THE EFFECTIVENESS OF APPLYING INFORMATION TECHNOLOGIES IN CONSTRUCTION TESTING LABORATORIES

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Abstract: This article explores the effectiveness of integrating information technologies into construction testing laboratories, with a focus on enhancing the quality control of concrete products in Uzbekistan. The study highlights the inefficiencies of manual testing processes, such as errors in documentation, lack of integration, and non-compliance with regulatory standards (e.g., UzDSt 1025:2020, UzDSt 2857:2015). It proposes a unified automated platform that streamlines the testing sequence—from client data entry and contract creation to sampling, test card generation, and protocol preparation. The methodology analyzes previous studies and technological advancements, demonstrating benefits such as error reduction, increased process speed, compliance with international standards (ASTM, AASHTO, ISO 17025), and improved transparency through cloud-based and LIMS integration. The developed system automates calculations, ensures legal and technical consistency, and boosts laboratory efficiency by 2–3 times. Future enhancements, including AI-based algorithms, IoT monitoring, and integration with state laboratories, are suggested to further elevate transparency and reliability in the construction sector.

Keywords: Information technology, construction testing laboratories, automation, concrete testing, quality control, regulatory standards, test protocols, laboratory efficiency, digital transformation , uzbekistan construction.

ЭФФЕКТИВНОСТЬ ПРИМЕНЕНИЯ ИНФОРМАЦИОННЫХ ТЕХНОЛОГИЙ В СТРОИТЕЛЬНЫХ ИСПЫТАТЕЛЬНЫХ ЛАБОРАТОРИЯХ

Аннотация: Эта статья исследует эффективность интеграции информационных технологий в строительные испытательные лаборатории, уделяя особое внимание улучшению контроля качества бетонных изделий в Узбекистане. В исследовании подчеркиваются недостатки ручных процессов тестирования, такие как ошибки в документации, отсутствие интеграции и несоответствие нормативным стандартам (например, UzDSt 1025:2020, UzDSt 2857:2015). Предлагается единая автоматизированная платформа, которая оптимизирует последовательность тестирования — от ввода данных клиента и создания контракта до отбора проб, генерации тестовой карты и подготовки протоколов. Методология анализирует предыдущие исследования и технологические достижения, демонстрируя такие преимущества, как снижение ошибок, повышение скорости процессов, соответствие международным стандартам (ASTM, AASHTO, ISO 17025) и улучшение прозрачности за счет интеграции облачных технологий и LIMS. Разработанная система автоматизирует расчеты, обеспечивает юридическую и техническую согласованность, а также увеличивает эффективность лабораторий в 2–3 раза. Предлагаются будущие улучшения, включая алгоритмы на основе искусственного интеллекта, онлайн-мониторинг через устройства IoT и интеграцию с государственными лабораториями, что позволит повысить прозрачность и надежность в строительном секторе.

Ключевые слова: Информационные технологии, строительные испытательные лаборатории, автоматизация, тестирование бетона, контроль качества, нормативные стандарты, тестовые протоколы, эффективность лабораторий, цифровизация, строительство в Узбекистане

INTRODUCTION

In today's rapidly evolving construction industry, the need to integrate modern technologies into the operations of testing laboratories, which serve as a critical link in ensuring quality control, is growing. Particularly, precision is paramount in testing the strength and quality of concrete products. To achieve this, aspects such as testing sequence, documentation, and compliance with regulatory standards are of utmost importance. From this perspective, deficiencies in the automatic generation of test protocols are among the primary issues reducing the operational efficiency of laboratories.

Many construction laboratories still conduct concrete product testing processes partially or entirely manually. Several technological stages—such as sampling, submission to the laboratory, preparing test cards, conducting tests, and formalizing protocols—are inherently interconnected, yet the level of integration between these stages remains low. This leads to problems such as errors in documentation, disruption of sequence, redundant entries, and a lack of transparency.

A key deficiency in the automatic generation of protocols is the use of calculation methods that do not fully comply with regulatory standards. In many cases, test results are merely measurements without proper analysis, presented in a simplified form. The failure to integrate formulas, indicators, or regulatory limits from applicable construction standards (e.g., UzDSt 1025:2020, UzDSt 2857:2015, etc.) into automated systems results in low-quality, imperfect protocols. This, in turn, leads to incorrect decisions by contractors and technical supervisors.

Moreover, the absence of a unified electronic platform or fully customized automated systems for generating protocols poses a significant barrier. Most laboratories rely on basic tools like MS Excel, Word, handwritten logs, and email for information exchange. This creates serious challenges in consolidating, analyzing, and storing documents within a single system.

In many laboratories, there is a lack of consistency between order forms, sampling certificates, test cards, and final protocols. Each document is created separately, with no standardized numbering or dating, leading to complications in identifying issues during inspections and determining legal accountability.

These issues are rooted in the lack of systematic automation in testing laboratories based on regulatory standards. Otherwise, existing technologies offer sufficient capabilities for generating protocols, performing calculations, maintaining sequence, and analyzing results. From this standpoint, full automation in laboratory operations not only enhances efficiency but also ensures consistency, reliability, and legal grounding in documentation.

Thus, the primary issue in construction testing laboratories—deficiencies in the automatic generation of protocols—should be regarded as a central problem undermining overall system efficiency. Addressing this requires technical solutions such as linking each stage to a unified automated system based on existing regulatory standards, coding calculation formulas and report templates, and managing data in real-time.

In the modern construction industry, laboratory testing—especially quality control of concrete products—is a critical stage in ensuring the safety, durability, and high quality of construction projects. In Uzbekistan, most laboratories still prepare test protocols manually, using

Microsoft Word or Excel. This leads to human errors, delays in documentation, and deviations from regulatory standards.

This article analyzes the possibilities of properly organizing the sequence of construction material testing using automated systems in construction testing laboratories and generating test documents (order forms, certificates, test cards, protocols) in compliance with Uzbekistan and international regulatory standards.

METHODOLOGY

A thorough analysis of previous studies and technological approaches to automating construction testing laboratories reveals that they all aim to enhance the accuracy, speed, and reliability of laboratory processes. Specifically, in concrete testing—such as compressive strength, modulus of elasticity, fracture strength, and other physical-technical properties—the introduction of automated equipment has led to the following key achievements:

Error Reduction: Automated systems virtually eliminate human errors (e.g., incorrect entries, measurement mistakes). Many studies highlight this as a critical factor in ensuring the accuracy of laboratory results and compliance with standards.

Increased Process Speed: Traditional methods required up to 16 hours to prepare, document, and deliver a test protocol. New systems reduce this to just a few minutes. Cloud-based platforms enable real-time sharing of test results.

Compliance with Standards: Automated systems operating based on international standards like ASTM and AASHTO ensure that laboratory tests adhere to globally recognized methodologies, providing reliable assurance for export-oriented products or large infrastructure projects.

Integration of Cloud Technologies and LIMS: Managing laboratory tests within a unified information system enables the creation, storage, and distribution of orders, samples, test cards, and protocols through a single platform. This reduces the workload on staff and enhances transparency for clients.

As acknowledged in the analyzed studies, automation is not merely a technical upgrade—it represents a transformation in management culture. Traditional laboratories are gradually becoming digital, with human intervention limited to critical decision-making and analytical evaluation stages. In Uzbekistan, particularly in sectors like large-scale infrastructure, road, and building construction, implementing these systems could serve as an effective tool for project managers and technical supervisors.

By developing an automated platform for construction laboratories based on existing technologies, it is possible to establish full technical and legal control over concrete testing processes, improve data reliability, and increase laboratory efficiency by 2–3 times. Future research in this field should focus on AI-based forecasting, automatic detection of quality failure factors, and the development of systematic reports.

1. Entering and identifying client information.

Initially, the system records information about the client organization or individual (name, TIN, STIR, bank account details, legal address, contact numbers, etc.). At this stage, data is entered electronically through a dedicated form and automatically saved to the database (see Figure 1). A unique ID number is generated for each client.

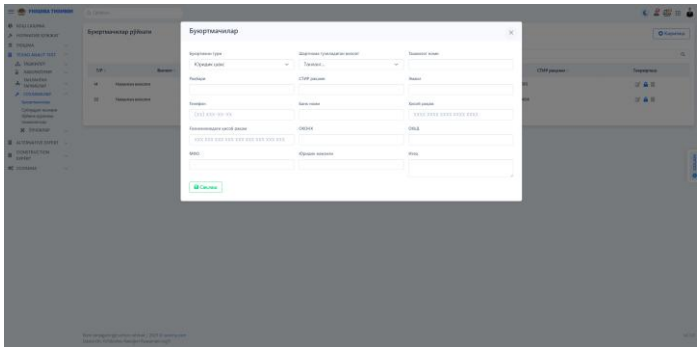

Figure 1. Form window for entering client information

2. Contract Section: Contract Type, Payment, and Agreements

The next stage is the contract creation section. Here, the user selects a previously entered client and specifies the contract type (e.g., one-time service, monthly plan, annual agreement, etc.), payment method (bank transfer, cash, credit card), and technical and legal requirements (see Figure 2). Based on the selected parameters, the system automatically generates the contract text, which includes client details, contract subject, service types, pricing, service duration, and other necessary clauses in an automated format.

3. Order Form Creation

Once the contract is approved, the process moves to creating the order form. At this stage, the types of tests requested by the client (e.g., compressive strength of concrete, water permeability, etc.) are selected. Test methods compliant with relevant regulatory standards are chosen for each parameter, initiating the formation of the test card (see Figure 3). The order form, including terms, date, number of samples, and other details, is saved. The system automatically assigns an order number, date, and responsible personnel.

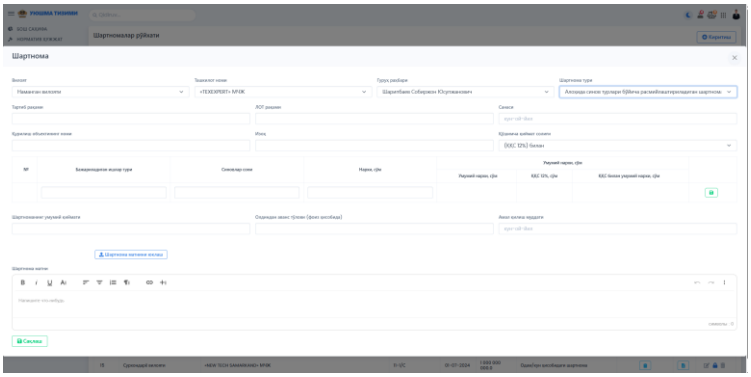

Figure 2. Automatically generated contract text

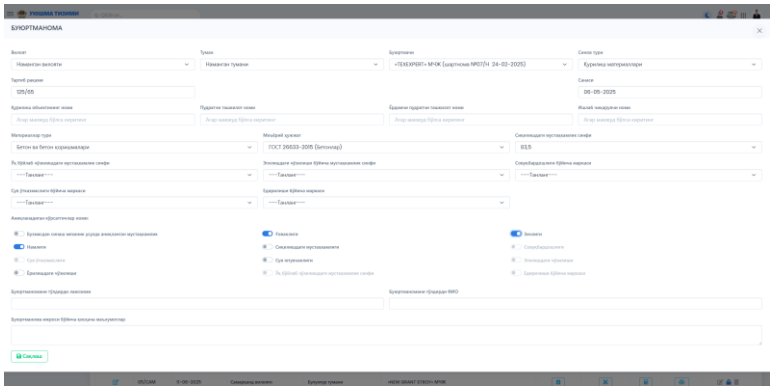

Figure 3. Order form filling window

4. Sampling and Test Card

The next stage is sampling. In this section, a laboratory representative prepares a certificate based on samples collected on-site. Details such as sample number, location address, testing deadline, and the date of submission to the laboratory are entered into the system (see Figure 4).

Simultaneously, the system generates a specialized test card based on the parameters selected in the order form. Calculation tables corresponding to each parameter are opened (e.g., weight of 3 concrete cubes, compressive strength, automatic calculation using the F = P/S formula).

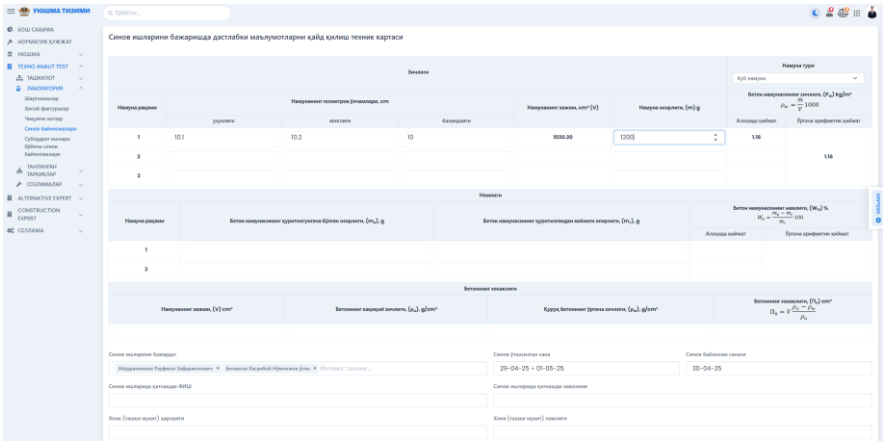

Figure 4. Calculation tables in the test card

5. Calculation Processes and Automatic Results

Once the test card is completed, the system performs automatic calculations. The process varies depending on the order type and test parameters, activating a dynamic calculation module (see Figure 5).

The developed automated platform integrates all stages of the testing process—from order acceptance to contract creation, order formalization, test card calculations, and protocol preparation—into a unified information system, ensuring sequence and improving quality.

CONCLUSION

The advantages of this platform are clearly evident in the following aspects:

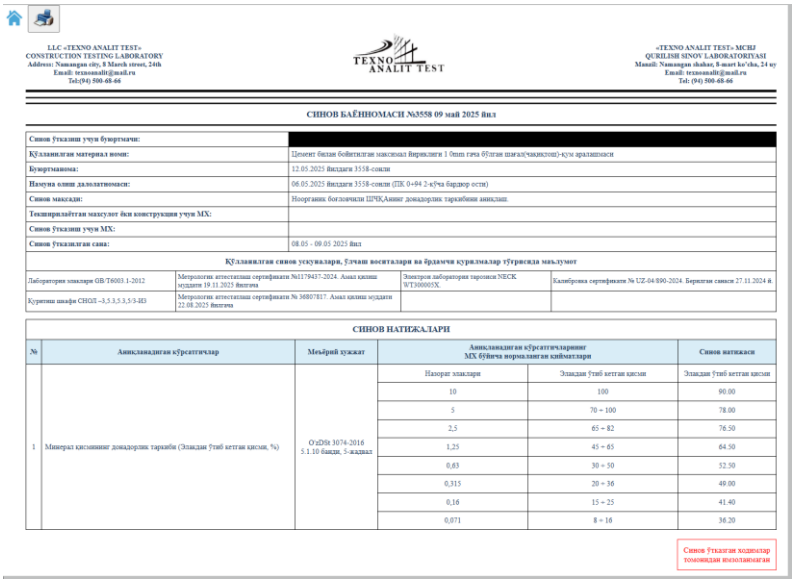

Figure 5. Samples from the test protocol

Each document is automatically generated based on the results of the previous stage, preventing user errors.

Based on information such as client details, contract, payments, and service type, the system automatically creates legally grounded texts.

Test cards and protocols are calculated in accordance with construction regulatory documents (e.g., UzDSt, GOST, etc.).

The system maintains consistent records of equipment, laboratory staff, and measurement methods, enabling electronic oversight compliant with ISO 17025 standards.

Users can only conduct tests on orders relevant to them and covered by an existing contract, ensuring document integrity and data security.

At the end of each stage, the system automatically generates a ready document in PDF format, which can be digitally signed or sent.Thus, the proposed automation approach elevates the workflow in construction laboratories to a higher quality level in terms of efficiency, accuracy, and compliance with regulatory standards. This not only simplifies the work of laboratory staff but also reduces human errors through the digitization of the entire control system, increases productivity, and ensures reliable results.

In the future, this system could incorporate functions such as **AI-based automatic evaluation algorithms, online monitoring via IoT devices,** and **integration with centralized state laboratories**. This would elevate the transparency and reliability of laboratory operations in our country to a new level.

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