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MONITORING LEVEL OF SERVICE NEAR URBAN HIGHWAY SEGMENTS BY NOISE LEVEL EVALUATION

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ABSTRACT

When possible, existing highway levels of service should be monitored by field measurements. As is the case with all fieldwork, traffic measurements are relatively expensive; they take time, personnel and equipment

This research look after the feasibility of developing an acoustic sensing model to monitor the traffic flow at the highway sections instead of continuous counting of volume or other method of traffic monitor and surveillance devices. Vehicle tires radiate the major source of road noise. These phenomena can be used by cross-correlating the acoustic responses from roadside microphones with highway measure of effectiveness. The results demonstrated the feasibility of detecting LOS in the acoustic manner.

The statistical regression technique gives power correlation model between the noise level as Noise Equivalent level or Noise Pollution Level and the density on the road sections. Other linear correlation models can be seen between these noise levels and the Level of Service of the highway but with less significant.

This noise measurement receiver continually measures noise levels and can give around-the-clock picture of LOS variations at highway section This model allows the designer/planner to obtain quickly the first approximation of the expected LOS.

KEYWORDS

Traffic Noise, Traffic Monitoring and Measure of Effectiveness.

INTRODUCTION

Highway evaluation is the most important process in the transportation engineering. In traffic analysis, many concerns towards this problem are done continually since the first steps. It is a fact that, traffic volume in highway is rarely constant with respect to time varying. It is changing from hour to hour rather that some time it is changing from minute to minute. These changes must be monitored for the highway in a continuous manner to evaluate the level of service works, then to control the traffic flow for the highway.

Many techniques of traffic monitoring are exist in such a manner of collecting the vehicle axle passages by Electro–mechanical or pneumatic tube [6]. Another developed a noise tolerant color segmentation algorithm and a recognition algorithm with video camera, which providing chromatic images of vehicles movements [11]. Other indirect methods use the radar speed meters, which is a portable modern unit [12]. All these procedures have many advantages and disadvantages of its use. The use of inductive loop presence detectors has many disadvantages. This include its inability to count a single traffic lane, its high visibility, and some problems with air switches going of alignment or double counting through the recognition of an echoed [16]. Other method required high financial package as well as the difficulty of the image recognition. The video camera monitoring need long time to extract the data so it still not particularly useful for routine surveys [3]. The radar counts the route volume by indirect way and has an equipment error in low speed in addition to the error related to the angle of the radar beam.

After that survey of the monitoring equipment, a new and efficient method should be selected to apply this monitoring. A fine balance should be achieved between a sufficient number of quality locations on one side, and the cost and availability of resources on the other [12].

Generally traffic flow might consider the major source of observed disturbance in urban area. So the major noise came from it [13]. Practically this is due to tire – roadway interaction and it is closely to traffic activity. Clearly it can say that the noise emitted follows the moment – moment details of traffic patterns so that it can be considered one of the monitoring tools of traffic flow, which is highly correlated with traffic parameters. Noise from automotive ignition systems and power transmission is studied in many papers and it has a minor effect on total noise emission [9].

It is decided to develop a prediction method for evaluation of traffic service level by monitoring the bulk noise contribution from each group of vehicles. In the other hand, a study of freely flowing traffic noise or theoretical consideration of individual vehicle noise cannot offer a suitable simulation of the flow rate. It might omit the effect of the surrounding area and other parameters. Thus, the prediction method must be able to handle traffic situations involving different mixes of cars and trucks, which traveling at different road speed [6]. So, the purpose of this research is to discuss how to conform noise measurement in acoustic concepts, to demonstrate how different vehicles contribute of over-all traffic level of service, which can be achieved by different roadway recording.

The main objective of this procedure is to derive an empirical model to infer the highway operation from measured value of noise. This is done instead of measure of other physical parameter and traffic related elements. In that way, offering a design / analysis tools by which highway engineers can evaluate highway level of service (LOS) in immediate approach day or night to the control office by simple technique telephone cable or other communication access.

SITE MEASUREMENTS

Different sites of traffic condition and level of service distribution were investigated as the several traffic parameters varied. The idealist site must be in the simplest case and assumed as a perfect road of constant cross-section, carrying constant vehicle volume at certain period. Also, it needs a highway with a straight grade or very shallow vertical curves in a relatively flat area with tract-type residential development that parallels to the highway [5]. The distance of (10m) would be subjected to the same from both sides of highway, and only a couple of receivers can adequately define the noise impacts. The highway can be defined as an element of constant infinite noise- source and constant characteristic [14]. Therefore, two arterioles in Mosul City and the third one in Kurkuk City were selected. They are the University, Al-Derkazleai & Baghdad arterioles respectively. About fifty-five sections on these highways were selected to cover much of the variation of traffic characteristics.

Applying the measurement to several approaches of these highways to cover much of the dynamic range of interest parameter, thus the results derived on the different bases may be similar. In addition, controlling the external noise in the daytime rather than evenings or at night might give results that are more logical. The noise measurements and other traffic parameter of highway selected should be made under a sampling basis over an extended period of time (a number of months) [7,12].

The standard sound level meter with decibel A-scale (dBA) reading is used. It can provide a single number measure of the stimulus that weights the frequency spectrum of the signal in accordance with subjective sensitivity to sounds of different frequency. The sound level meter is placed at a standard position of (1.2~1.5m) height from road surface and (1 m) away from curb at side of the highway unless dictated by unusual circumstances or other requirements [5,7,12]. The direction of the sound meter is corrected to the wind direction; however it put in the random reading option, which detected the noise source in any direction. Therefore, the observed data is independent of the direction of motion of the target vehicle, it dos not matter where the vehicle is traveling toward or faraway receivers (detector). The noise receivers should be carefully selected for noise analysis based on their acoustical representativeness [5].

The noise levels were measured simultaneously with the traffic parameter such as traffic volumes, percent of heavy vehicles, average speed, etc. The selected sections in these arterioles have road elements to be identified. These elements can be described by series of parameters that must be known or measured, and can be gathered under one of these topics traffic parameters, roadway characteristics, and observer characteristics. Noise measurements were done for variable sections for one hour at least to obtain vary values of noise level. The variation in ground impedance due to changes in ground cover and surrounding during different seasons of the year were investigated for selected section. An alpha factor is specified between each roadway and receiver [16]. The factor describes the amount of ground attenuation that occurs between the source and the receiver. The whole topographical situation for the proposed highway would be embedded in the measurement process. This may add a farther seasonal effect that influences the detection of noise, which might need to correct by seasonal correction factor in practice.

COMPUTATION OF NOISE LEVEL

Many studies were undertaken to review the community noise problems in complaint situations and to derive a method of predicting average community response to noise. Some study focuses on optimizing traffic conditions with other traffic characteristics such as light. Such a model was developed of a traffic queue at an intersection and optimized the problem in consideration [15]. It is believed that such a demonstration project could be conducted in conjugation with the experimental -programs for recognition the sound and identifies the noise level to give certain value.

The noise analyst should therefore carefully plan the locations, times, duration and number of repetitions of the measurements before taking the measurements. Meteorological (atmospheric) and other environmental conditions can significantly affect noise measurements. Particular attention should be given to the meteorological and environmental constraints described in the Traffic Noise Analysis Protocol [5]. For noise level, specific source mechanisms are not well defined nor are many quantitative measurements available in our country. Yet, details for understanding and control of the noise sources should be evaluated for any long-term progress. These can sizable reductions of the noise produce by highways. Traffic noise level has been developed by mathematical model from FHWA [16]. This model is more than methodology for predicting the noise level for existing and future highway. It can determine the potential effects on the land use sensitivity. Thus, were and when the treatments can applied. This can be computed by computer program, which contain many parameter concerns that community.

Several descriptors are used to express sound levels, which correlate with human perception. The Noise Equivalent/Energy Level (Leq) is a noise exposure descriptor that can used to assess the impacts of roadway noise. Leq is calculated by averaging the dBA noise levels measured over a specified period of time [4]. Use of Leq is appropriate for traffic noise analysis because these levels are sensitive to both the frequency of occurrence and duration of transportation noise events. Roadway noise levels are assessed in terms of a one-hour Leq, which is the average of instantaneous dBA sound levels measured over a period of one hour, expressed as Leq(h), which can be developing by the following formula[12]:

$$L_{eq} = L_{50} + (L_{10} - L_{90})^2 / 56 \qquad \text{..(1)}$$

Where: L50 = Noise level (dBA) that is exceeded 50 percent of the time;

L10 = Noise level (dBA) that is exceeded 10 percent of the time;

L90 = Noise level (dBA) that is exceeded 90 percent of the time.

In most cases, the noise levels deals with noise mitigation are average over individual noise events, such as the passage of individual vehicles. One commonly encountered average noise measures is the Noise Pollution Level (NPL), which is calculated as follows [5] :-

$$NPL = L_{eq} + (L_{10} - L_{90})$$
$$\therefore \cdots NPL = L_{50} + (L_{10} - L_{90}) + (L_{10} - L_{90})^2 / 56 \qquad \text{.........................(2)}$$

Many procedures developed in the past to attempt the highways noise level and its criteria [2,5,7,8,10]. Because of the multitudinous of fundamental, certain conditions must be weighted more heavily than others cases. The noise emitted by an automobile as it passes an observer deals with many parameters such as speed, type of automobile, headway and others. This considered the same parameter used in calculation of the service flow rate (v/c) and the LOS working in these sectors. The ultimate output of the procedure would be the calculation of the noise levels for ground positions on a mesh or grid system. From the output of the grid values, noise contours could be readily drawn.

LEVEL OF SERVICE CALCULATIONS

The highway evaluation by the term LOS and the noise emitting from the ambient of highway had the same criteria. It can be advocated by the simple representation of the main independent variable, which can derive form it. Various aspects of traffic noise and highway evaluation had been investigated. It cannot perform extensive analysis of all configuration and community situations along the route of a proposed highway. The selection of design parameters must be made as a simple, straightforward as possible, which related to capacity consideration and do not relate to safety or other factor [15].

The basic computer program for estimating LOS and the design speed using the HCS2000 was used. Any realistic number of lanes, with or without median separation can be collectively grouped as an equivalent (single lane). The estimation of LOS and of the characteristics is based on the ideal conditions [1]. Then they can be represented in numerical expression instead of alphabetical.

Although speed is a major concern of drivers, freedom to maneuver within the traffic stream and the proximity to other vehicles are also important. LOS criteria are based on the typical speed-flow and density-flow relationships. The LOS boundaries have each corresponding to a constant value of density. The LOS on a multilane highway can be determined directly based on the Free Flow Speed (FFS) and the service flow rate (vp) in pc/h/ln. After identify the appropriate segment of six lanes divided highway, the procedure can be simplified in few steps [1]. The measured FFS for the studied highways is around 90 km/h. On the base of this value construct an appropriate speed-flow curve of the same shape as the typical curves in the HCM2000. The curve should intercept the y-axis at the FFS. Then based on the flow rate (vp), read up to the FFS curve identified above to determine the average passenger-car speed and LOS corresponding to that point. Finally, the density of flow can be determined according to the following equation: -

$$D = {}^{vp}\!/_{S} \qquad \text{...(3)}$$

Where : D = density (pc/km/ln),

vp = flow rate (pc/h/ln), and

S = average passenger-car travel speed (km/h).

The LOS also can be determined by comparing the computed density with the density ranges provided in HCM2000 [1]. All these calculation were done using software of HCM2000 copyright on 2000 by TRB (HCS2000).

CORRELATION BETWEEN NOISE & LOS

There is considerable knowledge about the effects of steady – state noise (quite condition) and the relative annoyance of individual noise producing event [16]. However the effect of time – varying noise and the complexities of noise events has not been thoroughly investigated.

Many references show the variation of traffic noise over time for various conditions. By representing the noise measured value with respect to time elapsed calculated as NPL and Leq , fluctuation with interrelated highway measure of effectiveness, the correlation seem to be clearly and can give an initial conception. These relationships can be shown in Figure (1) with density of highway sections, and with the traffic volume represented by (vp) as shown in Figure (2) with less correlation with the dependent variable. Finally, the correlation with the LOS of these segments is represented in numerical value instead of the alphabetical grade as shown in Figure (3). It seems very clearly the contribution of density as well as volume in rising or falling in the noise values. The noise pattern can be seen to be spikes in lower noise level and to be coalescing with general rising in the noise level when the traffic volume increases. At this situation, the spike effect of single passing of vehicle is less pronounced [16].

This correlation is clearly inapplicable to high – density traffic flow, and modification of the foregoing - analysis is possible. The developed model has embedded parameter of road characteristics and capable of tolerating the intensity of traffic volume for noise emission. The correlation between them can be seen in Figure (4), for each point of measures in the study-area. It should be note that the highways noise data produced previously are forming on normal (Gaussian) distributions.

Simple correlation appeared for mixture of various vehicle classes based on the noise output of the different measure of effectiveness can be shown in Figure (4). In general, traffic situation is composing of infinity of variables, different cars driving at different speeds through continuously change in highway configuration and surrounding terrain. Obviously, to make the problem practicable certain assumptions and simplifications must be made by define the most important parameters involved and thus permits the prediction of the true situation with a certain degree of accuracy.

The only significant effort looked for correlation between density or corresponding flow rate and noise measured rather than the integer numerical LOS. The plot of highway density versus the noise measured satisfies the scores as shown in Figure (5) and Figure (6). In the other hand, less correlation appears between the noise measurements and the LOS as shown in both Figure (7) and Figure (8). By taking these considerations into account; the value judgment emphasis to be placed on various aspects of the acoustic environment.

STATISTICAL ANALYSIS AND RESULTS

The principle technique has to look for improved correlation between the physical measurement (noise – level distribution) and the parameter survey of traffic evaluation. Many reasons show that traffic noise and flow rate have same identification. First, traffic flow is not characterized by uniform spacing of vehicles as well as noise emission. Second, the absorption of sound in the atmosphere is a function of frequency and distances.

The regression techniques are used to process the noise level measured with the corresponding LOS or density for each section, and with the state where the largest coefficient of determination is found. These models are made by using two packages the SPSS v.11.0 and STATISTICA- Stat Soft, Inc. 1999 v.4.9.3. Table (1) gives the output of initial trials of various correlations of the dependent variables, (Traffic Density and LOS as numerical expression) with the most correlated independent variables obtained by stepwise regression. These results show no significant correlation, because the constant values have no means in such models. They have negative values some time in linear regression. That means no noise (or any sound) lowers than that value of traffic volume, which is not logical for such models.

The noise measurements are used both to determine existing ambient and background noise levels, and to calibrate the noise prediction model when appropriate. So calibration must be made through the quite period and details of noise measurements should be referred to modeling existing noise levels near existing facilities. Although measurement is preferred adverse environmental conditions, construction, unavailability of good measurement sites, or lack of time may make it necessary to calculate existing noise levels, using the appropriate traffic noise prediction model. However, this can only be done in areas where a defined highway source exists with minimal surface grid traffic or other contaminating noise sources. Often, a combination of measurements and modeling at various receivers is used to determine existing noise levels.

The noise source characteristics have substantially changed after the traffic makes an event. Thus making sound correlation if the model through the origin. Table (2) shows the multiple regression models without constant of all independent variable (noise levels) with the dependent variable (traffic characteristics). These models have a significantly correlation with acceptable value of standard error of estimate. The models are found successful and in particular they contributing all the expected variables.

Models with all dependent variables of noise level are meaningless because of high correlation between them. So a distinction will be made between independent variables to predict the traffic characteristics. Table (3) gives the result of different correlation of the selected independent variable Leq and NPL with the dependent one. The adjusted coefficients of determination illustrate that the power relation is the better representation of the correlation between variables for density. This relation is less complexity than others, when they have same value of adjusted coefficient of determination(R^2). As well as,it is linear for LOS.

The power relationship is shown in Figure (5) and Figure (6) for density – noise, which offers a model easy to apply. While, Figure (7) and Figure (8) shown the linear relationship for LOS – noise plotting. A comparison of measured and estimated results will be used for general planning, to convey the concept of noise, and to increase the reliability of the estimates, since these are often questioned. This can be due to the difficulties of relating to a noise level expressed as a hourly average, when in fact there are periods with higher and lower noise levels than the average.

Model calibration insures that existing noise level at the measured and modeled receivers are based on the same datum. The purpose of model calibration is to “fine-tune” the prediction model to actual site conditions, which are not adequately accounted for, by the model. In general, model calibrations are not recommended if site conditions, highway alignment, and profile are not expected to change significantly.

There are plans to extend the noise measurement with the addition of permanent traffic counting to classify the vehicles, so that measured noise levels can be compared with information on traffic volume and composition. Additional model for determining existing percent of Heavy vehicles for existing section can be seen in Figure (9). This model can be applied after make more calibration of noise levels at a greater resolution. This will become easier when the correlation between measured noise levels and actual traffic volumes at a known locality can be shown, especially to observe the effect of height of noise meter.

MODEL DISCUSSION AND CONCLUSIONS

The aims of supplementing traffic characteristics with a permanent noise measurement is to gaining a picture of how the traffic volume vary over the day, and enabling a comparison of measurement data with expected highways level of service. The noise measurement was set up in conjunction with traffic characteristics. Thus, the build system was designed to continually measure noise levels and store the information in a database, whenever possible. However, this may often not be the case. The selected receiver may not be a good or accessible location for setting up a sound level meter. In addition to the measurement sites, additional receivers are modeled to establish better resolution of noise levels.

On the base of foregoing considerations, suggested model for road service estimation from traffic noise can be derived. The research develops the criteria that should be used by the highway designer / planner. Thus, assessing the impact of the proposed traffic congestion on the adjacent highway facilities, then estimates the LOS quickly in considering desirable manner. It is believed that the performance of estimated model must have a demonstration study under long term of practicing to obtain the correction factors for other road segments, like intersections. In addition, making a better prospect for the stopped vehicle or crowded one also may give a signal for highway incidents.

Model calibration is defined as the process of adjusting calculated future noise levels by algebraically adding a calibration constant derived from the difference between measured and calculated noise levels at representative sites. So monitoring LOS of highway sections can be applied. However, limitations of collection data along highways section do not lend themselves to model calibration. By comparing the measured and estimated values, it can be seen that the measured values are generally higher than the estimated ones. It is seldom to have a value higher than the measured base value. Empirically derived model is limited to the extent that data are available for the appropriate range of observation conditions. Although the empirical model are becoming available to statistically describe LOS- noise interference, there are many questions that must be answered before criteria can be developed on the basis of the traffic evaluation

RECOMMENDATIONS

The available data and the developed model do not describe adequately the type and density of buildings or surrounding areas where the measurements were performed. So, further measurement where the type of area (commercial, residential, multi-story) and density of structures are the variables is suggested to define this adjustment more precisely.

- The full benefits of the data will not be known until a full year of measurement is available. Only then will it be possible to see how noise levels vary annually as well as daily. The shortcoming of the data is the shielding of the effect of special event and other circumstance must be studied more precisely.
- New data in other highway facilities may contribute greatly to the high noise levels. So the derive model must be examined with other highway section (interchange, elevated, depress, etc) when stochastic input disturbances and measurement noise are introduced into these model. However, predicted noise monitoring software must remove these events from the overall noise levels.
- A general site requirement must be studied for selection of noise measurement sites, which may be governed by the same

general guidelines as those for selection of sensors of highway incidents.

- ❖ The choice of receiver must acoustically equivalent of the area of concern. A project involving a major freeway that includes interchanges cuts and fills in an area of rolling terrain and non-tract mixed residential and commercial development will likely needed to study.
- ❖ As part of a comprehensive measurement program to monitor traffic, the use of simulation models to determine noise levels is recommended. As well as, monitoring terminal with GSM modem and Noise Monitoring Software can take place on one of the major approach roads. It is also possible to compare the results with meteorological data from an air station.

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Table (1) Various Correlation's with Constant Between The Dependent Variables (Traffic Characteristics) And Independent Variable (Noise Equivalent Level "Leq") Of The Study Sections Of Arterioles.

Dependent Variable	Relation Type	(R)	(Adj. R^2)	Equation And Coefficients
Density	Linear	0.299	0.0727	Density = -11.545 + 0.259 Leq
Density	Power	0.302	0.0739	Density = $0.000722*(Leq)^{2.1462}$
Density	Exponential	0.302	0.0739	Density = 0.9012+0.028449 Exp(Leq)
Density	Logarithmic	0.299	0.0723	Density = -76.17318+19.464 Log(Leq)
Density	Inverse	0.298	0.0717	Density = 27.366 - 1461.98 (1/Leq)
LOS	Linear	0.440	0.1784	N LOS = -6.383+0.108 (Leq)
LOS	Power	0.460	0.1969	N LOS = $6.3699E\text{-}10*(Leq)^{5.014385}$
LOS	Exponential	0.460	0.1968	N LOS = 0.01096+0.066475 Exp(Leq)
LOS	Logarithmic	0.439	0.1780	N LOS = -33.432+8.1423 Log(Leq)
LOS	Inverse	0.439	0.1775	N LOS = 9.848 – 612.6124(1/Leq)

Table (2) Model of Multiple Regression Analysis Without Constant For The Dependent Variable (Traffic Characteristics) And All Independent Variable (Noise Levels) of The Study Sections Of Arterioles.

Dependent Variable	(R)	Adjusted (R^2)	Standard Error of Estimate	Independent Variable	Coefficients (B)
Density	0.956	0.906	2.535	NPL	0.181
				L_{90}	0.199
				L_{50}	0.189
				L_{10}	0.192
				Leq	0.186
N LOS	0.937	0.866	0.685	NPL	0.168
				L_{90}	0.204
				L_{50}	0.188
				L10	0.187
				Leq	0.181

Table (3) Adjusted Coefficient Of Determination (Adj. R^2) For Various Correlations Without Constant For The Dependent Variables (Traffic Characteristics) And Independent Variables (Noise Level) Of The Study Sections Of Arterioles.

Relation Type	Noise Equivalent Level(Leq)			Noise Pollution Level (NPL)		
	Density	NLOS	vp	Density	NLOS	vp
Linear	.933	.893	.933	.930	.891	.931
Logarithmic	.929	.889	.930	.929	.888	.930
Inverse	.922	.876	.923	.921	.876	.922
Cubic	.934	.905	.936	.930	.893	.93
Power	.987	.642	.999	.986	.647	.999
Exponential	.987	.660	.998	.986	.653	.997

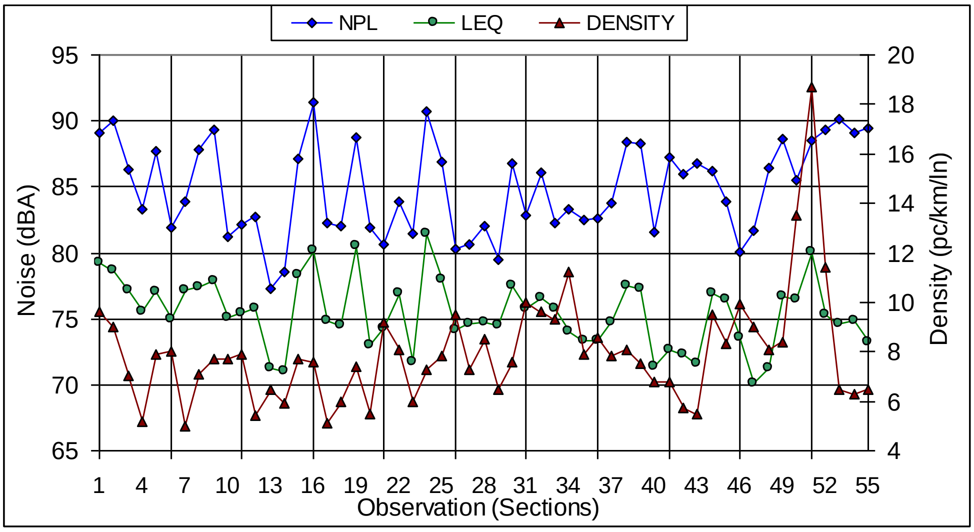

Figure (1) Noise Pollution Level and Equivalent Noise Level Frequency Conjugated with Highway

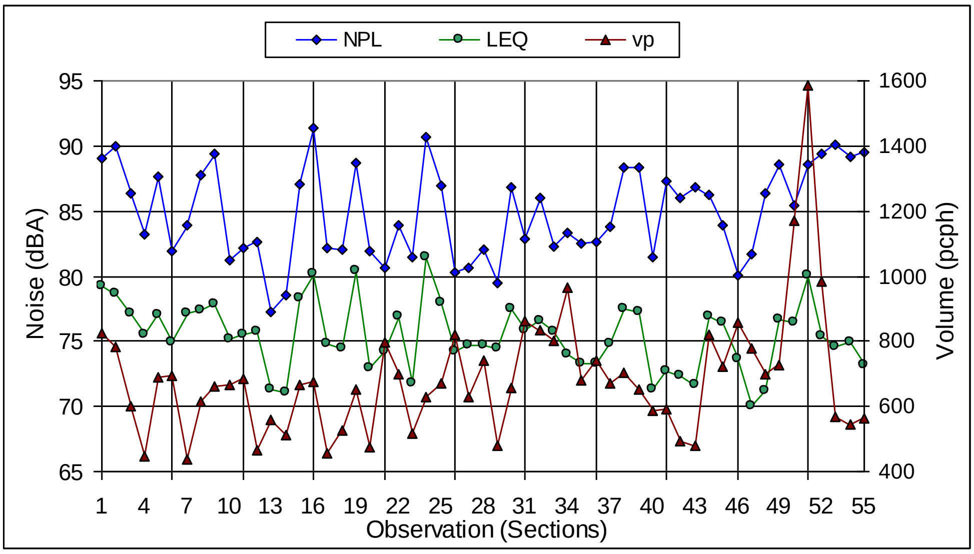

Figure (2) Noise Pollution Level and Equivalent Noise Level Frequency Conjugated with High way

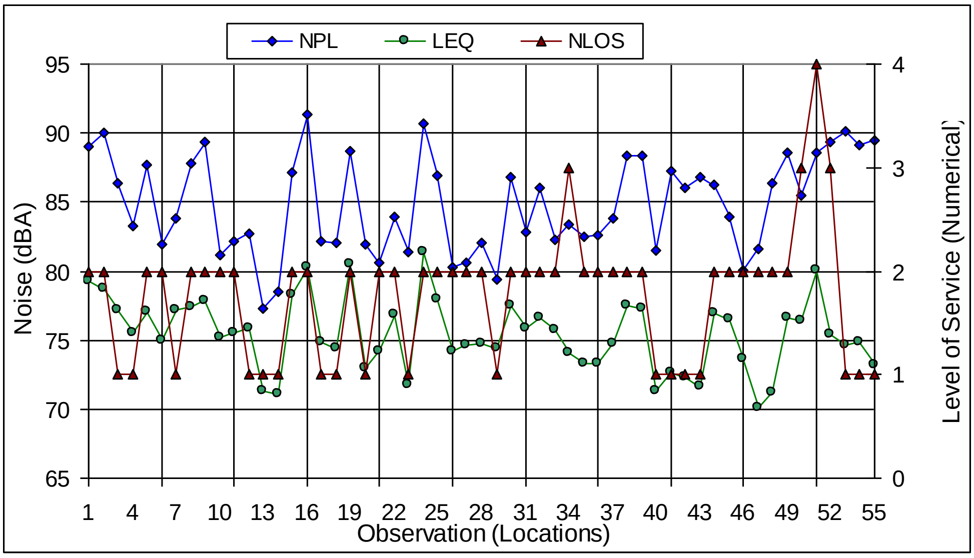

Figure (3) Noise Pollution Level and Equivalent Noise Level Frequency Conjugated with Highway

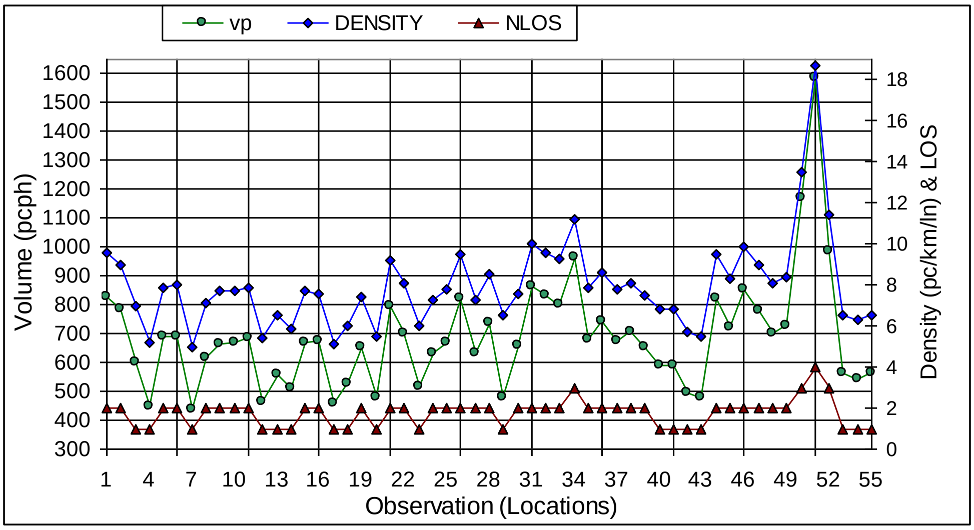

Figure (4) Correlation between Measure of Effectiveness For Selected Sections of Study highways.

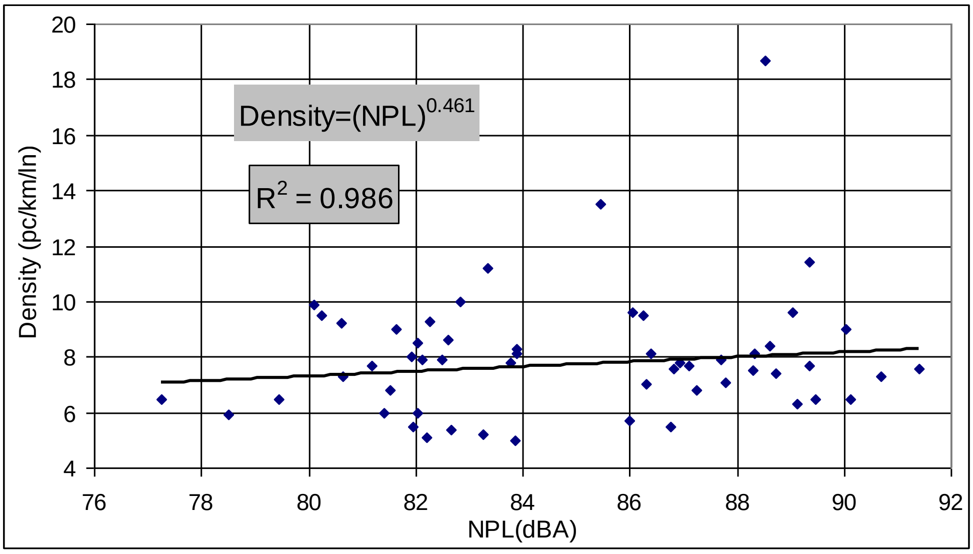

Figure (5) Traffic Noise Pollution Level Against Highway Density For Selected Sections.

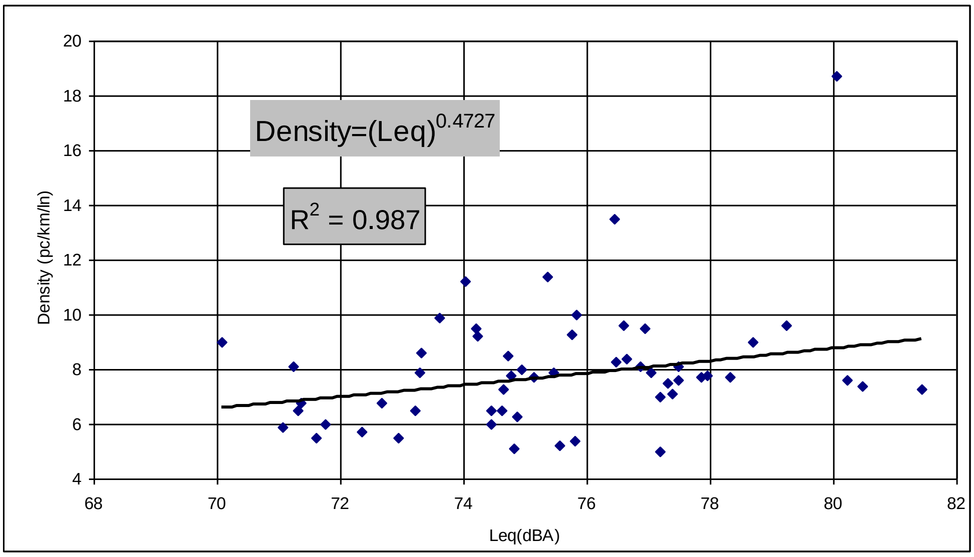

Figure (6) Traffic Equivalent Noise Level Against Highway Density For Selected Sections

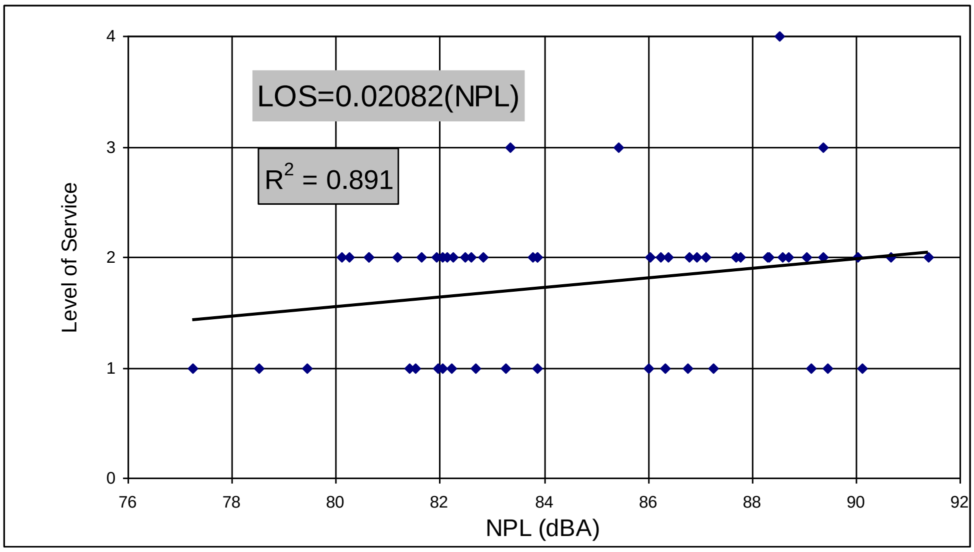

Figure (7) Traffic Noise Pollution Level Against Level of Service For Selected Sections.

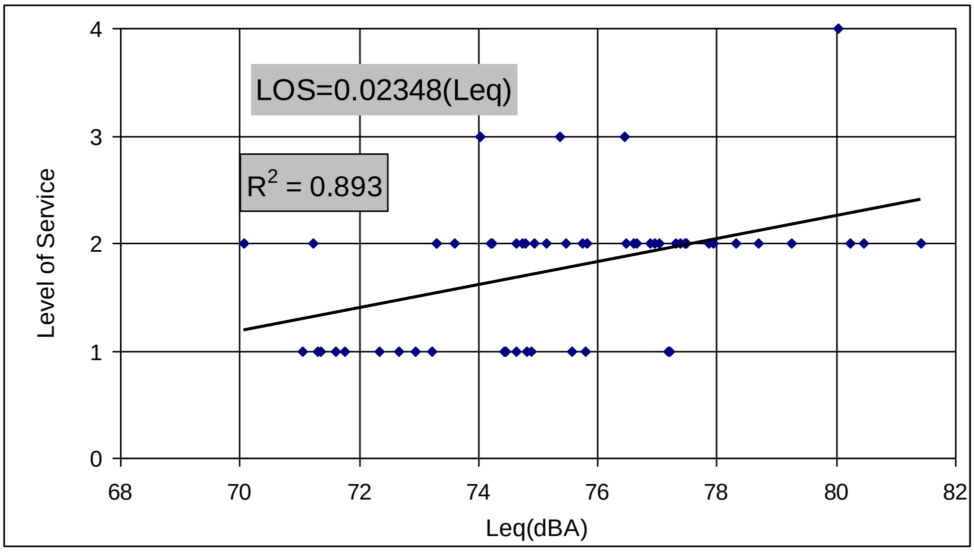

Figure (8) Traffic Equivalent Noise Level Against Level of Service For Selected Sections

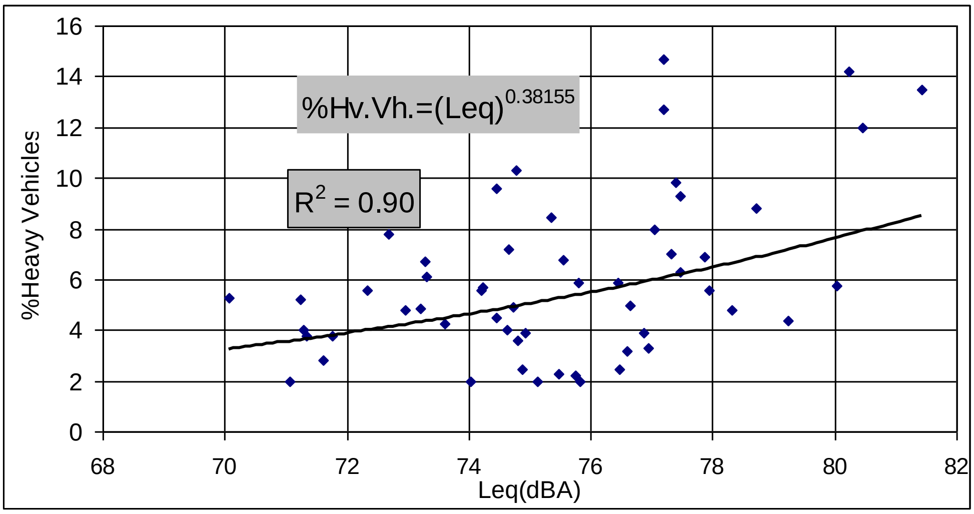

Figure (9) Traffic Equivalent Noise Level Against Percent of Heavy Vehicles For Selected Sections.

مراقبة مستوى الخدمة لمقاطع الطرق الشريانية داخل المدن بتقدير مستوى الضوضاء

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الخلاصة

إن المراقبة المستمرة لحالة الخدمة على الطرق من الأمور المهمة الواجبة في أقسام الطرق. وهي تتطلب الكثير من الجهد والمصاريف للمتابعة الموقعية .

أعد هذا البحث كمحاولة لإضافة طريقة بسيطة لأساليب مراقبة حالة الخدمة على الطرق. تعتمد على أساس التحسس الصوتي لمستوى الضوضاء في مقاطع الطرق بدلا" من الطرق الأخرى التقليدية منها أو المتطورة. أن الجزء الأعظم من الضوضاء على الطرق ناتجة عن عجلات المركبات المتحركة على الطريق لذا يمكن تطوير علاقة بين مستوى الضوضاء التي تقيسها لاقطة صوتية على مقطع الطريق وبين الحجم المروري المتواجد حينها ، أو أي مقياس من مقاييس خصائص حركة المرور.

تم الحصول على علاقة إحصائية بين مستوى الضوضاء على أساس المعدل المكافئ للضوضاء أو مستوى التلوث الضوضائي وبين الكثافة المرورية على الطريق كعلاقة أسية. أو كعلاقة خطية بين مستوى الضوضاء ومستوى الخدمة على الطريق ولكن بمقاييس إحصائية أقل معنوية. أن هذه النماذج يمكن أن تعطي صورة أولية على مدار الساعة لتغير مستوى الخدمة على المقاطع المرورية للطرق وبكلفة وجهد قليلين، مما يتيح لكل من المخطط والمصمم أن تتكون لديه صورة أولية عن مدى خدمة تلك المقاطع.

الكلمات الدالة

ضوضاء المرور، قياس ضوضاء المرور و مراقبته.