CLEAR ROADS
research for winter highway maintenance

RESEARCH BRIEF

DECEMBER 2022

AUTOMATED TOOLS FOR MEASURING INDOOR SALT STOCKPILES

RESULTS SUMMARY

After months of testing automated indoor stockpile measurement systems in the field, investigators provided data-driven insights to help agencies make informed decisions for managing their salt inventories.

PROJECT DETAILS

Project Title: Evaluation of Indoor Automated Stockpile Measurement Systems

Project Number: CR20-03

Project Cost: $84,727

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Need for Research

Many state and local transportation agencies with winter maintenance programs purchase their road salt before temperatures even start to drop. Continuing to make salt purchases with a long lead time throughout the season further allows these agencies to secure the best prices and assure availability. However, measuring and monitoring the quantity of salt in widely distributed stockpiles—including many sites without regular staff on-site—can be both challenging and time-consuming.

Establishing an accurate record of the volume of salt on hand can help an agency effectively manage its resources while continuing to provide a high level of service. With reliable real-time data, maintenance managers can make timely arrangements to supplement low inventory and better prepare for future winter seasons.

Objectives and Methodology

Traditionally, salt stockpiles are measured and monitored using manual tools like wheeled tape measures or labor-intensive technologies like handheld or tripod-mounted laser scanners. Advancements in automated technologies could save departments of transportation (DOTs) significant time and money by using fixed-location hardware to scan or photograph the salt piles at regular intervals and calculate the size of the piles with specialized software. To better understand these high-tech alternatives and their potential, Clear Roads agencies sought an evaluation of the various components and capabilities available for reliably reporting the amount of salt stored in an indoor facility.

A literature search and review of the systems currently on the market, as well as an investigation into the tools used by transportation agencies and related industries across the country to measure different kinds of material stockpiles, provided an initial overview of the available options. Next, researchers surveyed Clear Roads member agencies to gauge the experience users have had with automated measurement systems and contacted commercial vendors to identify which of their solutions could potentially meet agencies' needs. Factors of interest includ-

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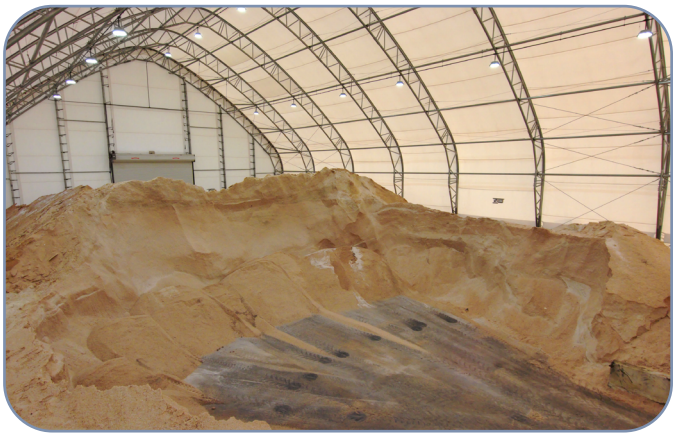

Both lidar and drone-based photogrammetry were used to measure Delaware DOT's indoor salt stockpile in Gravel Hill.

ed user-friendliness, durability, cost and compatibility with existing systems.

Three solutions from different vendors advanced to the next stage of the research: a mounted lidar scanner from Carlson; a mounted photogrammetry system from Stockpile Reports; and an unmanned aerial system (UAS) with an onboard camera system from Skydio, as analyzed by DroneDeploy software. Three Clear Roads member agencies—Delaware, Texas and Washington State DOTs—volunteered their active salt storage facilities and staff for testing the proprietary equipment and data processing software. Vendors installed their systems at different sites: the fixed-installation camera systems at two sites in Texas and one site in Washington, and the fixed-installation lidar systems in Delaware. The UAS was also flown in Delaware.

At each site, the fixed-installation camera and lidar systems automatically measured the salt stockpiles each day; the drone was flown periodically. To determine the precision and accuracy of the equipment, investigators conducted multiple types of comparisons. They compared traditional and automated measurements on static volumes of salt, as well as fixed salt volumes that were manually reconfigured. They also made before-and-after measurements with a known volume removed from the salt pile. Lastly, investigators varied the number of cameras used with the fixed photogrammetry system and changed lidar scan settings for the laser system to assess how that impacted the measurements.

Throughout the monthslong evaluation period, DOT staff continued to collect measurements through traditional methods. Data from material delivery receipts helped validate the information collected by the automated systems. In addition to objective metrics, agency staff considered other factors such as ease of installation and operation of the equipment and the quality of vendor support as they evaluated the equipment and software.

Results

Results from each automated system under evaluation were compared against one another and against traditional measurement techniques. The data collected by the systems proved internally consistent and reliable on a day-to-day basis, though not meaningful when salt piles changed by 20 cubic yards or less. Any over- or underreporting of salt was likely consistent throughout the year, making the measurement suitable for determining overall usage and identifying when stock was running low.

Of the three technologies evaluated in this project, the two fixed-installation systems functioned as intended with little or no involvement from DOT staff after installation. The UAS-based system also worked well, but as it relied on data collected by a manually operated drone, it cannot be considered an automated or semi-automated solution.

Benefits

Choosing the right technology for measuring a particular agency's salt stockpile involves many factors. With this research, transportation maintenance managers will be better equipped to understand the issues, benefits and potential challenges of using automated or semi-automated indoor stockpile measurement systems on their agency's salt inventory.

Several Clear Roads members reported that they are taking next steps to determine whether deployment of the technologies studied in this project will be feasible. Interested agencies should contact the three Clear Roads members involved with system testing for further guidance and recommendations.

"With more information about the different systems available to automatically measure indoor salt stockpiles, maintenance managers will be better able to more accurately and cost-effectively manage their agencies' resources."

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