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History of the all-welded Evgeny Paton Bridge

Abstract. *This article explores the history of science and technology through the lens of the design, fabrication, and long-term operational experience of the Evgeny Paton Bridge in Kyiv, the world's first all-welded highway bridge. Completed in 1953 and named after prominent welding pioneer Academician Evgeny Paton, the bridge represented a milestone in civil engineering and Soviet technological ambition during the postwar reconstruction era. The study examines the scientific and technical foundations that enabled the transition from riveted to welded structures, highlighting advances in metallurgy, structural analysis, and welding technology developed. It also considers the bridge's fabrication process, which involved large-scale application of automatic submerged arc welding and innovative solutions to challenges related to joint integrity, fatigue resistance, and thermal stresses. Drawing on archival materials, technical publications, and historical records, the article situates the bridge within broader political, institutional, and economic contexts, analyzing its role as both a functional infrastructure project and a symbol of Soviet scientific progress. The operational history of the bridge over more than seven decades is reviewed, emphasizing its structural resilience, maintenance practices, and the lessons learned that influenced later bridge engineering within the USSR and globally. It reflects on the interplay between scientific experimentation and practical engineering solutions, demonstrating how theoretical research was actively tested and validated through real-world implementation. The bridge's continued use into the 21st century provides a living laboratory for studying the long-term behavior of welded steel structures under dynamic loading and environmental stressors. In doing so, the article underscores the enduring relevance of historical technological achievements for current infrastructure policy, materials science, and engineering education. The Paton Bridge thus serves as a compelling case study in the evolution of large-scale welded construction and the ways in which technological innovation is embedded in broader historical narratives.*

***Keywords**: history of bridge construction; history of metal bridges; welding history; Evgeny Paton Kyiv Bridge; engineering solutions; problems of maintenance and restoration*

Introduction.

Bridges are one of the most important elements of road infrastructure and one of the oldest inventions of mankind. As a rule, bridges consist of spans and piers. The spans are used to take loads and transfer them to the piers; they may contain a roadway, crosswalk, pipeline and so on. The piers transfer loads from the spans to the bridge foundation. Based on the purpose of bridges, it is logical to conclude that bridge structures operate under the most severe operating conditions. Therefore, the use of advanced technologies, including welding, determines the reliability and safety of the structure.

The first real metal bridge was built in the central industrial region of England, in the county of Shropshire across the river Severn (Sedmak, Ković, & Kirin, 2022).

At first, welding in bridge construction was not as resounding a success as in other industries (Strelko, 2023). The main doubts were caused by the reliability and serviceability of welded assemblies. The main arguments against the use of welding were based on the phenomenon of weld fatigue due to insufficient toughness of the welded material. Therefore, welding was initially used only in repair and restoration operations.

The transition from riveted joints to welded steel bridge structures has dramatically changed the practice of bridge construction. Welding in bridge construction started to be used as early as in the 30s. Its introduction was very cautious, and at the first stage it was supposed to make welded only factory departure blocks, and the assembly was to be carried out on rivets. This is how combined bridge structures appeared - welded with riveted assembly joints.

One of the most famous welded bridges is the Kyiv Evgeny Paton Bridge. It is one of the bridges over the Dnipro River in the capital of Ukraine in the city of Kyiv. The bridge is named in honor of academician Eugene Oskarovich Paton, who was its author of the idea, initiator of development and chief designer. When designing the bridge, E. O. Paton for the first time proposed to use modern technology – electric welding instead of riveted joints in the installation of the main girder purlins. The engineer's innovation had not been tested anywhere before, and therefore caused resentment of his colleagues and displeasure of his superiors. However, the scientist still managed to get his idea for electric welding applied.

Researching the design and construction of the all-welded Evgeny Paton Bridge in Kyiv from the perspective of the history of science and technology requires posing a series of critical and interrelated questions that explore both the technical and socio-political dimensions of this landmark engineering achievement. First, it is essential to ask: what were the specific scientific and engineering innovations that made the construction of the world's first all-welded bridge possible, and how did these reflect the state of materials science, structural mechanics, and welding technology in the Soviet Union during the mid-20th century? Closely related is the question of how the bridge's design process integrated contemporary knowledge about fatigue resistance, thermal effects, and stress distribution in welded joints, and to what extent this knowledge was based on theoretical research versus empirical experimentation. Another important question involves the institutional and political context: how did the broader goals of Soviet industrialization, scientific advancement, and ideological emphasis on technological leadership shape the decision to build an all-welded bridge, and what role did government agencies, academic institutions, and key figures like Evgeny Paton play in promoting and legitimizing the project? Furthermore, it is necessary to ask how the bridge's construction methods and materials were selected, tested, and scaled, and what logistical and technological challenges had to be overcome in the absence of extensive precedent. The role of labor and expertise also warrants attention: what kinds of training, skillsets, and organizational systems were required to implement large-scale industrial welding on a civil engineering project of this magnitude, and how was knowledge shared or developed on site? Finally, a critical historical inquiry should examine how the Evgeny Paton Bridge influenced subsequent developments in bridge engineering, both within the Soviet Union and internationally, and how it was represented in media, scientific discourse, and public narratives as a symbol of modernity, national pride, and technological innovation.

Getting answers to the above questions was the purpose of this article.

Research Methodology.

Researching the design and construction of all-welded bridges is of profound importance from the perspective of studying the history of science and technology, as it illuminates a transformative moment in engineering practice that reflects broader industrial, technological, and societal shifts throughout the 20th century. The emergence of all-welded bridge construction signified not merely a change in technique but a paradigm shift in structural engineering philosophy, influenced by the interplay of scientific discovery, wartime necessity, industrial capabilities, and evolving transportation demands. Unlike riveted bridges, which relied on thousands of mechanically fastened joints, all-welded bridges introduced the concept of seamless load transfer, enabled by the science of metallurgy and the practical mastery of welding technologies. This innovation reduced material use, lowered dead loads, and simplified fabrication processes – yet it also posed new challenges, especially in understanding the fatigue behavior of welds, the properties of heat-affected zones, and the need for precise control during construction. The decision to transition toward all-welded structures was not made in isolation; it was grounded in advances in welding science – particularly arc welding – and a growing body of empirical research supported by academic institutions, government bodies, and engineering firms. For historians of science and technology, tracing this evolution provides insights into how scientific principles were translated into real-world applications, reshaping the built environment in ways that remain consequential today.

Studying the development of all-welded bridges also offers a window into the socio-economic and political contexts that drive technological innovation. For example, during and after *World War II*, the urgent demand for rapid infrastructure development, combined with labor shortages and material constraints, encouraged the adoption of more efficient, mechanized fabrication methods, among which welding was paramount. Welding technology, initially developed and refined for shipbuilding and armament production, found new peacetime applications in civil engineering – most notably in bridge construction. Furthermore, this transition required engineers to challenge and rethink traditional design norms, leading to the creation of new calculation methods, stress analysis models, and safety factors specifically tailored to welded structures. Such advancements highlight the dynamic interplay between theoretical knowledge and practical engineering, a core focus within the history of technology.

In addition, research into the design of all-welded bridges reveals how professional institutions, codes, and standards evolved in response to both successes and failures. Notable bridge collapses or structural issues due to fatigue cracking in welded joints during the mid-20th century served as catalysts for intensive investigation into fracture mechanics and material fatigue – topics that were still emerging in the scientific discourse. These incidents led to more conservative design approaches, rigorous inspection protocols, and international collaboration on welding standards, such as those developed by the American Welding Society or the International Institute of Welding. Historians of science and technology can explore how such feedback loops between practice and regulation influenced the broader discipline of structural engineering, shifting it from an empirical art to a more scientifically grounded profession. This evolution also demonstrates the role of failure as a driver of scientific advancement, illustrating how knowledge systems are shaped by real-world testing and recalibration.

Moreover, the study of all-welded bridges highlights the globalization of engineering knowledge. As countries rebuilt after *World War II* and entered periods of rapid modernization, the techniques and philosophies behind all-welded bridge construction spread across continents. Engineers from different cultural and educational backgrounds began to collaborate, sharing insights through international journals, conferences, and technical exchanges. In this sense, all-welded bridge construction serves as an example of "technological diffusion" – a process by which innovations are transmitted, adapted, and localized across borders. This phenomenon provides rich material for historians interested in how technologies travel and transform, influenced by regional needs, material availability, labor practices, and climate conditions. For instance, the adaptation of welding techniques for tropical climates or seismically active regions required modifications to design practices, welding materials, and inspection protocols, which in turn stimulated new research and innovation.

Furthermore, exploring the history of all-welded bridges underscores the intersection of human skill, machine capability, and scientific knowledge. Welding, unlike purely mechanized processes, remains a craft that demands precision, training, and tacit knowledge – especially when performed in challenging environments such as over rivers, in high winds, or on large-scale structures. The role of the welder, often overlooked in historical narratives, becomes central in this context. Oral histories, trade manuals, and training programs from the mid-20th century offer rich primary sources that reveal how this expertise was cultivated, transmitted, and institutionalized. From the perspective of science and technology studies, such research emphasizes the importance of human agency and the embodied knowledge that underpins even the most "technologically advanced" systems. It challenges deterministic views of technological progress by showing how real-world implementation depends on a blend of theoretical understanding and skilled labor.

Results and Discussion.

Idea. Justification. Scientific Research Underlying the Development.

In 1929, E. O. Paton decided to use welding instead of riveting in bridge construction. He shares his impression of the first time he saw the work of a welder: "The external simplicity of welding, the ease and ease with which the holder was operated by a young worker on the bridge, gave me an idea of welding as something very uncomplicated... It often happens like this: as long as a person is a novice in something new to him, as long as he looks only from the outside, everything seems clear, accessible and simple to him. So it was with me" (Paton, 1956, p. 103).

Single attempts in building welded bridges had so far failed (Poznyakov, Dyadin, Davydov, & Dmytrienko, 2021). That fact was first of all associated with a sharp drop in the load-carrying capacity of welded joints during manufacture of large-sized metal structures. The main cause for such a drop was a simple replacement of riveted joints on welded ones without taking into account the stressed state of welded elements and imperfection of welding technologies developed at the time, which led to crack formation both during manufacture (shop and site welding), as well as during operation of welded structures. Brittle fractures of welded structures in the 1940s began to bear a mass character, the majority of which had a number of features:

- fracture nuclei were usually located at the places of welded joints;
- fracturing occurred at very low operating loads and relatively high temperatures;
- a number of partial fractures of welded structures significantly increased.

As early as in the 30's by the works of E. O. Paton and B. N. Gorbunov in the E. O. Paton ElectricWelding Institute of the Academy of Sciences of the UkrSSR (PEWI) proved that it is most rational to use butt welded joints for structures operated under static and vibration loads, as they provide minimum stress concentration (Paton & Gorbunov, 1933). However, these conclusions of scientists were not used by designers for a long time due to the ingrained design methods of riveted structures.

The quality of welded bridge spans was low, and the steel itself had a high threshold of cold resistance. There were many deficiencies in the truss design, the main one being overlapped or overlapped joints. This resulted in a large accumulation of flank and lob joints in some places of the trusses, which caused high residual stresses from welding, contributing, in combination with the poor quality of welding and the selected steel, to the formation of cracks in the truss elements during installation and operation. This led a number of specialists and generally design organizations to strongly oppose the use of welding in railway and road bridges. As a result, on the eve of the *World War II* the rate of welded bridge construction in the USSR sharply decreased. During 10 years (1931–1942) only 28 welded spans weighing about 1,500 tons were built in the USSR.

However, welded bridge construction also had ardent supporters. First of all, E. O. Paton belongs to them. Foreseeing a great future for welded bridges, he continued with unflagging energy to study the problems of welded bridge construction. Researchers paid much attention to the study of the operation of combined rivet-welded joints as applied to bridge truss assemblies, longitudinal and transverse roadway girders with bond attachments. At the PEWI, E. O. Paton and V. V. Shevernytskyi (Paton & Shevernytskyi, 1948a; 1948b) have established the locations of destructive forces in the combined connection, in the connection with rivets, and also in the connection with welded seams. The properties of "welding steel" melted in puddling furnaces and used in old bridges were studied for this problem. Due to the lack of ductility of this steel and delamination, brittle fractures often occurred (Paton & Shevernytskyi, 1949).

Large experimental works on comparing the serviceability of welded and riveted trusses were carried out by E. O. Paton and B. N. Gorbunov (Paton & Gorbunov, 1935; Paton, Gorbunov, & Bershtein, 1937; Gorbunov, 1941). In tests of riveted and welded trusses with a span of 12 m, loosening of rivets was observed after 30 thousand loads, failure of welded and riveted trusses - after 230–250 thousand loads.

In 1940, when considering the construction project of a new road bridge over the Dnipro River in Kyiv, E. O. Paton proposed to apply the method of automatic submerged-arc welding for the manufacture of its elements. The Kyiv highway bridge was to be the first bridge in the world welded by automatic welding machines. Since it was very difficult to ensure the proper quality of seams at the construction site at that time, it was decided that all welding work should be done at the Babushkin Dnepropetrovsk Metal Construction Plant, and the assembly joints should be riveted. Within a month the design bureau of the PEWI developed a project and working drawings of the welding bench and chain turner to it. By the beginning of the war a considerable part of the structures was manufactured by the plant, two spans were delivered to Kyiv and one of them was assembled, seven spans remained at the plant. This metal was used in 1944 in the restoration of the Dnepropetrovsk bridge over the Dnipro River.

The question of construction of motor-road bridge in Kyiv across the Dnipro river was raised before the *World War II* (Lobanov & Kyrian, 2013). By that time the technical project of the bridge with driving atop and split through main truss girders, covering the spans of 58 m length (in the floodplain part) and 87 m (in the navigable one) was drawn up and approved. As in that period at the PEWI the method of automatic submerged arc welding was developed allowing the producing of high-quality welds, E. O. Paton proposed to manufacture spans of the bridge using welding.

And then, the opponents of application of welding in bridge construction raised their swelled heads over (Glavmostostroy, Leningrad Research Institute of Bridges, Glavstalkonstruktsiya, Ministry of Railways). At the meeting they stood up for the technology of riveting of bridges widely used by that time, and in support of that they presented the pictures from the foreign journals with fractured spans, in building of which the welding was applied. Evgeny Paton, basing on the results of the first profound research works of welding process, as well as on his intuition, was firmly convinced that the cause of the disasters abroad was not in the main principles of welding process, but in its wrong primitive application. The designers used to leave the design of bridges, accepted during riveting, unchanged, i.e. they did not consider the peculiarities of the process of joining the elements using welding. Besides, the steel applied for riveting turned to be quite unsuitable for welding, and quality of welds in use of manual welding at that time was disastrously low. After Evgeny Paton had briefly stated the principles of construction of the welded bridge in Kyiv across the Dnipro river, including the selection of steel suitable for welding, the application of automatic submerged arc welding and strict control of quality of welded joints, N. S. Khrushchev (Figure 1), the Secretary of the Central Committee, resumed: «We will weld the bridge. I mean weld! Failures of other countries shall not discourage us».

In 1999, Khrushchev's four-volume book "Time, People, Power" was published a complete transcript of tape recordings made by the disgraced leader of the CPSU. In a separate essay, Khrushchev touched on the circumstances of his first meeting with Yevgeny OskarovichPaton (Khrushchev, 1999, pp. 451–453). It was around 1940:

> *"...I once received a phone call from the Ukrainian academician Paton. I had heard of him before, but had never met him. I was informed that he was a very interesting person, a major machine builder who was interested in the problem of welded bridge construction. He asked to see me, and I took him in. A dense man, already in his old age, gray-haired, stocky, with a lion's face and prickly eyes, entered the office. When he said hello, he immediately took a piece of metal out of his pocket and put it on the table: "Here, look, Comrade Khrushchev, what our institute can do. This is strip iron (10-millimeter thick, I think), and I weld it like this." I looked at the welding. Since I am a metalworker myself, I had to meet with welding. Here was just a perfect seam, outwardly smooth, like a cast. He says, "That's submerged arc welding." I heard the word "flux" for the first time then. Paton had other inventions. He told me about the possibilities of submerged-arc welding, its benefits, how it facilitates labor, increases its productivity and the quality of welded works in general, especially their reliability. He was absorbed by the idea of welding all iron structures made of ferrous metal – bridges, rafters for flooring of buildings, etc. and proved that it was more profitable to weld them instead of riveting them; he drew such a picture before me that soon he would produce automatic machines with which we would weld ships. His eyes literally burned, and his words were so confident that he made others*

believe in his idea. He was good at showing his achievements to people who were not specialists, and he was able to convince them of the correctness of his arguments. I was literally fascinated by meeting and talking with Paton, his progressive, revolutionary technical ideas. Now I can say that Evgeny Oskarovich – is the father of industrial welding in the USSR".

Figure 1. E. O. Paton and N. S. Khrushchev: a business discussion (Lobanov, 2020).

A series of studies were conducted to find suitable steel and welding materials, to work out welding modes and other important details, which were closely monitored by Glavmostostroy, the Leningrad Research Institute of Bridges, Glavstalkonstruktsiya, and the Ministry of Railways. The problem was aggravated by the fact that on January 31, 1951, the welded span of the Duplessis bridge built in 1948 collapsed in Canada (Strelko, 2023).

In 1948–1949, Voloshkevich G. Z. found during testing of technology of submerged arc welding with forced formation of vertical weld that the electrode wire is melted at arcless discharge in the fused flux, i.e. in slag pool (Lyutyi, 2015). The new type of welding appeared – electroslag welding (ESW), based on electric conductivity of the molten slag. The problems of providing the stability of electroslag process and also designing of devices for maintaining of metal and slag pools, etc. were solved.

The obtained results allowed E. O. Paton to raise the question about construction of allwelded bridge in Kyiv across the Dnipro river, applying automatic welding not only under shop conditions but also in site (Lobanov & Kyrian, 2013). The proposal of Paton, supported by the Government of the USSR, was accepted, and the technical project, and later the working projects were amended correspondingly, considering the results of the recent investigations of the PEWI and also modernized design changes in accordance with the Resolution of the Council of Ministers of the USSR of May 17, 1948 of the project assignment which related to the following points:

- truss girders of the bridge shall be welded with a solid wall of not higher than 3.6 m;
- existing type of supports shall be preserved along the whole length with girth rails on columns;
- in the navigable spans the truss girders shall be applied with the solid haunches.

In 1946–1951 Evgeny Paton, the acknowledged leader in the field of welding and bridge construction, united and organized the joint work of bridge designers and staff members of the PEWI. They carried out a large complex of research and designing works to develop further the major principles of designing of welded bridges, made by E. O. Paton as early as 1933 (Paton, 1933). As a result of this large work (Lobanov, Kyrian, & Shumitsky, 2003):

- the new design of the bridge was made. Instead of the lattice principal girders of a high height, designed before the war, four solid-wall continuous girders with chords of thin-sheet metal and economic thin wall were designed. Their height was in the limits of railway dimensions for feasibility of fabrication and transportation by large blocks. To provide a local stability of the wall, a system of horizontal stiffeners, included into composition of section of principal beams, adaptable to manufacture and welding, was used. This allowed designers to reach a record thickness of walls of principal beams 1/250, at a minimum consumption of steel which is concentrated in chords. The latter were reinforced with second sheets under supports and in the middle of spans in accordance with bending moments. Principal beams over the bridge supports were reinforced from beneath by blocks in the form of support reinforcement;

- special grade of low-carbon steel «MSt3 for welded bridges», low-sensitive to the thermodeformational cycle of welding, was developed. It was produced by control of the chemical composition (≤ 0.20 % C; 0.12-0.25 % Si; 0.36-0.60 % Mn; ≤ 0.05 % S; ≤ .045 % P) (by the way, other papers list a different grade of steel, namely M16C (Poznyakov, Dyadin, Davydov, & Dmytrienko, 2021). Silicon and aluminium were used as deoxidizers, and the set thermal condition of rolling provided a fine-grain structure. Some experimental welded spans of railway bridges were fabricated from this steel;

- improved grades of electrode wires (manganese grade A, Sv-10GA) and fluxes (AN-348, AN-348A, OSTs-45) were developed and tested under the industrial conditions;

- equipment was updated and simplified for automatic and mechanized welding of structures in shop conditions, providing stability of the preset welding condition under the industrial conditions and accuracy of electrode direction along the weld (welding tractor TS-17-M, semi-automatic machine PSh-5, holder DSh-27);

- new methods and equipment for automatic welding of vertical butt welds with their forced formation were developed for erection of spans;

- technology of shop and site welding was developed;
- design solutions of welded connections of spans and sequence of their welding were determined using criterion of assurance of preset level of strength and ductility of welded joints. These characteristics were determined from the results of testing large-sized specimens of real defect-free welded joints at minimum temperature of service (in the given case -40 °C) with a record of tension diagram. It was assumed that the satisfactory operation of welded joint under the service conditions will be guaranteed if the rupture stresses sr reach the level of ultimate strength σ_t ($\sigma_r = \sigma_t$), which is not lower than that of the parent metal. Another important requirement was the development of a high plastic deformation ($\sigma_t > \sigma_y$) before the specimen rupture;
- the metal susceptibility to strain ageing and transition to brittle state was evaluated on specific largesized specimens with a natural stress raiser in the zone of welding (narrow slot in a longitudinal composite stiffener, welded up to the plate using fillet welds).

By the beginning of the 1950s, the comprehensive experimental information on the problem of cracking in welds was collected (Lyutyi, 2015). Studied were physical-chemical properties of molten fluxes and slags at high temperatures (viscosity, electric conductivity, surface properties, thermodynamic activity of oxides). The important process is the interaction of molten slag with solidified weld metal. As a result of investigations of weldability of the low-alloy steel, carried out under the supervision of E. O. Paton, it was found that the increase in steel tendency to transition into a brittle state in the process of welding thermal cycle depends on chemical composition, method of steel deoxidation in melting and grain size. The lowcarbon steel, killed by silicon and aluminium and rolled at optimum temperature, possesses the lowest threshold of cold brittleness in the heataffected zone (Paton & Shevernytskyi, 1948a; 1948b). As to the weld metal, then to avoid the cracks it is necessary that the amount of impurities, contributing to crack formation, did not exceed the definite value and were distributed uniformly in the rolled metal section. The main result of these investigations was the working out of requirements to steels for welded structures. E. O. Paton had a meeting with I. F. Tevosyan, Ministrer of Ferrous Metallurgy, and asked him to assist in making experimental samples of steels according to the technical specifications of the Institute. The request was immediately satisfied and steel, melted in Mariupol (Ukraine), possessed a good weldability at the absence of defects. Metallurgists had to support the point of view of E. O. Paton, such as «in steel production it is necessary to take into account the requirements of welders» (and ten years later the technologies of production of metals and alloys were developed at – PEWI and implemented by metallurgists in many countries).

These and other developments served as scientific grounds for designing, fabrication and construction of the first large all-welded bridge in Europe.

"Team" – the Scientists Who Realized These Ideas.

Everyone has heard the phrase "human resources decide everything", which has become old but has not lost its sacredness. The phrase has been used by leaders of different scales, from CEOs to heads of countries, but in any case, the meaning has always remained the same: the success of any enterprise depends on the efficiency of its employees. According to some historians (Kolodiazhnyi, 2014; Strelko & Pylypchuk, 2021), the phrase belongs to Klavdiy Semenovich Nemeshaev, the head of the South-Western Railway, and later the Minister of Railways in the cabinet of Count Witte. This phrase has not lost its relevance even today.

As in many other important, large and responsible projects, "personnel decided everything" and at different stages of research, design, construction and assembly of the Kyiv Evgeny Paton Bridge.

The general design of the Evgeny Paton Bridge structure was developed by the Kyiv Special Design Bureau (SDB No. 3) of the Promstalkonstruktsiya trust (now the Limited Liability Company "V. N. Shimanovsky Ukrainian Institute of Steel Structures" (V. N. Shimanovsky Ukrinstalkon LLC) with the participation of engineers A. Shumitsky, V. Kirienko, and I. Marakin (Shymanovskyi, Kotlubei, & Shalinskyi, 2019). A group of engineers from the Institute of Electrical Welding of the Academy of Sciences of the Ukrainian SSR consisting of V. Trufyakov, V. Shevernitsky, V. Novikov, G. Zhemchuzhnikov, and S. Ostrovskaya took part in the development of the bridge project under the general supervision of E. O. Paton.

Design of the Bridge. Construction.

The shop fabrication of metal structures of bridge of a total mass of about 10,000 t was realized since December 1951 to April 1952, and the site works were made since April 1952 to October 1953 (Lobanov, Kyrian, & Shumitsky, 2003). The total length of the bridge is 1,543 m. It has 24 spans, 20 by 58 m, and four fairway arches of 87 m (Figure 2a). In transverse section the span has four principal Ibeams with a solid wall, located at 7.6 m distance from each other (Figure 2b). They are joined by transverse braces. Longitudinal braces are availableonly in the lower chord between middle principal beams along the entire length of the bridge. Over the supports the longitudinal braces were mounted between all four principal beams. Upper chords are joined by transverse rolled braces to a reinforced plate of the bridge road, operating with them for bending. The total width of the bridge is 27 m (roadway is 21 m and two pedestrian ways by 3 m). There are two tram lines in the middle of the roadway.

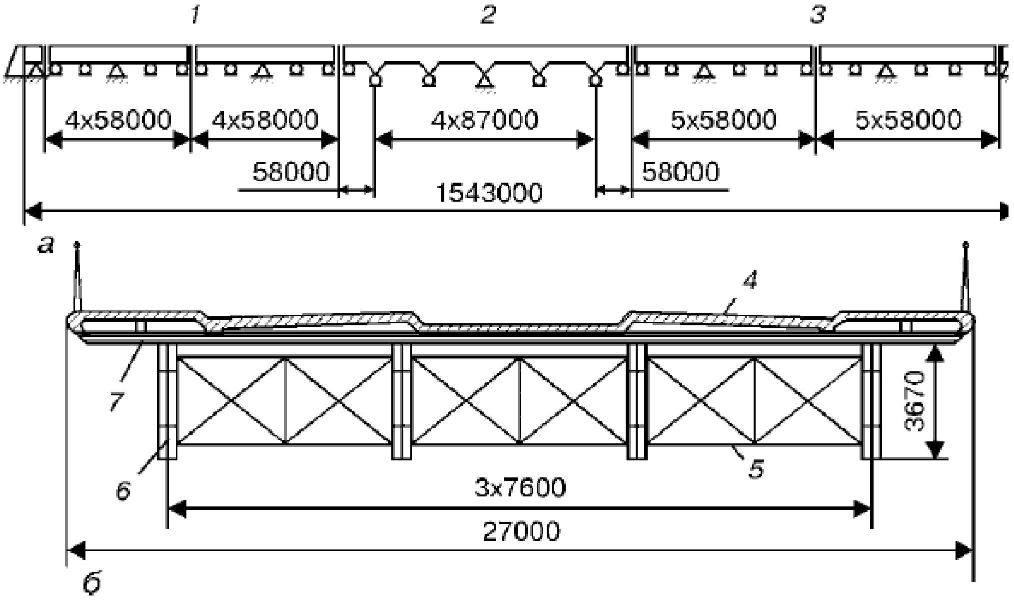


Figure 2. General scheme *(a)* and cross section *(b)* of the Evgeny Paton Bridge across the Dnipro river in Kyiv: 1 - left-bank area (two continuous four-span stiffening beams); 2 - middle area (the same, one six-span girder); 3 - right-bank area (the same, two six-span girders); 4 - reinforced-concrete plate of passageway; 5 - transverse braces between principal beams; 6 - principal welded I-beam with a solid wall; 7 - transverse rolled I-beam (Lobanov, Kyrian, & Shumitsky, 2003).

Due to earlier existing fractures of welded spans, the great attention was paid to the quality of welds, except using such design solutions of welded joints, which mostly satisfied the above-mentioned requirements for strength (Lobanov, Kyrian, & Shumitsky, 2003). Therefore, designing was based on the principle of maximum use of automatic and mechanized submerged arc welding in shop and site conditions. For this purpose, the principal beams were designed in the form of a I-beam with a solid wall having long longitudinal welds. Vertical stiffeners were replaced mainly by horizontal stiffeners. At the plant the erection elements of principal beams were manufactured in large blocks. Their length was 27–29 m and mass of about 38 t. In addition, a special design of a site butt with inserts for a vertical wall was developed that made it feasible to weld the lower chord butts by the automatic machine using run-out tabs, then their cutting and flush machining with a lower chord sheet. Butts of the vertical wall insert were designed for the automatic welding with a forced weld formation. Welding of butts with inserts of the upper chord was also provided by the automatic machines using run-out tabs, their subsequent cutting and flush machining with a chord. All this allowed 93 % of shop and 88 % of site welds of principal beams to be made by the automatic and mechanized submerged arc welding, that guaranteed their high quality.

The total length of the bridge is 1542.2 m, it consists of 24 spans (Poznyakov, Dyadin, Davydov, & Dmytrienko, 2021). The construction of the bridge began from the left bank of the Dnipro River. The right-bank part of the bridge consists of ten spans, which are overlapped by two all-welded fivespan continuous structures – (5×58) + (5×58) m. The middle part of the bridge over the navigable region of the river has six spans, which are overlapped by continuous all-welded structures – 58 + 4×87 + 58 (m). The left-bank part of the bridge has 8 spans of 58 m each and is overlapped by two four-span continuous welded structures – (4×58) + (4×58) m. In the cross-section, each structure has four main longitudinal beams of double-T section, consisting of a vertical wall with 3600 mm height and 14 mm thickness and girths of different thickness, varying from 30 to 80 mm, with a width of up to 1,000 mm (Figure 3).The stability of the beam wall is additionally provided by vertical stiffeners mounted with a step of 7.25 m. In six-span structures, the height of the wall above the intermediate supports is increased to 6,200 mm due to built on haunches.

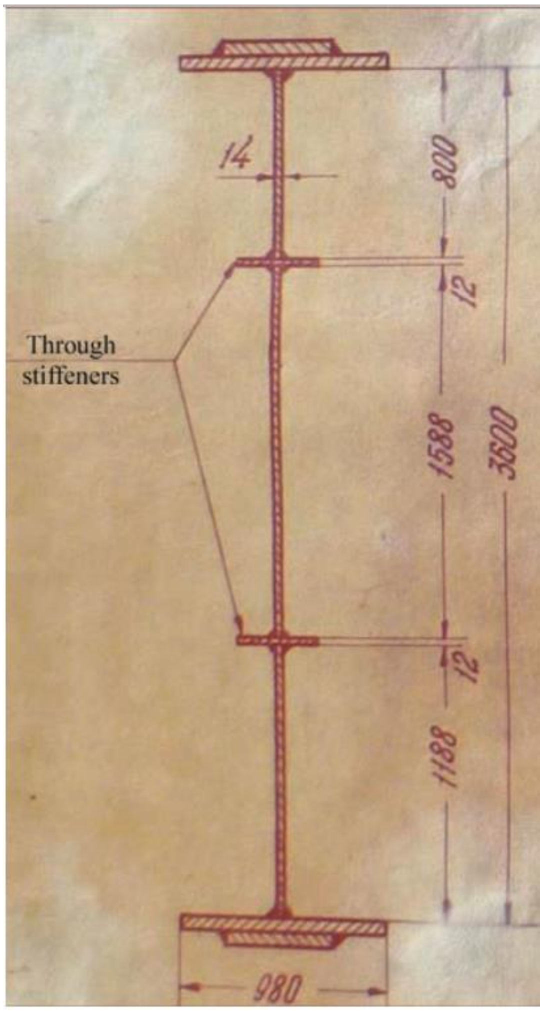


Figure 3. Cross-section of the truss of the main longitudinal beams of four- and five-span structures of the Evgeny Paton Bridge (Poznyakov, Dyadin, Davydov, & Dmytrienko, 2021).

In the process of bridge project development, a scientific school was established, as well as a methodological basis for integrated structural and technological design. As a result, the strength and durability of structures, static and fatigue resistance of welded joints, manufacturability of mechanized fabrication and welding, and large-block assembly are ensured.

So Who Named the Bridge?

Nikita Khrushchev wrote in his memoirs. (Khrushchev, 1999, pp. 467–469): *"When Paton died, the construction of a new bridge over the Dnipro River in Kyiv was being finalized. It was the biggest bridge in Kyiv. It was all-welded. Paton pushed for it, and I supported him, that an all-welded design be adopted. He was the technical supervisor for welding the bridge. I came to Ukraine on some business at that time. The Ukrainians were running around with the idea of naming this bridge after me. It surprised me, especially because by that time we had already decided to prohibit assigning to enterprises, institutions, collective farms, etc. the names of Party and government leaders who were in good health. And even a number of honorary names, which had been assigned earlier, we withdrew by a special decision. As I jokingly said at the time, we deprived of all rights and fortunes those people who had "hoarded" factories, plants and cities. There was even an unhealthy competition whose name would be given to more enterprises or collective farms. This is a wild thing! Under Lenin, I don't think this had ever happened before. Then sometimes the name of the living Budyonny (as a hero of the Civil War) was assigned. The names of the deceased were also assigned in memory of their good deeds they had done for the Party, for the people. I asked the Ukrainians: "Why do you want to assign my name to the bridge? This is a direct violation of the decision of the Central Committee. I am against it, especially since I myself was the initiator of such a decision. Don't you realize the position you are putting me in? I ask you not to go anywhere with proposals of this nature. And why do you have to search long and hard to find out who is more worthy of having his name given to this building? Here's Academician Paton. Please, make just such a proposal, and the government will approve it". So the bridge was named after Paton. And now this bridge, as they say, is alive and well, and people passing over it, remember its creator Academician Paton with a kind word".*

Thus, with a high degree of probability, we can say that it was Nikita Khrushchev who gave the name of the Kyiv highway bridge (Evgeny Paton Bridge).

Manufacturing.

All metal structures were manufactured at the Babushkin Plant in Dnipropetrovs'k (which was then the Molotov Plant), where a special workshop was set up for the ongoing production of large blocks and assembly elements (Lobanov, 2014) (see Figures 4).

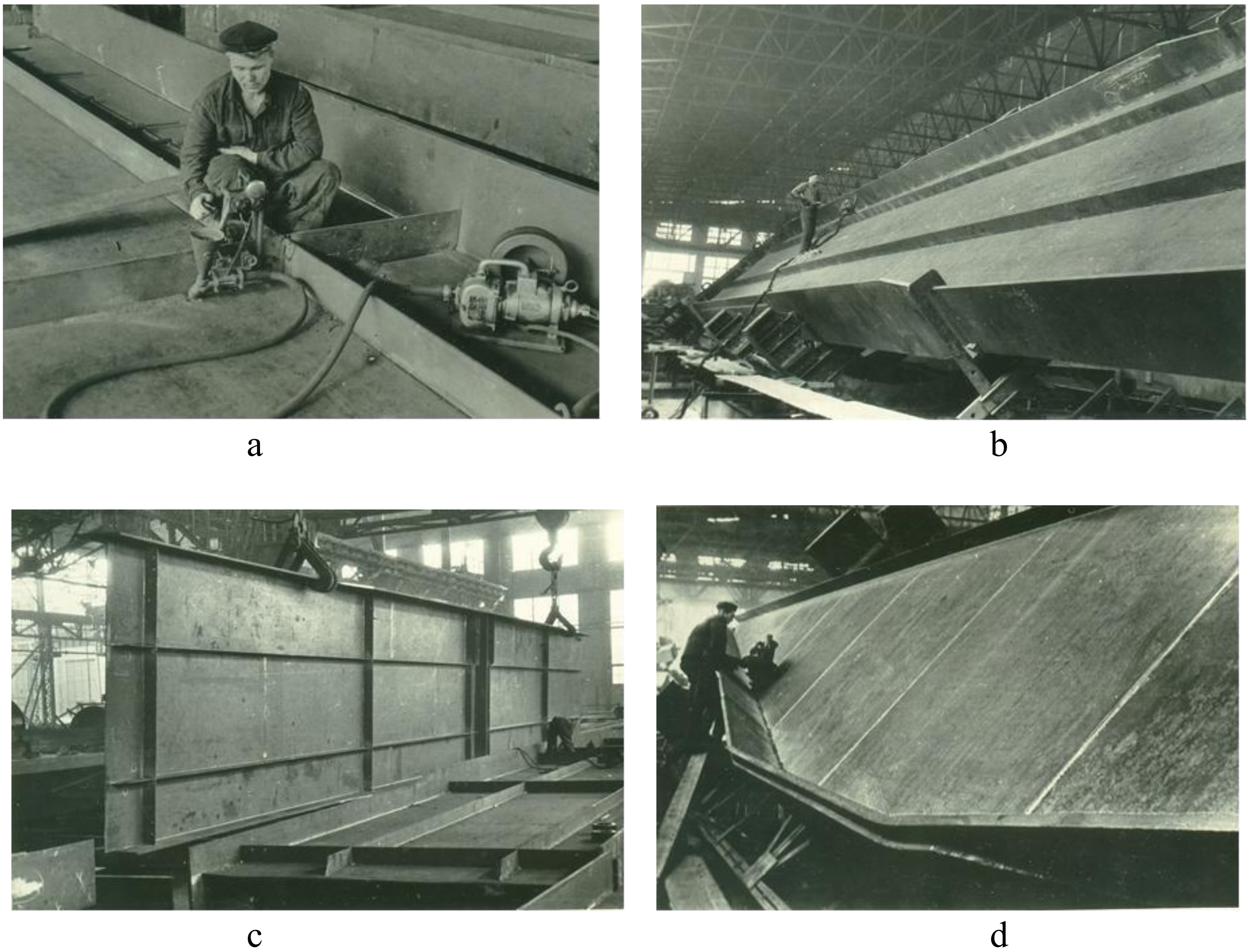
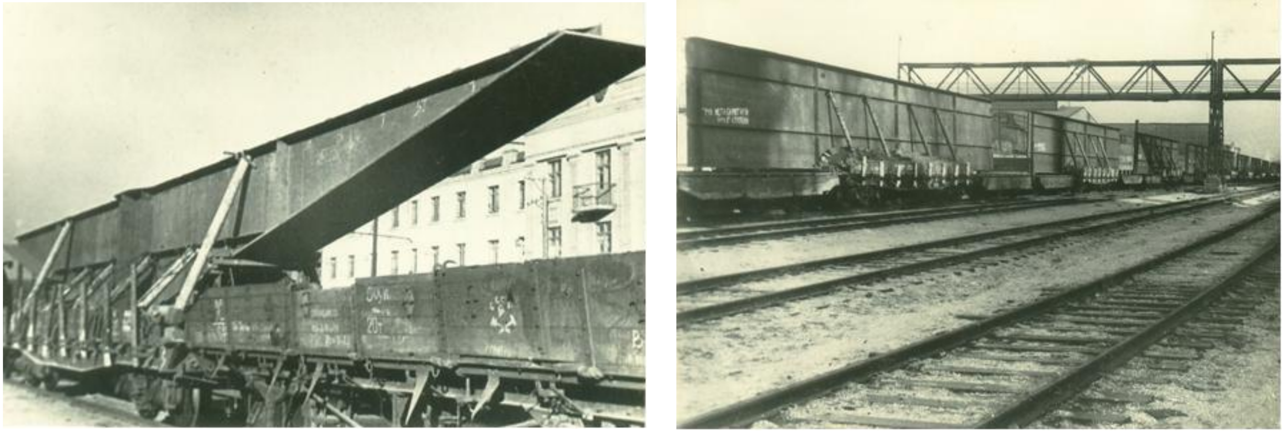


Figure 4. Large-block production of metal structures for the Evgeny Paton Bridge at the plant in Dnipropetrovsk (Lobanov, 2014), where: (a) welding-on of stiffener using semi-automatic machine PSh-5 with holder DSh-27; (b) process of welding of longitudinal butts using tractor TS-17M in the tilter; (c) welding-on of edges of stiffeners; (d) Welding of girth welds of haunch in the rig (Lobanov, 2014).

The realization of construction of the bridge was entrusted to the Ministry of Municipal Economy of the USSR, which organized the Special management of bridge construction (Lobanov & Kyrian, 2013). The construction of Kyiv bridge across the Dnipro river was carried out by the staff colleagues of Kyiv department of «Proektstalkonstruktsia», plant of metal structures (Dnepropetrovsk), Bridge Construction Group No. 2 of the Ministry of Railways, the PEWI and the Ministry of Municipal Economy of the UkrSSR in close cooperation between each other.

The delivery of ready assembly elements of the bridge to Kyiv was performed by railway transport (Figures 5).



a b

Figure 5. Transportation of metal structures of the Evgeny Paton Kyiv Bridge by rail (Lobanov, 2014), where: (a) haunch loaded on the platform; (b) echelon with main beams on the plant rails.

The workers of the Bridge Construction Group No. 2 trained and instructed by the specialists of the PEWI, carried out the welding works all the year round. The inspection, monitoring and acceptance of welding works were performed by the inspection bodies, organized and governed by the PEWI (see Figure 6 and Figure 7).

Figure 6. Construction of an all-welded bridge in Kyiv (Lobanov, 2020).

Figure 7. General view of welded site butt in the span (Lobanov & Kyrian, 2013).

The bridge was inspected by the laboratory of the Moscow Road Transport Institute both during the process of construction as well as after its completion (Lobanov & Kyrian, 2013). In conclusion the bridge was tested on static and dynamic loading (Figure 8). The tests gave the positive results.

Figure 8. Testing of the bridge (Lobanov & Kyrian, 2013).

Exploitation.

Many years of operation of welded bridges indeed confirm the reliability of their construction, provided that proper design principles, high-quality materials, and regular maintenance practices are observed. Since the mid-20th century, welded bridge structures have been widely used around the world due to their structural efficiency, reduced weight compared to riveted alternatives, and the potential for more continuous load paths. Over the decades, numerous welded bridges have demonstrated excellent durability and performance under various environmental and operational conditions. Their successful long-term service has contributed significantly to the advancement of welding standards and structural design codes, particularly in addressing issues such as fatigue, stress concentration, and the integrity of welded joints. While early concerns about the fatigue behavior of welds, especially in the heat-affected zones, led to cautious implementation, field experience and continuous monitoring have allowed engineers to refine welding techniques and improve detailing to reduce crack initiation risks. The accumulation of data from bridge inspections and load testing over time has shown that welded constructions, when properly executed, can maintain their structural integrity for many decades without significant degradation. As a result, the extended service life of numerous welded bridges around the world stands as practical evidence of their reliability, validating welded construction as a robust and enduring solution for modern infrastructure.

The Evgeny Paton Bridge across the Dnipro River in Kyiv was designed based on the conditions that the designed traffic intensity should be 10 thou cars per day (Poznyakov, Dyadin, Davydov, & Dmytrienko, 2021). During a long-term operation of the bridge, the load on its load-carrying elements gradually increased, which is associated both with an increase in the traffic intensity per day (currently it has increased by almost 10 times – during «peak» hours – up to 85 thou per day), as well as with an increase in car weight (Shymanovskyi, Kotlubei, & Shalinskyi, 2019). As a result of laying pipes of the heat pipeline and increasing the thickness of the asphalt concrete pavement, the constant loads on the bridge also increased. Taking that into account, in 1994–1998 the transverse beams of the bridge, which are located near the expansion joints, were reinforced, and additional stiffeners were mounted on some regions of vertical walls of the main beam trusses. Until 2019, the main longitudinal beams of the bridge were inspected only visually without the use of instrumental and physical methods of testing, which did not allow obtaining more detailed information on the actual technical condition of metal structures. Thus, according to the results of inspection of the bridge, performed at the end of 2018 by the specialists of LLC «V. M. Shimanovsky Ukrainian Institute of Steel Construction», it was pointed out that on the walls of the main beams of the structure in the locations of expansion welds, the formation of a layer of corrosion products was observed. Considering and analyzing the results of investigations, V. M. Shimanovsky Ukrainian Institute of Steel Construction came to the conclusion that the Evgeny Paton Bridge is in an emergrency situation and urgently needs major repairs with a partial replacement of its structural elements. This issue was repeatedly discussed at the meetings in the Kyiv City State Administration and «Kyivavtodor», on the results of which a decision was made on the reconstruction of the bridge and a need for a more detailed inspection of its structural elements. In 2019, the works on evaluation of general technical condition of the bridge were entrusted to LLC «V. M. Shimanovsky Ukrainian Institute of Steel Construction» with the involvement of specialists of the PEWI in terms of inspection of the main longitudinal beams of the bridge.

For such age bridges as Evgeny Paton Bridge, general world practice shows the following. Welded bridges that have served for many decades can benefit from a range of improvements aimed at extending their service life, enhancing safety, and optimizing performance under modern demands. One key area is the application of advanced non-destructive testing techniques, such as ultrasonic phased array or acoustic emission monitoring, which allow for early detection of fatigue cracks or internal flaws without interrupting service. Retrofit measures, such as attaching external reinforcement plates or fiber-reinforced polymer composites, can strengthen critical joints or members that have experienced stress accumulation. In cases where fatigue is a concern, techniques like toe grinding, TIG dressing, or ultrasonic impact treatment can significantly improve the fatigue resistance of welded connections by reducing stress concentrations and residual tensile stresses. Protective coatings and corrosion-resistant materials – such as weathering steel or metallization – can be applied or upgraded to enhance durability in harsh environments. Additionally, structural health monitoring systems equipped with sensors can provide real-time data on stress, strain, and environmental conditions, enabling predictive maintenance and reducing the risk of unexpected failures. Where traffic loads have increased beyond original design parameters, load distribution systems or even partial structural replacements with modern materials (like high-performance steel) may be introduced to improve capacity. Altogether, these improvements not only preserve the functionality of aging welded bridges but also adapt them to current and future performance standards.

Conclusions.

The importance of this research also lies in its relevance to sustainability and the lifecycle analysis of infrastructure. Many of the welded bridges built in the 1950s and 60s are still in operation today, and their performance over time provides a critical data set for evaluating the long-term behavior of welded joints, corrosion protection systems, and structural details. This historical performance informs modern approaches to asset management, retrofitting, and life-extension strategies. Understanding the successes and shortcomings of early welded bridge designs allows engineers and policymakers to make more informed decisions about maintaining or replacing aging infrastructure. From a historiographical perspective, this ties into broader questions about how past technological decisions continue to influence present and future possibilities – highlighting the path-dependent nature of technological development.

Finally, studying the history of all-welded bridges also provides a lens through which to examine broader themes such as industrial modernization, state-led infrastructure development, and the cultural meanings of technological progress. Bridges have long held symbolic power as markers of national pride, engineering prowess, and human ingenuity. The decision to use welding – a cutting-edge technology at the time – was often tied to narratives of progress and modernity, especially in nations seeking to assert their technological sophistication. As such, the story of all-welded bridge construction is not just a technical narrative but a cultural and political one. It intersects with themes of postwar reconstruction, economic development, labor relations, and even Cold War competition in technological display. For historians of science and technology, this intersectionality enriches our understanding of how engineering projects reflect and shape the societies in which they are embedded.

In conclusion, researching the design and construction of all-welded bridges offers valuable insights into the co-evolution of science, technology, and society. It reveals how scientific knowledge – particularly in metallurgy, structural analysis, and material fatigue – was mobilized to solve practical problems, leading to innovations that reshaped civil infrastructure. It highlights the roles of individual expertise, institutional support, and regulatory frameworks in shaping technological change. And it demonstrates how engineering is not merely a technical endeavor, but a deeply historical and cultural one, embedded within broader narratives of progress, modernization, and global exchange. By examining the history of all-welded bridges, we not only gain a better understanding of an important chapter in structural engineering but also enrich our comprehension of how science and technology operate as dynamic, interconnected forces within human history.

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Conflicts of interest.
The author declare no conflict of interest.

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Історія суцільнозварного мосту імені Євгена Патона

Анотація. *У цій статті досліджується історія науки і техніки крізь призму проектування, виготовлення та багаторічного досвіду експлуатації мосту імені Євгена Патона в Києві, першого у світі суцільнозварного автомобільного мосту. Завершений у 1953 році та названий на честь видатного піонера зварювання академіка Євгена Патона, міст став віхою в цивільному будівництві та радянських технологічних амбіціях під час повоєнної відбудови. У дослідженні розглядаються науково-технічні основи, які дозволили перехід від клепаних до зварних конструкцій, з акцентом на досягненнях у металургії, структурному аналізі та технології зварювання. Також розглядається процес виготовлення мосту, який включав широкомасштабне застосування автоматичного дугового зварювання під флюсом та інноваційні рішення для вирішення проблем, пов'язаних з цілісністю з'єднань, опором втомі та термічними напруженнями. Спираючись на архівні матеріали, технічні публікації та історичні записи, стаття розглядає міст у ширшому політичному, інституційному та економічному контексті, аналізуючи його роль як функціонального інфраструктурного проекту та символу радянського наукового прогресу. У статті розглядається історія експлуатації мосту протягом понад семи десятиліть, з акцентом на його конструкційної стійкості, методах обслуговування та отриманих уроках, які вплинули на подальше мостобудування в СРСР та в усьому світі. У статті розглядається взаємодія між науковими експериментами та практичними інженерними рішеннями,* *демонструючи, як теоретичні дослідження активно перевірялися та перевірялися шляхом реального впровадження. Подальше використання мосту в 21 столітті забезпечує живу лабораторію для вивчення довгострокової поведінки зварних сталевих конструкцій під динамічним навантаженням та стресовими факторами навколишнього середовища. Роблячи це, стаття підкреслює незмінну актуальність історичних технологічних досягнень для сучасної інфраструктурної політики, матеріалознавства та інженерної освіти. Таким чином, міст Патона служить переконливим прикладом еволюції великомасштабних зварних конструкцій та способів, якими технологічні інновації вбудовуються в ширші історичні наративи.*

Ключові слова: *історія мостобудування; історія металевих мостів; історія зварювання; Київський міст імені Євгена Патона; інженерні рішення; проблеми утримання та реставрації*

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