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| RESEARCH ARTICLE

Quantity Take-Off Strategies: Reducing Errors in Roadway Construction Estimation

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| ABSTRACT
Accurate quantity take-off (QTO) plays a critical role in various phases of bridge construction projects, from bid preparation and cost management to project execution. This essay presents conventional QTO methods and com- pares them with technology-driven methods, namely the use of Bluebeam Revu software. It analyzes how new technology can make quantity take-offs more accurate and efficient. Typical issues such as errors of measurement in manual measurements, incorrect interpretation of plans, and differences in documentation are analyzed in their impact on accuracy of bids and cost overruns. With reviews of literature, case studies, and comparative studies, the study determines the extent to which automation, standard workflow, and integration of software can signifi- cantly reduce QTO-related mistakes. The study draws attention to the role of new QTO technologies to improve estimation accuracy and make processes leading towards better delivery and cost control in bridge construction.

| KEYWORDS
Quantity Take-Off Strategies; Roadway Construction Estimation

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1. Introduction
Precise quantity take-off (QTO) is a secret to successful planning, estimating, and execution of bridge construc- tion projects. In highway infrastructure development where precise budgeting and scheduling are crucial, even minor inaccuracies in QTO can lead to cost overruns, schedule delay, and resource mismanagement. Traditionally, estimators have relied on manual measurement from printed drawings or basic digital applications, which are time- consuming and prone to human error. With digital transformation reshaping the construction sector, sophisticated software solutions are being embraced to enhance precision, simplify workflows, and increase collaboration. Blue- beam Revu is one such tool, a popular PDF-based application that facilitates markup, measurement, and estimation work on construction plans. This article delves into how Bluebeam Revu can be used to enhance quantity take-off efficiency and accuracy in bridge construction. The objective of this research is to compare classical QTO work- flows with Bluebeam workflows, highlight common challenges, and provide implementation best practices. Based on analysis of industry case studies, research studies, and expert viewpoints, this paper intends to demonstrate the value digital QTO tools bring to making the estimating process more efficient on large civil infrastructure projects.

2. Literature Review
2.1 Current Practices in Roadway Quantity Takeoff
Quantity takeoff is the first and essential step to be taken in the construction estimating. It involves studying con- struction drawings, separate and extract quantities to determine the material, labor, and equipments. Traditionally estimators are comfortable with paper plans, scales, and spreadsheets. Though this methods have their advantages. Is highly succesptible to human error specially if its working on a highly complex projects like bridge construction projects. Manual takeoffs also lack traceability and are time-consuming, particularly during revisions or value engineering exercises [1].

In Texas Department of Transportation (TxDOT) construction projects, the complexity of the work like earth- work, pavement layers, drainage,bridgework, and traffic control makes accuracy in quantity takeoff important to be successful in the bidding wars and project success. Estimators often use standardized item codes and pay items, which require a meticulous, methodical takeoff process [2].

2.2 Challenges in Manual Estimation Processes

The major drawbacks of manual estimation include:

- Complex plan sets can cause errors due to inaccurate reading or missing information.
- It is difficult to revise or vaidate takeoff due to lack of audit trail
- It is difficult to work in the teams at the same time due to physical nature of takeoffs.
- Manual estimation processes are relatively slower and can take further time if there is an addenda or design updates.

Manual takeoffs of quantities have been proven to greatly contribute to cost overruns and rework due to initial estimation mistakes [3].

2.3 Role of Digital Tools in Enhancing Accuracy

Computer software such as Bluebeam Revu, PlanSwift, and Autodesk Quantity Takeoff has emerged as a solution to the inefficiencies of the manual process. These software programs enable estimators to:

- Do the takeoff on the PDF files itself with consistent accuracy.
- Mutiple layer based categorization and color coding of each comonents of the bridge project.
- Create reusable tool sets for standardized items (e.g., traffic signs, curb ramps)
- Easily export pdf takeoffs to the excel sheet.

Use of digitals software for estimating not only help increase the accuracy of the takeoffs but also improve coordination among estimators, engineers, and project managers. As per the research cited here software takeoffs can reduce quantity errors by up to 60% and cut estimation time by 30-50%. [4]

2.4 Existing Research on Bluebeam and Other Takeoff Software

Due ability to handle big pdf plan sets and flexible customizable tools Bluebeam Revu is one of the most popular software in heavy civil industry. Bluebeam Revu offers measurement capabilities including dynamic fill, custom counts, and area/volume tools that enable estimators to get work done quicker without compromising consistency among teams. It was noticed by Sharma and Hossain (2020) in a comparative study that digital takeoffs produced more reliable outcomes across multiple users setting, with enhanced precision in complex projects likes inter- changes or bridges [5]. Other authors have highlighted the need to use integrated digital takeoff software with BIM software and cloud platforms, allows estimators to receive real-time design changes and cost impacts [6]. As the construction sector continues to digitalize, software like Bluebeam Revu is greatly facilitating the closing of the gap between cost estimating and design.

3. Methodology

3.1 Research Design and Data Collection Approach

The current study uses qualitative case study methods to examine the impact of using Bluebeam Revu during quantity takeoff on bridge construction. For research, it took the form of an observation study of actual estimating effort performed out on a DOT bridge work. Evaluating accuracy, efficiency, and users' experience before and after implementation was of utmost priority. DOT plans were used to carry out direct observation of takeoff process, structured interviews with estimators, and comparative analysis of historical estimates compared with those made using digital means. Other data were gathered through project documentation and quantity reports reported during bid preparation.

3.2 Case Study Selection Criteria

The selected case study bridge project is a medium sized TxDOT project that incorporates number of structural elements. The selection criteria included:

- Presence of intricate structural elements (e.g., drill shafts, columns, and caps)
- Availability required manual and digital estimation data.

- Involvement of experienced estimators familiar with traditional and digital methods
- Access to complete plan sets, specifications, and bid items

3.3 Tools Used: Bluebeam Revu for Digital Takeoff

Bluebeam Revu was utilized as the digital takeoff software due to its PDF-based compatibility with the plan sets and robust features that are particularly geared towards assisting civil engineering project estimation. It supports:

- Scaled measurements
- Measurement tools for area, length, and volume
- Predefined templates for common elements (e.g., columns, rebar, caps)
- Automated data transfer to Excel for cost estimation

3.4 Evaluation Metrics for Estimating Performance and Error Reduction

To evaluate performance, the following metrics were established:

- **Takeoff Accuracy:** Comparison between measured quantities and actual bid quantities
- **Time Efficiency:** Time taken to complete takeoff manually vs. using Bluebeam
- **Error Rate:** Number of miscalculations identified in each method
- **User Feedback:** Subjective assessment from estimators regarding clarity, ease of use, and traceability Studies such as those by Alwan and Jones (2020) emphasize the need for real-time collaboration and data

Consistency across construction teams. Bluebeam's cloud collaboration features and standardized workflows have been recognized as useful solutions for improving communication and reducing duplicate work in estimating and planning.

Despite these advancements, gaps remain in literature regarding best practices for implementing digital QTO solutions specifically in bridge construction, which involves complex geometry, specialized materials, and multiple structural components. This paper addresses these gaps by focusing on how Bluebeam Revu can be tailored to meet the specific requirements of bridge project estimators.

3.5 Application of Bluebeam Revu in a Bridge Project

Bluebeam Revu was applied in a real-world project: the construction of a bridge overpass over FM 2311 in McLen- nan County, Texas on SH 31. This was done to show practical benefits of digital takeoff software in bridge con- struction. This project that follows TxDOT standards involves complex bridge structural components. It requires accurate measurements of the bridge components in order to do the accurate estimation. The following chapters explore three fundamental types of measurements. These include linear measurements for length, 2D area mea- surements for surfaces, and 3D assessments for volume calculations.

3.6 Calibrating Scale in Bluebeam Revu

The first step in taking takeoff with bluebeam revu as shown in figure 1 and 2 is calibrating the plan using the calibrate tool. This helps software to align plan measurement with the real-life measurements. This is the most important step, which if done correctly, will minimize all the subsequent measurement errors.

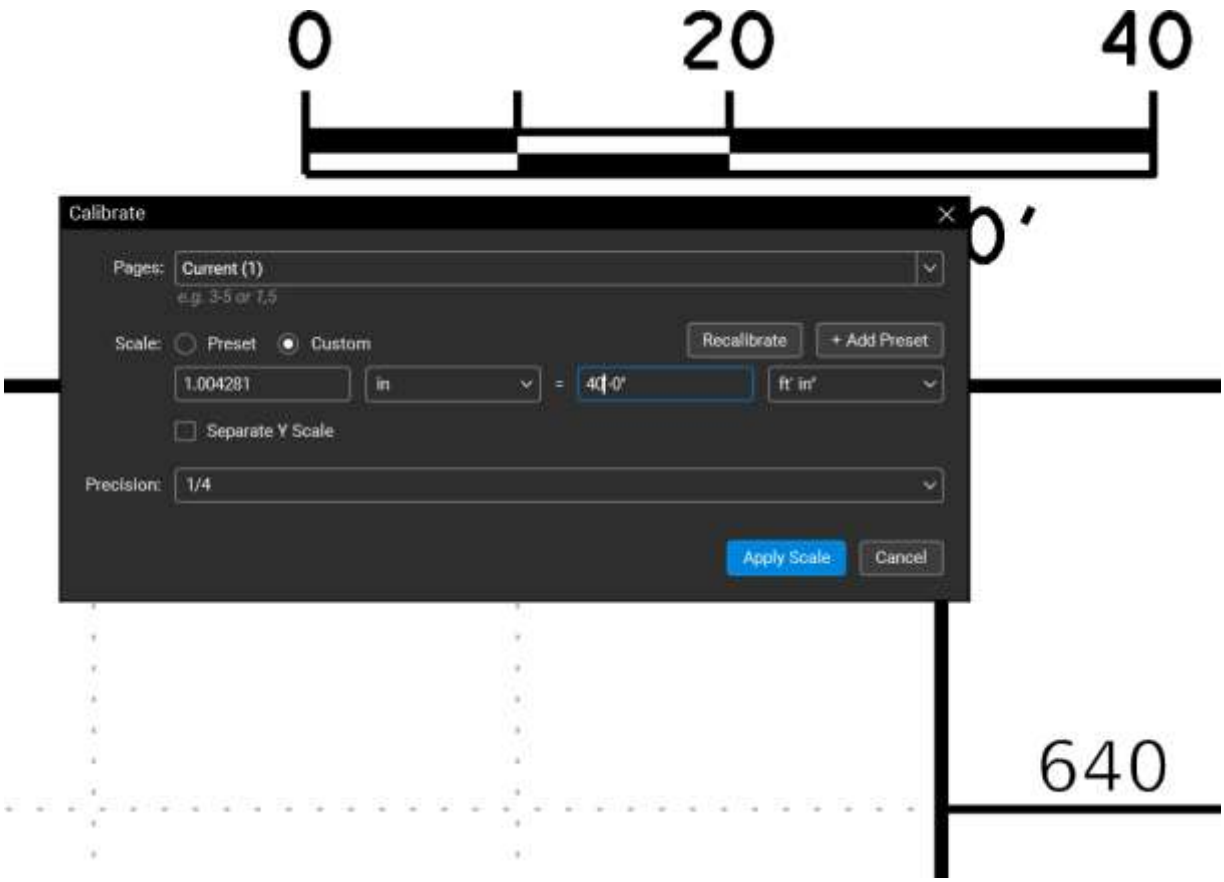

Figure 1: Using "Calibrate" software in Bluebeam Revu

3.7 Linear Take-Offs: Measuring Length-Based Elements

Once plansheet calibrate with the correct real-life measurement. Bluebeam's linear measurement tools is utilized to find the lengths of structural components as shown in Figure 3 like columns and drill shafts. These measurements are then used to calculate forms, reinforcing steel, and paint quantities, as well as excavation limits.

Figure 2: Using "Calibrate" software in Bluebeam Revu

3.8 Area-Based Take-Offs: Surface Calculations for Caps and Slabs

In construction drawings, surfaces like bent caps, abutment caps, and approach slabs need to be measured in square feet or square yards. These surfaces require accurate measurements (Figure 4) to facilitate payment and material ordering, such as filter

fabric, curing compounds, and other waterproofing materials. Bluebeam also allows the use of color-coded area tools for more intuitive measurements, enabling better QA/QC during internal estimate checks.

3.9 Volume Estimation: Calculating 3D Quantities for Bridge Decks

To calculate the volume as shown in Figure 5 of the bridge decks, Bluebeam Revu's volume measurement tool was utilized, where Bluebeam combines the known thickness with the measured area to automatically compute cubic yards. These measurements are important in determining the quantity of cubic yards of concrete required for the deck. These volume estimates are critical to ordering ready-mix concrete, sequencing of pours planning, and batch plant delivery scheduling. Deck areas on this project were first roughed out with the 2D area feature and then multiplied by slab thickness (typically 8–9 inches for TxDOT bridge decks) to estimate the total volume of concrete. Use of preconfigured sets of custom tools makes it easy to label all parts of the deck consistently, and data can be exported into spreadsheets for easy inclusion into cost estimates and bid templates. Streamlining reduced human error from manual calculations and made it easy to track and update quantities as needed.

4. Findings and Analysis

The results of applying Bluebeam Revu for quantity take-offs against traditional manual take-off methods are compared on the McLennan County SH 31 TxDOT (Texas Department of Transportation) Project

This section presents the results of applying Bluebeam Revu for quantity take-off on the SH 31 bridge project and compares it against traditional manual take-off methods. The analysis focuses on estimation accuracy, time savings, team feedback, and visual examples to demonstrate the practical impact.

4.1 Before and After Comparison: Manual vs Digital Take-Off

A side-by-side comparison was conducted between manual quantity take-offs (using printed drawings, scale rulers, and handwritten notes) and digital take-offs performed through Bluebeam Revu.Manual methods showed frequent inconsistencies, particularly when measurements spanned multiple plan sheets or required cumulative calculations. In contrast, digital take-offs provided more consistent and traceable results, as measurements could be easily veri- fied and referenced on the marked-up plans.

Additionally, digital tools allowed for easier duplication and updating of quantities when design changes oc- curred — a major challenge when working manually.

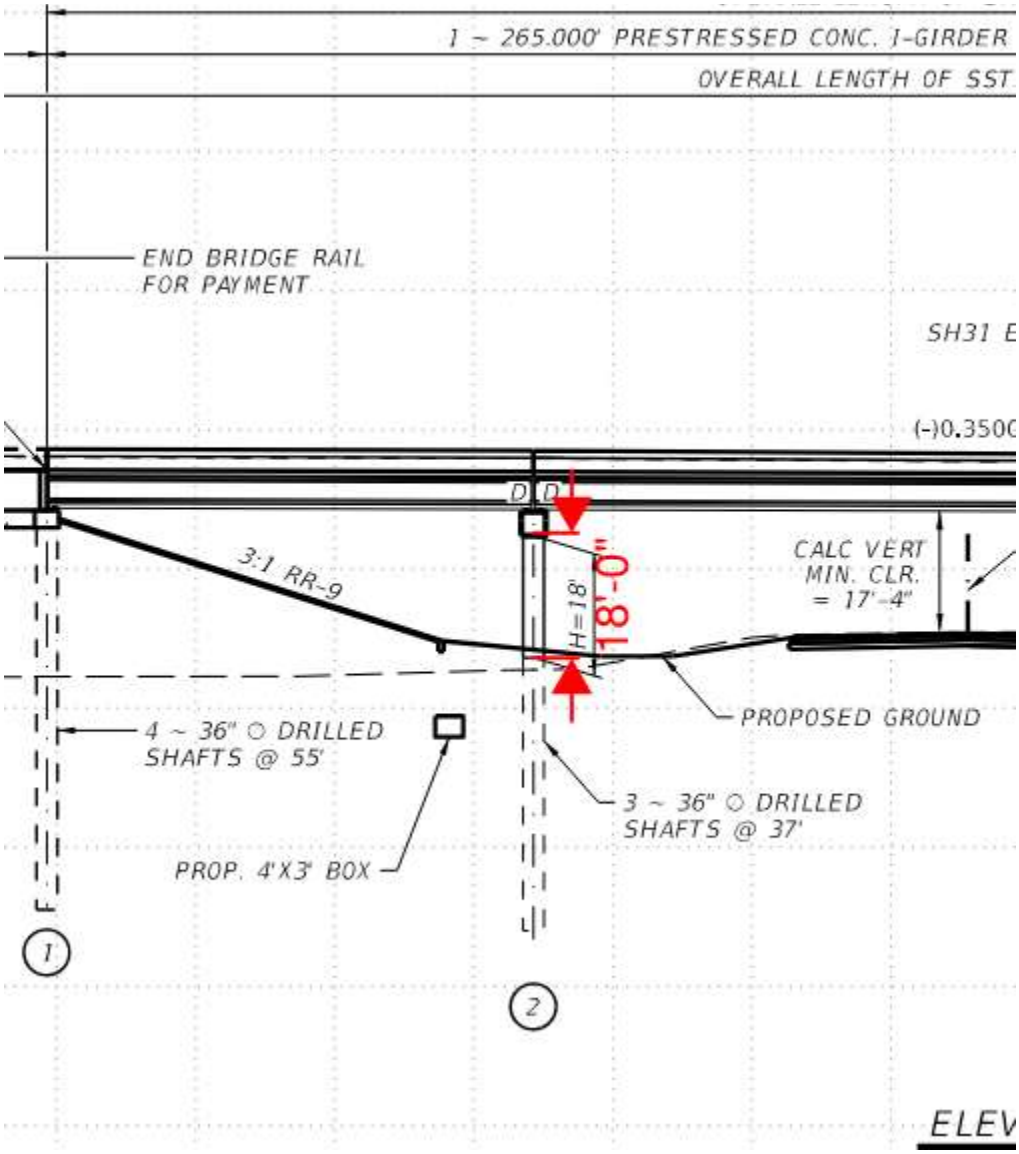

Figure 3: Measure length of the column in Bluebeam Revu

4.2 Reduction in Quantity Estimation Errors

A detailed review showed that using Bluebeam Revu reduced quantity estimation errors by approximately 15–20% compared to manual methods.Common manual errors, such as incorrect scale interpretation, missed components, and calculation mistakes, were minimized through calibrated drawings, standardized tool sets, and automated calcu- lations. The software's built-in checklists and markup summaries also helped in cross-verifying quantities, leading to more accurate and defendable estimates.

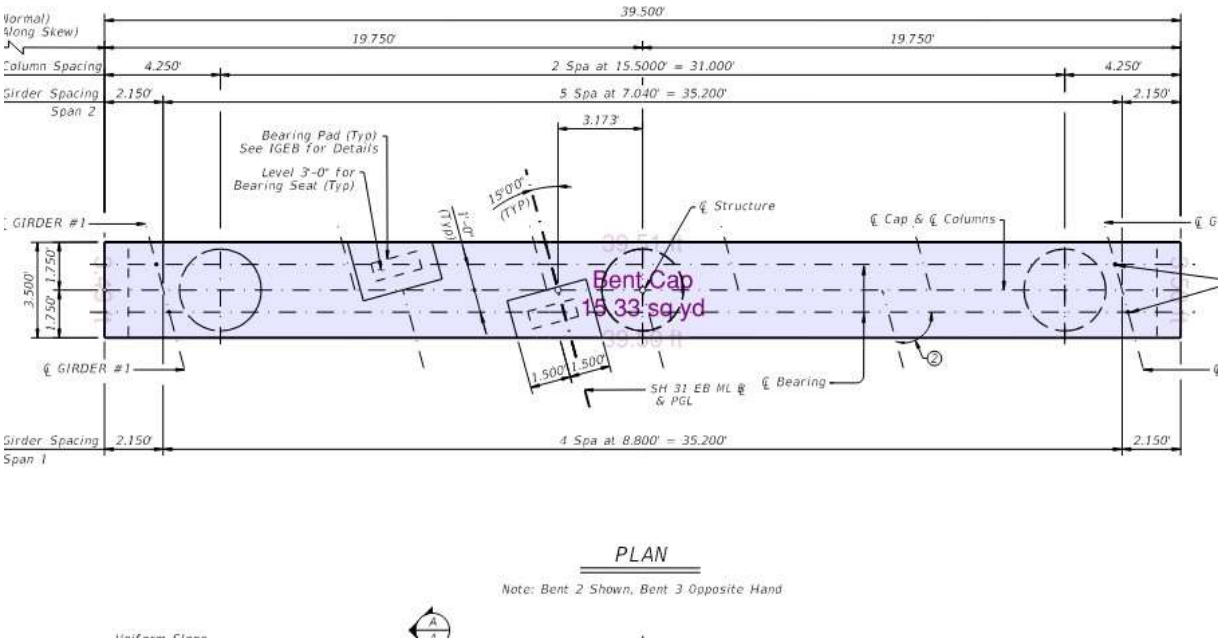

Figure 4: Measure the area of the bent cap in Bluebeam Revu

4.3 Time and Productivity Improvements

The adoption of Bluebeam Revu significantly improved the speed and efficiency of the quantity take-off process.On average, estimators reported a 30–40% reduction in the time required to complete a full bridge structure take-off compared to manual methods.Key time savings were observed in tasks like measuring repetitive elements (e.g., multiple columns) and updating quantities after drawing revisions. The ability to quickly export measurements into Excel further streamlined cost estimating workflows, enabling faster bid preparation without sacrificing accuracy.

4.4 Feedback from Project Teams and Estimators

Feedback was collected from estimators and project managers involved in the bridge project.The majority of users appreciated the clarity and organization that digital take-offs offered. They highlighted the benefits of visual markups, consistent measurement techniques, and the ease of verifying quantities directly on the digital draw- ings.However, some noted a learning curve when first adopting Bluebeam Revu, especially in setting up custom tool sets and calibrating drawings. Despite this, all participants agreed that the long-term advantages outweighed the initial investment in training.

4.5 Visual Examples and Screenshots

Several visual examples were captured throughout the project to demonstrate the difference between manual and digital take-offs:

- **Marked-up Plans:** Showing linear, area, and volume measurements directly overlaid on the construction drawings.
- **Excel Export Files:** Displaying automatically tabulated quantities ready for cost analysis.
- **Comparison Screenshots:** Highlighting side-by-side examples of manual sketches versus digital markups.

These visuals not only showcased the technical improvements but also helped explain the methodology to stakeholders unfamiliar with digital take-off practices.

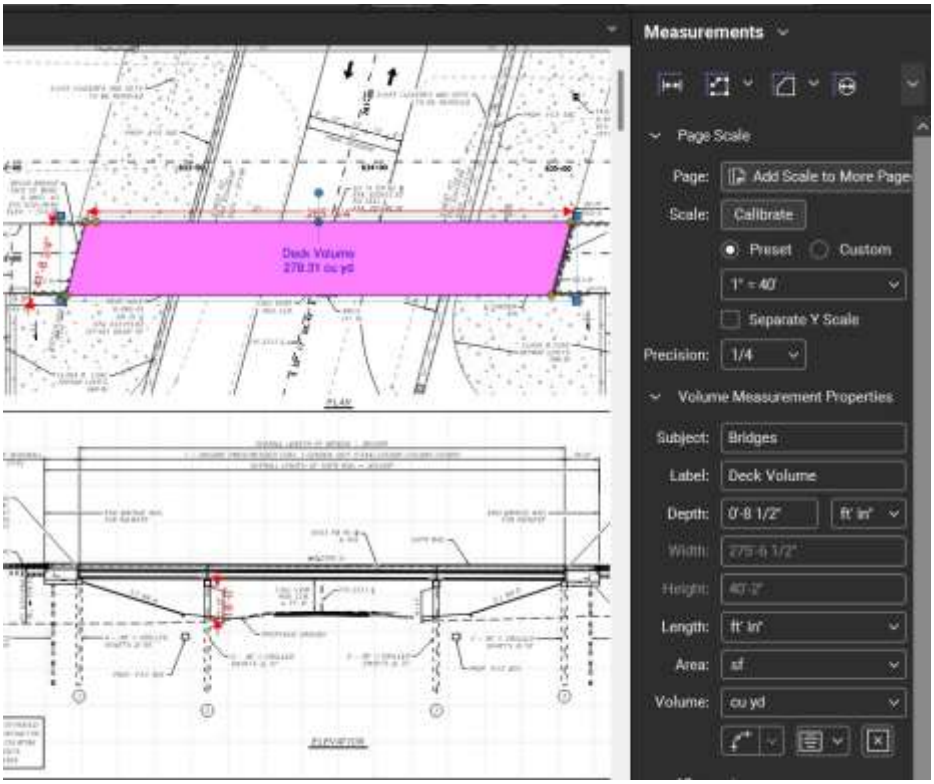

Figure 5: Measure the volume of the concrete for the bridge deck

4.6 The Future of Quantity Takeoff: Integrating AI and Automation

Like other industries construction industry is also evolving and integrating itself with artificial intelligence (AI) and automation technologies in quantity takeoff practices. While the traditional method has been trusted in the past is increasingly being replaced by artificial intelligent system that offer higher speed, accuracy, and predictability.

4.7 AI-Powered Automation in Quantity Takeoff

Recent studies have shown that AI technologies such as machine learning (ML) and natural language processing (NLP) can reliably automate quantity extraction from 2D drawings and specifications [1]. These AI models can detect items such as walls, doors, and structural members with exact accuracy, reducing the need for manual interpretation and minimizing errors by humans.

4.8 Object Recognition and Auto-Counting Tools

Advances in computer technology enables AI-based tools to automatically detect, select, and measure objects within the construction plans [2]. Software that uses these technologies will identify the the repetitive pattern in an elements like columns, beams, and fixtures, which speedup the takeoff process dramatically and improves consistency across large and complex projects

4.9 Predictive Estimation Using Machine Learning

Machine learning is further enhancing quantity takeoff by enabling predictive estimation models that analyze his- torical project data to forecast quantities and costs [3]. With the help of these models, data-driven decisions can be taken by estimators, which will improve the quality of the estimates. These decisions will also help in reducing the risk of cost overruns.

4.10 Real-Time Cost Feedback from BIM Models

The integration of Building Information Modeling (BIM) with cost estimating software is transforming project management through the provision of real-time feedback of cost impacts when design changes are implemented [4]. Estimators can view the impact on quantities and cost immediately through 5D BIM solutions from changes to structural elements so that better and faster decisions can be made during design and construction.

4.11 Integration of AI with Existing Tools

Platforms like Bluebeam Revu are also looking at integrations of estimating and other tools with artificial in- telligence to expand their capabilities [5]. Future enhancements may include automatic component recognition, analytical measurement suggestions, and smart error-checking systems, all of which would substantially improve the productivity of estimators and improve the reliability of quantity takeoff outputs.

4.12 Opportunities and Challenges in AI Adoption

While the integration of AI in quantity takeoffs will improve the efficiency, accuracy for the estimators, several challenges will remain to be solved. These include the incorporation of new AI techniques in their existing system, the need for high-quality structured data, cybersecurity concerns, and the requirement for new training programs for estimators [6]. Overcoming these barriers will help the implementation of AI in the construction estimating world.

4.13 Vision for an Intelligent Estimating Ecosystem

Vision for the future for estimating the ecosystem would be to create intelligent AI-supported takeoff tools that analyze and study historical data, track cost in real time, connected with all estimators. In this environment, estimators will transition from their traditional manual takeoff roles to more data-driven and take decision type of advisor roles. They will validate AI-generated results, manage risk assessment, and contribute to more robust and efficient infrastructure development

5. Conclusion

This research elucidates the role of computer applications like Bluebeam Revu in takeoff operations in road and bridge construction works. Estimators can be more precise, reduce human error, enhance efficiency, and respond more rapidly to plan change or addendums. Through the transition away from manual take-offs to digital take-offs, Bluebeam Revu's capabilities in linear, area, and volume measurements and the ability to directly export data into spreadsheets offer functional advantages that respond to industry demands for greater transparency and efficiency.

For projects involving public infrastructure like TxDOT bridges, such digital tools not only yield better cost control but also contribute to timely completion of the project along with enhanced construction quality. Strategic recommendations include investing in staff training, developing standardized toolsets within Blue- beam, exploring integration with other cost management software, and preparing for the next generation of AI- based enhancements.

By embracing these technologies, the construction industry can walk towards a smarter, faster, and more inte- grated future in quantity estimation.

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