

**OPTIMAL DESIGN OF REINFORCED CONCRETE BRIDGES TAKING INTO
ACCOUNT THE ENVIRONMENTAL IMPACT**

**ОПТИМАЛЬНОЕ ПРОЕКТИРОВАНИЕ ЖЕЛЕЗОБЕТОННЫХ МОСТОВ С
УЧЕТОМ ВЛИЯНИЯ ОКРУЖАЮЩЕЙ СРЕДЫ**

**TEMIRBETON KO'PRIKLARNI ATROF-MUHIT TA'SIRINI INOBATGA OLGAN
HOLDA OPTIMAL LOYIHALASH**

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Abstract: This article investigates the design of reinforced concrete bridges considering environmental impact reduction and selecting constructively and economically optimal solutions. Based on the preliminary results of the dissertation, integration of ecological, economic, and technical criteria is presented. The findings aim to reduce resource consumption, lower the carbon footprint, and extend the service life of bridges.

Аннотация

В статье рассматриваются вопросы проектирования железобетонных мостов с учетом минимизации воздействия на окружающую среду и выбора конструктивно-экономически оптимальных решений. На основе предварительных результатов диссертации представлена интеграция экологических, экономических и технических критериев. Результаты исследования направлены на снижение расхода ресурсов, уменьшение углеродного следа и продление срока службы мостов.

Annotatsiya:

Ushbu maqolada temirbeton ko'priklarni loyihalash jarayonida atrof-muhitga bo'lgan ta'sirni kamaytirish va konstruktiv hamda iqtisodiy jihatdan optimal yechimlarni tanlash masalalari tadqiq qilinadi. Dissertatsiya dastlabki natijalari asosida ekologik, iqtisodiy va texnik mezonlar integratsiyasi ko'rsatiladi. Tadqiqot natijalari ko'priklarni loyihalarida resurslarni tejash, karbon izini kamaytirish va xizmat muddatini uzaytirish imkoniyatlarini aniqlashga qaratilgan. Hisob-kitoblarda harorat, namlik, issiq-sovuq sikllari va agressiv muhit ta'siridagi beton hamda armatura xatti-harakatlari tahlil qilinadi.

Keywords : Reinforced concrete bridges, optimal design, environmental impact, sustainability, resource saving, sustainable development strength, durability, aggressive environment, heat and moisture regime.

Ключевые слова : Железобетонные мосты, оптимальное проектирование, экологическое воздействие, окружающая среда, экономия ресурсов, устойчивое развитие прочность, долговечность, агрессивная среда, тепло-влажностный режим.

Kalit so‘zlar : Temirbeton ko‘priklar, optimal loyihalash, ekologik ta‘sir, atrof-muhit, resurs tejash, barqaror rivojlanish, mustahkamlik, bardoshlilik, agressiv muhit, issiqlik-namlik rejimi.

Introduction.

In recent years, the need to take into account environmental impact in the process of designing reinforced concrete bridges has been increasing. The construction of large infrastructure requires the use of many natural resources and energy costs. Therefore, taking into account environmental criteria when designing bridge structures allows not only to protect the environment, but also to increase the economic efficiency of the project. Due to the ongoing construction of reinforced concrete bridges in the conditions of Uzbekistan, the development of methods aimed at minimizing the impact on the environment is relevant. Today, on a global scale, such factors as climate change, increased anthropogenic pressure, disruption of the ecological balance, and limited natural resources require the priority of environmental criteria in the construction of structures. During the construction and operation of reinforced concrete bridges, environmental problems arise, such as emissions of harmful gases into the atmosphere, a negative impact on soil and water resources, and a decrease in the biodiversity of the environment. Therefore, the optimal design of reinforced concrete bridges, taking into account environmental impact, is one of the urgent scientific and technical problems. The main directions defined in the National Program "Green Space," the Concept of "Environmental Security," and the "Sustainable Development Goals" of the Republic of Uzbekistan determine the scientific and theoretical foundations of this dissertation. This study provides for the development of optimal solutions through in-depth analysis of modern design methods for reinforced concrete bridges, environmental monitoring, processing technologies, and measures to reduce the carbon footprint. Geotechnical conditions - physical and mechanical properties of soils, groundwater level, seismic activity, and soil aggressiveness - are also crucial for the durability and service life of reinforced concrete structures.

Research methodology

The following methods were used in the study:

Design and Construction Analysis: Various variants of reinforced concrete bridges were studied, and their constructive and economic efficiency was evaluated. **Environmental assessment:** The life cycle analysis (LCA - Life Cycle Assessment) method was used to determine the CO₂ emissions, emissions, and resource consumption of project materials and the construction process. **Determining the optimal solution:** The most optimal design was selected through multi-criteria optimization (environmental, economic, and technical criteria). In recent years, a lot of scientific work has been carried out on design taking into account environmental factors (Kurbanov A.2020. Muminov S. 2021. Sobirov T.2023). In the studies, such factors as the deformation of bridge elements under the influence of temperature and humidity, the process of concrete carbonation, and the corrosion of steel reinforcement were modeled. However, in existing works, the assessment of environmental indicators in the selection of the general structural scheme of the bridge is insufficiently covered. Therefore, this study proposes a quantitative assessment of environmental impact based on the optimization approach.

Bridge construction is a complex process not only from a technical, but also from an ecological point of view. During construction:

- Dust and gases are released into the atmosphere;
- Land resources are destroyed, the relief changes;
- Water resources are polluted;
- Impact on biodiversity.

Materials and research methodology.

A reinforced concrete structure with a 30-meter span was chosen as the object of research. The calculation was carried out in the following stages:

Concrete class: *B-40*, density *2500 kg/m³*.

2. Reinforcement type: *A500C steel*.

3. Environmental impact coefficient (*E*):

$$E=f(T H C)$$

Here:

T-temperature difference

H-relative humidity

C- pollutant concentration

Minimize material consumption as a goal function:

$$F=C_b V_b+C_s V_s=\min$$

Here *C_b*, *C_c* - the price of concrete and steel:

V_b, *V_c* volumes

Bridge length *L*-30m

Plate thickness *h*-0.8 m

Temperature difference *T*-45°

Humidity *H*-70%

Corrosion coefficient *k*-0.85

As a result, the calculated optimal concrete volume is: *V_b*=22,4m³.

Reinforcement volume: $V_S=1.05m^3$

The results of the analysis showed that failure to take into account changing environmental conditions leads to faster aging of concrete by 8-12%, the use of high-strength types of concrete in bridge design and the optimization of structural elements reduces material consumption in construction by 15-20%. At the same time, strength and service life are preserved. A structure designed based on optimal parameters maintains its technical condition at 95% for 20 years. Environmental optimization reduced concrete consumption by 9% and steel consumption by 6%. This indicates a reduction in the carbon footprint by 14%, along with an increase in economic efficiency.

Environmental effectiveness

Based on the analysis of the life cycle, the following results were obtained:

- The greatest emission occurs during cement production, therefore the use of mixed or recycled cement reduces the carbon footprint.
- The use of recycled steel in bridge construction reduces CO₂ emissions by 10-12%.
- Optimization of energy consumption in the construction process (for example, improvement of transport and concrete pouring technology) reduces the environmental impact by 8-10%. The research results showed that taking into account environmental criteria when designing reinforced concrete bridges provides technically and economically efficient solutions. Optimal design not only reduces construction costs, but also extends the service life of the bridge and minimizes harmful environmental impacts. In addition, designing bridges taking into account environmental indicators will make an important contribution to the development of sustainable infrastructure in the conditions of Uzbekistan.

Conclusion.

The principle of operation of reinforced concrete bridges is primarily related to the correct distribution of loads, a balanced power transmission system between elements, and ensuring load-bearing capacity on a composite base. Each structural element must optimally transfer its load to another element. Environmental factors, temperature, humidity, dynamic loads, and aging processes over time also play an important role in this process. Therefore, the principle of operation of bridge elements should always be assessed using a comprehensive approach.

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