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Influence of Transport Loads on Crack Formation

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Annotation: A sharp increase in the cost of construction and operation of highways, increased speed and capacity of vehicles has brought to the fore the problems of ensuring the durability and reliability of road constructions and, in particular, pavements. Potential of modern cars gransport (high speed, a large load capacity) can be effectively and safely achieved without ensuring the reliability and durability of the whole range of transport construction. Given the close relationship between the processes of deformation and destruction, it should be noted that there is a clear lack of research on the processes of V destruction of the materials of the layers of the road surface. The lack of criteria For evaluating the properties of road construction materials in terms of the degree of destruction and the intensity of the destruction process does not allow us to design their properties with a sufficient degree of reliability and, as a result, to justify the strength resource of both layer materials and road pavements.

Key words: Deformation, cracks, load.

Introduction. Every year, the total number of cars on the roads of the Republic of Uzbekistan increases by about 21 % [1], including cars that exceed the standard load on the single most loaded axle. The main network of existing highways in Uzbekistan was designed and built more than 20-30 years ago, under less load [2] than today. The problem is that the axial load on the road surface increases, and there are not enough financial and technical means to strengthen the structure of the road surface.

An increase in the load capacity leads to an increased transport impact on the road surface with the premature appearance of deformations and destruction. A further increase in the load from vehicles on the road structure leads to intensive destruction, as a result, the work capacity of the road structure is quickly exhausted. This problem requires scientific research to study the condition of road structures under the influence of heavy loads.

Outstanding scientists in the CIS were engaged in the assessment of the impact of traffic flow on the road structure and the study of the stress-strain state[3, 4, 5, 6, 7] and in Uzbekistan [8]. Their studies have shown that the formation of deformations and fractures is influenced not only by the design load, but also by the number of loading cycles. With repeated loads, residual deformations accumulate, which later leads to destruction. Forecasting of deformations and destructions on asphalt concrete surfaces, contributes to the timely decision to improve the condition of the pavement and the road structure as a whole.

Analysis. Deformation - a change in the relative position of body particles associated with their movement. During deformation, a change in the size and shape of the body occurs without changing its mass and loss of continuity. Distinguish between elastic and residual (plastic) deformation. Elastic deformations disappear almost instantly after removal (passage) of the load. Residual deformations do not disappear after unloading and can accumulate under repeated loading.


Destruction - a change in size, shape and body weight with loss of continuity.

The main types of fractures and deformations of pavements and coatings should include: cracks (transverse, longitudinal, oblique), a network of cracks, breaking off (chipping) of edges, wear (abrasion), peeling, chipping, potholes, subsidence, breaks, deeps, ruts, the waves [4].


If necessary, linking the state of the pavement, which ultimately reflects the state of the entire road structure, with the speed of a single passenger car and the average speed of the traffic flow [4], an indicator of the actual degree of deformation of the pavement (on pavement surface)

$$R_f = \frac{S_{def}}{S_{over}} \quad (1)$$

here S_{def} - damage area in the area under consideration, m^2;

S_{over} - total area of the surveyed road section, m^2.

Permissible degree of deformation of the coating is [4]

$$R_{al} = 1 - K_H \quad (2)$$

here KH - reliability level of pavement [4].

In the German standard [9], the total estimated number of applications of the design load for the period of operation allows you to assign the road to a certain construction class and select the required structure from the album by its value, bypassing the stage of analytical calculation.

Methods. The total calculated number of applications of the calculated load to a point on the surface of the structure over the service life [11] is determined by the formula:

$$\sum N_p = f_{пол} \sum_{m=1}^{n} \left(N_{lm} K_c \cdot T_{рдг} \cdot 0{,}7\right) \cdot S_{m.сум} \cdot k_n \quad (3)$$

$$\sum N_p = 0.7 \cdot N_p \frac{K_c}{q\,(T_{сл}-1)} T_{рдг} \cdot k_n \quad (4)$$

where N is the number of car brands; N_{lm} – daily traffic intensity m grade in the first year of service (in both directions), ed./day; N_p – given the intensity of the last year of life, ed./day; $Sm._{sum}$ – total coefficient of reduction of the impact on road clothing vehicle m grade to rated load, Q- defined in tab. 1; T_{rdg} – the estimated number of days in a year corresponding to the state of structures when it accumulates residual deformations: for roads of the I road-climatic zone (Sirdara, Yangier, Almalyk, Bekabad, Tashkent, Ferghana, Andijan, Samarkand, Denov, Sherabad, Kukan, Urgench, Khiva) of Uzbekistan, Trdg = 76 days, II DKZ (Jizzak, Dustlik, Guzar, Karshi, Mubarak, Termez, Pap, Namangan, Shakhrisabz) – 112 days, III DKZ (Nukus, Chimbay, Zhangeldi, Gallaorol, Muynak, Bukhara)– 134-151 days, IV DKZ (Karakalpak, Navai, Nurata, Akbaytal, Moshikuduk)– 183 days; K_n – coefficient taking into account the likely deviation of the total movement of the average expected: for the roads I – II categories kn = 1,44, roads III – IV categories K_n = 1,24-1,35; K_C coefficient summation, defined specified service life TSL.; f-the factor loading of lanes road.

In most countries of the world, there are restrictions on the weight parameters of motor vehicles that determine their design (Table. 1) [12].

National restrictions on the weight parameters of motor vehicles in Europe and the CIS

Table 1.

Estimated axle load, tn	European and CIS countries
9-9,5 tn	Poland, England
10 tn	Russia, Moldova, Estonia, Lithuania, Latvia, Kazakhstan, Belarus, Ukraine, Sweden, Switzerland, Finland, Norway, Denmark, Hungary, Bulgaria, Austria
11 tn	Czech Republic, Germany, Slovakia, Netherlands
12 tn	Portugal, Italy, Belgium
13 tn	Uzbekistan, France, Luxembourg, Spain, Greece

Table 1 shows that 16 countries out of 31, i.e. 54.5%, prefer to focus on the calculated static loads on a single vehicle axle of 10 tn. (or 100 kN) [12]. This is indicated by the fact that many of these countries are located in close proximity to the oceans and seas. Therefore, it is enough for them to design road structures of a non-rigid type up to 100 kN. Other countries, and, in particular, Uzbekistan, which do not have access to the sea, design road structures of a non-rigid type of more than 130 kN, since the main cargo turnover is accounted for by road transport. Therefore, in our republic, due to the impact of transport loads and natural and climatic factors, there is a high wear, deformation and destruction of the road surface. To date, about 70 % of the country's roads require repair and reconstruction.

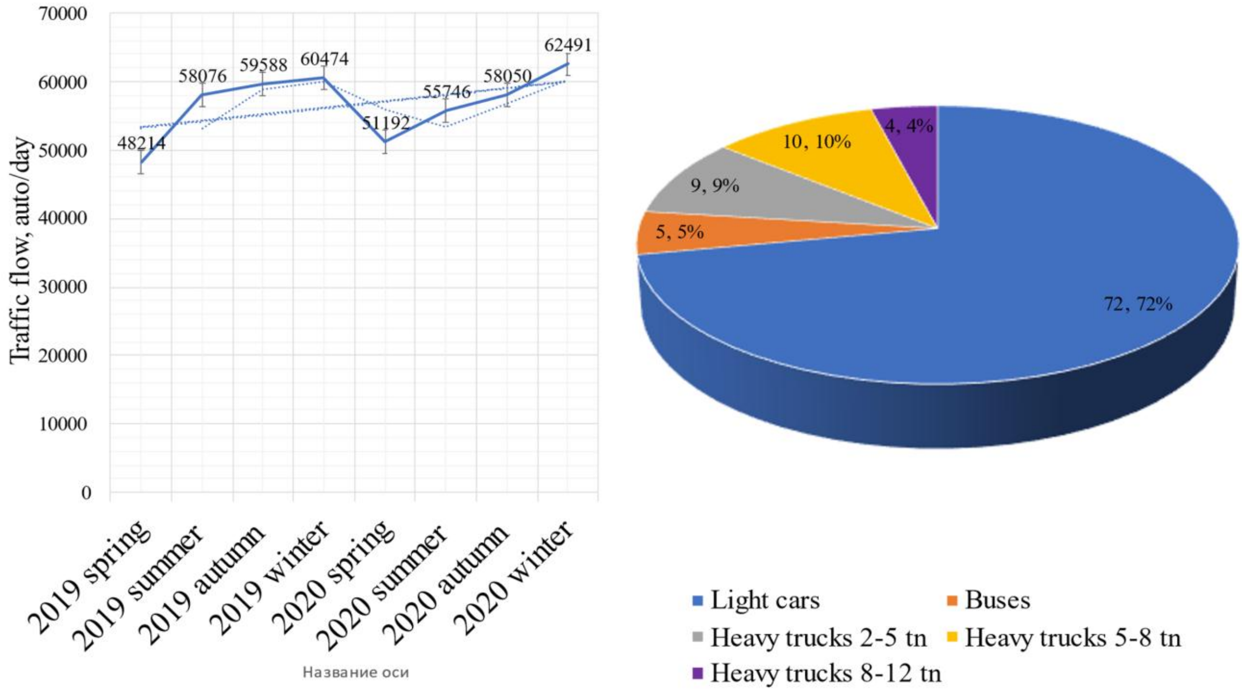
The existing state of the road network of the Tashkent region meets the requirements for the length and configuration of roads. However, in terms of transport and operational qualities, it does not meet the requirements of road transport. Consequently, the road infrastructure of the Tashkent region has not reached a sufficiently high level of operation, as a result of which road wear has increased, transport costs have increased, and this has a negative impact on the development of the economy.

Results. The country's transport system is developing systematically. Road transport has now become the most popular form of transport. Due to the fact that cargo and passengers are transported by cars mainly over short distances compared to rail and water transport, road transport occupies quite a large place in the total volume of cargo turnover (about 65% in terms of cargo turnover and 93% in terms of passenger turnover).

The total number of vehicles in the region is 164 thousand units. Of these, passenger cars make up 77.5 %, trucks 12.5%, buses 3.5 % and other 6.5 %. The number of vehicles for every 1 km of a public highway is 42.7 units/km. In recent years, the total number of vehicles has been increasing due to passenger cars. Passenger cars make up 60-75% of the traffic on international and national roads, and 75-90% on local roads. An increase in the number of passenger cars in the flow leads to an increase in the average speed of the flow, therefore, the number of road accidents.

The international highway M-39 "Almaty-Bishkek-Tashkent-Termez-Shakhrisabz" is the main economic road of the Republic. The M-39 highway "Almaty-Bishkek-Tashkent-Termez-Shakhrisabz" was chosen for the experimental work. The dynamics of changes in the intensity of traffic and the composition of the flow are shown in the following figures: (Fig. 1).

Fig. 1. Dynamics of changes in traffic intensity and Flow composition diagram



For our republic, it is necessary to timely predict deformations and destructions on highways, and plan restoration measures to improve the condition of the pavement.

To predict deformations and destructions of roads with asphalt-concrete surfaces in Japan, the following formula is used [13]:

$$MCI = 10 - 1.48\, C^{0.3} - 0.29\, D^{0.7} - 0.47\sigma^{0.2} \quad (5)$$

C : Crack formation ratio (%); D : Track size (mm)

σ : Road level (mm);

MCI : Maintenance Control Index – (Road Maintenance Control Index) is an indicator of a comprehensive assessment of the road surface.

At the same time, there are three phases of destruction [16]:

1. the beginning of crack formation;
2. the period of stable crack growth;
3. the stage of intensive crack growth.

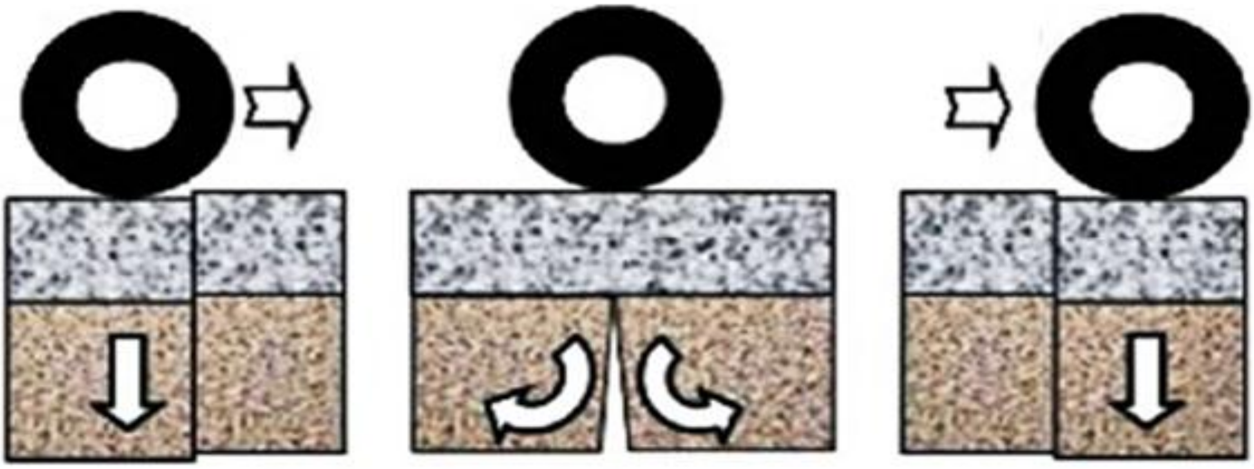


Fig. 3. The mechanism of formation of reflected cracks due to the impact of the load of vehicles

With a change in the macro-roughness, the thickness of the road surface also decreases, which leads to the formation of cracks. At the same time, the overall decrease in macro-roughness can be described by the M. V. Nemchinov equation [10]:

$R = a * \exp[-b * M] + C$, мм (6)

where M - is the number of cars that have passed; a, b, C - are coefficients that depend on the size of the rubble, the hardness of the coating and the composition of the traffic flow.

The type and number of defects on the road surface are determined on the basis of a visual assessment. All defects found on the coating are divided into types according to their characteristic features (Table 2) and determine the main strength defects in each section under consideration. For example, if a network of cracks is not found on the site, then frequent cracks are considered as the main defect. If there are no frequent cracks, then the site is estimated by rare cracks (see Table 2) [15].

Table 2

Type of defect	Characteristic features of the coating defect
A. Strength defects	
Cracks: single	transverse and oblique cracks located at a distance of more than 15-20 m from each other
separate	Transverse and oblique cracks located at approximately the same distance from each other. The distance between adjacent cracks is 10-15 m
rare	transverse and oblique cracks (often with branches) are not connected to each other. The average distance between adjacent cracks is 4-10 m
frequent	transverse and oblique cracks with branches, sometimes connected to each other, but, as a rule, do not form closed shapes. The average distance between adjacent cracks is 1-4 m
grid of cracks	Transverse and longitudinal cracks developed in the zone of coasting bands and forming closed, mainly quadrangular shapes with a distance between the sides of less than 1 m. Often accompanied by subsidence,

	cell formation and wave formation
exclusionary	Smooth distortion of the transverse profile of the road surface, localized along the strip rolling. On coatings arranged with the use of binders, it is usually accompanied by longitudinal cracks and a grid of cracks
drawdowns	A sharp distortion of the coating profile, which has the appearance of a depression with rounded edges. On coatings arranged with the use of binders, subsidence is accompanied by a grid of cracks, often also covering the coating areas directly adjacent to them
waves	Regularly alternate (after 0.5-2.0 m) on the surface of depressions and ridges, in the transverse direction with respect to the longitudinal axis of the road. As a rule, they occur on roads with transitional types of pavement
B. Defects caused by the influence of violations in the production technology of work	
breaks	Complete destruction of the road surface for its entire thickness with a sharp distortion of the surface profile
chipping and peeling	Surface destruction of the coating due to the loss of individual grains of mineral material and peeling of the binder
potholes	Local destruction of the road surface, having the form of depressions with pronounced edges
shifts	The displacement of the surface, which is usually observed on steep descents, in places where cars stop and brake. Sometimes there are gaps in the coating in the places of the shift
open depths	Cover with a grid of cracks. It is accompanied by the squeezing of the soil on the surface of the coating at the time of passing under the wheel of the car

The average value of the reduction in the thickness of the coating for a year due to wear can be calculated using the formula of M. B. Korsunsky [4]:

$$N_{srg} = a + b * N / 1000, \text{ mm} \quad (7)$$

here a - is a coefficient depending on the weather resistance of the coating and climatic conditions; b - is an indicator depending on the strength of the coating material, the degree of its moisture content, composition and speed of movement; N - is the intensity of movement, auth.day.

The methodology for ensuring transport requirements for roads takes into account two types of cracks - narrow, 1-3 mm wide, and wide, more than 3 mm, and also includes two methods for predicting the timing of cracking of coatings [8].

a) The number of years before the appearance of cracks in the coating:

b) $T_{mp} = 4.21 \exp(0.319 M_{ОД} - 17.1 N/M^2_{ОД})$ (8)

where N - is the total number of vehicles passing through one lane on the roadway in a year, reduced to the equivalent number of standard axial loads of 80 KN in million

c) The area covered by the formation of cracks:

$$\delta_{mp} = 1.76 \cdot \omega_{мин}^{0,23} \cdot T \quad (9)$$

Predicting deformation and destruction is a major problem in the road industry, as the increase in trucks in the flow negatively affects non-rigid road structures. For this reason, during the operation of roads, such qualities of the road as: flatness, roughness, wear, and deteriorates the safety and comfort of traffic, various defects of the pavement and road surface appear, which leads to their premature destruction. The impact of natural and climatic factors in the regions of the republic is also the cause of the formation of cracks and deformations. Due to the influence of natural and climatic factors, in the regions of the republic, the characteristic deformations are-track formation.

The problem of track formation and deformations is quite multifaceted and is associated with transport and operational indicators, the quality of the highway and the performance of road structures.

In [14], track formation is considered to be local wear, mainly formed in the coasting band. The average amount of wear over the entire width of the roadway is recommended to be determined by the formula:

$$h_{ср} = К \cdot h_{н} \qquad (10)$$

where K - is the coefficient of unevenness of wear, an average of 0.6 is taken....0.7;

$h_{н}$ – the measured value of wear in the coasting band, mm.

The solution to this problem requires the prediction of deformations and destruction of the road surface to improve transport and operational indicators and increase the service life of the road.

Summarizing the above, it should be noted that there is a task to provide the life cycle of roads, conducting research as road construction, and based on the results of the study to assign specific actions for repair and maintenance of road surface while also improving the operational condition of the road.

Conclusions. The type of road damages in Tashkent region can be grouped by 3 (three) types of damages such as:

a) type of cracks;

b) type of disintegration, dominated by potholes, this one is began in the form of ravelling; and

c) type of depression, it is began with the deformation.

Several maintenance project has been done to improve the road condition. In the future it is important to design the road which consider the factors that effect the road damages and to consider the overloading of vehicles.

References

1. https://regulation.gov.uz/ru/document/4087
2. ШНК 2.05.02-95 - Автомобильные дороги (Проектирование).
3. Матвиенко Ф.В. Прогнозирование величины необратимой деформации дорожной конструкции от воздействия транспортного потока М.: Транспорт, 2010, с. 97.
4. Васильев А.П. Эксплуатация автомобильных дорог. 1 часть. М.: Академия. 2010. - 316 стр.
5. Васильев А.П. Проблемы разработки методов прогнозирования глубины колеи на автомобильных дорогах // Проблемы строительства и эксплуатации автомобильных дорог в начале XXI века. М.: МАДИ(ТУ), 2000. С. 4-32.
6. Васильев А.П., Коганзон М.С., Яковлев Ю.М. Предложения по учету остаточных деформаций при расчете дорожных одежд нежесткого ти-па//Наука и техника в дорожной отрасли.,- М.:, "Дороги", 1997, №1. С. 5-6.
7. Илиополов С.К. Разработка основ комплексного учета динамических воздействий для расчета и конструирования дорожных одежд: Автореферат дисс. д-ра техн. наук.

МАДИ, 1999.-35 с.

8. Садиков И.С. Прогнозирование и управление транспортно-эксплуатационными качествами автомобильных дорог. – Ташкент: Адолат, 2004. – 238 с.
9. Richtinien fűr die Standardisierung des Oberbaues von Verkehrsflächen. RSTO 200. FORSCHUNG Geselschaft fűr Strassen – und VERKEHR wesen. Ausgabe 2000. BAST.
10. Немчинов М.В. Сцепные качества покрытий и безопасность движения автомобилей. – М.: Транспорт, 1985. – 224 стр.
11. MQN 46-08. Инструкция по проектированию нежестких дорожных одежд
12. https://openkid.ru/dopustimye-nagruzki-na-os-v-stranah-nagruzka-na-os-osevaya-nagruzka.
13. http://smapse.ru/shizuoka-university-universitet-sidzuoka.
14. Некрасов В.П., Алиев Р.М. Эксплуатация автомобильных дорог. Учебник для автодорожных вузов. 2 изд., перераб. М.: Высшая школа, 1983.
15. ОДН 218.1.052-2002 Оценка прочности нежестких дорожных одежд
16. Бахрах Г.С. Подход к определению срока службы асфальтобетонных покрытий / Г.С. Бахрах // ДОРОГИ И МОСТЫ. – 2014. – Вып. 32/2. – С. 250-263.