**To the Assessment of Technical and Operational Condition of Urban Reinforced Concrete Bridges and Overpasses**

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**Abstract.** The paper provides an assessment of the technical condition of urban reinforced concrete bridges and overpasses. The authors studied the technical data sheets of about 300 reinforced concrete bridge structures in Tashkent; only 20-25% of the total number of such structures have a service life of more than 50 years without major repairs or reconstruction. Based on the results of a survey by the authors of about 30 city bridge structures, it was established that the main damage to spans and supports of reinforced concrete bridges and overpasses is caused primarily by poor waterproofing conditions, expansion joints and lack of drainage pipes. The main technical and operational indicators (TEI) are also analyzed in detail and formulated as criteria for assessing the technical condition of bridge structures in Tashkent. Methods for assessing the technical condition of the city's bridge park objects have been determined - absolute and relative. Their purposes are indicated.

**Key words:** assessment criteria, maintainability, durability, intensity, operation, traffic safety and comfort, throughput, load capacity

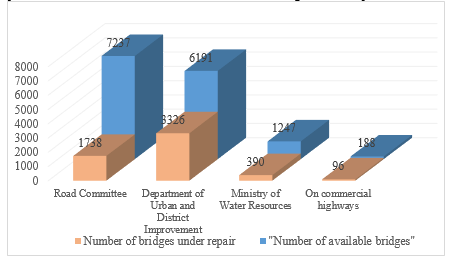
**INTRODUCTION**

Construction work conducted on a large scale in recent years in the Republic of Uzbekistan provides great opportunities for the development of road transport infrastructure.

By the Decree of the President of the Republic of Uzbekistan No. UP-60 dated January 28, 2022, the implementation of paragraphs 192-197 began, which set such tasks as improving the unified urban transport system in the conditions of a developing metropolis, and modernizing intercity route vehicles to ensure safe and convenient transit services. Based on the goals set, a “Highway Development Program” was developed; its implementation includes the integration of a unified network of highways connecting the capital and major cities of the Republic. Following this program, it is important to improve methods for calculating the phased reconstruction and repair work of 1512 bridge structures existing in the republic, considering the construction, reconstruction, and repair of 57.8 thousand kilometers of roads already existing in Uzbekistan [1, 2].

# **LITERATURE SURVEY**

At present, an inventory of existing bridges, overpasses, tunnels, and other man-made structures was conducted in the Republic of Uzbekistan to maintain them in the required condition, as well as implement specific measures including repair and other types of reconstruction of bridge structures. Analyzing the technical condition of bridge structures, it should be noted that as of the summer of 2023, 14,863 of structures in question are in operation in the Republic, 3,394 of which are not on the balance sheet of the relevant departmental organizations, 5,550 (37%) need repair and reconstruction, of which 741 are in disrepair or poor condition and need restoration, and 4890 structures need repair work (Fig. 1) [1, 2, 3]. A significant part of these objects is located in the city of Tashkent - the capital and largest city of the Republic. In this article, the authors assessed the technical and operational condition of urban reinforced concrete bridges and overpasses.



**FIGURE 1.** Condition of bridges built in the republic

One of the indicators of the city's growth and its transformation into a metropolis is the active growth in population, which leads to the need to build facilities for the city’s transport system. It is known that the dynamic growth of the city of Tashkent in recent years has led to an increase in traffic flow, which has tripled, amounting to more than 750-800 thousand cars per day. Today, more than 250 bridge structures are in operation in Tashkent being a heavy load on the city’s transport infrastructure [4, 5]. Appr. 60% are under the supervision of the Main Department of Improvement, special departments for operation, maintenance, and repair of artificial constructions of cities and districts. Analyzing the operational state of the city's reinforced concrete bridge structures, which constitute a significant number, they were divided into three conditional categories according to the time of their construction. Thus, bridge structures built in 1892-1960 constituted the first category, the second category includes bridge structures erected in 1960-1990, and the last category includes structures built from the 90s of the 20th century to the present day.

**FIGURE 2.** Categories and number of bridges by year of construction

As a result of the analysis, it was stated that the bridge structures were constructed according to individual and standard designs. The list of structural elements of reinforced concrete bridges and overpasses in the city of Tashkent that have undergone visual inspection is presented in Table 1. overpasses.

**TABLE 1.** Brief data on the analyzed bridge structures at the second stage

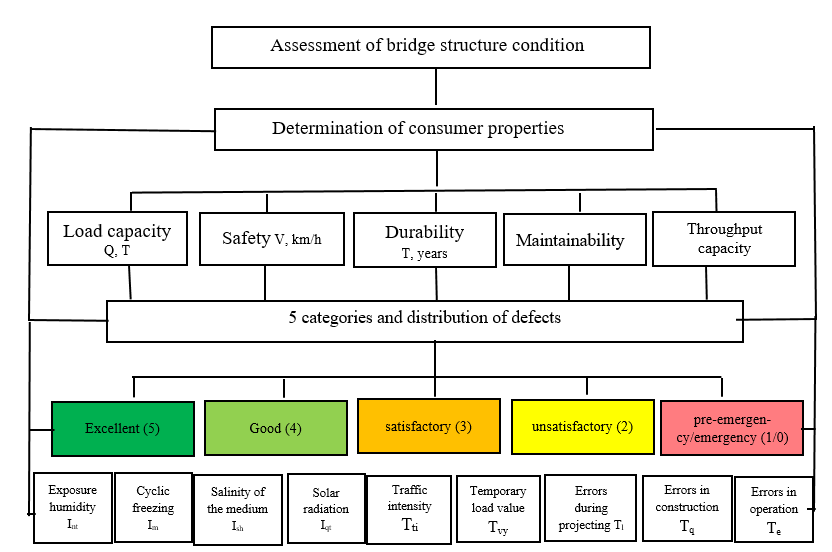
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **№** | **Name of the street where the bridge structure is located** | **Year of construc tion** | **Year of recons tuction** | **Length/dimension** | **Year of inspec tion** | **Mate rial** | **Catego ry by year** |
| 1 | Kichik Beshegoch(Starodubtseva) | 1932 | 2018 | 26,6 / 6,8 | 2015 | r/c | I |
| 2 | Avliyo ota (Kafanova) | 1933 | 1998 | 10,0 / 6,7 | 2019 | Brick | I |
| 3 | T.Shevchenko | 1939 | 2005 | 33,6 / 10 | 2019 | r/c | I |
| 4 | A. Temur (Movaraunnahr) | 1942 | 1997 | 41,5 / 12,5 | - | Brick | I |
| 5 | Navoiy | 1947 | 2006 | 26,5/21 | 2019 | r/c | I |
| 6 | KHAI (Asomov) | 1954 | 2006 | 57 / 13,5 | 1996 г. | r/c | I |
| 7 | Asaka | 1956 | 2001 | 20,6 / 6,1 | 2015 | r/c | I |
| 8 | Mironshokh (Budenny) | 1962 | 1998 | 10 / 6,7 | 2019 | r/c | II |
| 9 | Bobur (Airport) | 1967 | - | 523,6 / 17,3 | 2021 | r/c | II |
| 10 | Bobur | 1967 | - | 28,2 / 21 | - | r/c | II |
| 11 | Bunyodkor | 1971 | - | 137 / 28,1 + 2\* 5 |  | r/c | II |
| 12 | Beruni | 1973 | - | 52,6 / 38 + 2\*3,0 | 1996 | r/c | II |
| 13 | A. Kadiri | 1974 | - | 176 / 22,0 | 1990 | r/c | II |
| 14 | Farkhod | 1974 | - | 135 / 21 | - | r/c | II |
| 15 | KHAI (Abdurakhmanov) | 1975 | - | 25 / 29,2 | - | r/c | II |
| 16 | Korasaroy | 1975 | - | 18,1 / 22,4 | - | r/c | II |
| 17 | Oltinsoy (Nabi-Khasanov) | 1976 | - | 24,1 / 24 | - | r/c | II |
| 18 | A. Donish | 1977 | - | 315 /27 + 2\*1,7 | 2004 | r/c | II |
| 19 | St. Oybek (metro station Kosmanavty) | 1985 | - | 27,0 / 28,0 |  | r/c | II |
| 20 | Korasaroy | 1993 | - | 14,3 / 17,1 | - | r/c | III |
| 21 | Sagbon | 1994 | - | 9,0 / 17,2 | - | r/c | III |
| 22 | Bobur | 1995 | 2000 | 85,1 / 13+13 | - | r/c | III |
| 23 | A.Temur (Movaraunahr) | 1997 |  | 41,64 / 11,7 | 2019 | r/c | III |
| 24 | A.Temur | 1997 |  | 34,4 / 7,0 | - | concrete | III |
| 25 | 1. Donish | 1999 | - | 495,6 / 25,0 | - | r/c | III |
| 26 | Gavkhar | 2000 | - | 247 / 19 | - | r/c | III |
| 27 | KHAI | 2001 | - | 45 / 22 |  | r/c | III |
| 28 | А.Каdiri | 2014 | - | 469,6 / 15 | - | r/c | III |
| 29 | Mukimi | 2016 | - | 889,7 / 16,7 | - | r/c | III |

The bridges and overpasses listed in the table were distributed by time category based on the date of their construction, which makes it possible to say that they were designed for different regulatory loads, and located in different parts of the capital; this indicates differences in operating conditions.

Currently, the IKN-140-21 instruction [6] is in force in the Republic of Uzbekistan, in accordance with which the technical condition of bridges and overpasses is assessed. It should be noted that this instruction assumes the assessment of a bridge structure solely on the general technical condition, which does not include certain important criteria, and thus, according to the authors of the article, does not completely determine the necessary technical indicators.

Analyzing in this study literary sources published by Russian scientists concerning the operation of bridge structures (A.I. Vasiliev, S.A. Bokarev, V.I. Shesterikov [7, 8, 9]), the standards of the Russian Federation ODM 218.4.001-2008 [10] and Japanese standards, the following technical and operational indicators were proposed as criteria for assessing the technical condition of an operating structure: **“traffic** **safety and comfort", "durability", "load capacity", "throughput", and "maintainability**" (Fig. 3), analyzed in detail below.

The analysis made it possible to determine the number of conditional categories, which turned out to be 6, and their names [6]. Following the conventional division of the accepted categories, “5” is an indicator of the excellent condition of the structure, “4” indicates that the structure has minor defects, “3” corresponds to the average indicator where there are minor damages, in a structure of the “2” category, there is already a significant deterioration in the technical condition, and bridge structures that have received a "1" category are considered dangerous. Finally, "0" means bridges and overpasses in critical condition.



**FIGURE 3.** Main technical and operational indicators

Analyzing the factors and impacts affecting the technical condition of operated structures in Tashkent, the authors stated that these factors are significantly influenced by the natural and climatic conditions of the city’s environment, caused primarily by its geographical location and man-made factors of a large metropolis. Based on the fact that the structures operating in Tashkent have their own uniqueness and specific conditions, it is recommended to develop an individual approach when assessing their technical condition.

**TOI “traffic safety my and comfort”,** the main criterion of which is the smoothness of the road surface, which includes the presence of roughness, potholes, significant profile fractures, and rutting. The degree of acceleration, expressed in *g* (gravitational acceleration) transmitted to vehicles, realizes the transformation from “comfort” to “safety” [3, 11, 12].

In the framework of this study, by TOI “traffic safety and comfort” we mean a general criterion for assessing the technical condition of a bridge structure, considering the trouble-free operation of the structure and ensuring a safe speed for vehicles.

**FIGURE 4.** Indicators of damage and defects in elements of the bridge structure in accordance with TOI “traffic safety and comfort”

Analysis of the ranking of defects and damages by the categories and TOI gives the indicators shown in Figure 5, *a*. Next, we consider the influence of negative factors affecting bridge structures (Fig. 5, *b*).

|  |  |  |  |
| --- | --- | --- | --- |
| *а)* |  | *b)* |  |

**FIGURE 5.** Ranking of defects and damage to bridge structures  
a - depending on the category according to TOI “traffic safety and comfort” (distribution density); b – influence of TOI “traffic safety and comfort”

Analysis of the plot in Figure 5, *a* show that more than 65% of the total number of damages are in categories “4” and “3”, which correspond to “minor” and “significant” damages. The data in Figure 5, *b* show that the most negative effect causes moisture content, amounting to 18.2%, followed by the negative impact of the movable load - 17.5%, while insufficient operational measures (16.9%) also have a high indicator.

**TOI "durability".** Modern researchers have concluded that the concept of “durability” implies the service life of a structure until the loss of its load-bearing capacity, expressed in years. It should be noted that “durability” is divided into two main types: physical and moral. Physical durability is an indicator of the deterioration of the technical and operational condition of an object, while obsolescence is associated with the predicted parameters of the traffic flow of vehicles and the proposed TOI. To a greater extent, it is related to TOI “throughput” and “carrying capacity”, to a lesser extent - to TOI “traffic safety and comfort”.

Within the framework of the developed methodology, the authors adopted the physical durability of the bridge structure under TOI “durability”. Thus, Figure 6 shows defects and damage to structural elements that affect TOI “durability”.

**FIGURE 6.** Ranking of defects and damage by structural elements that affect TOI “durability”

The span structure of a bridge is the element most subject to negative impacts when assessing TOI “durability”. The analysis of the damage distribution is shown in Figure 7, *a*. The data shows that the number of defects and damages classified as “4” and “3” constitutes about 65% of the total number of assessment categories. It should be noted that the same pattern was observed when assessing TOI “traffic safety and comfort” (Fig. 7, *a*).

Analysis of graph 7, *b* showed that operational deficiencies amounted to more than 23.1%, which indicates that untimely repair work was not realized due to insufficient funding for the road transport industry. The next highest indicator is the impact of moisture content on the elements of the bridge structure (18.8%).

|  |  |
| --- | --- |
| *а)* | *b)* |

**FIGURE 7**: Distribution of damages and defects:  
a – depending on TOI “durability” (distribution density); b – influence of factors on TOI “durability”

**TOI “Load capacity”.** This TOI is the most common and its description is given in many regulatory documents [6, 7, 10]. Researchers proposed to limit the weight or speed of vehicles according to the circulating loads, which depends on the category being established. The load on the structure's axle and the vehicle's total weight must be limited.

On average, about 5% of bridge structures in the city of Tashkent have restrictions on load capacity. Data from Figure 8 show that the spans of bridges and overpasses are subject to the greatest negative impact, which amount to 68% of the total number of elements.

**FIGURE 8.** Indicators of defects and damage in accordance with TOI “load capacity”

The analysis showed the presence of defects and damages of the first category (insignificant damage), which amounted to 48.3% of the accepted estimate for TOI “load capacity” (Fig. 9, *a*).

|  |  |  |  |
| --- | --- | --- | --- |
| *а)* |  | *b)* |  |

**FIGURE 9**: Distribution of damages and defects:  
a – depending on the category according to TOI “load capacity” (distribution density); b – influence of factors on TOI “load capacity”

It should also be noted that the analysis of the data given in the graph showed that 24% of the elements of bridge structures assessed by TOI “load capacity” have indicators “2” and “1/0”, which mean their dangerous and critical condition. The intensity of vehicle traffic (18.9%) and the presence of deficiencies in the operation of the bridge structure, which amounted to 21.3%, also have a negative impact.

**TOI "Throughput".** Many researchers in their studies suggest the assessment of TOI “throughput” depending on the size of the passage, however, in our opinion, it should be assessed by the speed of vehicles passing the bridge structure, which allows us to consider appropriate to introduce coefficient "K" - the ratio of the traffic speed on the object under consideration and on the highway on which it is located.

K=Vms/Vk (1)

The connection between the passage dimension and the vehicle speed is also obvious, but note, that it is not always directly proportional [13, 14, 15, 16].

The distribution of defects and damage across 6 categories by TOI “throughput” is shown in Figure 10.

|  |  |  |  |
| --- | --- | --- | --- |
| *а)* |  | *b)* |  |

**FIGURE 10:** Distribution of damages and defects:

a – depending on the category by TOI “throughput” (distribution density); b – influence of factors on TOI “throughput”

The data given in the graph shows that the most negative impact on TOI “throughput” is the errors at the design stage (the highest indicator) - 30%, while other indicators are much smaller and amount to 21% (movable loads) and 19.4% (traffic intensity).

**TOI “maintainability”.** TOI “maintainability” considers all aspects related to the possibility and efficiency of repair work on a structure, including the technical feasibility of repairing damage, the need to develop a project for repair, and the complexity of repair work performed. This indicator helps determine the level of convenience and resource expenditure required for successful restoration of elements or structures [17, 18, 19, 20, 21].

By TOI “maintainability”, category “4” implies the clearing of work on the maintenance of the bridge structure, while category “3” indicates excess maintenance or repair of an object or its element; category “2” is assigned for a major overhaul, whereas category “1/0” is given when the inappropriateness of restoration work is revealed or there is a need to replace a structural element. Figure 11 displays data on the distribution of damage and defects that affect TOI “maintainability” depending on structural elements.

FIGURE 11. Distribution of damages (defects) affecting TOI “maintainability” by structure elements

|  |  |  |  |
| --- | --- | --- | --- |
| *а)* |  | *b)* |  |

**FIGURE 12:** Ranking of quantitative indicators of damage and defects

a – depending on the category of TOI “maintainability” (distribution density); b – influence of factors on TOI “maintainability”

From the analysis of Fig. 12, *a,* it is clear that the share of structures requiring repair and overhaul work is more than 54%. This means that more than half of the structures require various repair work. It can also be noted that 13.79% of structures fall into the reconstruction category. This suggests that some facilities require more serious changes and modernization [3].

The span structure is the most susceptible to the influence of factors of summary assessment in technical examinations since various types of defects and damage were found in 40% of cases. Damage and defects in supports are detected on average in 18% of cases, which is also a significant indicator and requires attention when conducting repair work. Defects and damage to the bridge roadbed account for 42%, which indicates the need to pay special attention to the condition of the bridge roadbed when performing the technical examination and repair work (Fig. 13).

**FIGURE 13.** Total distribution of damages (defects) affecting TOI by structure elements

Supports; Span structures; Bridge roadbed

Thus, these indicators make it possible to identify the most vulnerable elements of the structure that require special attention and maybe a priority for repair activities.

**FIGURE 14.** Total influence of factors on TOI in the presence of damage

Based on the study conducted, it was determined that the main factors reducing the level of technical condition of bridge structures are the effect of *moisture content* (18.2%), the amount of *movable load* (17.5%), and *operational deficiencies* (16.9%), as shown in Fig. 14.

**CONCLUSIONS**

1. Currently, in the Republic of Uzbekistan, instruction IKN 140-21 is in force for assessing the technical condition of bridges and overpasses; however, this document has several shortcomings, one of which is the determination of the general indicators of the object, and not the identification of its criteria.

2. During the study, the authors examined bridges and overpasses in the city of Tashkent. As a result, it was found that elements of the bridge structures were damaged and defective due to faulty expansion joints, poor waterproofing, and defective system of drainage pipes.

3. To assess the technical condition of bridges and overpasses, the authors identified technical and operational indicators (TOI), such as “**safety and traffic comfort,” “durability,” “load capacity,” “throughput,” and “maintainability**.

4. Based on the influence of defects, a detailed assessment of the technical condition of the object of study was performed using known methods, evaluation criteria, and impact factors.

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