

Analysis of technical and operational condition of urban reinforced concrete bridge structures

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Abstract. The article analyzes the technical condition of urban reinforced concrete bridge structures. The authors studied the technical passports of all bridges and overpasses in Tashkent and made direct technical inspections of more than 10 bridge structures. As a result, most of the shortcomings and defects of the existing bridge structures in the city were revealed. In Tashkent, there is a significant number of reinforced concrete bridge structures, the service life of 60 to 100 years (24% of the total number), a significant part of which (42%) has been operated for many years without major repairs. A "four-level" approach is proposed, which contains four stages of analysis, and evaluates the technical condition of the operated reinforced concrete bridge structures.

1 Introduction

In our country, bridges, overpasses, and other types of transport facilities are being built according to excellent projects, fully meeting international standards; they are becoming more comfortable for the population and are of great importance in improving the well-being of people.

Currently, positive results are being achieved in traffic flow management in our major cities through the construction of new modern bridges, according to modern projects, together with the world's leading international organizations in the field of bridge building.

In particular, the development of the city of Tashkent's road infrastructure is under the President's constant attention due to the constant increase in the population and vehicles in the capital. Over the past 10 years, the number of cars in Tashkent has doubled from 250,000 to 510,000. Therefore, there are a lot of congestion and traffic jams on the roads; certain shortcomings in traffic regulation are observed.

Decrees of the President of the Republic of Uzbekistan No. PP-3632 "On approval of the program for the construction, reconstruction and capital repair of road bridges, overpasses, and other artificial structures in the Republic of Karakalpakstan, regions and the city of Tashkent for 2018-2022," dated March 29, 2018, and No. PP- 4545 "On measures to further improve the management system of the road industry," dated December 9, 2019 [1, 2] are important programs to raise work to a new level.

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2 Problem Statement

An inventory of existing bridge structures was conducted in the republic to maintain the existing bridges, overpasses, tunnels, transport solutions, and other engineering structures in proper condition and to take specific measures to repair and restore bridge structures. As a result, it was found that as of March 1, 2021, there are 14,755 bridge structures in the republic, of which 3,324 are not assigned to departmental organizations, 1,009 are in pre-emergency or emergency condition, 5,930 structures are in a state of repair [3].

Based on the inventory results, practical measures were identified to assign bridge structures (not assigned to departmental organizations) to the relevant ministries and departments and local governments. More than 10 regulatory documents on the current repair of bridge structures have been developed and put into practice [4].

The tasks specified in paragraphs 192-197 of the Decree of the President of the Republic of Uzbekistan No. PF-60 "On the Development Strategy of New Uzbekistan for 2022-2026," dated January 28, 2022, to develop a unified transport system that connects all types of transport to create the opportunity to get and return to the destination based on daily transportation between major cities, a road development program for the next 5 years was developed for the rapid development of the road network between Tashkent and major cities of the republic. According to it, it is planned to construct, reconstruct and repair highways of 57.8 thousand kilometers, to perform stage-by-stage reconstruction and repair of 1512 existing bridges and other engineering structures.

Currently, the total number of bridge structures in the city of Tashkent exceeds 300. Almost 70% of them are under the jurisdiction of the "Cities and Districts Improvement Department". In total, the department has 216 bridge structures within its jurisdiction (Fig. 1) [5].

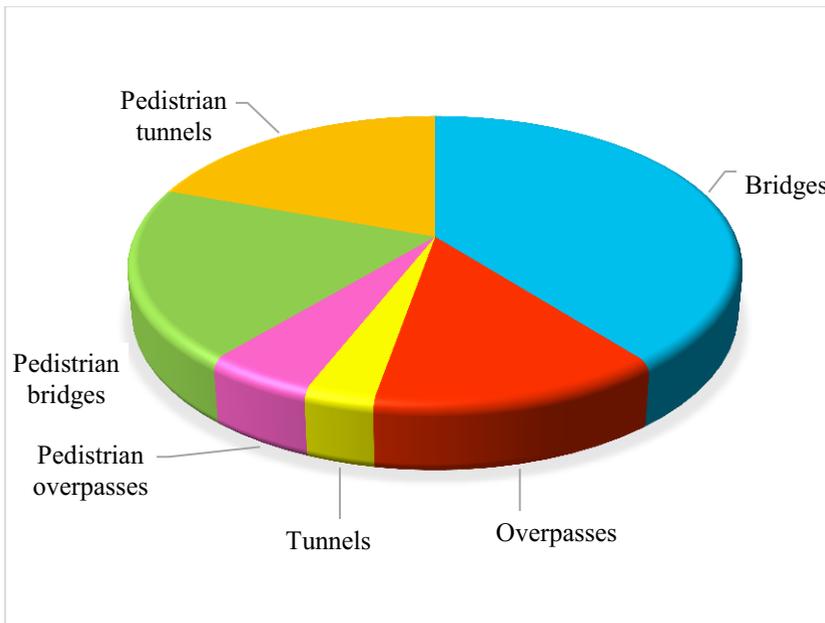


Fig. 1. A number of bridge structures are under the jurisdiction of the "Cities and Districts Improvement Department" of Tashkent.

Most of these structures were built between the 60s and 90s of the last century. It should be noted that the number of existing bridge structures has sharply increased over the last few years (Fig. 2) [5].

As seen from the graph, the area of bridge structures built before 1990 in Tashkent was 736.599 m², and this figure has doubled over the years of independence. It should be noted that the technical and operational condition of most of these bridge structures is unsatisfactory, as they are not given due attention.

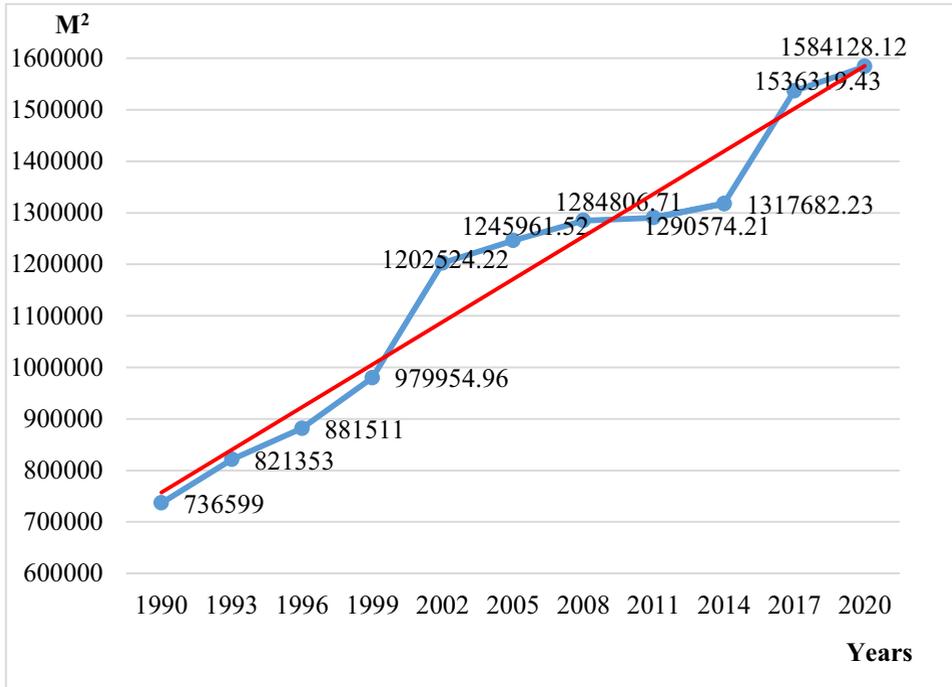


Fig. 2. Growth dynamics of the total area of operated bridge structures in Tashkent

The authors studied the technical passports of bridge structures under the jurisdiction of the "Cities and Districts Improvement Department" (85 bridges and 29 overpasses), including direct technical inspections of more than 10 bridge structures. It was established that the condition of the expansion joints of most bridge structures in Tashkent is unsatisfactory (Fig. 3, *b*). Figure 3*a* shows a significant subsidence on the road section of the overpass along A. Kadyri street near the Ankhor canal in the Yunusabad district.



Fig. 3. Defects in the roadway and cracks in the expansion joints of bridges and overpasses in Tashkent

In addition, a number of defects and damage were observed in the structural parts of bridges. Figure 4*a* shows the rusting of the reinforcement of the crossbar structure (an emergency state). The lower part of the slab of the overpass span structure at the intersection of Gavkhar and Bunyodkor streets (in the Chilanzar district) is rusted, and working reinforcement is exposed (*b*), and in the lower part of the beam 24 m long, there are diagonal cracks (*c*) at the points of support on the truss-bearing plate of the bridge built in 1970 in A. Kadyri street.

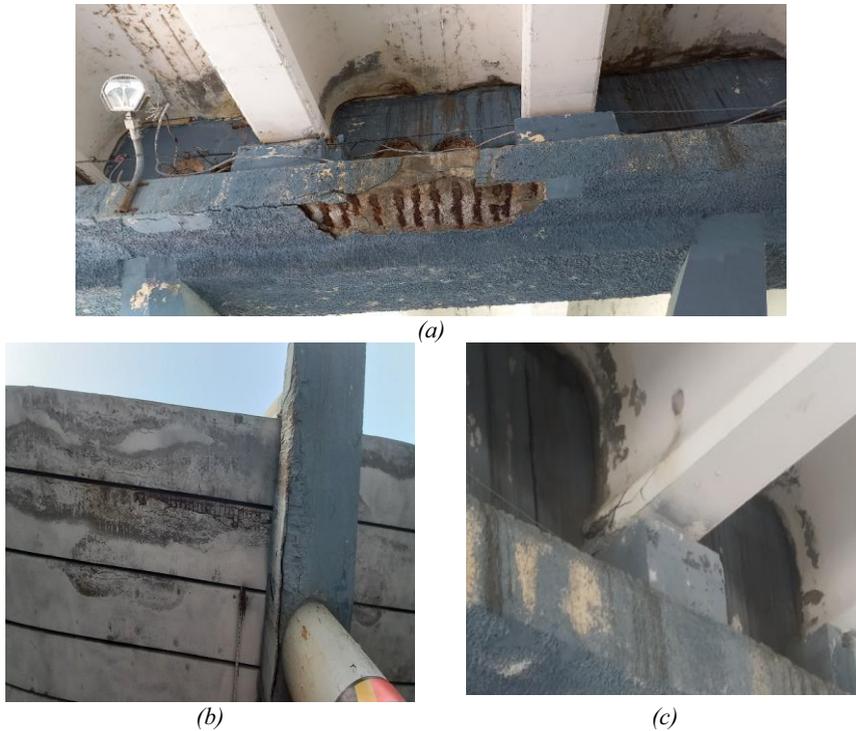


Fig. 4. Defects and damage to overpasses in Tashkent: a is rusting of reinforcement in the crossbar; b is defects and damage in the lower part of the span slab, c is diagonal cracks in the places of support on the bridge truss-bearing plate

Underbridge clearance defects were observed in more than 30 bridges (Table 1). Figure 5 shows the deplorable state of the road bridge across the Salar Canal along Asaka street, located in the Mirzo-Ulugbek district. The bridge was built in 1956 and renovated in 2001. It should be noted that according to the technical and operational indices, this bridge must be reconstructed.

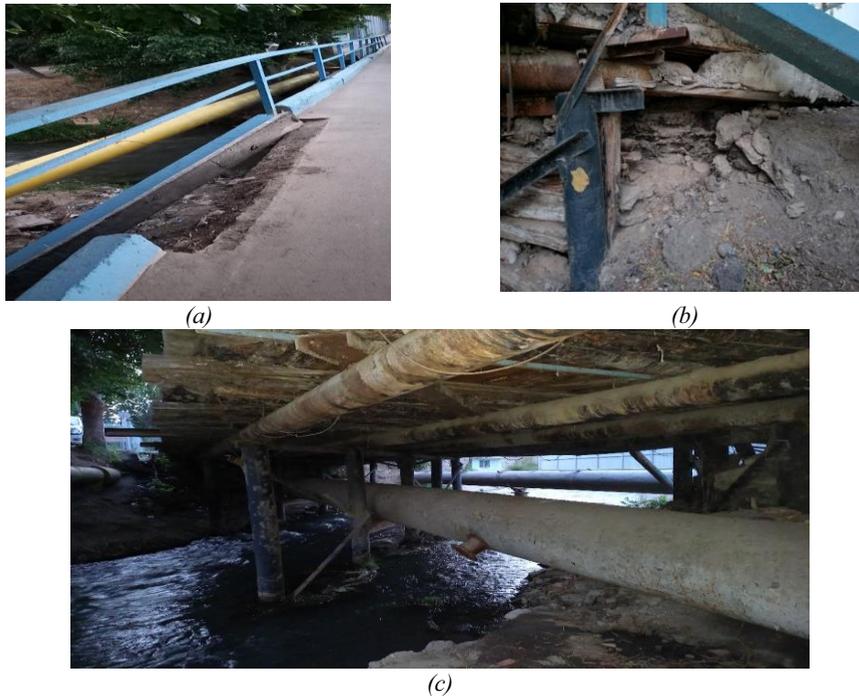


Fig. 5. Defects of underbridge clearance and bridge structures

Typical defects and damages for all bridges (85 bridges) over the years in Tashkent were combined into one system, presented in Table 1.

Table 1. Typical defects and shortcomings of structural elements of bridges in Tashkent

Element of the bridge deck	Defects and damage
Bridge deck	<ul style="list-style-type: none"> - potholes and uneven pavement; - cracks in the coating above the expansion joints of the closed type; - unsatisfactory mating of the coating with expansion joints of open type; - violation of the waterproofing and drainage system; - absence or insufficient length of drainage pipes;
Span structures	<ul style="list-style-type: none"> - concrete chips, destruction of the protective layer; - transverse cracks in the slab; - longitudinal cracks along the working reinforcement; - water leaks, leaching; - carbonization of concrete; - exposure and corrosion of reinforcement;
Bearings	<ul style="list-style-type: none"> - vertical cracks; - destruction of concrete; - water leakage, leaching; - exposure and corrosion of reinforcement.

The table shows many defects in the bridge deck (road pavement), waterproofing, and expansion joints. Figure 6 shows the percentage of general defects and bridges damaged in Tashkent over the years.

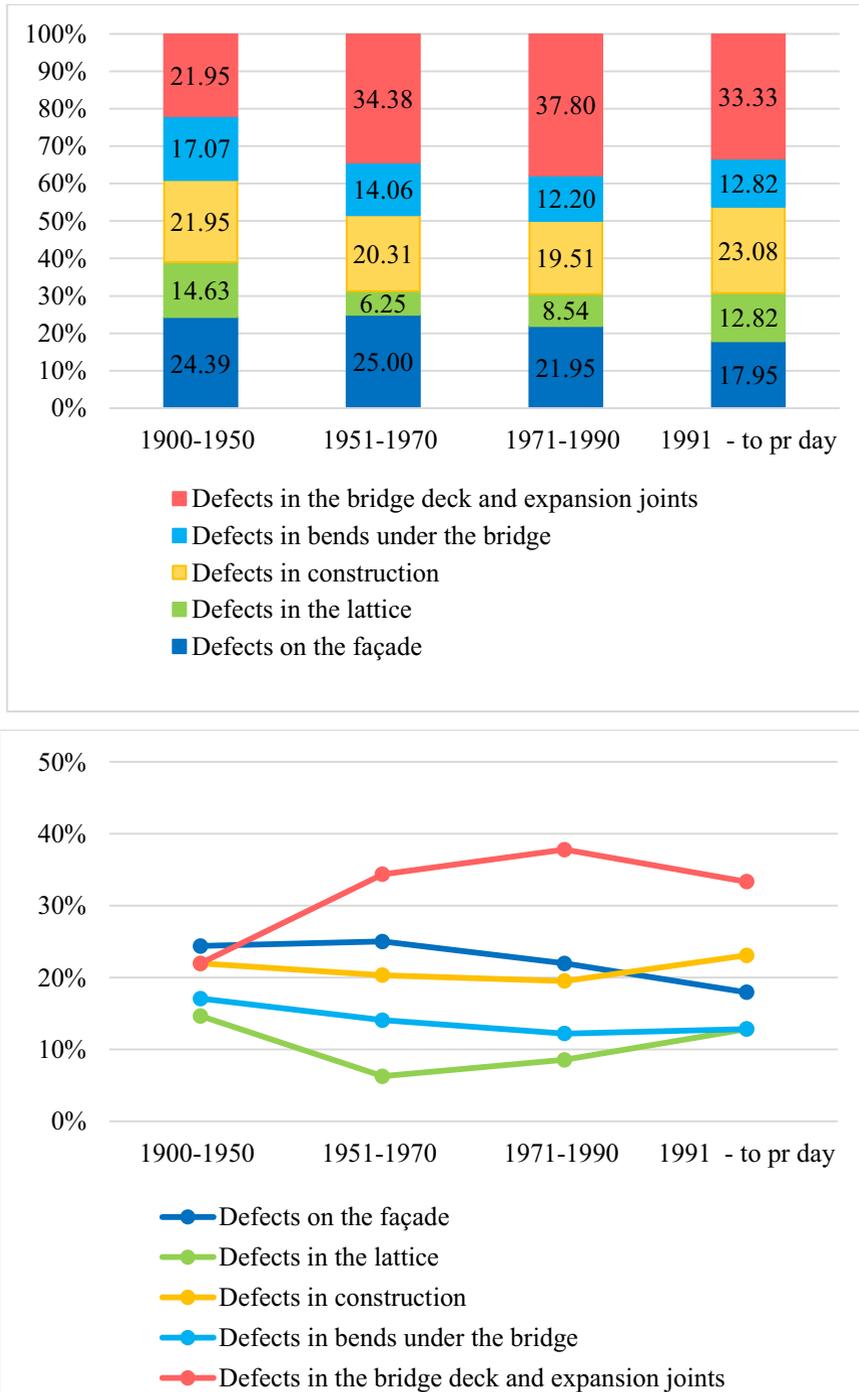


Fig. 6. General defects and damage to bridges in the city of Tashkent over the years (in percent)

As seen from the graph, according to the inspection results, the technical condition of some bridges operating in the city of Tashkent for 25-50 years (built in 1970-90) was unsatisfactory. It should be noted that the most common defects and shortcomings of city bridges are the insufficient size of the underbridge clearance, the defects in the bridge deck (roadway), expansion joints, facade, railings, and other structural elements. For example, cracks and damage are often observed (38%) in waterproofing and expansion joints.

Thus, the modern bridgework of the city is characterized by the presence of many reinforced concrete bridge structures. Among these bridge structures, there are old bridges and overpasses built before the 50s of the last century and relatively new structures built at the end of the 20th century and the beginning of the 21st century [6, 7, 12].

Estimates of the *operational reliability* of such bridge structures should be assessed especially responsibly, considering all the favorable and unfavorable *factors* of the urban environment in Tashkent. A significant role is played by the physical condition of reinforced concrete bridges and overpasses and the main characteristics of materials that determine the reliability and durability of the structure.

Prominent researchers worldwide were engaged in determining the operational bearing capacity of reinforced concrete bridges based on technical diagnostics: they are Do Min Khius, M.E. Kreger, F.M. Bachman, V.P. Chirkov, J.E.Ereen, M.J.Smith, D.A.Goodyear, V.M.Bondarenko, A.V.Nosarev, V.O.Osipov, Yu.V.Zaitsev, L.I.Iosilevsky, E.S. Karapetov, A.A. Bely, and researchers working in our country R.K. Mamazhanov, N.A. Krasin, Ch.S. Raupov, R.Z. Nizamutdinova, Kh.A. Baibulatov, I.G. Ganiev and others [5, 8, 11].

It should be noted that in the Russian Federation, when assessing the technical condition of operated urban reinforced concrete structures, A.A. Bely [9, 10] proposed a *"three-level" approach*, with three stages of analysis, which gives practical recommendations for improving the St. Petersburg bridge park. Analyzing his studies [9, 10] for the city of Tashkent, taking into account natural-technogenic conditions (seismic, dry-hot climatic ones, etc.), a *four-level approach* was proposed to assessing the technical condition of operated city bridge structures.

	I level	II level	III level	IV level
	Approximately 200 reinforced concrete bridges and overpasses in Tashkent	20 most significant and "characteristic" structures	1. Bridge over the Salar Canal, passing along Asaka street. 2. Bridge over the Ankhor Canal in A. Kadyri street. 3. Overpass at the intersection of Gavkhar and Bunyodkor streets.	Overpass at the intersection of Gavkhar and Bunyodkor streets.
The character of structures study	Preliminary analysis	Complete, detailed analysis	Most detailed content analysis	Active monitoring of urban bridge structures
Basic results of the study	General pattern of the technical condition, identification of the main defects and damage	Identification of patterns between the damage and factors affecting structures	Improving the methods for forecast assessment of the technical condition of the bridge structure	Development of geo-information electronic platform "Digital Bridge Monitoring"

Thus, the "four-level" approach proposed by the authors includes four analytical stages, which evaluate the technical condition of operated reinforced concrete structures.

The first level is a preliminary, generalized analysis of the total number of bridge structures. The number of structures subjected to analysis is about 200. This level or "stage" allows us to give a general pattern of the technical condition of operated reinforced concrete bridges and overpasses, to obtain the relevant characteristics for the entire park of bridge structures.

The second level is a complete, detailed analysis of the most significant reinforced concrete bridges and overpasses in Tashkent. The number of buildings subjected to analysis is 20. The criterion for selection from the total number was architectural and historical "merits", operational features, and problems arising over the years of their operation.

The third level is the most detailed, meaningful analysis of the state of reinforced concrete bridges and overpasses. Three structures were selected: the bridge over the Salar Canal on Asaka street, the bridge over the Ankhor Canal on A. Kadyri street, and the overpass at the intersection of Gavkhar and Bunyodkor streets. The analysis of the state of specific structures at the third level was determined by the need to evaluate the data obtained at the previous second level and consider them over time. The data of the studies conducted at the third level were used as the basis for the methods to assess and predict the technical condition of structures, using the main technical and operational indices that determine the reliability and functionality of reinforced concrete bridge structures in Tashkent.

The fourth level is the active monitoring of urban bridge structures. At this stage, an electronic database of urban reinforced concrete bridge structures will be created. Based on the active monitoring of a specific bridge, a geo-information electronic platform, "Digital Bridge Monitoring," will be developed.

3 Conclusion

Based on the analysis of scientific research in the field of operation of urban bridge structures and the analysis of survey data on reinforced concrete bridge structures in Tashkent, the following conclusions can be drawn:

- Tashkent is characterized by seismic, climatic features, and operating conditions of engineering structures, which must be taken into account in the process of maintaining bridge structures;

- about 60% of the city's road structures operated by various organizations in Tashkent are reinforced concrete bridges and overpasses. The service life of a significant number of these bridge structures is from 60 to 100 years (24% of the total number), and a significant part of them (42%) operates without major repairs for many years;

- according to the results of a survey of more than 10 bridge structures in the city, it was found that the main damage to the spans and bearings of reinforced concrete bridges and overpasses in Tashkent was caused, first of all, by the poor state of waterproofing and expansion joints;

- the issue of assessing and predicting the technical condition of operated bridge structures is very relevant due to the lack of unified approaches and methods for such assessment and forecast;

- the specifics of operation in a metropolis dictate the need for special approaches to control the technical condition of urban bridge structures. As a result, based on the statistical data of urban bridge structures for the city of Tashkent, taking into account natural and technogenic conditions (seismic, dry-hot climatic ones, etc.), **a four-level approach** was proposed to assess the technical condition of operated urban bridge structures;

– note that the issues of introducing and improving the system of active monitoring of reinforced concrete bridge structures in highway operation are not sufficiently studied in bridge engineering in the country. Currently, the problems of active monitoring of reinforced concrete bridge structures on highways are widely studied in foreign research centers in Japan, the USA, China, Russia, etc.;

- an electronic database of urban reinforced concrete bridge structures will be created. Based on the active monitoring of a specific bridge, a geo-information electronic platform, "Digital Bridge Monitoring," will be developed.

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