Journal of Siberian Federal University. Engineering & Technologies 2022 15(2): 248–260
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DOI: 10.17516/1999-494X-0388

УДК 625.78

# Traffic Noise Forecasting on Tashkent City Main Streets

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Received 17.02.2022, received in revised form 09.03.2022, accepted 17.03.2022

**Abstract.** Traffic noise is considered to be the most important that must be eliminated within the environmental problems of cities, as well as lead to various diseases of the population living in the roadside area. The article analyzes the work done to date on this topic, and for the first time examines the relationship between traffic flow and its impact on the noise level, which is the main source of traffic noise on the main streets of Tashkent. Traffic noise measured by GOST 20444–2014 «Noise. Traffic flow. According to» methods of measuring noise description « conducted in the 1 class NORSONIC140(Nor140) noise according to GOST17187–2010(IES61672–2002). Also, on the basis of the research, a model for forecasting traffic noise on the main streets of Tashkent was developed and compared with other models.

**Keywords:** City highway streets, traffic noise, traffic intensity, traffic composition, traffic speed, basic diagram of traffic flow, density of trasnport flow, practical road capacity, regression analyze, model, prediction models.

Citation: Kholikov, A.I., Azizov, K. Kh. Traffic noise forecasting on Tashkent city main streets, J. Sib. Fed. Univ. Eng. & Technol., 2022, 15(2), 248–260. DOI: 10.17516/1999-494X-0388



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# Прогноз дорожного шума на главных улицах Ташкента

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**Аннотация.** Считается, что шум трафика – наиболее важный элемент, который должен быть устранен в рамках решения экологических проблем городов, поскольку может привести к различным заболеваниям населения, проживающего в придорожной полосе. В представленной работе впервые исследуется связь между потоком трафика и уровнем шума на главных улицах Ташкента. Шум движения оценивали согласно ГОСТ 20444–2014 «Шум. Транспортные потоки. Методы определения шумовой характеристики» и ГОСТ 17187–2010 (IEC 61672–2002) «Шумомеры» в соответствии с руководством пользователя Norsonic 140 (NOR140). На основе исследования была разработана модель прогнозирования дорожного шума на главных улицах Ташкента, проведено ее сравнение с другими моделями.

**Ключевые слова:** улично-дорожная сеть, шум дорожного движения, интенсивность движения, состав движения, скорость движения, принципиальная схема транспортного потока, плотность транспортного потока, практическая пропускная способность, регрессионный анализ, модели прогнозирования.

Цитирование: Холиков, А. И. Прогноз дорожного шума на главных улицах Ташкента / А. И. Холиков, К. Х. Азизов // Журн. Сиб. федер. ун-та. Техника и технологии, 2022, 15(2). С. 248–260. DOI: 10.17516/1999-494X-0388

## Introduction

The impact of traffic noise on a person is an increasingly environmental problem that is not adequately assessed. Over-the-norm noise levels pose a risk to human health, contributing the most to traffic noise[1]. Studies show that the most common source of noise in our environment today is transport-related, traffic noise becomes the main source of noise in urban conditions [2]. Road traffic noise is one of the most relevant sources in the environmental noise pollution of the urban areas where dynamics of the traffic flow are much more complicated than uninterrupted traffic flows [3]. he major sources of noise are industrial noise, traffic noise and community noise. Out of the above three noises the source that affects the most is the traffic noise, almost 70 % of noise is contributed by vehicle noise [4].

A total of 2380 km in the city of Tashkent are streets and roads, which of 284 (12 %) km are main streets of the city, other 5 (0.2 %) km are cement-coated and 2375 (99.8 %) km are paved roads [5].

At present, the vehicles are considered the main source of noise that can damage the environment, and in cities it is character by the traffic intensity. Despite the increase in the level of motorization in our country over the years, studies on the state of traffic noise in the city of Tashkent have not been carried out to this day.

According to observations from Australian researchers, in large cities noise reduces the duration of human life to 8–12 years [6,7]. Also, on the negative impact of noise on a person, noise was found to be 36 % more dangerous than smoking [8].

The negative impact of noise on a person can be seen in the following 1-th scheme in general [9].

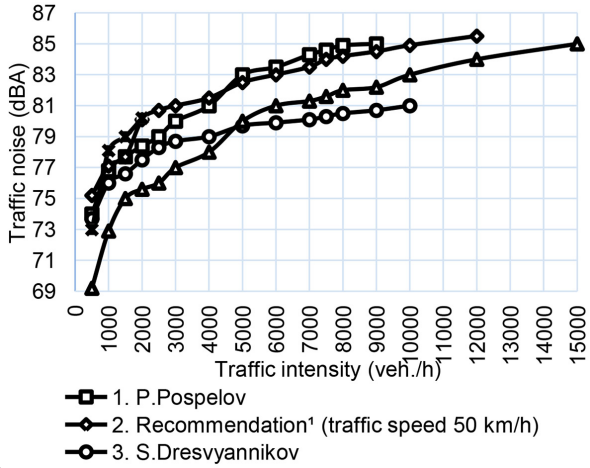
**SCHEME 1. Negative impact of noise on a person**

| | | | | |
|---|---|---|---|---|
| ***Noise level, 30-40 dBA*** - At night it can cause anxiety and malaise. | ***Noise level, 50-60 dBA*** - Has a harmful mental effect. | ***Noise level 70 -85 dBA (long time effect)*** - Headache; - Feeling heavy at the end of the working day or at the end of the day(in the city); - Memory thirst; - Dizziness when moving sharply; - Slow concentration of attention; - Drop the mood; - Anger output; - Change of skin sensitivity; - Falls in working capacity, rapid fatigue; - Sleep rhythm disturbances(daytime sleepiness, night sleep disturbance); - Nervno-fatigue and weakness associated with psychological effects; - Decreased appetite; - Temporary hearing loss during noise(infection after noise exposureoladi); - Pain in the heart, stomach and gallbladder; - Violation of heart activity and tone. | ***Noise level 85-90 dBA (long time effect)*** - Ear pain; - Decreased hearing at high frequency; - Loss of hearing as a result of continued exposure. | ***The noise level is higher than 130 dBA*** - Contusion; - Sharp weakening of the ability to lead. |

## 2. Methods

Traffic noise can also be seen as an increase in traffic noise with an increase in the amount and speed of movement on the basis of a certain law. The results of the research conducted by most scientists[10,11,12,13,14] are summarized below in Fig.1.

The results of the research presented in Fig. 1 above show that the traffic speed and the traffic intensity should be taken into account the percentage of trucks contained in it. To date, no observations




[1] Recommendations for taking into account the requirements for environmental protection in the design of highways and bridge crossings.

Fig 1. The effect of the amount of movement on traffic noise (the graph was prepared by A. Kholikov based on the authors' data)

have been made on the impact of the share of trucks in the amount of movement of the main streets in the cities of the Republic on traffic noise. G. Osipov [13] and P. Pospelov [15] conducted observations of the influence of the share of trucks in the volume of traffic in the CIS countries on traffic noise, the results of which are presented in Fig. 2.3, respectively.

According to the above information, it is necessary to know the state of traffic noise in the main streets of Tashkent City. For the first time in Tashkent we conducted research on the effect of the amount, speed and composition of movement on traffic noise. Observations were carried out on the main streets of the city of Tashkent, which are presented in Table 1 as research objects:

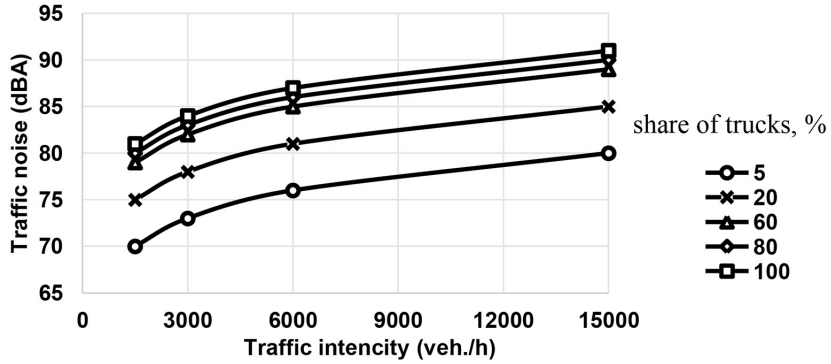



Fig 2. According to the results of G. Osipov's observation, the impact of the share of trucks in the intensity on traffic noise.

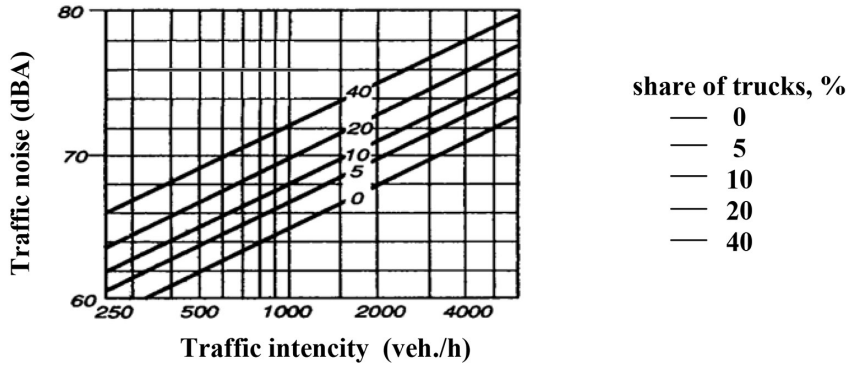



Fig 3. According to the results of P. Pospelov's observation, the impact of the share of trucks in the intensity on traffic noise.

Table 1. Characteristics of research object

| № | Street name | Surface condition | Lanes |
|---|---|---|---|
| 1 | Nurafshon | Coating defect-free, movement structure 97–100 % light vehicles | 3x2 |
| 2 | New Sergeli | | |
| 3 | Nukus | | 4x2 |
| 4 | Amir Temur | | |
| 5 | Little ring road | Coating defect-free, movement structure 5–20 % heavy vehicles | 4x2 |

By analyzing several methods for measuring traffic noise [16], GOST 20444–2014 «Noise. Traffic flow. Methods of measuring the description of noise « [17] measuring work on the Nor140 device [18] in order to measure the traffic noise, the microphone of the Hummer was placed at a distance of 7,5±0.2 m from the axis of the edge motion tape of the vehicle and at a height of 1.5±0.1 m from the surface. The intensity was calculated by a mobile device to the image, the traffic speed was measured using a stopwatch, and the results obtained were processed by a mathematical-statistical method.

## 3. Results and discussion

The results of the research carried out on the main streets of the city with 3x2, 4x2 lanes, which are the selected objects, are presented in the following 4,5 pictures.

The research presented in Fig. 1 Above and the results obtained on the main streets in Tashkent City differ from each other. On the streets of the city of Tashkent, almost all light cars with the content of movement are cars produced in our country. The amount of movement itself to evaluate the traffic noise does not give a sufficiently accurate result, that is, with an increase intensity, the traffic speed also changes. This requires the study of the connection of the state of traffic noise according to the basic diagram of the traffic flow.

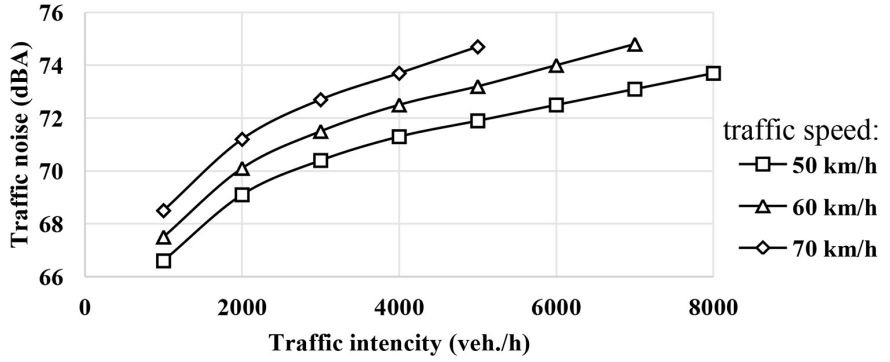



Fig 4. Influence of speed and traffic intensity on traffic noise on city highways with a 3x2 lane

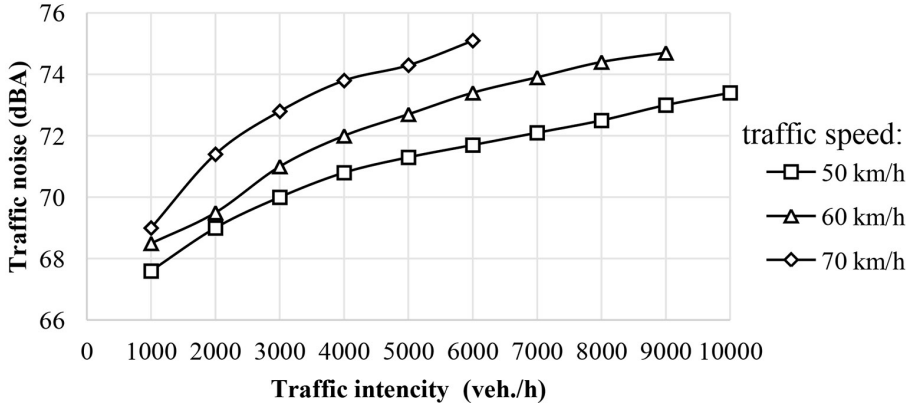



Fig 5. Influence of speed and traffic intensity on traffic noise on city highways with a 4x2 lane

In the study of traffic flows, it is considered a holistic process characterized only by external parameters. With this approach, macroscopic models are created that take into account such characteristics as the speed, intensity of traffic flow, traffic density, etc. (Fig. 6) [19].

If we analyze the diagram, then the left part of the curve reflects the steady state of the traffic flow, then the partially connected and connected stream reaches the point of maximum conduction – the ability to transfer (point Na max = Pa). In the process of these changes, the speed of the traffic flow decreases, characterized by the tangent of the angle of inclination α of the radius vector drawn from 0 point to the desired point of the curve, which characterizes the change of Na. One of the research findings was α. According to the results of observations conducted on Temur street, its ability to conduct was studied, as well as the link between the main diagram of the flow of transport and the level of noise in transport is presented in Fig. 7.

According to the basic diagram of the traffic flow, with an increase in the density of the traffic flow, the noise level decreases. In the observations of S. Dresvyannikov [11], the density of the traffic flow increased from 40 avt/km to 100 auto/km, which determined a decrease in the equivalent level of

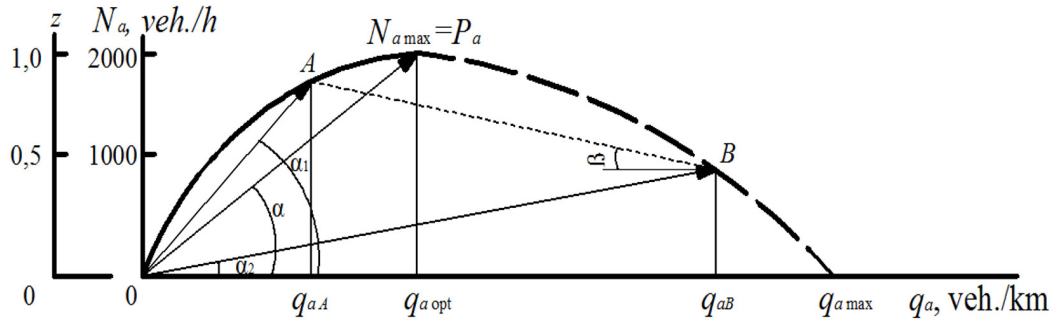



Fig 6. Basic diagram of traffic flow

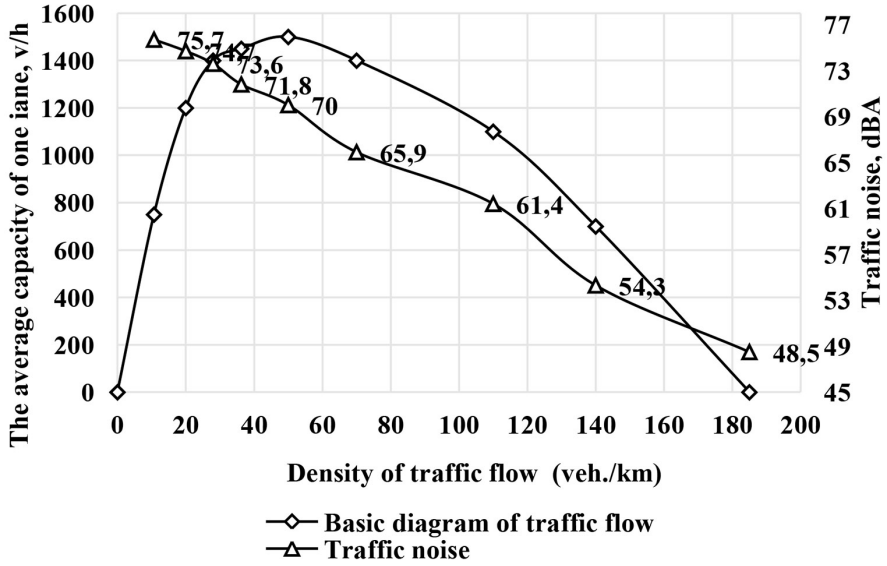



Fig 7. Basic diagram of traffic flow and interaction of traffic noise

noise from 75 DBA to 70 DBA. A. On Temur Shokh street, traffic flow density increased from 20 auto /km to 100 avt/km, noise equivalent level decreased from 75,8 DBA to 68,5 DBA (Fig. 8).

Another important consideration in obtaining a clear result on the main diagram of the traffic flow and the interaction of traffic noise is the share of trucks in the content of this amount of movement.

As a result of the study of the impact of the share of trucks in the amount of movement on the level of traffic noise, it was concluded that P. Pospelov, G. Osipov the state of traffic noise can be seen in Fig. 9 in case of 20 % of heavy trucks in the composition of the total amount of movement in the results of observation on the main streets of Tashkent City.

Since the state of traffic noise would be different, depending on the characteristics of the cars in which each country is involved in the amount of movement. The impact of the main indicators of traffic flow on traffic noise in the conditions of the city of Tashkent was determined. Based on the results obtained, preliminary data were obtained for the development of a model for forecasting future traffic noise in terms of the amount of movement, speed and composition, as well as the state of traffic noise of the main streets in the city of Tashkent will be possible to evaluate the model developed in the future.

Statistical methods are often used to find their empirical correlation by processing the observational results.

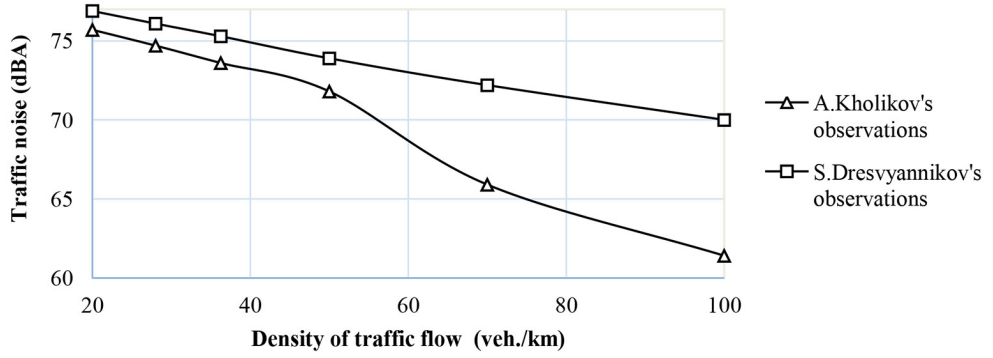



Fig 8. Change of traffic noise relative to traffic flow density

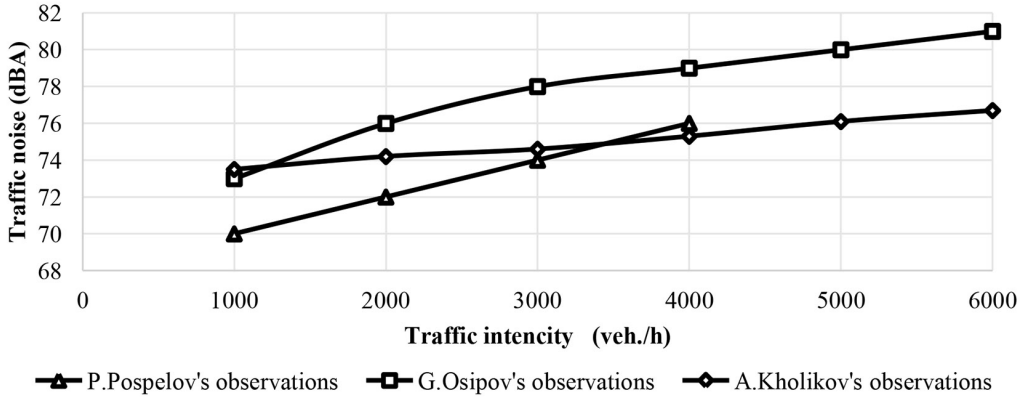



Fig 9. Traffic noise status of the intensity, which is 20 % of the heavy vehicles in the composition

The concept of relationship between mathematical quantities is represented by the concept of the function y = ((x) when one value of the argument x corresponds to only one of the values of the function y [20]. There is a linear relationship between the amount of motion and the noise level in the models improved by [21] and P. Pospelov[22], S. Yu. Dresvyannikov[12], N. N. Minina[23], Z. Xudoyberdiyev[24], V. Vasilova[25], E. S. Karnaux[26], T. Subramani [27] and between created models until these days as FHWA model(USA), CoRTN(Enland), German standard: RLS90 model (Germany), Italian C. N.R. model (Italy), StL86+(Shweden), ASJ RTN-Model 2008(Japan), Nord 2000 Model(Norway)

In the modeling of the conducted analyzes by the methods of correlation-regression analysis, the factors considered play an important role in the selection of the best forms of communication.

The multivariate regression equation can be expressed as follows [28]:

$$Y = f(\beta, X) + \varepsilon,$$

**here:** $X = (X_1, X_2,\ldots, X_m)$ – vector of independent (explanatory) variables; β – vector of parameters (to be determined); ε – random error; Y – dependent variable.

The most commonly used theoretical linear regression equation of multivariate regression models is: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_m X_m + \varepsilon$ or for individual observations i, i = 1,2, …, n:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_m x_{im} + \varepsilon_i.$$

**here** $\beta=(\beta_0, \beta_1,\ldots\beta_m)$- vektor of unknown parametres (m+1), $\beta_j$ coefficient, j=1,2,… ., m, j-theoretical coefficient of regression. This coefficient describes the effect of the value of Y on the change in Xj. Based on n observation to asses equation of regression is evaluated as follows:

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_m x_m$$

**here:** $b_0, b_1, \ldots, b_m$ – evaluation of parameters $\beta_0, \beta_1, \ldots, \beta_m$.

During the measurement of traffic noise on the city's main streets, more than 400 measurements were made and 8 indicators affecting it were measured, and as a result of regression analysis using Excel on the basis of all indicators, we obtained the following model:

$$\mathbf{L_{экв}=16,1+2,6ln(N)+7,5ln(V)+1,1ln(P)+0,83\phi+0,03T+0,02F+0,41IRI-0,02n}$$

**here:** N-movement rate, avt / h; V-speed, km / h; Percentage of trucks in the P-traffic volume,%; roughness of pH coating, mm; T-air temperature, °S; F-humidity,%; IRI-coating smoothness, m / km; n is the number of bands.

We examine the significance of the regression equation based on Fisher's F-criterion. Calculated value equal to ($F_{equal}$) = 381,47. The value of the F-criterion in the table is 0.95 with a confidence interval of 1.96 and the degrees of freedom u1 = k = 8 and u2 = p-k-1 = 411–8–1 = 402 drawn up.

If $F_{calculations} > F_{table}$, the regression equation must be recognized as true..

The R correlation indicates that there is a gypsum correlation between factors with a multiplicity factor of 0.94.

$R^2$ shows that about 88 percent of the involuntary variable variability with a plurality coefficient of 0.88 was accounted for in the model, and 12 percent was conditioned by other factors not included in the model.

Table 2

| Y (L) | X1(N) | X2(V) | X3(P) | X4(ϕ) | X5(n) | X6(T) | X7(F) | X8(IRI) |
|---|---|---|---|---|---|---|---|---|
| Noise level, dBA | Traffic volume, avt / h | Traffic speed, km / h | Proportion of truck and passenger cars in the volume of traffic,% | The roughness of the coating, mm | Тасмалар сони (та) | Air temperature, °C | Humidity,% | Coating smoothness, m / km |

Table 3. Conclusion of the results

| Regression statistics | |
|---|---|
| Multiple R | 0,940003 |
| R-square | 0,883605 |
| Normalized R-square | 0,881289 |
| Standard error | 1,208997 |
| Observations | 411 |

| Analysis of variance | | | | |
|---|---|---|---|---|
| | df | SS | MS | F |
| Regression | 8 | 4460,683 | 557,5853 | 381,4705 |
| Remainder | 402 | 587,5927 | 1,461673 | |
| Итого | 410 | 5048,275 | | |

| | Coefficients | Standard error | t-statistics | P-Value | Lower 95 % | Upper 95 % | Lower 95,0 % | Upper 95,0 % |
|---|---|---|---|---|---|---|---|---|
| Y-inter-section | 16,20114 | 1,408877 | 11,49933 | 1,19E-26 | 13,43146 | 18,97083 | 13,43146 | 18,97083 |
| N | 2,580842 | 0,111717 | 23,10154 | 9,41E-76 | 2,361219 | 2,800465 | 2,361219 | 2,800465 |
| V | 7,427337 | 0,21682 | 34,2557 | 2,7E-121 | 7,001093 | 7,85358 | 7,001093 | 7,85358 |
| P | 1,079308 | 0,083466 | 12,21226 | 2,17E-29 | 0,855224 | 1,183392 | 0,855224 | 1,183392 |
| ϕ | 0,856587 | 0,183324 | 4,672526 | 4,06E-06 | 0,496193 | 1,216981 | 0,496193 | 1,216981 |
| T | 0,032808 | 0,009853 | 3,32962 | 0,00095 | 0,013437 | 0,052178 | 0,013437 | 0,052178 |
| F | 0,015933 | 0,006207 | 2,566704 | 0,010628 | 0,00373 | 0,028136 | 0,00373 | 0,028136 |
| IRI | 0,424058 | 0,153309 | 2,766034 | 0,005936 | 0,12267 | 0,725445 | 0,12267 | 0,725445 |
| n | -0,02015 | 0,049087 | -0,41044 | 0,681705 | -0,11665 | 0,076353 | -0,11665 | 0,076353 |

Table 4

| | L | N | V | P | $\phi$ | T | F | IRI | n |
|---|---|---|---|---|---|---|---|---|---|
| L | 1 | | | | | | | | |
| N | 0,21182265 | 1 | | | | | | | |
| V | 0,83052255 | -0,16115103 | 1 | | | | | | |
| P | 0,51788157 | -0,2782489 | 0,45128775 | 1 | | | | | |
| ϕ | 0,06870358 | 0,05175355 | -0,056536 | 0,11298845 | 1 | | | | |
| T | 0,01221733 | -0,13292011 | -0,07001468 | 0,33622374 | -0,05461618 | 1 | | | |
| F | 0,02763409 | 0,02371008 | 0,13004953 | -0,30293307 | -0,20318145 | -0,66446049 | 1 | | |
| IRI | 0,18571707 | -0,06484675 | 0,26848534 | -0,09254632 | -0,2366946 | -0,13568968 | 0,23209232 | 1 | |
| n | -0,24053778 | 0,25905384 | -0,35085319 | -0,33315244 | 0,23911646 | -0,15889478 | 0,06007489 | 0,08451249 | 1 |

We evaluate the significance of the regression coefficients using the Student's t criterion.

The calculated values of the Student criterion are as follows: b1 = 23.1; b2 = 34.2; b3 = 12.2; b4 = 4.67; b5 = 3.3; b6 = 2.6; b7 = 2.8 b8 = 0.4; At the significance level a = 0.05 and the number of degrees of freedom y = p-k-1 = 402, the value of the criterion in the table is 1.96. When $|bn| > t_{table}$, the regression coefficients b1,2,… ..8 are significant. $|b5| < t_{table}$ b5 = is the number of bands in the path and is not significant for the results obtained by the model.Regardless of the number of strips, the formula looked like this:

$$\mathbf{L_{экв}=16,1+2,6ln(N)+7,5ln(V)+1,1ln(P)+0,83\phi+0,03T+0,02F+0,41IRI}$$

The improved model matrix shows that the increase in traffic noise is mainly due to the speed of movement. Next is the amount and composition of action in terms of importance. The movement was excluded because the number of tapes was not significant.

This formula serves to determine the noise level when planning buildings along city highways. To verify the reliability of the improved model and compare it with existing models, the following real measured noise levels are shown in the graph in Table 5 and Fig. 10.

## 4. Conclusion

For the first time, the state of traffic noise on the main streets of Tashkent was studied as a result of research. Due to the fact that 90–95 % of the cars in the traffic volume are national cars, the basic model of noise forecasting for the main streets of Tashkent has been improved. The R correlation of the improved model indicates that there is a gypsum correlation between factors with a multiplicity factor of 0.94. Also, R2 shows that about 88 percent of the involuntary variable variability with a plurality coefficient of 0.88 was accounted for in the model, and 12 percent was conditioned by other factors not included in the model. It can be seen that the difference between the improved model and the real measured results is up to 0.5–2 dBA. You can also see the StL86 + model with a difference of 4–5 dBA close to the real results compared to other models. The results of the remaining 8 models cannot be used to determine the noise level of the main streets of Tashkent. Based on the results of traffic noise forecasting using the improved model, it is possible to take measures to prevent future acoustic inconveniences.

Table 5

| № | Time, hour | N, avt / hour | V, km / h | P,% | Ф, mm | T, °C | F,% | IRI, m/km | Real result, дБА | Model result, дБА |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $7^{00}$–$8^{00}$ | 3552 | 65 | 3 | 1,2 | 25 | 40 | 2,5 | 73,3 | 73,3 |
| 2 | $8^{00}$–$9^{00}$ | 5688 | 60 | 3 | 1,2 | 25 | 40 | 2,5 | 73,9 | 73,9 |
| 3 | $9^{00}$–$10^{00}$ | 6180 | 30 | 3 | 1,2 | 25 | 40 | 2,5 | 71,5 | 68,9 |
| 4 | $10^{00}$–$11^{00}$ | 5580 | 40 | 3 | 1,2 | 25 | 40 | 2,5 | 70,6 | 70,9 |
| 5 | $11^{00}$–$12^{00}$ | 5544 | 40 | 3 | 1,2 | 25 | 40 | 2,5 | 70,6 | 70,8 |
| 6 | $12^{00}$–$13^{00}$ | 5751 | 40 | 3 | 1,2 | 25 | 40 | 2,5 | 70,6 | 70,9 |
| 7 | $13^{00}$–$14^{00}$ | 5280 | 42 | 3 | 1,2 | 25 | 40 | 2,5 | 70,8 | 71 |
| 8 | $14^{00}$–$15^{00}$ | 5220 | 42 | 3 | 1,2 | 25 | 40 | 2,5 | 72,8 | 71 |
| 9 | $15^{00}$–$16^{00}$ | 5076 | 44 | 3 | 1,2 | 25 | 40 | 2,5 | 71,1 | 71,3 |
| 10 | $16^{00}$–$17^{00}$ | 5352 | 42 | 3 | 1,2 | 25 | 40 | 2,5 | 70,9 | 71,1 |
| 11 | $17^{00}$–$18^{00}$ | 5290 | 42 | 3 | 1,2 | 25 | 40 | 2,5 | 70,8 | 71 |
| 12 | $18^{00}$–$19^{00}$ | 4644 | 45 | 3 | 1,2 | 25 | 40 | 2,5 | 69,1 | 71,3 |
| 13 | $19^{00}$–$20^{00}$ | 6840 | 30 | 3 | 1,2 | 25 | 40 | 2,5 | 69,8 | 69,2 |
| 14 | $20^{00}$–$21^{00}$ | 5616 | 50 | 2 | 1,2 | 25 | 40 | 2,5 | 72 | 72,1 |
| 15 | $21^{00}$–$22^{00}$ | 4068 | 62 | 1 | 1,2 | 25 | 40 | 2,5 | 72,2 | 72,2 |
| 16 | $22^{00}$–$23^{00}$ | 2676 | 68 | 1 | 1,2 | 25 | 40 | 2,5 | 70,9 | 71,8 |

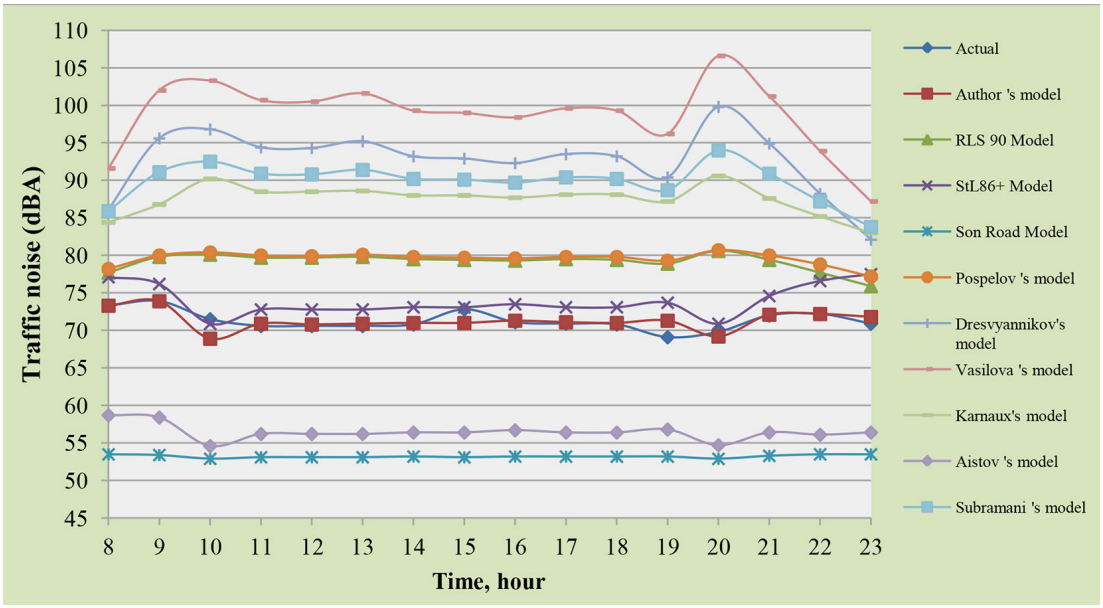



Fig 10. Comparison of improved model and existing models

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