**Assessment of Road Traffic in Areas with Limited Visibility by Physical Means**

Utkir Isokhanov1, a), Dildora Abdurazzakova1, b), Еrkinjon Аbdusаmаtоv1, c), JovokhirNarziyev1, d),Navruz Negmatov1, e) and Shokhrukh Babakhan2, f)

1*Tashkent State Transport University, 1 Temiryulchilar St., Tashkent 100167, Uzbekistan*2*Khoja Akhmet Yassawi International Kazakh-Turkish University, Bekzat Sattarhanov ave., 29, Turkistan, Kazakhstan*

*a) Corresponding author:* [*isoxanov\_u@tstu.uz*](mailto:isoxanov_u@tstu.uz) *b)* [*dildora\_a@tstu.uz*](mailto:dildora_a@tstu.uz) *c)* [*abdusamatov\_e@tstu.uz*](mailto:abdusamatov_e@tstu.uz) *d)* [*narziyevj205@tstu.uz*](mailto:narziyevj205@tstu.uz) *e)* [*negmatovnavruz201@tstu.uz*](mailto:negmatovnavruz201@tstu.uz) *f) babakhan.shokhrukh@ayu.edu.kz*

**Abstract.** This scientific article analyzes the primary causes of road traffic accidents involving pedestrians in areas with limited visibility—particularly in conditions such as fog, darkness, sharp curves, and complex terrain. A key issue identified is the insufficient use of available technical capabilities by drivers when navigating through such environments. The study uses physical modeling, distance and braking calculations, and speed-based mathematical analyses to examine vehicle movement and accident risk scientifically. The findings show that over 22% of traffic accidents in areas with limited visibility are directly linked to drivers failing to fully utilize their technical options. For instance, in situations where a Lacetti vehicle could have been safely stopped in time, the driver failed to apply the brakes promptly, resulting in a collision. More broadly, the study confirms that 91% of road traffic accidents occur due to driver error, emphasizing the urgent need for targeted interventions in these high-risk situations. Based on the research, several proposals have been developed. These include enhancing driver culture, organizing specialized training courses on road safety, and introducing traffic rule education in general education schools. Such preventive strategies are considered vital in mitigating the frequency and severity of pedestrian-related traffic accidents. In conclusion, the study highlights the need for a systemic approach that combines technical, educational, and behavioral measures to reduce accident risks. Implementing these recommendations can significantly improve safety outcomes and foster better interaction between drivers and pedestrians, particularly in environments where visibility is limited.

**Key words:** traffic accident, pedestrian, car, obstacle, driver, speed

**INTRODUCTION**

One of the most common types of traffic accidents is hitting a pedestrian. A pedestrian is not in the driver's line of sight while driving. In such cases, the view of the road is limited in front and on the sides of the car. A pedestrian moves for some time without being seen by the driver and suddenly appears for the second. Such a road is frequent due to traffic accidents, especially in the difficult conditions of old cities with narrow streets (vehicles standing on both sides of the road or snow avalanches reduce the traffic area) and lack of discipline of pedestrians. Pedestrian crashes account for 23% of all collisions in the view limited by a fixed barrier, and approximately 27% of all collisions in the view limited by an oncoming vehicle [1, 2, 3, 4].

In 2023, 47.2% of traffic accidents related to pedestrians in the city of Tashkent. According to statistics, about 70% of collisions occur at street crossings in residential areas, as well as 32% at unmarked crossings, 9% at unregulated pedestrian crossings, and 7.7% at regulated pedestrian crossings [5, 6, 7, 8, 9].

**FIGURE 1.** Analysis of road traffic incidents involving pedestrians in the city of Tashkent in 2023

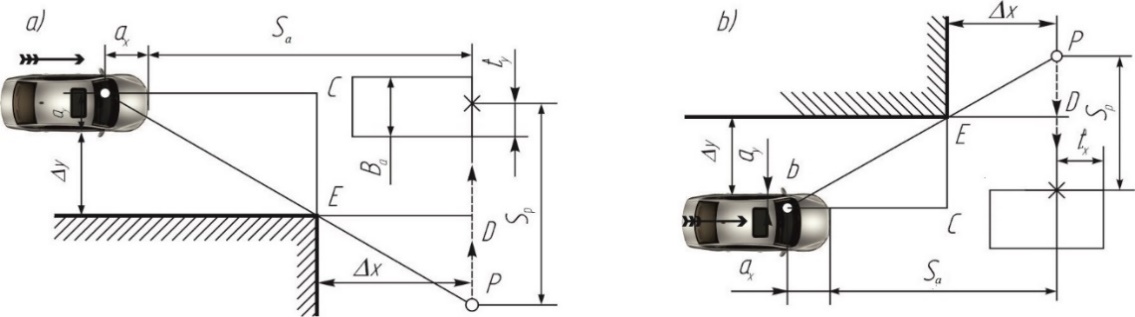
In general, the study of pedestrian traffic is still in its infancy. Pedestrian's choice of movement pattern on the road depends on his level of knowledge of the road, psychophysiological condition, purpose and urgency of movement, width of the road and characteristics of traffic flow (speed, intervals, intensity, type of vehicle).

Fixed obstacles with limited plan view (high fence, corner of the house, car or trolleybus standing on the road and curbs), as well as vehicles moving to the side or in the opposite direction to the collided vehicle limited to Objects that limit visibility are usually not in front of the driver, but slightly to the side. In order to see them, the driver must look closely, so that the obstacle is under the visual control of both eyes - in the field of vision with both eyes. Such eye movements sometimes take considerable time, which is accounted for by differential values of the driver's reaction time [10, 11, 12, 13, 14].

**MЕTHОDОLОGY**

If the driver fails to apply the brakes and the pedestrian is struck by the vehicle’s front end, the incident is treated as an impact with a fixed obstacle under restricted visibility conditions (see Fig. 2).

When analyzing such road traffic incidents, the time when a dangerous situation occurs is determined by the time when a pedestrian is in the driver's field of vision, usually due to an obstacle that limits visibility.

****

**FIGURE 2.** Schematic view of hitting a pedestrian behind an immovable barrier. option a, option b

This moment does not correspond to the time when pedestrians cross the dangerous zone (road edge or sidewalk, the center line of the road) or when the direction and speed of movement change. If the person who appointed the forensic expert indicates another moment of the emergence of a dangerous situation (for example, the beginning of the movement of a pedestrian on the road), then the expert must express his opinion in the conclusion and follow this instruction [15, 16, 17, 18, 19].

The time of the pedestrian due to the obstacle and the corresponding position of the vehicle on the road are calculated based on two conditions: geometric and kinematic. At the same time, they determine the location of the driver in the vehicle, after which they move the pedestrian and the vehicle away from the driving position accordingly until the driver and pedestrian are aligned with the angle of the object that limits the view. Thus, the car and the pedestrian are set to the position they occupy when the dangerous situation starts. Subsequently, the calculations establish the distance in meters between the vehicle and the point of impact [20, 21, 22, 23].

Sometimes experts conditionally combine the driver's position from the front corners of the car, often from the left side, without having information about the location of the driver in the cabin (from the place of impact, the distance in front of the car and the distance to its side) . This assumption gives simpler formulas, but it introduces a significant error in the definition of *Sa* and is not recommended. The visibility coordinates of the driver's seat in domestic cars are listed in Table 1.

Let us calculate the distance between the vehicle and the location of the pedestrian at the moment the driver could first observe them (see Fig. 1).

Since right triangles are similar ("visible triangles"), we have a geometric condition.

Here: х- the distance between the line of movement of pedestrians and the object that limits visibility; у- the distance between the vehicle and the object that limits visibility; ax and aу distances from the driver's seat to the front and sides of the vehicle closest to the object that limits visibility.

**TABLE 1** View coordinates of the driver's seat

|  |  |  |  |
| --- | --- | --- | --- |
| **Car** | **Distances, m** | | |
| **ax** | **aу** | **ау** |
| Matiz | 1, 45 | 0,35 | 1,05 |
| Spark | 1, 7 | 0,4 | 1,1 |
| Neksiya | 1, 8 | 0,5 | 1,1 |
| Kobolt | 2, 0 | 0,5 | 1,05 |
| Lasseti | 2, 0 | 0,5 | 1,32 |
| Malibu | 2, 2 | 0,6 | 1,4 |
| Kaptiva | 2, 7 | 0,7 | 1,4 |
| Gazel | 1, 0 | 0,4 | 1,8 |
| Isuzi | 1.1 | 0,5 | 2,0 |
| Damas | 1, 0 | 0,5 | 1,4 |
| Kaptiva | 2, 05 | 0,6 | 1,8 |
| Man | 2, 5 | 0,7 | 1,8 |
| Xovo | 2, 4 | 0,6 | 1,9 |
| Chakman | 2, 4 | 0,7 | 1,8 |
| MAZ | 1, 1 | 0,7 | 1,8 |
| Kamaz | 1, 0 | 0,6 | 1,9 |
| Skreypir | 2, 8 | 0,9 | 1,6 |

Since the car and the pedestrian are moving equally, the pedestrian passes the path Sp and the car moves for the same time interval ("kinematic case"):

*Sp,* exponent and in addition to the expressions, we get an equation with one unknown (*Sa*):

This is a second-order equation for determining how far *Sa* is from the scene of a traffic accident, since the values of other parameters included in this equation are known, it is recommended to replace them immediately to simplify the calculations, and then *Sa* is determined.

The equation obtained on the basis of the calculation scheme shown in Fig. 1a. This figure describes the relative position of three points corresponding to the driver (v-point), the pedestrian (l-point) and the object's limiting view angle (ye-point). These three points can be on the same straight line in two cases: the car and the pedestrian have not yet reached the corner of the obstacle in their movement, and they have already passed it [24, 25, 26, 27, 28, 29, 30].

After identifying *Sa,* the study produced a seemingly endless collision and traffic accident. The obtained value of *Sa* is compared with the stopping distance, which determines the possibility of stopping the car before the pedestrian lane with a timely response to the appearance of the driver. Sаhttps://studfile.net/html/2706/20/html_fuYhQGnXrK.tbNM/img-sUdxKW.pngSо, the driver is checked by comparing the driver with timely braking and starting the movement from the scene of the pedestrian traffic accident. Since the dangerous situation is determined by the time when the pedestrian can be detected by the driver, it is necessary to take into account not only the distance traveled by the pedestrian in the limitless field of vision (https://studfile.net/html/2706/20/html_fuYhQGnXrK.tbNM/img-QG6Ac4.pngу+lу), but also the slightly larger vision need in some cases this extra thing is very important. The condition for safe passage under the influence of the end surface of the vehicle should be written as follows:

Here: *S'p*- this is the ability of the driver to brake in time when he has the opportunity to see the pedestrian.

Here and below, for simplicity, it is assumed that the length of the path traveled by the pedestrian before striking is always less than the distance between the vehicle line and the road boundary. If it follows from the circumstances of the case, for example, the pedestrian Sp walked along the sidewalk, then the time when the pedestrian crossed the border of the traffic section is considered to be the beginning of a dangerous situation.

If the view is limited to a parked vehicle, it is rendered at a right angle with sides that match the overall dimensions.

According to some authors, a driver passing by a stationary trolley should look down to see the legs of approaching pedestrians, and when moving around a passenger car, he should look up to see their heads. The inconsistency of such recommendations is obvious.

Figure 1b. the pedestrian was able to walk a distance of *Sp* at the time of impact.

Va in this case, the analysis of the road traffic incident begins with the determination of the distance of the car from the place of collision with the pedestrian when it can be determined.

Geometric condition

The kinematic situation also changes slightly:

except for the last *Sp* formulas, we get

Substituting the numerical values of all the known exponents, we arrive at the quadratic equation for the required subtraction in solving *Sa,* as in the previously discussed case, with the "plus" sign before the radical. The resulting *Sa* value is compared with the stop path. Pedestrians must be able to cross the road safely.

**RЕSULTS**

In the study, a road vehicle traveling with uniform velocity of 18 m/s at a span of 4.3 meters at the right-hand side of the pedestrian wall, using limited visibility, struck a pedestrian who exited the corner of the wall after other pedestrians. A pedestrian was traveling at 1.5 meters/hour at a distance x = 1.0 m from the wall. The total width of the Lacetti vehicle is 1.7 linear meters, the overall length is 4.5 linear meters, and the maximum possible deceleration is 5.0 m/s2. Time T =1.0 s is characterized by the dimensions of the position of the driver's seat in the cabin: ax=2.3 m, ay=2.3 m. The distance from the rear axle to the front axle is 3.0 m.

Pedestrian 1 was struck by the vehicle’s right side, with the point of impact located 1.8 meters behind the car’s front.

At the scene of the incident, the road is asphalt, flat, dry, horizontal, at night, sunny.

The conditional symbols listed below are applied in mathematical operations:

\* - for multiplication; 2 - squaring; / - for division, and ^0.5 for square root extraction.

T - denotes the driver’s reaction time, taken as 1.0 second.

*j - represents the deceleration rate of the Lacetti vehicle, which is 7.19 meters / second squared (m/s²).*

*Va represents the speed of the Lacetti vehicle, which is 18 meters / second (m/s).*

*lх*- represents the distance from the Lacetti vehicle to the point where it struck the pedestrian with its right side, which is **1.8 meters.**

***Vp*** – pedestrian movement speed, 1.5 metres/hour;

***Sp***- The pedestrian covered a distance of 4 meters before reaching the scene of the incident.

***La***- The total length of the Lacetti car is 4.5 m.

***Вa***- The Lacetti has a total width of 1.7 meters.

**ax** and **aу** - distances from the driver's seat to the nearest object that limits visibility to the front and sides of the car, 2.3 m.

Pedestrian sight distance is determined as follows:

*(Sa+2,3—1,0)/(4,3+2,3)=1,0\*18/[(Sa+1,8)1,5-4,3\*18]*

After simple transformations, we get:

1,5S2a—72,75Sa—215,91=0, here Sа=51,3 m the path the pedestrian was on before the collision,

Sp= 51,3\*1,5/18=4,3 m.

Thus, we have determined the initial position of the car and the pedestrian, since from this moment the pedestrian is completely in the field of vision of the driver, then the subsequent analysis (calculation of estimated versions) does not differ from the analysis.

Pedestrian 2 was struck by the end surface of the vehicle. The point of impact is located 1.5 meters from the car’s right side. All other parameters remain unchanged from the previous calculation.

Viewing distance

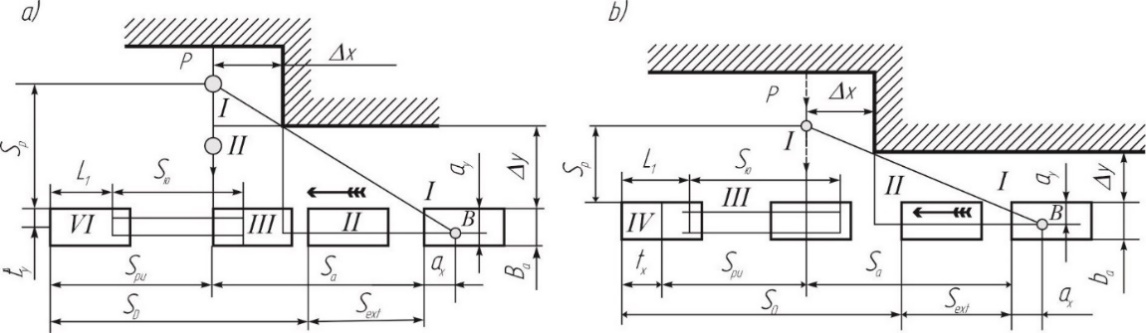
*(Sa+2,3-1,0)(Sa1,5/18-4,3-1,8)=(4,3+2,3)1.0*

after substitution we arrive at 1,5S2a—109,65Sa-263,88=0, The distance from the vehicle to the collision point was 75.5 meters The road is the path of a pedestrian before being hit by a traffic accident:

Sp=75,5\*1,5/18 =6,3m.

We turn to the analysis of pedestrian impact in slow motion of a car. Expert calculations in the study of such analyzes are much more time-consuming and complex than previously performed calculations. However, from a methodological point of view, there are no major differences from the options discussed above. First, the parameters of the car's movement are determined, and then, based on the visibility conditions, how far the car was from the pedestrian when the latter entered the driver’s field of vision.

Consider a pedestrian hitting the front of the car and running, the calculation diagram corresponding to this situation Figure 1-a shows the position of the vehicle (pedestrian) at the time of the occurrence of a dangerous situation. place of the traffic accident, number IV - state after stopping. The most difficult stage of the analysis of such a road traffic accident is to determine how far the vehicle was from the place of the traffic collision.



**FIGURE 3.** A view limited by a fixed barrier, a schematic view of impact during braking a - option - b - option

In the event of a traffic accident, whether or not the driver had the technological capability to avoid the avoiding the collision through timely braking of the Lacetti car. is solved by comparison.

In the event of a traffic accident, whether or not the driver had the technological capability to avoid the avoiding the collision through timely braking of the Lacetti car, vehicle's the stopping distance, denoted as So, and its separation from the scene of the accident at the value of Sa, representing the moment of traffic danger, is obtained by means of comparison [3].

In this traffic situation, the stopping distance of the Lacetti vehicle is calculated as follows:

As a result of the performed actions, the stopping distance of the Lacetti vehicle traveling at a speed of 64.8 km/h has been calculated, and the results are presented in Table 2.

Furthermore, the distance between the Lacetti and the scene of the accident at the moment the pedestrian had moved 4 meters is determined as follows:

Following the analysis, the calculated distance from the Lacetti vehicle (traveling at 64.8 km/h) to the accident scene is shown in Table 2.

**TABLE 2.** Technical capabilities of the Lacetti

|  |  |  |  |
| --- | --- | --- | --- |
| Va, kilometres/hour | Sа, metres | So, metres | In relation to the technical feasibility |
| 64,8 | 75,5  51,5 | 45,85 | He owns |

By comparing the outcomes of the operations described above, it was found that So < Sa. So, under the conditions of this vehicle collision, since the danger in relation to traffic has arisen, the driver of the Lacetti possessed the technical means to avoid the accident through timely braking.

**CОNCLUSIОN**

This study has analyzed the impact of limited visibility conditions—such as fog, darkness, terrain features, and road curvature—on road traffic safety. Through the use of physical modeling, distance measurements, and speed-based calculations, the study assessed the technical potential to prevent accidents, particularly involving pedestrians. The research showed that when drivers respond within standard reaction times and braking systems function properly, many collisions in limited-visibility zones can be avoided.

Furthermore, the analysis revealed that visibility restrictions significantly reduce the time and space available for hazard recognition and response, making it essential to enhance warning systems, install physical traffic control devices, and design road environments that support early detection of obstacles. The calculated stopping distances and driver sight limitations demonstrated the need for strict speed regulation in such areas.

In conclusion, physical assessment methods remain vital tools for identifying risk zones and informing engineering-based traffic safety interventions in conditions of restricted visibility. The findings highlight the importance of combining technical countermeasures with driver awareness to effectively reduce accident rates in these high-risk environments.

**REFERENCES**

1. Sudebnaya Avtotekhnicheskaya Ekspertiza, Part 2 (Moscow, 1980), p. 491.
2. V. A. Ilarionov, Ekspertiza Dorozhno-Transportnykh Proisshestviy: Uchebnik dlya Vuzov (Transport, Moscow, 1989), p. 255.
3. Primeneniye Differentsirovannykh Znacheniy Vremeni Reaktsii Voditelya v Ekspertnoy Praktike (Moscow, 1987).
4. Ispolzovaniye v Ekspertnoy Praktike Eksperimental’no-Raschetnykh Znacheniy Parametrov Tormozheniya Avtotransportnykh Sredstv (VNIISÉ, Moscow, 1995).
5. N. M. Kristi, Metodicheskiye Rekomendatsii, Scientific Research Laboratory of Autotechnical Expertise, TsNIISÉ.
6. E. Fayzullayev, S. Khakimov, A. Rakhmonov, S. Rajapova, and Z. Rakhimbaev, “Traffic intensity on roads with big longitudinal slope in mountain conditions,” E3S Web Conf. **401**, 01073 (2023). <https://doi.org/10.1051/e3sconf/202340101073>.
7. S. Khakimov, “Vehicle ride regime as a main factor for GHG emission reduction,” AIP Conf. Proc. **2432**, 030127 (2022). <https://doi.org/10.1063/5.0089563>.
8. E. Fayzullaev, B. Tursunbaev, S. Xakimov, and A. Rakhmonov, “Problems of vehicle safety in mountainous areas and their scientific analysis,” AIP Conf. Proc. **2432**(1), 030099 (2022). <https://doi.org/10.1063/5.0089596>.
9. S. Khakimov, S. Rajapova, F. Amirkulov, and E. Islomov, “Road intersection improvement – main step for emission reduction and fuel economy,” IOP Conf. Ser.: Earth Environ. Sci. **939**, 012026 (2021). <https://doi.org/10.1088/1755-1315/939/1/012026>.
10. K. Kutlimuratov, S. Khakimov, A. Mukhitdinov, and R. Samatov, “Modelling traffic flow emissions at signalized intersection with PTV Vissim,” E3S Web Conf. **264**, 02051 (2021). <https://doi.org/10.1051/e3sconf/202126402051>.
11. S. Khakimov, E. Fayzullaev, A. Rakhmonov, and R. Samatov, “Variation of reaction forces on the axles of the road train depending on road longitudinal slope,” E3S Web Conf. **264**, 05030 (2021). <https://doi.org/10.1051/e3sconf/202126405030>.
12. A. Khalmukhamedov, R. Samatov, and S. Rajapova, “Prospects for the use of an automatic system for weight and dimensional control of vehicles in the Republic of Uzbekistan,” AIP Conf. Proc. **3045**(1), 050031 (2024). <https://doi.org/10.1063/5.0197415>.
13. R. Samatov and U. Samatov, “Improvement of methods for assessing the quality of road transport services,” AIP Conf. Proc. **2432**, 030094 (2022). <https://doi.org/10.1063/5.0091190>.
14. E. Z. Faizullaev, A. S. Rakhmonov, U. M. Mukhtorjanov, S. Turdibekov, and S. I. Nasirjanov, “Parameters of the access road for disaster situations on the roads in the mountain area,” E3S Web Conf. **401**, 03022 (2023). <https://doi.org/10.1051/e3sconf/202340103022>.
15. S. Rajapova, “Innovative ways to train drivers and improve their skills,” AIP Conf. Proc. **2432**, 030100 (2022). <https://doi.org/10.1063/5.0090825>.
16. K. Rustamov, S. Komilov, M. Kudaybergenov, S. Shermatov, and S. Xudoyqulov, “Experimental study of hydraulic equipment operation process,” E3S Web Conf. **264**, 02026 (2021). <https://doi.org/10.1051/e3sconf/202126402026>.
17. K. Sharifbaeva, G. Niyazova, D. Abdurazzakova, I. Abdurashidov, and R. Alimardonov, “Formation of methodical competence of special subjects teachers in technical universities,” AIP Conf. Proc. **2432**, 050043 (2022). <https://doi.org/10.1063/5.0089618>.
18. O. Rabat, Sh. Pirnaev, K. Rustamov, I. Usmanov, Sh. Shermatov, and K. Magdiyev, “Development of corrosion-resistant material for asphalt concrete cutting part,” E3S Web Conf. **587**, 03012 (2024). <https://doi.org/10.1051/e3sconf/202458703012>.
19. S. Korabayev, J. Yuldashev, U. Isokhanov, S. Makhkamova, and N. Saparboyeva, “Overcoming obstacles: solving cutting resistance problems,” E3S Web Conf. **587**, 03015 (2024). <https://doi.org/10.1051/e3sconf/202458703015>.
20. Turdibekov, S., Xamraqulov, R., Negmatov, N., Raximbayev, Z. The method of calculating the parameters of the materials delivery mechanism of the technological materials distributor. BIO Web of Conferences 145, 03025 (2024) Forestry Forum 2024 https://doi.org/10.1051/bioconf/202414503025
21. Khalilova, G., Rakhmonov, A., Samatov, R., Razhapova, S, Abdusamatov, E., and Shermatov, S., “Methodology for Calculating the Share of Parking-Searching Vehicles in Traffic Congestion on Multi-Lane Roads,” International Conference of Young Specialists on Micro/Nanotechnologies and Electron Devices, EDM. https://doi.org/10.1109/EDM65517.2025.11096677
22. Fayzullayev, E., Khakimov, S., Rakhmonov, A., Rajapova, S., and Abdurazzakova, D. “Correct choice of parameters of runaway truck ramp on the mountain roads is factor in saving people's lives,” AIP Conference Proceedings. <https://doi.org/10.1063/5.0267594>
23. Choriev, J.A., Faizullaev, E.Z., Khakimov, S.K., and Rakhmanov, A.S., “The Impact of the Number of Street Intersections on Traffic Safety in Karshi City,” Springer Nature <https://doi.org/10.1007/978-3-031-83595-7_37>
24. Khalilova, G. Kh., Choriyeva, M. Sh., Samatov, R. G., Abdurazzokov, U. A., & Urunov, D. A. (2025). AI Integration in Smart Car Parking Stations (pp. 125–133). https://doi.org/10.1007/978-3-031-88846-5\_15
25. Kapski, D., Semchenkov, S., Gamulsky, I., Ikromov, A., Omarov, J., and Abruev, S., “Assessment measures developed to improve quality of route transport Polotsk and Novopolotsk,” E3S Web of Conferences, 515, 03003. <https://doi.org/10.1051/e3sconf/202451503003>
26. Mikhaltsevich, M., and Ziyaev, K., “Modeling the braking process for motorcycle with ABS,” E3S Web of Conferences, 592, 07002. <https://doi.org/10.1051/e3sconf/202459207002>
27. Mukhitdinov, A., Yusupov, U., Tukhtamishov, S., and Urinbayev, Q., “Results of the study of the influence of an average longitudinal slope of routes on the life of tires in the quarry,” AIP Conference Proceedings 040041. <https://doi.org/10.1063/5.0197301>
28. Petrovich, B. V., and Ugli, A. A. A., “Analysis of static load on a tire in quarry operating conditions,” AIP Conference Proceedings 030017. <https://doi.org/10.1063/5.0266786>
29. Tursunbaev, B. H., Fayzullaev, E. Z., Akbarov, N. A., and Nigmatov, H., “A new methodology for evaluating the efficiency of complex machine mechanisms,” AIP Conference Proceedings 040098. <https://doi.org/10.1063/5.0145575>
30. Tursunov, S. R., Khikmatov, R. S., and Khusanov, S. N.-U., “Increasing the efficiency of the use of mining transport due to increasing the periodicity of maintenance time,”. AIP Conference Proceedings 050021. https://doi.org/10.1063/5.0197547