MODERN TENDENCIES IN DEVELOPMENT OF HIGHWAYS IN RUSSIA

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Abstracts: *In the report the data on the level of motorization and the road network length in the Russian Federation, the rates of its growth from 1995 till 2010 are presented. The necessity to enhance the pavement is validated and the new approach to road pavement design and construction are discussed. The current system for diagnosing and monitoring the road conditions used in Russia is defined.*

Key words: *road network, state and growth prospects, pavement, new tendencies in design, diagnostic system, road condition estimation*

I. CURRENT STATE AND TENDENCIES IN THE DEVELOPMENT OF ROADS IN RUSSIA

In the last 15 years the rate of motorization in the country increased. Rapid motorization in Russia will continue in the foreseeable future. According to the predictions of the Ministry of Transport of the Russian Federation, in year 2010 the car park will amount to approximately 36-39 million automobiles (table 1). Traffic volume in the

road network has increased by 5%, and growth of the traffic intensity on the main roads has reached 26.2%.

The motorization growth ratio predetermines the necessity to speed up the road network modernization development.

Table 1. *The number of vehicles in Russia (at the end of the year)*

	1990	2001	2010
Lorries (including pick-ups and vans), thous. pcs.	2744	3329	4927…5321
Passenger cars, thous. pcs.	8964	21152	31299…33805

including owned by the citizens, thous. pcs.	8677	19984	29571…31938
Number of automobiles per 1000 of citizens, pcs.	80	169	250…270*
Average increase in vehicle park per annum, %	7,7 (from 1990 till 2001)		5…6* (from 2002 till 2010)
Increase in the total number of vehicles, thous. pcs.	12733 (from 1990 till 2001)		11745…14645* (from 2002 till 2010)

Note. ** - Forecast. (The proportion of the passenger cars in year 1990 ≈ 76,56%; in year 2001 ≈ 86,4%).*

Over the period of 1995-2000 the length of the road network increased from 519 to 584 thous. km including increase in the federal road network from 41 thous. km to 46.3 thous. km. Within these years 33.9 thous. km. of roads were built and reconstructed, including 18 thous. km. of newly built roads, 183.2 thous. km. of reconstructed roads and 290 km of bridges; the public road network was replenished with 47 thous. km. of roads supervised by farm producers.

In the Programme “Modernization of the Transport System in Russia (for the period of 2002-2010)” it is envisaged that by year 2010 the public roads network will increase by 1.1 times. The length of the public roads network in 2010 will total 670 thous. km including 50 thous. km of federal and 620 thous. km of regional roads. The length of the roads with capital type of pavement will amount to 428 thous. km, and those with the transition type – to 212 thous. km. The length of the roads with four and more traffic lanes will increase from 4.3 to 8 thous. km, i.e. nearly twofold, that will drastically reduce the possibility of traffic jams.

Traffic capacity of the most congested sections of the primary interregional and international routes will increase 1.5-2 times, and on an average, by 10-12% within the network. Level of congestion, characterizing correspondence between the road network technical level and its traffic volume, will on average amount to 0.4-0.6 within the network what is optimal according to comfort, safety and efficiency of transportation.

Under these circumstances the road network development and road service quality management is the task of primary importance, its solution exercises direct influence over the pace of the socioeconomic development of the country. Modernization of the existent public roads is becoming of great importance, i.e. bringing their application properties and service state into line with the requirements of the country’s car park and factual traffic volume. The application properties include speed, fluidity, safety and comfort of driving, road capacity and the level of congestion, the capacity to carry automobiles and road-trains with the permissible axial load, total weight and clearance limit as well as environmental safety.

The efficiency of road works can be significantly enhanced if in the process of planning one proves and optimizes the management decisions based on the estimation of the factual road situation. To adequately utilize facilities and physical resources meant for reconstruction, repairs and maintenance of roads, the Ministry of Transport of the Russian Federation and State Technical University-MADI have developed and implemented the system of road situation maintenance based on the results of the systematical monitoring, diagnostics and evaluation of the real road service state. This system is based on the complete, objective and reliable information on parameters, characteristics and conditions of roads and road buildings operation, availability of faults and the terms of their emerging, traffic flow characteristics that can be obtained in the course of diagnosis, inspection, acquisition, analysis and organization of the data bank on road service quality. The management system created and the data bank make it possible to objectively estimate and predict the road and road buildings state in the process of further operation. The complex index of the road service conditions takes into account influence of the following key elements, parameters and characteristics: width of the main reinforced surface of carriageway and width of the bridge; road shoulder width and condition; traffic volume and composition; longitudinal grade and sight distance; curvature in plan and superelevation slope; longitudinal surface roughness; skid resistance coefficient; pavement condition and durability; roughness in transverse direction (rut depth); traffic safety; engineering equipment and instruments; level of maintenance management.

Over a period of years the federal road repairs have been planned and carried out on based on the results of the diagnostics. For the first time in the road sector of the Russian Federation an evidence based, objective and reliable system of road service monitoring and diagnostics have been developed and widely used, it is necessary for effective management of the application properties by developing projects and performing works on road reconstruction, total overhaul and maintenance.

The road application properties are provided by real level of their maintenance, geometrical parameters, technical characteristics, engineering equipment and instruments. Diagnostic makes it possible to detect origin of faults, justify the road repair and maintenance type and scope. The diagnostics system generalizes (synthesizes) of the main regulations requirements to the road application properties and contributes to the increase in the quality of service.

The diagnostic system makes it possible to effectively control the operational condition of the certain road sections, certain routes or certain roads and the road network altogether.

II. NEW TENDENCIES IN DESIGN AND CONSTRUCTION OF ROAD PAVEMENTS

The following factors predetermine modern tendencies in development of pavement calculation and construction methods in Russia:

- Growing demands of the current road traffic which consists of a significant portion of lorries and a high number (more than 65%) of passenger cars.

- The sudden increase in the number of cars (according to the Ministry of Transport of the Russian Federation over the period from 1991 to 2025 – 4-5.5 times, including an increase in the number of lorries – 4.8 times) created necessity in radical modernization of the road network and, in the first instance, modernization of the federal roads.

- Analysis of the real life time of pavement in the Russian Federation and other countries shows that when put in the same operational conditions rigid pavement has the life time of 1.6-2 times longer than that of flexible pavement.

- Modern tendencies in improvement of road engineering, development of new road-building materials such as modified high-quality cement concrete, fiber and polymer concrete, high-strength composites and so on; evolution of structural concepts and techniques contribute to expansion of rigid and composite pavement (bituminous concrete pavement with cement concrete sub base).

- The current road network has mostly flexible pavements including bituminous concrete pavement with the sub base made of materials that are unsuitable for bending tension (this is mostly broken stone); such paving materials don't provide for the standard life time of the pavement as in such structures only a relatively thin bituminous concrete pavement works in bending; in other words, in the current operational conditions flexible pavement of the capital type should have a sub base of binding agent-treated and steady working in bending materials that will last till the pavement total overhaul.

In 2001 new designing standards of flexible pavements were introduced in the Russian Federation. The peculiarity of the new method of flexible pavement strength calculation lies in the fact that the structure calculation is based on the three failure criteria (aggregate pavement elastic modulus, shear resistance of the constructional layers and subfoundation, bending tension resistance of indistinguishable constructional layers) that are determined considering replication influence (aggregate computational number of applications) on the pavement life time. The old method presumed stress calculating based on the influence of the perspective (as at the life time end) daily average number of stress applications (reduced to the equivalent thrust load).

Synthesis of the 60-year-old practice of rigid pavements application in the former USSR and the Russian Federation makes it possible to consider that in the overwhelming majority of cases the imperfections causing their early aging are connected not with the designing and constructional miscalculations, but with the failure to comply with the regulations on constructional and operational methods of the rigid pavement, and in single cases with failure to comply with the regulations on the materials used.

At the same time it is worth mentioning that within the period stated we continued to improve pavement designing, calculation and construction methods including more advanced rigid pavement construction.

In a number of countries the traditional indistinguishable cement concrete pavement with metal pegs in the contraction joints is gradually replaced by solid-drawn continuous or fiber reinforced pavement what makes it possible to lengthen the life time 1.5-2 times as compared to the unreinforced pavement. In the 1970-s some control sections with continuous reinforced pavement were laid in Moscow (Profsoyuznaya Street, Altufyevskoe Shosse) that are in effective operation even nowadays.

Continuous reinforced pavement was also laid at some airfields of the former USSR.

Continuous reinforced pavement and subgrade calculation is much different from that of indistinguishable unreinforced pavement and subgrade. The most significant differences lie in the validation theoretical reinforcement percentage, identification of the opening width of the reinforced breaches, reinforcement durability calculation, engagement stop resistance calculation and so on.

Based on the results of the experimental construction, building regulations for designing and construction of continuous reinforced pavement and subgrade were developed.

At the moment the following aspects of pavement design are of relevance in the Russian Federation:

- Contraction crack resistance analysis for the bituminous concrete pavement.
- Analysis of cohesionless or slightly cohesive subgrade for rigid constructional layers.
- Analysis of unreinforced indistinguishable joint-free subgrade made of low-modulus cement concrete for rigid and flexible constructional layers.
- Analysis of fiber-reinforced indistinguishable joint-free pavement and subgrade.
- Analysis of bituminous concrete pavement with indistinguishable cement concrete subgrade including joint-free pavement made of low-modulus cement concrete and so on.

One of the most important aspects of pavement durability implementation and enhancement in the Russian Federation is the analysis of cement concrete durability limits under the joint action of repeated dynamic traffic loading and alternate periodic freezing and throwing. Due to the fact that at the moment the theoretical bases for cement concrete cold resistance analysis are developed insufficiently, the problem stated should be studied and solved on the experimental basis. The experimentations will make it possible to validate the rational and effective strength reserves for the rigid pavement what provides for the necessary level of durability (i.e. the life time). Another acute problem lies in the enhancement of the methods for the objective technical and economic comparison of rigid and flexible pavement that takes into consideration not only expenses on construction and repairs, but also on transportation under different operational conditions of the pavements compared.

At the moment the construction expenses for the top class roads with the rigid and flexible pavement differ insignificantly – within 5%. Nevertheless, the current methods for technical and economic comparison usually underestimate the influence of the difference in the life times of the rigid and flexible pavement on the transportation cost.

Comparative analysis of the domestic and foreign designing and construction decisions concerning pavement make it possible to consider that the technical level of such decisions in our country is rather close to those in the highly developed countries abroad. The engineering decisions and modern road machinery differ insignificantly from the foreign analogs. The practice of rigid pavement construction showed that:

1. Rigid pavement has the highest life ratio and according to this criterion has no substantial alternative under the current conditions in the Russian Federation.

2. In the process modernization of the primary roads it is advisably to use on a large scale the following types of pavement:

- Monolithic cement concrete pavement.
- Monolithic cement concrete subgrade for rigid and flexible pavement, providing stable bending tension resistance.
- Continuous reinforced pavement and subgrade.
- Fiber reinforced pavement and subgrade.
- Rolled concrete subgrade.
- Modified concrete pavement and subgrade, including thin continuous reinforced layers to strengthen flexible pavement.
- Polymer concrete reinforcement providing low traffic noise level.

3. At the moment we advise to apply rigid pavement in the following fields:

- Primary multilane roads.
- Federal and regional roads, class II-III.
- Access ways and by-passes.
- Toll roads.
- Industrial roads.
- Municipal roads.

4. To expand the scope of application of the new rigid pavement it is necessary to organize and systematically perform operational monitoring, to carry out laboratory and in situ field experiments concerning cement concrete durability limits under the joint action of repeated dynamic traffic loading and alternate periodic freezing and throwing.

III. THE CURRENT SYSTEM FOR DIAGNOSING AND ESTIMATING THE ROAD CONDITIONS

General provisions diagnostics and estimation of the road conditions are two interconnected steps in the process of road conditions management.

Diagnostics is inspection, accumulation and analysis of the information on the parameters, characteristics and conditions of road operations, on imperfections and the reasons of their emergence and other data necessary to estimate and forecast the road conditions in the course of the further operation.

Road conditions estimation is the determination of the degree of compliance of the real road characteristics and parameters to the regulations satisfying traffic demands.

The scope and description of the diagnosing works depend on the method of the road conditions evaluation.

Stages in the development of the methods for road conditions diagnosing and estimation

Starting with the first half of the last century the road conditions diagnosing and estimation was performed according to the availability, nature and number of faults (deformations, corrosions, departing from the regulations), that characterized the road from the position of durability, efficiency, life time and so on,

In various evaluation methods the number of such factors fluctuated between 10 and 40. Usually not the entire road conditions but the conditions of the pavement was estimated. The necessary information was accumulated applying visual method.

The second generation of the methods for road conditions diagnosing and evaluation is represented by composite and complex methods, the core of which lies in the fact that the road is considered ***engineering transportation*** construction meant for safety traffic with specified speed and loads.

Road conditions are estimated not only according to technical parameters and characteristics but also according to transport quality figures (TQF) that a road assures: speed, safety, admission rate, axel weight limit etc.

Herewith each parameter, characteristic and value is evaluated separately. As a result for every road section there are from 20 to 80 absolute or relative numbers with different units of measurement illustrating compliance to or deviations from regulations, here they help to solve the problem of function and most important maintenance actions.

Diagnostic data are collected both visually and using measuring equipment and laboratories.

Third generation of methods for generalized or complex evaluation of road conditions is based on the concept of purpose of function of a road as a means for customer service, consumers of road services that in some way pay for these services.

From consumers' point of view the most important are the transport and operational characteristics assured by a road: continuity, speed, convenience and traffic safet, traffic capacity and a level of congestion, axel weight limit and other figures that are relevant to consumer characteristics of roads.

One of the first methods of this generation is HDM-III (Highway Design and Maintenance) and its further modification HDM-IV where there is an extended evaluation of parameters of plan, longitudinal profile and pavement conditions according to their influence on an average speed of vehicular traffic.

Since 1990 in Russia is widely used a method developed by Prof. A.P.Vasiliev, a method of complex evaluation of road quality and condition according to its consumer characteristics based on this principle.

In some cases methods of the first and the second generation are used.

The basic indices of an evaluation of

quality and condition of roads according to consumer characteristics

An integral index that most fully reflects main consumer characteristics is a traffic speed evaluated through a coefficient of provision of design speed rating:

$$Csr = \frac{Va.max}{V_r} \quad (1)$$

Csr – coefficient of provision of speed rating; Va.max – actual maximal possible and safe speed of a single passenger car assured by road at its actual parameters and condition, km/h; V_r – design speed, km/h.

For calculation convenience as a base of speed rating is assumed speed that equals to 120 km/h. Then:

$$C_{sr} = \frac{V_{a.max}}{120} \quad (2)$$

As an additional index is taken a number that shows permissible carrying capacity and axel weight limits that were reduced to the coefficient of provision of speed rating reasoning from proportionality of speed and carrying capacity influence on vehicle productivity.

Assured by a road level of serviceability, comfort and traffic safety are estimated with the help of the coefficient of engineering structure and provision of the necessary facilities (C_{nf}) and with the coefficient of the maintenance degree (C_m).

For the generalized complex estimation of road quality and its maintenance degree they determine index of road quality and condition (I) which includes a complex parameter of transport quality and operation condition (CI), a parameter of engineering structure and provision of the necessary facilities (C_{nf}) and a the coefficient of the maintenance degree (C_m):

$$I = CI \cdot C_{nf} \cdot C_m \quad (3)$$

Procedure of estimation of transport quality and operation condition of road

In the process of development of this procedure the most complicated methodical problem has been solved. The problem was to find a mode of reduction of effect of various parameters and figures on the consumer characteristics to one quantity indicator describing these characteristics.

Transport quality and operation condition of each characteristic road section is estimated by a total coefficient of provision of speed rating C_{pci}^{total} which is assumed as a complex index of road transport quality and operation condition on a given road section $CI_i = C_{pci}^{total}$.

For deriving total TQF index they calculate partial indices taking into account the effect on the main index of following parameters and characteristics: widths of carriageway - C_{cl1}; width and condition of shoulders - C_{cl2}; traffic volume and traffic composition - C_{cl3}; longitudinal grades and visibility of a road area - C_{cl4}; radiuses of horizontal curves and superelevation - C_{cl5}; roughness of pavement - C_{cl6}; skid resistance coefficient the pavement - C_{cl7}; condition and strengths of road base - C_{cl8}; depths of ruts - C_{cl9}; traffic safety - C_{cl10}.

Maximum traffic speed is determined by a computed method or by measuring the speed on the road. Most often in use is a computed method when partial indices of rated speed provision are determined on the basis of data about parameters and characteristics of the road gained by direct measurements and road conditions surveys.

During primary survey they collect data on all parameters and characteristics of a road, and during the following ones they collect data only on variable parameters and characteristics. All the information enters in a line graph which later on is only adjusted.

The problem of an estimation of the effect of each parameter on traffic speed is in determining the physical sense and mechanism of such effect, choosing a calculation scheme and giving some mathematical description that allows defining a top speed of a design car. By dividing maximal possible speed by a base design speed they get a coefficient of rated speed provision.

As an initial one is taken a scheme of movement of a single or a first car in a group of cars that goes along the lane with a maximal possible speed which is determined by the effect of parameters, characteristics and a condition of road on interacting of the car with the road, on driver's psycho physiological condition and his perception of the circumstances on the road, side effect of the cars going on adjacent lane and possible restrictions from cars going ahead on the lane (longitudinal effect).

During measurements on the road they accept as a maximal possible speed a speed of 85% of provision for a single car ahead of the group of cars or traffic speed of 95% of provision.

Explicit numbers of indices of rated speed provision are first gained by calculation on the base of known or again determined interrelations, schemes and formulas where the parameter to be estimated is an argument, and function is a speed of a car, and then indices are mustered experimentally by measurement of actual speed of cars on the roads.

It is determined that all the estimated parameters of the road according to their character of the effect on the scheme of car movement can be divided into 4 groups:

1. Parameters that effect cars or driver and through them they influence on traffic scheme and first of all on speed not interrelating with other parameters. Among such parameters are:

- Roughness and strength of pavement.
- Traffic flow and its composition on the main lane (longitudinal restrictions).
- Axel load (total permissible vehicle weight).

2. Parameters that in correlation with one or more others effect driver's perception of road and decision about driving mode. Among such combinations are:

- Widths of carriageway and strength edge strip.
- Width and condition of shoulder.
- Widths of carriageway and traffic

volume on adjacent lane.

- Visibility and skid resistance coefficient on a horizontal section etc.

3. Parameters that in correlation with one or more others effect on interaction of a car with the road and on speed. Among such parameters are:

- Longitudinal grade, rolling resistance and skid resistance coefficient on upgrade.

- Radiuses of horizontal curve, superelevation and transversal skid resistance coefficient on a horizontal curve and others.

4. Parameters and their combination that simultaneously affect on interaction of a car with the road, driver's perception of road and through these factors on the car moving. Among such parameters are:

- Longitudinal grade, skid resistance coefficient and visibility of road surface on the downgrade movement.

It is determined that a driver chooses speed mode estimating the entire situation on the road in total. But in difficult conditions one single parameter or their combination have here the most influence. That is why an estimation of effect of each parameter in different combinations was carried out and the most unfavorable of them were determined.

On each characteristic road section they get 10 partial indices of rated speed and on the base of these indices was defined transport quality and operation condition CI:

$$CI = f(C_{cl1}, C_{cl2}, \dots, C_{cl10}).$$

To solve the problem calculations in three models were analyzed and compared:

The first model is a multiplicative one where summarized values of CI are determined by multiplying all partial indices.

Theoretical premise of this model is a conjecture that parameters of road render cumulative effect on traffic speed according to distributive law.

The second model is where the summarized value of index of design speed provision is obtained as the least value from 10 partial indices of design speed i.e. one of the parameters of the road or a combination of parameters unified in one partial index on this section effects most of all on traffic speed or safety.

The third model is an expansion of function of summarized index of design speed provision in a Taylor series limiting the series to member that are not higher than third order.

Theoretical premise of this model is a conjecture that road parameters render complex aggregate effect on traffic speed that can be estimated through enumeration of their different combinations with limits regarding dual and triple interaction. And at the same time on every section 3 coefficients that have the least value are chosen from 10 partial coefficients.

The functional test of models has been carried out by comparison of the results of calculation from all three models for the same road sections to the results of measurements of actual traffic speed on these sections. In total there were chosen about 50 road sections of different categories in various regions of Russia.

The results of the test showed that the first model gives significantly understated values of summarized index of rated speed provision especially in range of low values. Difference of calculated values from actual attains 40-50% and more.

The third model gives results that are most closely congruent with the results of actual measurements. The mathematical expectation of discrepancies is 0,004, with a variance of a discrepancy is 0,003, and a mean square deviation of discrepancies is 0,057.

The second model gives results that are close enough to the results of actual measurements. The mathematical expectation of discrepancies is 0,045, with a variance of discrepancies is 0,004, a mean square deviation of discrepancies is 0,06. However the second model in comparison with the third has essential virtue which consists in its elemental simplicity and accessibility. At the same time results of determining the summarized index of rated speed provision coincide well with actual results. Therefore the second model has been accepted as a working one.

Thus, value of the summarized coefficient of design speed provision on each road section is accepted equal to one of 10 partial coefficients that is the least in value.

A graph is drawn to visualize reduced design and cutting of road, critical parameters and characteristics, partial and summarized values of coefficients of design speed provision on each road section, and also superimpose lines of normative and maximum-permissible least parameter of CI.

The analysis of this graph easily allows to determine road sections that match and mismatch the demands for consumer characteristics of roads, to specify quantitatively extent of misfit, to determine its reasons and simultaneously to assign on each section a complex of provisions on elimination of all or some part of the determined deficiencies and on adjustment of road to complete or partial correspondence to normative demands.

On the basis of stated above the procedure of estimation of transport quality and operation condition of road network maintained by a road agency, road network of separate territory or a road network of the country as a whole is developed.

Determining the index of engineering equipment and provision of the necessary facilities. An index of provision of the necessary facilities and engineering equipment (Ieq) is determined on the base of the value of index of imperfection of compliance of engineering equipment and provision of the necessary facilities on the road (Ic).

Imperfection of compliance here is absence, insufficient amount or misfit to normative demands to parameters, constructions and to a feature placement of engineering system and provision of the necessary facilities.

The coefficient of imperfection of compliance of engineering system and provision of the necessary facilities is determined by results of diagnostic study of roads under formulas:

$$I_{eq.} = \frac{1}{8} \cdot (I_i + I_S) \quad (4)$$

$$I_i = I_{i1} + I_{i2} + \ldots + I_{i7} \quad (5)$$

I_i – partial index of imperfection of compliance of places for rest which functional influence is spread for significant road sections; I_{i1} … I_{i7} – partial indices of imperfection of compliance of elements of engineering equipment which functional influence is spread on short road sections (crossings, junctions, entries and at-grade intersections, bus stops, barriers, sidewalks and foot - paths in settlements, road carriageway marking, road lighting, traffic signs).

The value of index of provision of the necessary facilities and engineering equipment (I_{eq}) for each kilometer of road is assumed depending on the value of Ic according to Fig. 1 and place in a line graph of motor road quality and condition estimation.

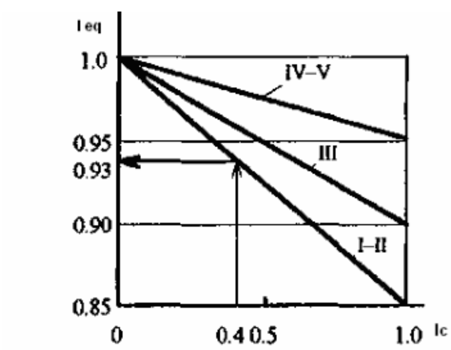

***Fig 1.** Graph for determining the value of I_{eq}: I, II, III, IV, V – categories of roads*

Determination the index of maintenance (I_o). This index is determined on the ground of the results of the road conditions estimation performed by a specially appointed commission in compliance with the active regulations on the road conditions estimation.

To estimate the road on the ground of the visual examination the commission uses rates 5, 4, 3, 0 depending on the defects of the main elements of the road revealed: the roadbed and drainage system, pavement, engineering structures, environment and engineering machinery, landscaping and planting.

First, each element of the road on each section is estimated, and then the aggregate index of maintenance on each particular section or kilometer is rated:

$$P = \frac{P_1 + P_2 + P_3 + P_4 + P_5}{5} \quad (6)$$

where P1, P2, P3, P4, P5 – index of maintenance of each road element.

The index of maintenance is then rendered into the index of operational maintenance (Fig. 2).

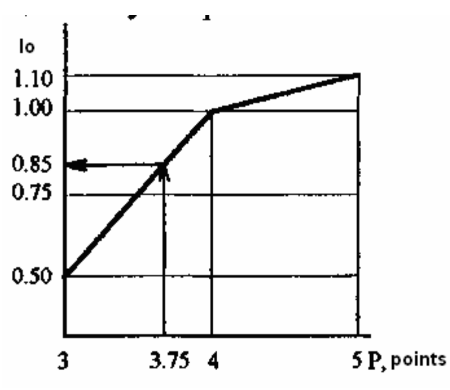

***Fig 2.** Diagram for determination of (I_o)*

Overall estimation of highway quality and condition

Overall index of quality and condition

for each road (road section) is determined from the formula 3.3.

The degree of compliance of factual road application properties with the regulations is estimated by the relative index of road quality and condition:

$$Q_r = \frac{I_r}{CI_r} \qquad (7)$$

where I_r - overall index of road quality and condition; CI_r – regulatory requirements to aggregate factor.

The road fully meets the regulatory requirements if $Q_r \geq 1$.

Increase in the overall index of road quality and condition is determined from the following formula:

$$\Delta I_r = \frac{I_r^e - I_r^b}{I_r} \cdot 100\% \qquad (8)$$

where I_r^e, I_r^b - overall indexes of road quality and condition as at the beginning and the end of the period under report.

On the ground of the road and network quality and condition analysis main tendencies in enhancement of traffic operational characteristics, the order and sequence of maintenance, repair and rehabilitation works are planned.

The methods of repair and reconstruction planning as well as the methods of strategy validation under the limited financial and material resources were developed based on the results of the road condition diagnostics and estimation.

There is software making it possible to perform the condition estimation and technical and economic analysis using PC.

IV. CONCLUSION

The method for diagnosing and estimation of the road condition according to the degree of compliance with the demands of the road and service users was developed, the end objective of the above method is to enhance the road application properties.

The method for diagnosing and estimation of highway quality and condition according to the application properties was approved as official regulation in Russia, Belarus and Kazakhstan.

Alone on the territory of Russia approximately 30-40 thous. km of roads are yearly estimated applying this method. A system of diagnostic centers a full set of instruments, equipment, mobile laboratories and computing, making it possible to implement all the aspects of the method, was set up. The practical work in the field of diagnosing and estimation of federal highway network condition is performed under supervision of Road Research Institute of Russia where the federal data bank on roads was established. The annual plans for repair and maintenance works are developed based on the results of road conditions estimation.

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