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Application of Economic and Mathematical Modeling In a System Approach to Planning Repair and Reconstruction of Road Bridges

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Abstract. *In this article, the author substantiates the methodology of a systematic approach to planning and managing the repair and reconstruction of bridges, as well as the relevance of developing and implementing an economic and mathematical model to determine the optimal overhaul life of bridges, offers methodological foundations for the development of a regulatory framework for planning and managing the repair and reconstruction of bridges, an algorithm and computer program for calculating the overhaul life of road bridges using simulation modeling. The scientific and practical significance of the results of the study lies in the fact that the theoretical provisions are brought to specific recommendations for the development of standards for planning and managing bridge repairs.*

Introduction

All types of transport are developed in the Republic of Uzbekistan. To date, the total length of the country's railways is 6.5 thousand kilometers. In terms of railway density, the republic occupies a leading position in Central Asia. Road transport also plays a significant role in the transportation of goods and passengers. Over the years of reforms, more than 43.5 thousand kilometers of roads have been built and put into operation in the country, 97% of which have a hard surface.[1]

The results of the analysis and systematization of statistical materials on the state of the road facilities of the Republic of Uzbekistan show that despite the constant growth in the category of roads and the capitalization of road bridges, the level of their transport and operational condition does not always meet modern requirements.

The President of the Republic of Uzbekistan, Sh. M. Mirziyoyev, emphasized that “A number of road bridges and overpasses need to be repaired, and some are completely abandoned,

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[1] https://bht-tour.uz/ru/strani/uzbekistan/transportnaya_sistema. Transportation system

the task was set to take an inventory of all bridges, develop a targeted program for their repair and restoration."[2] Calculations show that the consequence of the low transport and operational qualities of roads and bridges are significant annual losses in road transport and in non-transport sectors of the national economy, which, as a whole for Uzbekistan, as the analysis showed, in the network of public roads and the park of reinforced concrete structures are estimated in millions of soums. In addition, the low technical condition of roads and artificial structures leads to an increase in the rate of their physical deterioration.

The parliamentary request of the Senate of the Oliy Majlis, sent to the Cabinet of Ministers to ensure the safety of vehicles, emphasizes that "According to the results of the inspection carried out on the roads of Uzbekistan, today there are about 15 thousand bridges, the state of operation of 40% of bridges and overpasses is unsuitable, unsatisfactory, and they are in need of repair. When studying the performance of work on the delivery of ownerless bridges located on highways to persons who maintain bridges, it was found that 3477 bridges were not transferred to their owners."[3]

This situation is largely due to the existing shortcomings in the planning of the repair and reconstruction of roads and artificial structures and, first of all, the almost complete absence of a system of preventive maintenance based on a set of interconnected technical and economic norms and standards. The existing regulatory framework for planning the repair of roads and road bridges is extremely scarce. It is represented by several documents published at different times and not related to each other, which contain far from complete and often contradictory information about the types, composition and frequency of repair work. In addition, the methodology for their development does not have a scientific basis. As a result, when planning repairs of road bridges, a subjective approach prevails, the need for them is systematically underestimated, and the required preventive measures to ensure the safety and reliable operation of structural elements, as a rule, are not carried out. In this regard, the further development and qualitative improvement of the methods of planning and managing the repair and reconstruction of road bridges, based on econometric and statistical research methods, is a necessary condition for improving the efficiency of the functioning of roads and artificial structures. Consequently, a significant reduction in the costs of the national economy for the transportation of goods and passengers, since 98 percent of freight and 85 percent of passenger traffic in the republic is carried out by road transport [35].

An analysis of the impact of the state of artificial structures on annual losses in road transport and in non-transport sectors of the national economy shows that their size depends on the transport and operational qualities of roads and bridges, as well as on the level of knowledge of road specialists [12-17, 34, 36, 37]. Therefore, the development and implementation of an economic and mathematical model for determining the optimal overhaul life of artificial structures used in the process of planning and managing the repair of road bridges is an urgent problem [1-11, 15, 18-22, 25-35].

Literary research

Prior to independence in the Republic of Uzbekistan, the only regulatory document

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[2] https://www.gazeta.uz/ru/2019/10/02/roads/. Meeting of the President of the Republic of Uzbekistan Sh.M. Mirziyoyev dedicated to the development of the road sector (October 2, 2019).

[3] https://repost.uz/kazhdie-dva-metra-yama. In Uzbekistan, 77.9 thousand kilometers of roads need to be repaired: the Senate sent a parliamentary request to ensure the safety of car traffic

regulating the timing of repair work on roads and bridges was the Regulation on the scheduled preventive maintenance of the superstructure of the track, subgrade and artificial structures of railways [32]. The regulation, along with the estimated frequency of repair work on railway bridges, also considers the frequency of repair work on artificial road structures. However, such a division is very formal, since the range of repair work and the frequency of their implementation (with the exception of the replacement of asphalt concrete pavement on road bridges) is completely the same for the types of structures under consideration.

Thus, the main disadvantage of the above standards is the identification of the operating conditions of railway and road bridges, despite the fact that each of these types of structures has a different strength, unequal in intensity, place of application and effects of the calculated and actual live loads, different safety factors of the main structural elements.

In the 60-70s of the last century, the maintenance of reinforced concrete bridges was practically not carried out. The performance of work on the average and capital repairs of structures was equated in terms of the frequency with the corresponding repairs of roads, and was reduced mainly to the replacement of wooden and temporary bridge crossings with new ones, i.e. to new construction.

By the beginning of the 1980s, the irrationality and lack of foresight of such exploitation began to manifest itself quite sharply. As a result of the time delay, the need for all types of repair work has increased significantly. Due to the lack of scheduled preventive maintenance and the timely elimination of minor defects, the durability of many structural elements of bridges, including superstructures, decreased by 25-50%: there were disproportions between the transport and operational state of constantly repaired and reconstructed roads and those located on them poorly maintained bridges.

The situation that has arisen has led to the need for the formation of research works in the field of reliability, durability of artificial structures, effective organization and planning of their repair, including in the direction of improving the rationing of their service life between repairs. One of the first such studies was the development of a manual on the automation of interrepair planning systems for the repair and reconstruction of bridges at the level of the ministry and republican associations [37], which, along with the problems of automating planned calculations at the level of road management, also touched upon the formation of a regulatory framework.

The most complete list of repair work on road bridges and the corresponding turnaround time was developed in Ukraine [24,30,31]. So, for example, in [24], three options for estimates of the frequency of repair work proposed at different times are considered: 1) according to the instructions IN 218-038-84, 2) according to expert estimates and 3) “recommended”, which cover not only the average, but also overhaul of artificial structures. Its authors propose, when assigning overhaul periods of service for road bridges, to focus on the "recommended" frequency of repair work, which is established by them, based on the other two above-mentioned estimates in the following order: if there are two values of the frequency of repair work (according to instructions and according to expert estimates), priority receives the one that is established by the expert method: in all other cases, the “recommended” is the frequency given in the instructions.

The general shortcomings of the works under consideration is also the lack of differentiation of most of the proposed standards by types of reinforced concrete structures, as well as by the conditions of their functioning under temporary load. Meanwhile, the expediency of the latter is proved by the example of the roadway elements in another Ukrainian monograph [30]. It shows the terms of defect-free operation of the main structural elements of the carriageway of reinforced concrete bridges, depending on the range of changes in the intensity of traffic passing through them

Make a conclusion about the significant impact of traffic intensity on the defect-free service life of many elements of the carriageway of road bridges. So, when the traffic intensity of cars changes from 25 to 35 thousand cars/day, the period of defect-free operation of the coating decreases by 3-5 times, waterproofing and drainage by 1.5-3 times, entry devices by 8-12 times. At the same time, it should be noted that the periods of defect-free operation of structures or their elements cannot be identified with the frequency of repair work, the need for which is due not so much to the fact of the appearance of a particular defect as to their type, development volume and degree of influence on performance and durability of structures. Therefore, in order to establish the overhaul periods of operation of the considered elements of the carriageway of bridges, it is necessary to conduct special studies on the classification of existing defects, identify the dynamics of their development and assess the degree of influence of individual defects on the level of the transport and operational state of structures.

A characteristic feature of all the above works is the use of heuristic methods in the normalization of overhaul periods of service: methods of analogies, comparisons, expert assessments. The main prerequisite for their use for solving this important problem was the lack of a sufficient number of statistical observations on the level of physical wear and tear of structures and the service life of their structural elements, which preclude the possibility of using more accurate methods of standardizing overhaul periods. However, it is well known that heuristic methods give good results only when certain requirements or boundary conditions are clearly fixed when assigning certain estimates. Since these requirements were not formulated in any of the analyzed works, the standards obtained using them are subjective, which raises certain doubts about the possibility of their practical application.

The work [23] is devoted to the methodology for substantiating the overhaul service life of prestressed span structures of reinforced concrete bridges using the example of statistical processing of data on the number, length and size of the opening of oblique cracks in the walls of beams of span structures. The essence of the methodology is to determine the probability of crack opening process ejection beyond the normalized level, calculated for each year of the analyzed period of operation of the structure, and on this basis to establish the volume of repair work to prevent their development. At the same time, the optimal overhaul life of the beams of superstructures is found by the minimum value of the “given value”.

From the condition of optimization of the “presented cost”, the permissible failure probability was found, equal to 0.05, according to which the overhaul service life of beam spans with pre-stressed reinforcement was determined, which is 9 years.

The obvious advantages of the proposed technique include a fairly thorough study of the dynamics of crack opening and the probability of this process in reinforced concrete prestressed bridge structures.

However, it has a number of significant drawbacks, the main of which are as follows:

- it is not provided for the possibility of carrying out preventive repair work to prevent the over-rated level of crack opening;
- the reduced cost chosen as a criterion is “reduced” only in name, since the difference in the cost of repairing structures is not taken into account;

- the area of application of the methodology is relatively narrow due to taking into account only one of the totality of other possible and simultaneously occurring defects in prestressed structures.

Methods for a feasibility study of the timing and volume of reconstruction (widening) of road bridges based on the use of a functional model of dynamic programming are considered in [26-28]. In these works, it is proposed to determine the optimal terms and dimensions of the widening of structures by comparing the possible strategies for the development of their dimensions economically, and no restrictions are imposed on the minimum dimensions of the dimensions of the bridges according to the conditions of their operation (the traffic intensity of the passing loads).

In the work of scientists from the Moscow Road Institute (MADI) [33], based on the analysis of defects and ways to eliminate them, the authors distinguish two sets of works carried out to repair structures:

1. Aimed at restoring damage to the elements of the bridge carriageway (including pavement, leveling layer, waterproofing, protective layer, expansion joints and drainage systems).
2. Aimed at increasing the durability of the supporting structures of the structure (prevention of corrosion of reinforcement, development of cracks, concrete chipping.).

As a result of the calculations performed according to the analyzed method for reinforced concrete bridges with frame reinforcement, the following values of the frequency of repair work were obtained: for a set of works to increase the durability of load-bearing structures - 8-10 years; for a set of works to maintain the roadway structures in a satisfactory condition - 6-9 years.

I. The positive side of the MADI methodology is an attempt at an integrated approach to determining the overhaul life of bridges based on the optimization of all types of repair costs, which are established depending on the level of the transport and operational state of the structure. The negative aspects of the methodology include, first of all, the very conditional nature of the recommended calculations, which is due to the following reasons: great uncertainty and fluctuations in the types and volumes of work for which the average cost is set; reduction of various operating conditions of structures to only three states (stages), allowing for an extremely consolidated interpretation of them in the absence of strict quantitative criteria; wide range of possible solutions.

II. Finishing the analytical analysis of the current and recommended overhaul service life of structures and methods for their determination under consideration of the MADI methodology, it is necessary to draw the following general conclusions: At present, there is no sufficiently substantiated and acceptable for practical use method of normalizing the overhaul periods of service of road bridges, which negatively affects the organization of the system of their repair and transport and operational conditions.

III. To create a science-based methodology for normalizing the overhaul life of bridges, it is necessary:

- give strict definitions of the concepts of all types of repairs;
- to study the relationship and possible interchangeability between them;
- substantiate the criterion of optimality;
- develop a sufficiently accurate and efficient method for solving the problem.

IV. The determination of the overhaul periods of service of bridges and their elements should be based on a careful consideration of the specific conditions of the features of their operation, the developed quality standards and research to establish the patterns of their wear over time.

Methodology

The author proposes the most rigorous and scientifically based systematic approach to determining the overhaul life of structures, which consists in studying the processes of interdependence and interchangeability of various types of repair impacts and establishing on their basis the optimal strategy for all types of repair work. This means that when using it, objectively existing quantitative relationships between the volumes of each type of repair impacts and the service life of the main structural parts or elements of the bridge are assumed to be known.

However, taking into account that so far there are no sufficiently systematized scientific developments on the mathematical description of these regularities, in order to solve the problem, the probabilistic-statistical dependences of wear (volumes of repair work) of certain types of structural elements on their life can be proposed. services. At the same time, taking into account the features of the identified regularities and the possible scope of their application, the following restrictions should be introduced.

1. The possible terms for the overhaul of the structural elements of the structure are accepted within the pre-established range of the maximum and minimum frequency of their implementation.

The maximum frequency of these works is determined based on the conditions of modern implementation within the accepted time limits for the current repair of each element of the bridge, i.e. from the moment of occurrence of the defect to the moment corresponding to the limiting volume of its development. Within the framework of the proposed classification of repair work, the maximum frequency of overhaul of each of the elements under consideration should be taken equal to its service life, since only during a major overhaul are the elements replaced due to their complete wear.

The minimum frequency of overhaul works is assumed to be equal to the period of occurrence of defects on the considered structural element of the structure.

2. Possible terms for carrying out work on the current repair of structural elements of bridges are established within a statistically determined time interval for the development of their defects, i.e. from the moment of occurrence of defects to the moment of the limiting state of the element, characterized by the established limiting volumes of development of defects.

3. The dynamics of the development of defects in each of the considered elements of the structure is assumed to be constant, regardless of the number and timing of their current repairs.

4. Changing the term of the current repair of bridge elements in the accepted range of their values (with the exception of the term of the corresponding limit value) does not affect the choice of terms for the overhaul of elements. This limitation, together with the previous one, makes it possible to form a finite number of repair strategies for each structural element of the structure. For example, if it is known that the period of development of defects in the element under consideration is 15 years, and the maximum frequency of overhaul is set to 24 years, then the number of possible strategies will be 195.

5. The physical wear of each of the elements of the structure is taken independent of the physical wear of its other elements. This means that the timing of current and major repairs of individual elements do not depend on each other.

Under these restrictions, the problem statement for determining the optimal overhaul life of road bridges can be formulated as follows.

Statistical characteristics of the distribution of the volume of work on current repairs depending on the timing of its implementation, as well as the volume of major repairs (replacement cost) and the possible range of terms for its implementation for each structural element of the structure are given. Also known are the sizes of losses in road transport from untimely current repairs of individual elements of bridges.

It is required to determine such terms for the implementation of current and major repairs of the structure as a whole, which provide a minimum of the reduced costs for the repair of the structure and the implementation of the transport process during the entire period of its operation.

The criterion for solving this problem in a formalized form can be written as follows.

$$Z = \sum_{i=1}^{n}\sum_{j=1}^{m_i} C_{ij}\beta_{t_{ij}} + \sum_{i=1}^{n}\sum_{k=1}^{q_i} K_{ik}\beta_{t_{ik}} + \sum_{i=1}^{n}\sum_{j=1}^{m_i}\sum_{\tau_{ij}=t_{ij}-(t_{T_i}-t_{To_i})}^{t_{ij}} \lambda_{\tau_{ij}}^{T}\beta_{\tau_{ij}} - Q \rightarrow \min, (3.1)$$

где: C_{ij} *- cost of the th current repair of the structural element of the bridge , soums;*

n – the number of structural elements of the structure taken into consideration;

m_i *- number of ongoing repairs* i *- element for the period of comparison of options,* $m_i = \dfrac{t_{cp}}{t_{Ti}}$ *where* t_{Ti} *- variable overhaul period for current repairs,* t_{cp} *- the accepted term for comparing options;*

t_{ij} *- term of the current repair of the i element, year;*

K_{ik} *- cost of* k *- overhaul i – structural element of the bridge, soum.;*

q_i *- number of major repairs carried out i – element for the period of comparison of options,* $q_i = \dfrac{t_{cp}}{t_{ki}}$ *where* t_{ki} *- variable overhaul period;*

t_{ik} *- term for the k overhaul of the i element, year;*

$\beta_{t_{ij}}, \beta_{t_{ik}}$ *- conversion factors for multi-time costs;*

$\lambda_{\tau_{ij}}^{T}$ *- the value of losses in the year, due to the deviation of the considered frequency of the current repair of the i element from the minimum possible , soum.;*

t_{To_i} *- minimum frequency of current repair of the i element, years;*

Q *- residual repair costs, expressing the effect of the consequences for options with different cost characteristics, soum.*

Based on the stationarity of the considered processes of wear of elements of structures, i.e. taking into account only the average values of the volume of repairs (mathematical expectations), the formation of possible options for solving the problem is quite simple - for each year of current and major repairs, taking into account the discount coefficients, the amount of costs for their implementation is calculated, as well as losses on vehicles, if they take place for each structural element. The minimum total (for all elements) cost value determines the best option. It is this approach that was used by the author in [25] when optimizing the timing of medium (current) repairs of road bridges.

However, the use of the above premise in conditions of significant variability in the volume of defects, and therefore, repair work, leads to very inaccurate results. Therefore, to solve the problem of determining the optimal interrepair service life of bridges, taking into account the stochastic nature of the wear of their structural elements, simulation methods were often used to study and analyze probabilistic processes.

Analysis and results

The calculation of the optimal overhaul life of bridges was carried out according to the developed program “Bridge” on a computer. The principle of operation of the program provides for a two-stage calculation procedure. At the first stage, for each of the possible periods of reconstruction of the bridge in the given ranges of control periods for its widening, the optimal strategy for carrying out repairs (current and capital) of each structural element of the structure, as well as the optimal size of the widening, is calculated. At the second stage, based on the summation of the reduced costs for the repair of all structural elements of the structure and its widening from each of the possible reconstruction options, the optimal broadening period and the optimal strategy for repairing the road bridge as a whole are established.

The main program sums up the reduced costs for each possible period of reconstruction of the structure and finds their minimum total value, which characterizes the optimal period for widening the bridge and the optimal strategy for carrying out its current and major repairs corresponding to this period. The final results of the calculations are printed out in the form of Table 1.

Final calculation results to be printed

Periodicity of repair work, years, (at G-7; No.=92 a/s; P=3% linear) Quantity (times) Terms, years	Periodicity of repair work, years, (at G-7; No.=92 a/s; P=3% linear) Quantity (times) Terms, years	Periodicity of repair work, years, (at G-7; No.=92 a/s; P=3% linear) Quantity (times) Terms, years
1. CASH (Broadening on G-8) 33 1 33	1. CASH (Broadening on G-8) 33 1 33	1. CASH (Broadening on G-8) 33 1 33
2. Overhaul (TRR):	2. Overhaul (TRR):	2. Overhaul (TRR):
1) Coatings - 19 2 19.52	1) Coatings - 19 2 19.52	1) Coatings - 19 2 19.52
2) Sidewalks - 33 0 -	2) Sidewalks - 33 0 -	2) Sidewalks - 33 0 -
3) Expansion joints - 11 4 11,22,44,55	3) Expansion joints - 11 4 11,22,44,55	3) Expansion joints - 11 4 11,22,44,55
4) Waterproofing - 17 2 17.50	4) Waterproofing - 17 2 17.50	4) Waterproofing - 17 2 17.50
5) Railings - 33 0 -	5) Railings - 33 0 -	5) Railings - 33 0 -
6) Support cones - 25 2 25.58	6) Support cones - 25 2 25.58	6) Support cones - 25 2 25.58
3. Current maintenance (TTR)	3. Current maintenance (TTR)	3. Current maintenance (TTR)
1) Coatings - 1 25 9-18.28-32.42-51	1) Coatings - 1 25 9-18.28-32.42-51	1) Coatings - 1 25 9-18.28-32.42-51
2) Sidewalks - 10 5 10,20,30,40,50	2) Sidewalks - 10 5 10,20,30,40,50	2) Sidewalks - 10 5 10,20,30,40,50
3) Expansion joints - 1 35 4-10.15-21.37-43.49-55	3) Expansion joints - 1 35 4-10.15-21.37-43.49-55	3) Expansion joints - 1 35 4-10.15-21.37-43.49-55
4) Waterproofing - 1 20 10-16,27-32,-43-49	4) Waterproofing - 1 20 10-16,27-32,-43-49	4) Waterproofing - 1 20 10-16,27-32,-43-49
5) Railings - 3 5 20,23,26,29	5) Railings - 3 5 20,23,26,29	5) Railings - 3 5 20,23,26,29
6) Beams of a superstructure - 9 5 9,18,27,42,51	6) Beams of a superstructure - 9 5 9,18,27,42,51	6) Beams of a superstructure - 9 5 9,18,27,42,51
7) Supports - 15 3 15.30.48	7) Supports - 15 3 15.30.48	7) Supports - 15 3 15.30.48
8) Opera cones - 2 11 14-24,40-48	8) Opera cones - 2 11 14-24,40-48	8) Opera cones - 2 11 14-24,40-48

At the same time, the following indicators were taken as the initial data for calculating the standards for overhaul periods for each group of bridges: traffic intensity (in the range of established values for the bridge dimensions under consideration) - 92, 369, 1012 and 2391 vehicles / day; the growth rate of traffic intensity, 3% of the traffic composition - trucks 69%, buses 10%, cars - 21% and the length of the bridge is 38m.

The results of the calculation of the standard overhaul periods of service of reinforced concrete road bridges in comparison with the recommended work [25] are shown in Table 2.

Analysis of the obtained results allows us to draw the following conclusions:

- recommended by work [25] standards of overhaul service life of bridges are, as a rule, overestimated in comparison with the optimal ones. A particularly significant difference in the overhaul period occurs during the overhaul of expansion joints (7 years), support cones (13 years), current repair of the coating (5 years), supports (9 years);
- the frequency of current repairs does not depend on the traffic mode on the bridges (the size of their carriageway), while for major repairs, the influence of traffic intensity on the time between repairs is very significant. Specified testifies to expediency of differentiation of capital repairs;
- to ensure the effective functioning of reinforced concrete bridges, it is necessary to carry out annual work to repair the main elements of their carriageway (covering, expansion joints, waterproofing).

Table 2

The results of the calculation of standard overhaul periods of service of reinforced concrete road bridges with frame reinforcement

Name of types of repair work Periodicity, years According to [22] Optimal for bridges with dimensions G-7 G-8 G-10 G-11.5	Name of types of repair work Periodicity, years				
	According to [22] Optimal for bridges with dimensions G-7 G-8 G-10 G-11.5	Optimal for bridges with dimensions			
		Г-7	Г-8	Г-10	Г-11,5
I. Widening (reconstruction) of the structure - 33 29 28 13	I. Widening (reconstruction) of the structure - 33 29 28 13	33	29	28	13
II. Overhaul:	II. Overhaul:				
coatings 18 19 19 19 19	coatings 18 19 19 19 19	19	19	19	19
sidewalks 36 33 36 36 36	sidewalks 36 33 36 36 36	33	36	36	36
expansion joints 18 11 11 11 11	expansion joints 18 11 11 11 11	11	11	11	11
waterproofing 18 17 17 17 17	waterproofing 18 17 17 17 17	17	17	17	17
railings 36 33 29 27 19	railings 36 33 29 27 19	33	29	27	19
support cones 12 25 25 25 25	support cones 12 25 25 25 25	25	25	25	25
Maintenance:	Maintenance:				
coatings 6 1 1 1 1	coatings 6 1 1 1 1	1	1	1	1
sidewalks - 10 10 10 10	sidewalks - 10 10 10 10	10	10	10	10
expansion joints - 1 1 1 1	expansion joints - 1 1 1 1	1	1	1	1
waterproofing - 1 1 1 1	waterproofing - 1 1 1 1	1	1	1	1

railings - 3 3 3 3	railings - 3 3 3 3	3	3	3	3
span beams 12 15 15 15 15	span beams 12 15 15 15 15	15	15	15	15
Support 24 15 15 15 15	Support 24 15 15 15 15	15	15	15	15
support cones - 2 2 2 2	support cones - 2 2 2 2	2	2	2	2

Note: the table was developed by the author.

Conclusions and offers

The obtained results of the scientific generalization of the study made it possible to substantiate the following comprehensive conclusions and recommendations:

1. The lack of an adequate level of regulatory framework for planning and managing the repair of artificial structures, including road bridges, will not provide an opportunity for the successful development of the road sector, in particular, and for the development of the national economy as a whole. Although this is a purely managerial problem, it is also macroeconomic in its implications. In the process of scientific research, the methodological foundations for the development of a regulatory framework for planning and managing the reproduction of artificial structures, as well as forecasting in the development of strategic decisions for the development of the road sector of the Republic of Uzbekistan, with an emphasis on econometric aspects, were substantiated. Thus, not only theoretically and methodologically, but also practically, a very important task of planning and managing the reproduction of artificial structures, as well as the development of the road sector, can be solved.

2. The calculations were performed by the developed computer and standard program for generating random variables.

The developed algorithm and computational program make it possible to determine the overhaul life of bridges depending on the size and traffic intensity. Analysis of the results shows that the time between repairs of artificial structures depends on the size and intensity of traffic.

3. Using the scientific and practical recommendations developed in the course of this scientific study, leaders of all levels of road management get the opportunity to implement modern methodological foundations for strategic planning and management of road bridge repairs.

Among them: methods of organizing strategic planning; method of economic analysis of the road sector for decision-making at the stage of developing a development strategy; economic and mathematical methods for determining the overhaul life of road bridges;

4. The practical significance of the results of the study lies in the fact that the theoretical provisions are brought to specific recommendations for the development of standards for planning and managing the repair of road bridges. The main theoretical and practical recommendations can be used by the authorities in the framework of the development and implementation of strategies for the socio-economic development of the region.

The practical results of scientific research will be in demand in business life due to the growth of effective demand for road infrastructure services in the Republic of Uzbekistan and the professionalism of domestic management and the transition to a digital economy.

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