Traffic Noise Levels [Leq dB(A)] of four-lane Roadway.

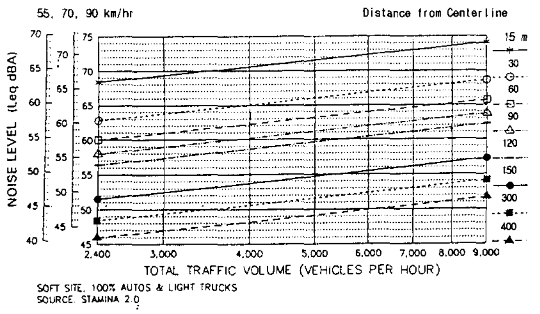

Figure 6. Traffic Noise Levels [Leq dB(A)] of six-lane Divided Roadway.

Note: This analysis is based on the following assumptions:

- Soft site (grass surface between roadway and receptors)
- Straight roadway of infinite length
- Constsnt vehicle speed
- Free flowing traffic
- No shielding (no tree, buildings, etc., between roadway and receptors)
- Flat terrain
- Level roadway (no uphill/downhill grade)
- Vehicle mix (100% automobiles and light trucks)

Step 2. Select the TNS graph.
Select the TNS graph corresponding to the roadway configuration identified in Step 1:

- Two-lane: Figure 4
- Four-lane: Figure 5
- Six-lane divided: Figure 6

Step 3. Predict traffic noise level.
Enter theTNS graph with total traffic volume (X-axis) and follow it to the
appropriate receptor distance line, and then read the estimated Leq noise [dB(A)] for the
average speed of concern from the Y-axis.

Step 4. Assess traffic noise impacts.
Assess the impact of the estimated traffic-related noise level. The following should be considered to determine if more detailed modeling analysis (e.g., with STAMINA2.0) should be performed. The presence of any of these factors suggests that more detailed modeling should be performed:

- Different roadway configuration
- Complicated topography or elevated/depressed roadway, etc.
- Receptor affected by a number of roadways or roadway segment, such as curves and multiple roadways
- Different vehicle mix (i.e., large percentage of medium-or heavy-duty trucks)
- Noise levels at or above 67dB(A)

Example

For example, in the case of the redential area (see Fig.7 and 8), the values (numbers in black with white backgrounds) of the calculated contour lines and of the measured levels (numbers in white with black backgrounds) agree quite well. Despite the fact that the calculated noise levels include the effects by the access roads, the pattern of the contours shows a reasonable tendency indicating a decline in the noise levels from the trunk roads to the surrounding area.

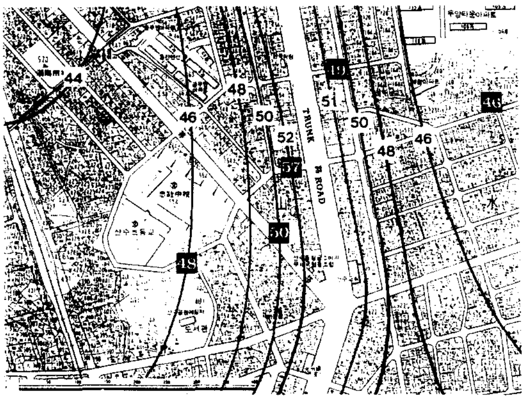

Fig.7. Map of newly constructed residential area with one trunk road. Measured values are indicated by white figures with a black background. Countour lines are shown and the levels are indicated by black numbers. [L50dB(A)]

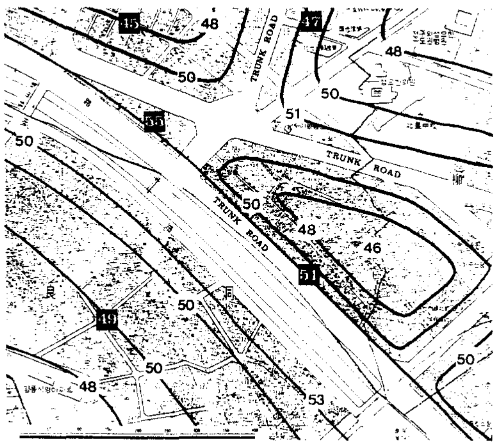

Fig.8. Map of old residential area with three trunk roads. Measured values are indicated by white numbers with a black background. Contour lines are shown and their levels are indicated by black numbers. [L50dB(A)]

On the other hand, in the case of the commercial area(see Fig.9), the agreement is not good. A large error of more than 3dB can be seen. This may be due to the noise produced by commercial activities in the area which might affect the measured noise levels.

Fig.9. Map of commercial area. Measured values are indicated by white numbers with a black background. Contour lines are shown and their levels are indicated by black numbers. [L50dB(A)]

An example to demonstrate the TNS procedure considers a residence near a four-lane roadway. The total traffic volume on the roadway during the peak hour is 2,000 automobiles and light trucks with an average vehicle travel speed of 90km/h. The distance from the roadway centerline to the nearest residential property is 30m. The character of the roadway is straight, flat and continuous. The area between the roadway and the property is level with the road, grassy, and free of obstructions. The TNS graph, Figure 5, is used to predict the noise from traffic on the four-lane roadway.

Using the peak traffic volume of 2,000 vehicles per hour and the receptor distance of 30 m, the Leq is predicted to be 66.5 dB(A) without background (Figure 10).

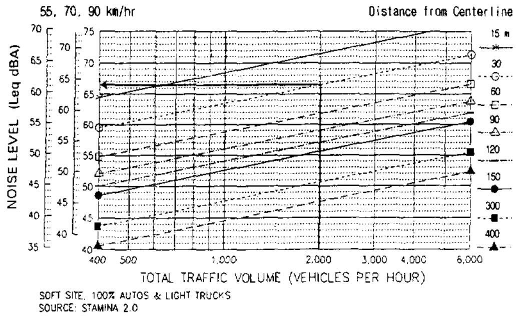

Figure 10. Traffic Noise Levels[Leq dB(A)] of four-lane Roadway.

Discussion

A simplified method for estimating and screening traffic noise associated with various typical roadway scenarios is presented. Comparison of noise levels can be made between the different roadway configurations, traffic volumes, vehicle travel speeds, and receptor distances. The TNS procedure is intended to screen traffic noise to help determine the need for more detailed modeling analysis of situations that are similar to the scenarios presented.

The TNS procedure is easy to use and requires peak hour traffic volumes and roadway geometry to assess hourly noise impacts (i.e., during peak hour traffic). The widely accepted Leq descriptor is utilized and may be used to estimate other noise values such as the Ldn. The basis of this approach is the FHWA's accepted STAMINA2.0 computer model. The screening approach presented here probably can be more accurately applied than the FHWA monograph or the HUD Guidelines. Although this procedure has less flexibility (i.e., in adapting it to use with scenarios that are different from those presented), additional TNS graphs could be developed for different roadway scenarios.

The TNS procedure can be an effective tool for planners and consultants involved in assessing community noise impacts from traffic. Careful judgement should be exercised in applying this graphical procedure to specific situations. The user should be familiar with basic noise analysis techniques and with the STAMINA2.0 computer modeling procedure.

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