

INNOVATION SCIENCE AND TECHNOLOGY

ISSUE 10, PART I / OCTOBER 2026

 **Acceptance of papers**



**Acceptance of
papers**

Published monthly



Topics

economics,
technology, social
sciences



EDITOR-IN-CHIEF:

Mirzaliyev Sanjar Makhamatjon ugli

DEPUTY EDITOR-IN-CHIEF:

Makhmudov Nosir Makhmudovich
DSc., Prof., Academician

DEPUTY EDITOR-IN-CHIEF:

Ochilov Bobur Bakhtiyor ugli – Senior
lecturer at TSUI

THE SCIENTIFIC-POPULAR ELECTRONIC
JOURNAL **"INNOVATION SCIENCE AND
TECHNOLOGY"** HAS BEEN REGISTERED
UNDER THE NUMBER **C-5669633** BY THE
AGENCY FOR INFORMATION AND MASS
COMMUNICATIONS (AOKA) OF THE
REPUBLIC OF UZBEKISTAN, EFFECTIVE
FROM OCTOBER 9, 2024.

CONTACTS

Phone: **+998 50 737 87 88**

Website: <https://ist-journal.uz>

Email: innovationist2025@gmail.com

The scientific electronic journal "Innovation Science and Technology" has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Editorial board:



Sharipov Kongiratbay Avezimbetovich,
Doctor of Technical Sciences (DSc), Professor



Abdurakhmanova Gulnora Kalandarovna, Doctor of
Economic Sciences (DSc), Professor



Cham Tat Huei,
Doctor of Philosophy (PhD), Professor (Malaysia)



Muhammad Imran Sadiq
Doctor of Philosophy in Economics (PhD), Professor,
Malaysia



Ahmed Aziz Ismail
Doctor of Technical Sciences (DSc),
Professor (Egypt)



Lee Chin
Doctor of Philosophy in Economics (PhD), (Malaysia)



Asongu Simplicie
Doctor of Philosophy in Economics (PhD), Cameroon



Rui Dang
Doctor of Chemistry (DSc), Professor, China



Zahoor Ahmed
Doctor of Philosophy in Economics (PhD), Turkey



Shujaat Abbas
Doctor of Philosophy in Economics (PhD), Russia



Tina A Coffelt
Doctor of Philosophy in Educational Sciences (PhD),
USA



Abdikarimova Dinara Rustamxanovna
Doctor of Economic Sciences (DSc), Professor

Kurbonbekova Mohichehra Turobjonovna
Doctor of Economic Sciences (DSc), Professor

Alimardonov Ilkhom Muzrabshokovich
Doctor of Economic Sciences (DSc), Professor



Razakova Barno Sayfieva
Doctor of Philosophy in Economics (PhD)



Khasanov Sarvar Ulugbek ugli
Doctor of Philosophy in Economics (PhD)



Kholikova Rukhsora Sanjarovna
Associate Professor (PhD)



Xoliyorova Shoxista Qahramon qizi
PhD in Economics, Assistant Lecturer at the Department TSUE

Nasiba G'anjon qizi Sattorova
PhD, Senior Lecturer at the Department of Banking

CONTENTS

IMPLEMENTATION OF THE IMPROVED METHODOLOGY IN PRACTICE AND ASSESSMENT OF ITS ECONOMIC EFFICIENCY	8
Eshniyazova Yulduz Yuldashbayevna	
EXPERIMENTAL OPTIMIZATION OF DESIGN AND ENERGY PARAMETERS OF A GARLAND-TURBINE MOBILE MICRO HYDROPOWER PLANT FOR FREE-FLOWING WATER	13
Sultonov Sanjarbe, Zokirov Islomjon, Nurillaev Ahadullo, Abdullaev Shavkat	
METHODOLOGY FOR INCREASING THE EFFICIENCY OF CREDIT OPERATIONS IN COMMERCIAL BANKS	19
Djumaniyazov Ikram Karimbaevich	
COMPARATIVE ANALYSIS OF A COMPACT RESIDUAL CONVOLUTIONAL MODEL AND LINEAR REGRESSION FOR IMAGE SUPER-RESOLUTION	27
Husan Arziqulov Normurod o'g'li	
COMPARATIVE EVALUATION OF MACHINE LEARNING ALGORITHMS AND CLASS IMBALANCE HANDLING STRATEGIES FOR CREDIT CARD FRAUD DETECTION	33
Mahmudova Dilnoza Avaz qizi	
DIGITAL TRANSFORMATION OF FINANCIAL RESOURCE MANAGEMENT IN PUBLIC SOCIAL SECTOR INSTITUTIONS	39
Khasanov Tulkin Axmatovich	
WAYS TO ENSURE THE STABILITY OF THE CAPITAL BASE OF COMMERCIAL BANKS	45
Isakov Isobek Janabay's son	
CROSS-DAY EXPERIMENTAL EVIDENCE OF THERMAL-LOAD SHIFTING IN A SOLAR-DRIVEN HYDRONIC RADIANT FLOOR WITH MACROENCAPSULATED RT52 PHASE CHANGE MATERIAL	50
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
STUDY OF THE TRACTION DYNAMICS OF AN AGGREGATE CONSISTING OF A FRUIT-HARVESTING MACHINE AND ITS TWO-AXLE CONTAINER-CARRYING TRAILER PLATFORM	59
Norchayev Davron, Sardor Nigmatjonov, Norchayev Jaloliddin, Norchayev Rustam	
PRIORITY DIRECTIONS FOR STRENGTHENING THE FINANCIAL STABILITY OF AGRICULTURAL ENTERPRISES	67
Kulmatov Zafar Jumanazarovich	
METHODOLOGICAL APPROACHES TO DEVELOPING UNIVERSITY STUDENTS' DIGITAL COMMUNICATIVE COMPETENCE BASED ON EMOTIONAL INTELLIGENCE	73
Malikakhon Kamiljanova	
SIMULTANEOUS REMOVAL CHARACTERISTICS OF OIL AND HEAVY METAL IONS BY BIOFLOCCULANTS BASED ON THE CELLULOSE-DMAEMA/PEPA COMPOSITE	80
Xayitboeva Dilshoda, Ibragimov Nasrilla, Jumaev Anvarbek	
ECONOMIC ANALYSIS AND DEVELOPMENT STRATEGY OF THE WOOD-POLYMER COMPOSITES MARKET	84
Abdumalikova Zarnigor, Ayubova Indira, Jumaev Anvarbek	
ENERGY UTILIZATION ANALYSIS OF AGRICULTURAL DRYING BASED ON INTEGRATED SOLAR THERMAL AND PHOTOVOLTAIC ENERGY SUPPLY	89
Ibragimov Umidjon, Mirzayarova Sevara, Khujayorova Aziza	
RECENT ADVANCES IN THE SYNTHESIS OF NANOSTRUCTURED MATERIALS FOR ZINC-ION BATTERIES	96
Diyorbek Absattorov, Dilnoza Erimbatova, Murodjon Samadiy	
ENTHALPY-MODEL SELECTION AND PRACTICAL IDENTIFIABILITY OF A MACROENCAPSULATED RT52 RADIANT FLOOR UNDER UNCERTAIN BRANCH FLOW	101
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
THE IMPORTANCE OF THERMAL ENERGY STORAGE SYSTEMS IN ENHANCING THE EFFICIENCY OF SOLAR DRYERS	110
B. A. Hikmatov, M. S. Mirzaev,	

METHODOLOGY AND PRINCIPLES FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ADAPTIVE ECONOMIC MODELS OF HIGHER EDUCATION.....	117
O'lmasxo'jayev Zoirxo'ja Abbos o'g'li	
FORECASTING ECONOMIC EFFECTS OF GREEN INNOVATION IN MINING THROUGH COST REDUCTION, ENERGY SAVINGS AND LONG-TERM COMPETITIVENESS.....	122
Kurbanova Mehriniso Nematjanovna	
AN INTELLECTUAL HYBRID MODEL AND FEATURE SPACE FOR NAMED ENTITY RECOGNITION IN KARAKALPAK TEXTS	127
Kalmuratov Bekbosin Kushkinbaevich, Uzakbaev Jangeldi Sabit-uli, Rzambetova Suliwxan Baxtiyarovna	
COMPARATIVE ANALYSIS OF EXISTING METHODOLOGIES FOR ASSESSING THE EFFICIENCY OF LENDING PRACTICE	133
Turdiyev Eralijon Muxtarovich	
STRATEGIC MANAGEMENT OF SERVICE QUALITY: ADAPTING THE GAP MODEL TO SERVICE ENTERPRISES.....	140
Tuxliyev Baxtiyor Maxmaziyayevich	
ORGANISATIONAL AND LEGAL FOUNDATIONS FOR THE DEVELOPMENT OF ISLAMIC FINANCE IN UZBEKISTAN	145
Khodjaev Aziz Shovkatovich	
REGIONAL TRANSMISSION OF MACROECONOMIC SHOCKS AND THE DYNAMICS OF ECONOMIC CONVERGENCE	153
Elyor Nazarov	
PRIORITY DIRECTIONS FOR INCREASING SECTORAL DIVERSIFICATION IN THE ECONOMY OF UZBEKISTAN'S REGIONS	159
Mamarasulov Nozimjon Mamajonovich	
THE ROLE OF STATE STRATEGIC RESERVES IN ENSURING FOOD SECURITY: POLICY EVOLUTION AND REASSESSMENT OF THE MILITARY SUPPLY SYSTEM IN THE CASE OF UZBEKISTAN.....	165
Bazarov Nazirjon Sobirovich	
LOCAL ADAPTATION OF MRA-FW FOR CARDIOVASCULAR RISK ASSESSMENT IN ARAL SEA REGION INPATIENTS.....	170
Uteuliev Niyetbay, Saytov Aralbek, Saytov Kamiljan	
GREEN FINANCE IN UZBEKISTAN: FROM SOVEREIGN BONDS TO FOREIGN DIRECT INVESTMENT IN RENEWABLE ENERGY (2021–2026).....	176
Temirova Nozima Shuhrat qizi	
IMPROVING THE ACCOUNTING OF REVENUE, EXPENSES AND FINANCIAL RESULTS IN PRIVATE HIGHER EDUCATION INSTITUTIONS	182
Saidova Kamolat Farhodovna	
THE IMPACT OF DIGITAL TRANSFORMATION ON SERVICE DELIVERY EFFICIENCY IN LOCAL HIGHER EDUCATION INSTITUTIONS.....	187
Masaidova Marguba Muratovna	
INVESTIGATION OF METAL REFINING DURING ELECTRIC ARC WELDING.....	195
Ermatov Ziyadulla, Rakhmatullaeva Nozima, Galperin Leonid	
STATE AND INSTITUTIONAL SUPPORT FOR THE EXPORT ACTIVITIES OF CONSTRUCTION ENTERPRISES.....	200
Mirzayeva Khulkar Abduladjon kizi	
ECONOMIC DIPLOMACY AS THE EXTERNAL TIER OF INVESTMENT GOVERNANCE: INSTITUTIONAL DESIGN AND IMPLEMENTATION GAPS IN UZBEKISTAN.....	207
Imamov Javokhir	
METHODS FOR IMPROVING THE EFFICIENCY OF PRODUCTION RESOURCE UTILIZATION IN AGRICULTURE	213
Nurxonov Nurkomil Qahramon ugli	
COMPARATIVE ANALYSIS OF MACHINE LEARNING ALGORITHMS FOR AUTOMATIC TOPIC CLASSIFICATION OF KARAKALPAK NEWS TEXTS.....	218
Asenbayev Nurbek Adilbayevich	

JOINT OPTIMISATION OF EXTERNAL-WALL INSULATION THICKNESS AND RADIANT-FLOOR HEAT OUTPUT FOR A SOLAR-CONCENTRATOR-HEATED DWELLING IN THE CLIMATE OF BUKHARA.....	223
Jurabek Kamolov, Sokhib Temirov, Marjona Makhmudova	
IMPROVING THE METHODOLOGY FOR ECONOMIC ANALYSIS OF CONSTRUCTION SERVICE COSTS AT SOCIAL FACILITIES	234
Gapparov Azim Kayumovich	
SPATIOTEMPORAL TRENDS IN WATER QUALITY ALONG THE TASHKENT URBAN REACH OF THE CHIRCHIK RIVER: A PAIRED MONITORING ANALYSIS FOR 2017–2024	241
Ruziev Dilmurod, Matkaziye Dilshod, Begzod Burkhonov, Abdurakhimova Durdona, Yuldosheva Saodat	
ECONOMIC REGULATION OF ENVIRONMENTAL EXTERNALITIES IN CONSTRUCTION INDUSTRY ENTERPRISES: A GRADUATED PAYMENT-SUBSIDY MECHANISM AND FORECASTING APPROACH	251
Xolov Xamza Tojiddinovich	
DIFFERENTIATED APPROACHES TO INCENTIVIZING THE TRANSITION OF SMALL BUSINESSES TO THE FORMAL ECONOMY	260
Yunusov Marat Erkinovich	
THE EFFECTIVENESS OF CORPORATE GOVERNANCE IN BANKS AND ITS IMPACT ON FINANCIAL PERFORMANCE AND RISKS	266
Susanna S. Alieva	
GREEN INNOVATION-INVESTMENT EFFECTIVENESS AND STRATEGIC FORECASTING IN THE CABLE INDUSTRY: EVIDENCE FROM UZKABEL.....	273
Igamberdiev Karimberdi	
LEVEL OF ADAPTATION OF PUBLIC INFRASTRUCTURE FOR PERSONS WITH DISABILITIES IN BUKHARA.....	280
Bomurodova Madina Voxidjon qizi	
FREQUENCY-DEPENDENT ASSESSMENT OF FACADE SOUND INSULATION REQUIREMENTS UNDER NOISE EXPOSURE FROM ABOVE-GROUND METRO SYSTEMS.....	285
Zafar Tulaganov, Rakhmatullo Pirmatov	

УДК 699.844:625.42

FREQUENCY-DEPENDENT ASSESSMENT OF FACADE SOUND INSULATION REQUIREMENTS UNDER NOISE EXPOSURE FROM ABOVE-GROUND METRO SYSTEMS

Zafar Tulaganov

PhD Researcher, Tashkent University of
Architecture and Civil Engineering
E-mail: tulyaganovzafar8@gmail.com

Rakhmatullo Pirmatov

Professor, Department of Buildings and Industrial
Structures Tashkent State Transport University

Abstract. This study presents a frequency-dependent assessment of facade sound insulation requirements for buildings exposed to elevated metro noise in Tashkent. The analysis uses octave-band noise spectra, field measurements near Matonat and Tuzel stations, and sanitary noise limits. The results indicate that night-time noise limits are exceeded by up to 33 dB at Matonat and 31 dB at Tuzel within the 250–1000 Hz frequency range. The findings highlight the importance of considering frequency-dependent insulation characteristics when selecting facade components. At a design facade noise level of 78 dB(A), none of the evaluated glazing systems meets the 30 dB(A) night-time limit for residential rooms. The 40 dB(A) daytime limit is achieved only by laminated and double-chamber acoustic glazing systems.

Keywords: elevated metro, facade sound insulation, octave-band spectrum, indoor noise, acoustic comfort, spectrum adaptation term, noise regulation.

Annotatsiya. Tadqiqotda Toshkent shahridagi yerusti metropoliteni shovqini ta'siriga uchraydigan fuqarolik binolari fasadlarining tovush izolatsiyasiga qo'yiladigan talablar chastotaga bog'liq holda baholangan. Tahlilda «Matonat» va «Tuzel» bekatlari yaqinidagi fasad zonalarida o'tkazilgan o'lchovlar, oktava chastota spektrlari va shovqinning sanitariya me'yorlari hisobga olingan. Natijalarga ko'ra, 250–1000 Gts diapazonida tungi me'yoriy ko'rsatkichlardan oshish «Matonat» hududida 33 dB, «Tuzel» hududida esa 31 dB gacha yetgan. Fasad elementlarini tanlashda tovush izolatsiyasining umumiy ko'rsatkichlari bilan birga ularning chastotaviy xususiyatlarini hisobga olish zarurligi asoslangan. Fasad oldidagi hisobiy shovqin darajasi 78 dBA bo'lganda, ko'rib chiqilgan oynalash variantlarining hech biri turar joy xonalari uchun belgilangan tungi 30 dBA me'yorini ta'minlamagan. Kunduzgi 40 dBA me'yoriga esa faqat ko'p qatlamli va ikki kamerali akustik oynalash tizimlari mos kelgan.

Kalit so'zlar: yerusti metropoliteni, fasad tovush izolatsiyasi, oktava spektri, bino ichidagi shovqin, akustik qulaylik, spektral moslashtirish ko'rsatkichi, shovqinni me'yorlash.

Аннотация. Представлена частотно-зависимая оценка требований к звукоизоляции фасадов гражданских зданий, подвергающихся воздействию шума наземного метрополитена в Ташкенте. Анализ основан на результатах обследования фасадных зон вблизи станций «Матонат» и «Тузель», октавных спектрах шума и санитарных нормативах. Установлено, что в диапазоне 250–1000 Гц превышение ночных нормативных значений достигает 33 дБ на участке «Матонат» и 31 дБ на участке «Тузель». Обоснована необходимость учёта частотных характеристик звукоизоляции при выборе фасадных конструкций. При расчётном уровне шума у фасада 78 дБА ни один из рассмотренных вариантов остекления не обеспечивает соблюдения ночного норматива 30 дБА для жилых комнат. Дневной норматив 40 дБА обеспечивается только многослойным и двухкамерным акустическим остеклением.

Ключевые слова: наземный метрополитен, звукоизоляция фасада, октавный спектр, шум в помещении, акустический комфорт, спектральный показатель адаптации, нормирование шума.

INTRODUCTION

Urban rail transport is an integral component of sustainable mobility; however, above-ground metro lines generate specific acoustic loads on nearby residential and public buildings. Unlike underground lines, above-ground sections radiate noise directly into the urban environment. The resulting acoustic field comprises rolling noise generated by wheel–rail interaction, vibrations of the track superstructure, acoustic radiation from elevated guideway components, and sound reflected from surrounding building surfaces [1–3].

For buildings located near above-ground metro sections, the facade serves as the primary acoustic barrier between the external transportation noise field and the indoor environment. The acoustic performance of a facade is determined not only by the overall sound level but also by the spectral composition of the incident noise. When the dominant frequency components of metro noise coincide with frequency ranges in which windows, installation joints, or ventilation openings exhibit reduced sound insulation, additional protective measures may be required to ensure indoor acoustic comfort, even when the facade achieves an acceptable single-number sound insulation rating. Therefore, alongside the weighted sound reduction index (R_w), the spectrum adaptation term (C_{tr}) is used to account for noise sources dominated by low- and medium-frequency components, including rail transport [4].

The adverse effects of transportation noise on human health, particularly sleep quality, have been documented in comprehensive epidemiological studies [5]. These findings highlight the particular importance of nighttime conditions in establishing noise limits and designing acoustic protection measures.

Tashkent provides a representative case study of this issue, as above-ground metro sections pass close to existing residential and public developments. As part of the doctoral research, acoustic measurements were conducted in facade zones near the Matonat and Tuzel metro stations [6, 7]. The objective of this study is to develop a frequency-dependent assessment of facade sound insulation requirements based on octave-band data and to identify the frequency bands that most strongly determine the need for structural and acoustic protection measures.

The scientific novelty of this study lies in formulating facade sound insulation requirements not only in terms of overall sound levels but also across individual octave frequency bands, through direct comparison of the noise spectrum generated by above-ground metro operations with regulatory reference curves. The proposed approach also incorporates separate assessments of compliance with daytime and nighttime noise limits for residential interiors.



Figure 1. Frequency-Dependent Model of Noise Transmission from an Above-Ground Metro System Through the “Source–Propagation Path–Facade–Room” Framework¹

LITERATURE REVIEW

In a study published in 2016, Li X., Thompson D. J., and Jones C. J. C. examined the mechanisms of railway bridge noise generation, including wheel–rail interaction, vibration of structural components, and acoustic radiation. The authors synthesized scientific findings concerning the characteristics of noise propagation from

¹ Авторская разработка

rail transport systems [1]. In 2025, Song L., Luo T., Zhang B., and Liu X. investigated the acoustic characteristics of noise generated by trains operating on elevated urban rail transit structures. Their findings are relevant to assessing the noise impact of above-ground metro lines on surrounding buildings [2].

In 2025, Liu Q., Han X., Wang X., and Zhang Y. investigated noise radiation from elevated rail transit systems incorporating track structures with different elastic properties. Their study highlights the importance of track structural characteristics in assessing acoustic impacts [3]. The international standard ISO 717-1:2020 establishes methods for evaluating airborne sound insulation in building elements, including the application of the weighted sound reduction index R_w and spectrum adaptation terms. These provisions provide a methodological basis for assessing the acoustic performance of facade and window systems [4].

The World Health Organization's guidelines for the European Region, published in 2018, synthesize scientific evidence on the effects of transportation noise on human health, sleep quality, and living conditions [5]. The reviewed studies address the mechanisms of transportation noise generation, its propagation characteristics, and methods for evaluating the sound insulation performance of building elements. Based on these findings, a frequency-dependent assessment of facade sound insulation requirements for buildings located near above-ground metro lines is considered appropriate, taking into account octave-band noise spectra and regulatory limits for daytime and nighttime conditions.

RESEARCH METHODOLOGY

Input Data. This study utilizes generalized octave-band spectra obtained from acoustic surveys conducted in facade zones near the above-ground Matonat and Tuzel metro stations in Tashkent as part of doctoral research. The assessment is based on octave-band sound pressure levels because facade components, particularly windows and glazed structures, exhibit substantially nonuniform sound insulation performance across different frequencies. The measured data are compared with daytime and nighttime regulatory reference curves used in sanitary noise assessments [8, 9]. The measurement methodology is based on references [10–12], while the calculation of indoor sound levels follows the approach presented in [13].

The nature of the input data should be explicitly clarified: the spectra presented represent generalized (smoothed) values derived from the survey results rather than individual measurement records. The associated limitations are discussed in Section 5.

Calculation Equations. The facade is considered a composite acoustic system comprising opaque wall sections, window units, installation joints, ventilation openings, and potential buffer zones. The overall sound transmission coefficient of such a facade within a specified octave band is determined through area-weighted energy summation:

$$\tau_{\Sigma}(f_k) = \frac{\sum_{j=1}^m S_j \tau_j(f_k)}{\sum_{j=1}^m S_j} \quad (1)$$

Where $\tau_{\Sigma}(f_k)$ is the overall sound transmission coefficient of the facade in the octave band with center frequency f_k ; S_j is the area of the j -th facade element, m^2 ; $\tau_j(f_k)$ is the sound transmission coefficient of the j -th element; and m is the number of facade elements considered.

The equivalent sound insulation performance of the facade is expressed as follows:

$$R'_{\Sigma}(f_k) = 10 \lg \frac{1}{\tau_{\Sigma}(f_k)} \quad (2)$$

where $R'_{\Sigma}(f_k)$ is the equivalent sound reduction index of the facade as a whole, dB.

The indoor sound pressure level resulting from noise incident on the facade is expressed as:

$$L_{in}(f_k) = L_{out,fac}(f_k) - R'_{\Sigma}(f_k) + R_c(f_k) \quad (3)$$

where $L_{in}(f_k)$ is the calculated indoor sound pressure level, dB; $L_{out,fac}(f_k)$ is the sound pressure level incident on the facade, dB; $R_c(f_k) = 10 \lg (S/A)$ is the receiving-room correction, dB; S is the area of the external building envelope, m^2 ; and A is the equivalent sound absorption area of the room, m^2 .

To compare two facade configurations, the reduction in indoor sound level achieved through an improved facade solution is determined as follows:

$$\Delta L_{impr} = L_{in,base} - L_{in,sol} \quad (4)$$

where ΔL_{impr} is the improvement achieved by the selected facade solution, dB; $L_{\text{in,base}}$ is the calculated indoor sound level for the baseline configuration, dBA; and $L_{\text{in,sol}}$ is the calculated indoor sound level for the improved configuration, dBA.

The required facade sound insulation for a specified permissible indoor sound level is determined from Equation (3):

$$R_{\text{req}} = L_{\text{out,fac}} - L_{\text{in,adm}} + R_c + \Delta_s \quad (5)$$

where R_{req} is the required facade sound insulation, dB; $L_{\text{in,adm}}$ is the permissible indoor sound level, dBA; and Δ_s is the safety margin accounting for uncertainty, installation quality, and potential acoustic leakage paths, dB.

Assumptions Adopted for the Calculation Scenario. In the calculation scenario presented in Section 3, $R_c = 0$ dB, corresponding to the condition $S = A$ (reference room), and $\Delta_s = 0$ dB. These assumptions enable different glazing configurations to be compared on a consistent basis. When designing a specific building, the values of R_c and Δ_s must be determined according to the actual room geometry and the assessment of installation quality.

The sum $R_w + C_{tr}$ is used as the sound insulation performance indicator for facade elements because the noise spectrum of above-ground metro systems is characterized by predominantly low- and medium-frequency components [4].

ANALYSIS AND RESULTS

Table 1 presents the octave-band sound pressure levels measured in facade zones near the Matonat and Tuzel metro stations, together with the regulatory reference curves for areas immediately adjacent to residential buildings. The spectra exhibit nonuniform frequency distributions, with elevated sound pressure levels observed in the 250–1000 Hz frequency range at both locations. This characteristic is particularly important when selecting facade and window systems.

Table 1. Octave-Band Sound Pressure Levels in Facade Zones and Regulatory Reference Curves for Adjacent Areas, dB²

Location / Frequency, Hz	63	125	250	500	1000	2000	4000	$\backslash(L_{\text{Aeq}})\backslash$, dBA
Matonat station (survey)	68	72	75	76	73	68	61	77.3
Tuzel station (survey)	66	70	73	74	71	66	59	75.3
Daytime regulatory limit (adjacent area)	75	66	59	54	50	47	45	55
Nighttime regulatory limit (adjacent area)	67	57	49	44	40	37	35	45

Note. The L_{Aeq} values for the surveyed locations were calculated by energetically summing the octave-band sound pressure levels after applying A-weighting corrections. For the regulatory reference curves, the corresponding overall permissible values are presented.

The comparison indicates that, at 63 Hz, the measured sound pressure levels remain below the daytime regulatory reference curve. However, substantial exceedances of the regulatory limits are observed from 125 Hz onward. At the Matonat location, the daytime regulatory limits are exceeded by 6 dB at 125 Hz, 16 dB at 250 Hz, 22 dB at 500 Hz, and 23 dB at 1000 Hz. At the Tuzel location, the corresponding exceedances are 4, 14, 20, and 21 dB, respectively. Thus, the most significant exceedances of daytime regulatory limits occur in the 500 and 1000 Hz octave bands.

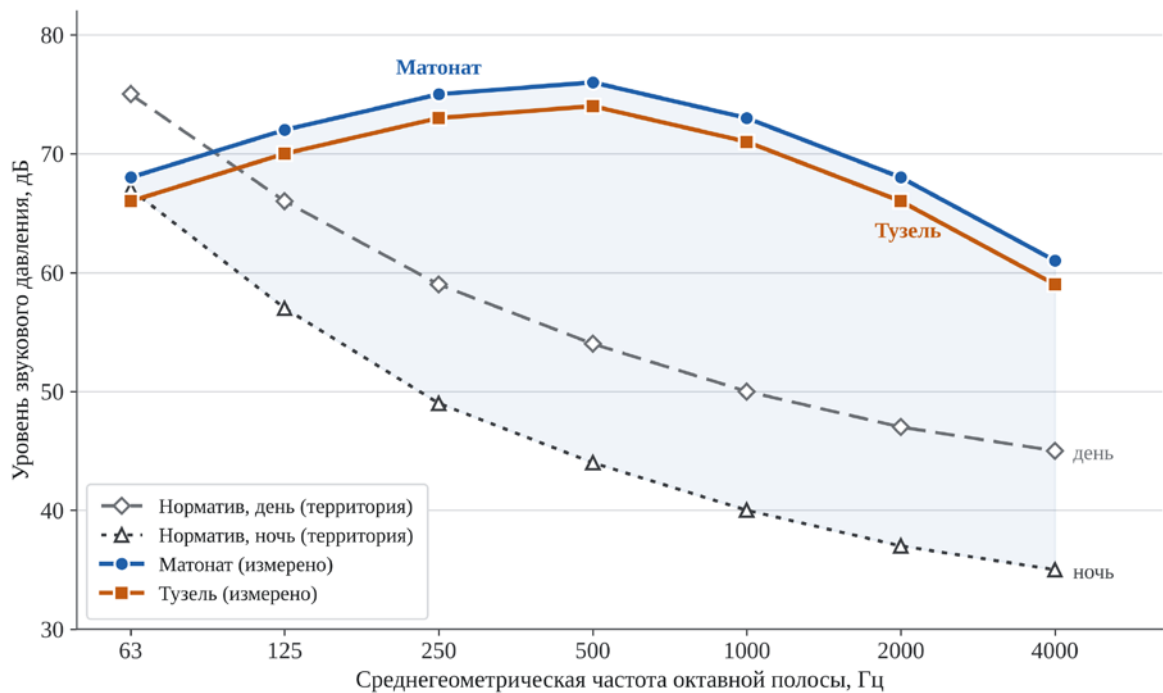


Figure 2. Octave-Band Noise Spectra in the Facade Zones of Matonat and Tuzel Stations Compared with Regulatory Reference Curves for Adjacent Areas³

A comparison of nighttime conditions indicates more stringent requirements for acoustic protection (Table 2). At the Matonat location, the measured levels exceed the nighttime regulatory reference curve by 1 dB at 63 Hz, 15 dB at 125 Hz, 26 dB at 250 Hz, 32 dB at 500 Hz, 33 dB at 1000 Hz, 31 dB at 2000 Hz, and 26 dB at 4000 Hz. At the Tuzel location, the corresponding differences are -1, 13, 24, 30, 31, 29, and 24 dB. These findings confirm the importance of establishing nighttime acoustic protection requirements based on both overall sound levels and frequency-dependent assessments.

Table 2. Exceedance of the Nighttime Regulatory Reference Curve by Octave Band, dB⁴

Location / Frequency, Hz	63	125	250	500	1000	2000	4000
Matonat — exceedance	1	15	26	32	33	31	26
Tuzel — exceedance	-1	13	24	30	31	29	24
Difference (Matonat – Tuzel)	2	2	2	2	2	2	2

3 Авторская разработка

4 Авторская разработка

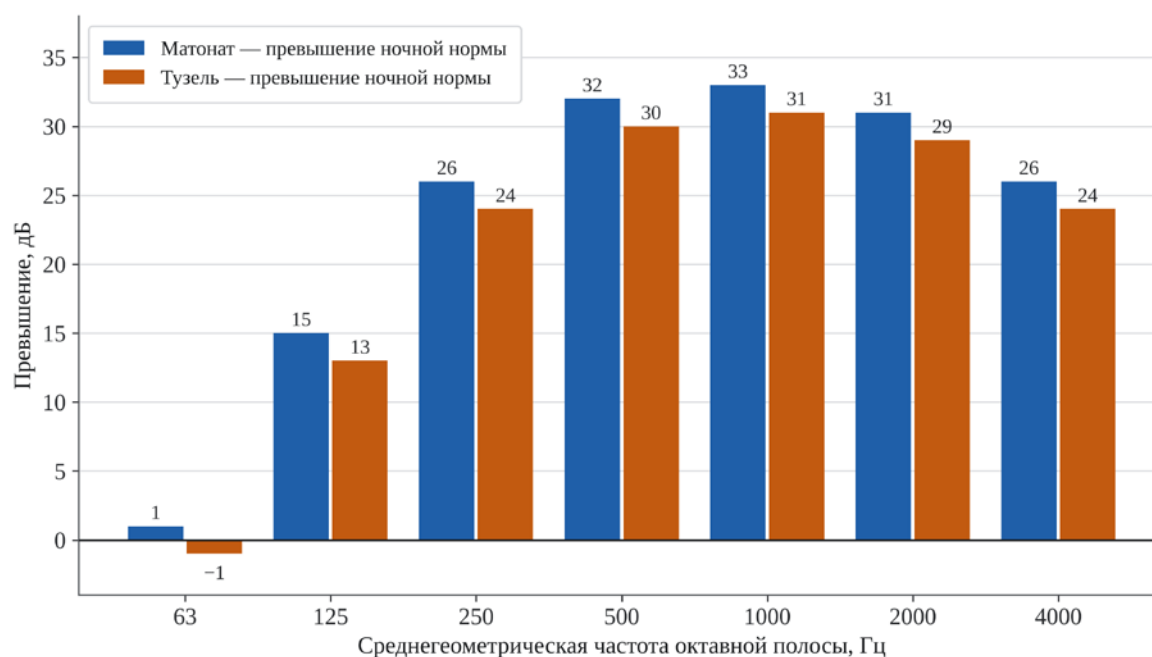


Figure 3. Exceedance of the Nighttime Regulatory Reference Curve by Octave Band at the Surveyed Locations⁵

An additional calculation scenario was examined for an external sound level of 78 dBA at the facade. This value is consistent with the overall sound level of $LA_{экв} = 77,3$ dBA derived from the octave-band spectrum at the Matonat location (Table 1) and was rounded upward. The scenario was used to compare the relative acoustic performance of different glazing configurations. The results are presented in Table 3.

Table 3.

Calculation Scenario: Indoor Sound Levels at an External Facade Sound Level of 78 dBA ($RC = 0$ дБ, $\Delta s = 0$ дБ)⁶

Facade glazing configuration	$R_w + C_{tr}$, dB	L_{in} , dBA	ΔL_{impr} , dB	Difference from daytime limit (40 dBA), dB	Difference from nighttime limit (30 dBA), dB
Single glazing	21.0	57.0	—	+17.0	+27.0
Double glazing, 4–6–4	29.0	49.0	8.0	+9.0	+19.0
Double glazing, 4–16–4	32.0	46.0	11.0	+6.0	+16.0
Laminated acoustic glazing	39.5	38.5	18.5	–1.5	+8.5
Acoustic double-chamber glazing	46.0	32.0	25.0	–8.0	+2.0

Note. The daytime (40 dBA) and nighttime (30 dBA) limits apply to living rooms in residential apartments and were adopted from references [8, 9]. The indoor sound levels L_{in} were calculated using Equation (3), assuming $R_C = 0$ дБ, то есть $L_{in} = 78 - (R_w + C_{tr})$.

⁵ Авторская разработка

⁶ Авторская разработка

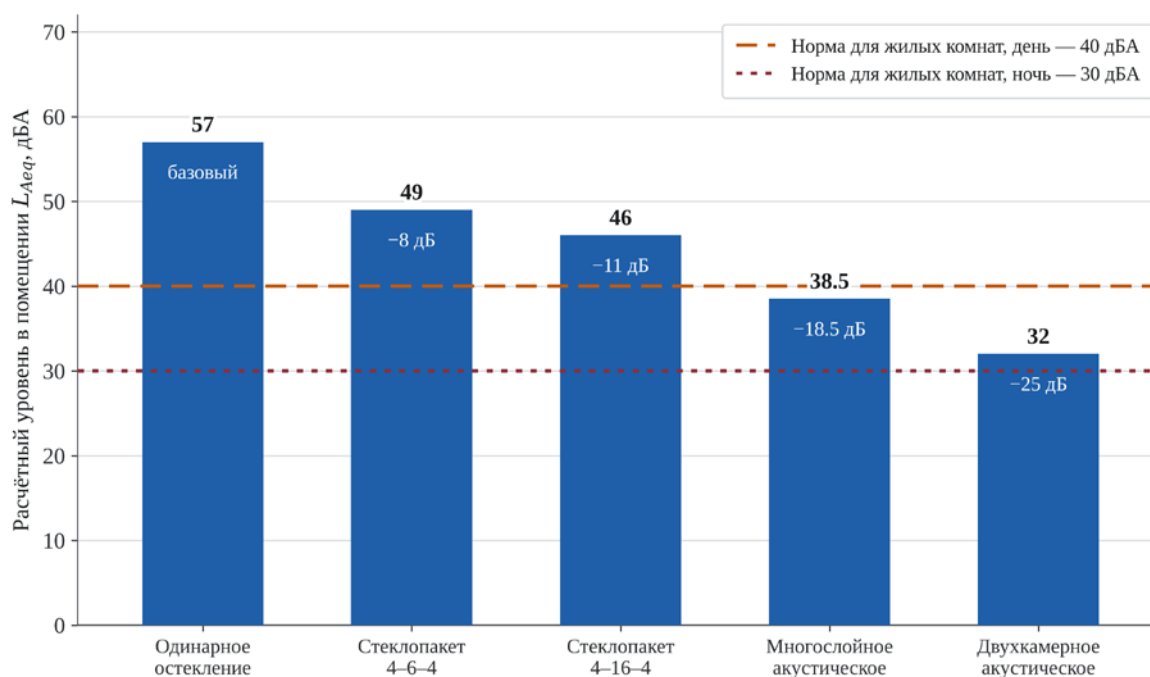


Figure 4. Calculated Indoor Sound Levels for Different Glazing Configurations at an External Facade Sound Level of 78 dBA⁷

The numerical comparison demonstrates that single glazing results in a calculated indoor sound level exceeding the daytime regulatory limit for residential living rooms by 17.0 dB and the nighttime limit by 27.0 dB. When conventional double-glazed units with configurations of 4–6–4 and 4–16–4 are used, the daytime limits are exceeded by 9.0 and 6.0 dB, while the nighttime exceedances reach 19.0 and 16.0 dB, respectively. Laminated acoustic glazing satisfies the daytime limit with a margin of 1.5 dB, although the nighttime limit is exceeded by 8.5 dB. Acoustic double-chamber glazing provides a margin of 8.0 dB relative to the daytime limit; however, the calculated indoor sound level remains approximately 2.0 dB above the nighttime limit.

The findings confirm that acoustic facade design for buildings located near above-ground metro lines must account for the frequency-dependent characteristics of sound insulation. The greatest exceedances occur not in the lowest octave band of 63 Hz but predominantly within the 250–1000 Hz frequency range. This is particularly important because many window systems exhibit nonuniform sound insulation performance and may demonstrate reduced acoustic attenuation within resonant frequency ranges, including the mass–air–mass resonance region.

A comparison of the Matonat and Tuzel locations reveals a consistent difference of approximately 2 dB across all examined octave bands, with higher sound pressure levels recorded at Matonat. Although this difference is relatively small, substantial exceedances of nighttime regulatory limits are observed at both locations. Consequently, structural and acoustic protection measures are necessary in both cases. The differences between the locations should be considered when selecting the safety margin Δ_s and determining facade performance requirements, without altering the overall need for protective measures.

The calculation scenario demonstrates that conventional window systems require additional improvements in acoustic performance to ensure compliance with indoor noise limits during both daytime and nighttime periods. For double-glazed units with configurations of 4–6–4 and 4–16–4, the daytime regulatory limits for residential living rooms are exceeded by 9.0 and 6.0 dB, respectively. This finding emphasizes the importance of distinguishing between regulatory limits applicable to adjacent outdoor areas and those established for indoor environments, as their application without appropriate differentiation may result in inaccurate assessments of the acoustic performance of conventional glazed structures.

Even acoustic double-chamber glazing must be combined with airtight installation joints, acoustically protected ventilation systems, and effective control of potential sound leakage paths. When ventilation is provided by opening windows, the actual sound insulation performance of the facade decreases substantially, regardless of the nominal laboratory rating of the glazing unit. Furthermore, achieving an overall facade sound

7 Авторская разработка

insulation rating of approximately $R_w + C_{tr} = 46$ dB, including the effects of installation joints and ventilation openings, presents considerable technical challenges. This further demonstrates the need for comprehensive acoustic protection measures rather than relying exclusively on glazing replacement.

Low-frequency and structure-borne noise components transmitted through elevated guideway structures and the ground also require particular attention. Their assessment extends beyond the scope of airborne sound insulation provided by the facade and requires separate investigation in accordance with reference [14].

In practical building design, facade noise protection should include the selection of acoustic glazing based on octave-band data and the $R_w + C_{tr}$ rating; the use of airtight connections between window frames and surrounding walls; the installation of acoustically attenuated air inlets or mechanical ventilation systems; the orientation of noise-sensitive rooms away from above-ground metro lines; and in situ acoustic verification following construction or renovation in accordance with reference [12].

The octave-band spectra presented in this study represent generalized values derived from acoustic surveys conducted in facade zones and do not constitute individual measurement records. In particular, the difference between the Matonat and Tuzel locations is exactly 2 dB across all seven octave bands (Table 2), reflecting the data generalization procedure rather than an independently measured frequency-dependent difference. Further validation requires independent measurements in each octave band, including documentation of the sound level meter type and accuracy class, measurement dates and meteorological conditions, microphone height and distance from the facade plane, the number of train pass-by events considered, and the expanded measurement uncertainty in accordance with references [10, 11].

Further clarification is required regarding whether the external facade sound level $L_{out, fac}$ accounts for sound reflection from the facade surface. Depending on the adopted measurement configuration, this may introduce differences of up to 3 dB, directly affecting the calculated indoor sound levels.

The $R_w + C_{tr}$ values presented in Table 3 represent nominal sound insulation ratings of glazed structures. Under in situ conditions, facade sound insulation is generally 3–5 dB lower than laboratory values because of installation joints, ventilation openings, and flanking sound transmission. Therefore, the final assessment should be based on in situ measurements conducted in accordance with reference [12].

The calculation scenario assumes $R_c = 0$ dB and $\Delta_s = 0$ dB. For an actual room, R_c may vary by several decibels in either direction, depending on the ratio between the area of the external building envelope and the equivalent sound absorption area.

CONCLUSIONS AND RECOMMENDATIONS

1. A frequency-dependent approach to assessing facade sound insulation requirements under noise exposure from above-ground metro systems has been developed. The octave-band data obtained in facade zones near the Matonat and Tuzel stations indicate that the most substantial exceedances of regulatory limits occur within the 250–1000 Hz frequency range.

2. At the Matonat location, exceedances of nighttime regulatory limits reach 32 dB at 500 Hz and 33 dB at 1000 Hz. At the Tuzel location, the corresponding exceedances are 30 and 31 dB. These findings demonstrate the importance of considering not only overall sound levels but also the spectral relationship between metro noise and the frequency-dependent sound insulation characteristics of facade components.

3. The calculation scenario for an external facade sound level of 78 dBA indicates that single glazing results in an indoor sound level of approximately 57 dBA, whereas acoustic double-chamber glazing reduces the calculated level to approximately 32 dBA. Thus, the improved glazing configuration provides a 25 dB reduction in indoor sound level relative to the baseline configuration.

4. The examined glazing configurations demonstrate different degrees of compliance with the nighttime regulatory limit of 30 dBA for residential living rooms. Even with the most effective configuration, the calculated indoor sound level exceeds the established nighttime limit by approximately 2 dB. Meanwhile, compliance with the daytime limit of 40 dBA is achieved only with laminated acoustic glazing and acoustic double-chamber glazing.

5. Effective acoustic protection of buildings requires an integrated approach combining glazing selected according to the $R_w + C_{tr}$ rating, airtight installation, controlled acoustically attenuated ventilation, and appropriate spatial arrangement of noise-sensitive rooms. The calculated results require further refinement through in situ measurements for each individual building.

Practical Recommendations

1. Apply frequency-dependent assessments of facade sound insulation when designing buildings located near above-ground metro lines.

2. Use laminated acoustic glazing and acoustic double-chamber glazing in accordance with applicable regulatory requirements.

3. Ensure airtight installation joints and incorporate acoustically attenuated ventilation systems.
4. Provide appropriate spatial arrangements of residential rooms in relation to transportation noise sources.
5. Conduct in situ acoustic measurements to verify the effectiveness of the adopted design solutions.

REFERENCES:

1. Li X., Thompson D. J., Jones C. J. C. Review of recent progress in studies on noise emanating from rail transit bridges // *Journal of Modern Transportation*. – 2016. – Vol. 24, № 4. – P. 237–250. – DOI: [10.1007/s40534-016-0112-8](https://doi.org/10.1007/s40534-016-0112-8).
2. Song L., Luo T., Zhang B., Liu X. Characteristics of noise caused by trains passing on urban rail transit viaducts // *Sustainability*. – 2025. – Vol. 17, № 1. – Art. 94. – DOI: [10.3390/su17010094](https://doi.org/10.3390/su17010094).
3. Liu Q., Han X., Wang X., Zhang Y. Investigation of the noise emitted from elevated urban rail transit paved with various resilient tracks // *Materials*. – 2025. – Vol. 18, № 5. – Art. 968. – DOI: [10.3390/ma18050968](https://doi.org/10.3390/ma18050968).
4. ISO 717-1:2020. Acoustics. Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation. – Geneva : International Organization for Standardization, 2020. – 24 p.
5. Environmental noise guidelines for the European Region. – Copenhagen : WHO Regional Office for Europe, 2018. – 160 p. – URL: <https://www.who.int/europe/publications/i/item/9789289053563>.
6. Tulyaganov Z., Abduvasikova M., Muminov A., Rashidov J. Improving acoustic performance of building envelopes in residential buildings located near elevated metro lines // *International Journal of Research Publication and Reviews*. – 2026. – Vol. 7, № 4. – P. 2038–2041.
7. Пирматов Р. Х., Тулаганов З. С., Тошмухамедов Ж. К. Влияние шума надземного метрополитена на жилые территории // *Educational Research in Universal Sciences*. – 2023. – Т. 2, № 4. – С. 734–740.
8. СанПиН 0008-20. Санитарные правила и нормы допустимого шума в жилых и общественных зданиях, на жилой территории и в зонах массового отдыха населения. – Ташкент, 2020.
9. ШНК 2.01.08-24. Защита от шума. – Ташкент : Министерство строительства и жилищно-коммунального хозяйства Республики Узбекистан, 2024.
10. ISO 1996-2:2017. Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of sound pressure levels. – Geneva : International Organization for Standardization, 2017. – 48 p.
11. ГОСТ 23337-2014. Шум. Методы измерения шума на селитебной территории и в помещениях жилых и общественных зданий. – Москва : Стандартинформ, 2015. – 23 с.
12. ГОСТ 27296-2012. Здания и сооружения. Методы измерения звукоизоляции ограждающих конструкций. – Москва : Стандартинформ, 2013. – 28 с.
13. ISO 12354-3:2017. Building acoustics. Estimation of acoustic performance of buildings from the performance of elements. Part 3: Airborne sound insulation against outdoor sound. – Geneva : International Organization for Standardization, 2017. – 32 p.
14. ISO 14837-1:2005. Mechanical vibration. Ground-borne noise and vibration arising from rail systems. Part 1: General guidance. – Geneva : International Organization for Standardization, 2005. – 44 p.

Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2026. № 10

© When materials are reproduced, the INNOVATION SCIENCE AND TECHNOLOGY journal must be cited as the source. Authors are responsible for the accuracy of the information in materials and advertisements published in the journal. Editorial opinions may not always align with those of the authors. Submitted materials will not be returned to the editorial office.

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

“The journal “INNOVATION SCIENCE AND TECHNOLOGY” has been registered by the Agency for Information and Mass Communications under the Administration of the President of the Republic of Uzbekistan from 09.10.2024 under the registration number №390637. License number: C-5669633. PNFL: 30407832680027

Our address: Tashkent city, Yunusobod district, 19th block,
House 17.



Acceptance of articles

Published every
monthly



Directions

Social, economic, political,
technological, scientific



Scopus || Scientific electronic journal specializing in Scopus

CERTIFICATE NUMBER: №390637

**ORDER NUMBER ACCORDING TO
THE LICENSE REGISTER: C-5669633**

CONTACT:



Contact us
+998 50 737 87 88



Telegram channel
t.me/scopus_IST2100



Journal official website
<https://ist-journal.uz/index.php/IST>