eISSN: 2229-3213 pISSN: 2229-3205
The Journal of Applied Science and Social Science
Volume 16,Issue 06 June, 2026

INTERNATIONAL PRACTICES IN MODERN BRIDGE CONSTRUCTION (A CASE STUDY OF PEDESTRIAN BRIDGES)

Umarov Abduraxim Maxammadumar ugli.
Senior lecturer of the Department of Machines and Equipment,
Associate Professor, Faculty of Mechanical Engineering,
E-mail: abdurahimumarov27@gmail.com
+998 99 910 04 27

Usanov Dilshodbek Azizbek ugli.
student of the Faculty of Mechanical and
Chemical Engineering, Department of Technological
Machines and Equipment, group K 11 22

Abstract This paper analyzes advanced international practices in modern bridge construction, focusing on the integration of Building Information Modeling (BIM) technologies and innovative welding methodologies for high-strength steel structures. Within the scope of this study, the creation of digital twins at the LOD 300-400 level, geometric Clash Detection, and 4D/5D modeling for time and cost optimization in pedestrian bridge design are evaluated. Furthermore, the paper investigates the metallurgical characteristics of structural steel alloys and provides a comparative analysis of industrial welding techniques, including SAW, GMAW, FCAW, and MMA, along with non-destructive testing (NDT) methods such as ultrasonic (UT) and radiographic testing.Keywords: BIM, Tekla Structures, Digital Twin, 4D/5D Modeling, Submerged Arc Welding (SAW), Flux-Cored Arc Welding (FCAW), Ultrasonic Testing (UT), Clash Detection.

1. Introduction Pedestrian bridges are critical components of modern urban infrastructure, ensuring pedestrian safety across transport corridors, railways, and natural barriers. Today, the global bridge construction industry faces significant challenges, including minimizing structural design errors, optimizing material consumption, and ensuring structural integrity throughout the asset's lifecycle.International experience, particularly from countries like Norway with advanced expertise in complex bridge infrastructure, demonstrates that incorporating digital ecosystems during the design phase and automated/robotic welding during manufacturing dramatically enhances project efficiency. The primary objective of this study is to analyze and scientifically substantiate the integrated benefits of utilizing BIM platforms and advanced welding technologies in modern pedestrian bridge construction.

2. Methods To integrate the design, structural calculation, and construction workflow of pedestrian bridges into a unified system, a comprehensive software stack and methodological framework were implemented:

-Global Geometric and Geospatial Integration: Autodesk Revit and Autodesk Civil 3D were utilized to ensure the alignment of the bridge architecture with local topography and the surrounding road network.

-Detailed Structural Modeling (LOD 300-400): Tekla Structures was used to build a high-fidelity digital twin of the steel structure, down to individual bolted connections, gusset plates, and weld geometries. This digital twin directly generated fabrication data for automated CNC machinery.Statics and Dynamics Structural Analysis: The BIM model was exported to finite element analysis (FEA) software, including LIRA-SAPR, SCAD Office, and Robot Structural Analysis, to calculate dead loads, live loads (pedestrian traffic), wind dynamics, vibrations, and seismic forces.Crowd Safety and Evacuation Simulation: Pedestrian Simulation software was employed to mathematically model crowd capacity and evaluate emergency evacuation parameters.

3. Results The digital modeling and technological evaluation yielded structured data regarding the performance of structural materials and the efficiency metrics of digital workflows.3.1. Efficiency Analysis of Structural MaterialsMaterial TypeStructural SystemsKey Operational Features & AdvantagesStructural SteelGirder (balka), truss (ferma), arch, and cable-stayed (vanti)High specific strength, enabling the bridging of large spans with minimal dead weight.Reinforced ConcretePrecast or cast-in-place (monolithic)High stability, long-term durability, and low maintenance with no immediate anti-corrosion treatment required.Composite MaterialsFiber-reinforced polymer (GFRP)Absolute corrosion resistance, ultra-lightweight, and high durability in aggressive environments (salts, chemical reagents).3.2. Parametric and Economic Benefits of BIMParametric Efficiency: Any modifications made to the global bridge dimensions (e.g., height or span length) automatically trigger real-time updates across all workshop drawings, material take-offs (MTO), and technical specifications.Clash Detection Integration: Hard and soft clashes between rebar cages and utility conduits were identified and resolved within the virtual environment long before construction began on-site.4D (Time) and 5D (Cost) Scheduling: For steel truss installations over active highways, 4D sequencing minimized road closure times by aligning daily erection schedules directly with cash flow allocations.

4. Discussion 4.1. Metallurgical and Structural Analysis of WeldingLow-alloy steels commonly used in bridge construction (e.g., 15XSND, 10G2S1) exhibit good weldability. However, the rapid thermal cycles of heating and cooling can induce microstructural changes in the Heat Affected Zone (HAZ), potentially leading to brittle martensitic formations. To guarantee that the tensile strength of the weld joint matches the base metal, the use of welding consumables enriched with deoxidizers like Manganese (Mn) and Silicon (Si) is scientifically mandatory.The functional principles of weld joints vary based on the nature of the dynamic loads:Butt Joints (Stikovoy): These joints absorb severe tensile and compressive stresses within the main load-bearing girders, requiring Complete Joint Penetration (CJP / polniy provar).Fillet Joints (Tavr): Used to join vertical webs to horizontal flanges, where the weld throat (katet) size is determined based on dynamic fatigue load calculations.

4.2. Technological Comparison of Industrial Welding Processes

-Submerged Arc Welding (SAW): This process is the industry standard for fabricating heavy steel I-girders and box sections in workshop environments. The granular flux blanket completely isolates the arc from atmospheric contamination, yielding deep penetration, high deposition rates, and defect-free welds while minimizing human error.

-Gas Metal Arc Welding (GMAW / MIG-MAG): Executed under Argon or CO_2 shielding gas, this method prevents oxidation and allows high-speed welding of complex spatial truss joints in multiple positions (horizontal, vertical, overhead).

-Flux-Cored Arc Welding (FCAW): Utilizing a tubular wire filled with flux, FCAW is highly effective for open-air site assembly. It provides better arc stability under windy conditions compared to gas-shielded methods and reduces weld spatter.

-Shielded Metal Arc Welding (SMAW / MMA): This highly versatile manual method remains indispensable for field assembly in tight spaces and for securing secondary components (handrails, stairs).Quality Diagnosis: Bridge structural welds are subjected to 100% Non-Destructive Testing (NDT). Ultrasonic Testing (UT / UZK) is applied to detect internal volumetric flaws and micro-cracks, while Radiographic Testing (RT) is mandatory for critical structural nodes.

5. Conclusion This study confirms the exceptional efficacy of transitioning from traditional workflows to integrated digital ecosystems in the bridge construction sector:

-BIM and Digital Twins (LOD 300-400) eliminate geometric errors during the pre-construction phase, thereby significantly reducing material waste.

-The combination of automated SAW in the workshop and FCAW during site erection, validated by mandatory UT (UZK) inspection, guarantees structural resilience against dynamic and fatigue loads.

-Upon project completion, the digital asset (BIM model) is handed over to the client, serving as the foundational database for remote monitoring, corrosion tracking, and predictive maintenance throughout the bridge's operational lifecycle.

REFERENCES

1. Resolution of the President of the Republic of Uzbekistan No. PP-57 dated February 16, 2023, "On measures to accelerate the introduction of renewable energy sources and energy-saving technologies in 2023."
2. Slavyanov, N. N. Fundamentals of Welding and Casting Metals Using an Electric Arc.
3. Krampit, N. Y., & Krampit, A. G. Pulsed MIG/MAG Welding Processes and Deformation Monitoring of Thin-Walled Structures.
4. UDK-105M Ultrasonic Flaw Detector: Technical Manual and Inspection Methodology.