

Scanning

T

he morning after the collapse of a 30-foot section of the top floor of a six-story, 1000-car parking garage at CAMC General Hospital,

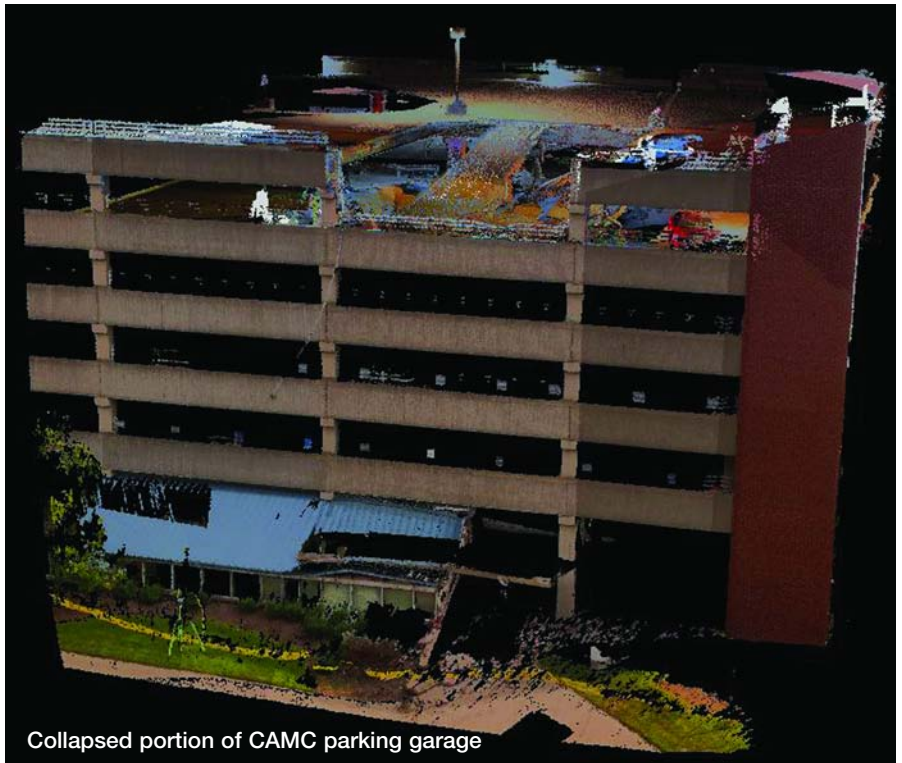
Charleston, West Virginia in July 2004, survey crews from E.L. Robinson Engineering Co. were summoned to collect detailed geometric survey data of the garage. Their job was to assess the damages and structural soundness of the structure and to assist with diagnosing the failure. Tom Rayburn, survey manager for E.L. Robinson, chose 3D laser scanning for capturing the most comprehensive collection of survey data points as quickly and accurately as possible.

Using the laser scanner, surveyors were able to collect in excess of 72 million data points in a three-day period. E.L. Robinson Engineering provided survey-grade data of the entire exterior of the garage within a week of the accident, compared with what may have taken a month

using other surveying techniques. Not only was this data beneficial for answering the requests of the engineers' original requirements, the as-built survey data can be used in the future for new projects relative to the parking garage structure.

No Existing CAD Model

Since the structure was built in 1980, nothing other than blue-line plans of the structure existed, and no previous survey data was available for the analysis. No electronic CAD drawings were available, so a wireframe model was developed based on a set of blueprints; the mission of the survey team was to develop a CAD model based on the sur-



Scanning a Garage Collapse

>> By Tom Greaves

vey data and compare the results with the design plan.

The key elements that needed surveying included the vertical column location, spandrel beam locations, and mapping the actual site of the structural failure. The engineers needed enough survey data to determine if the ledger beam (spandrel beam) failure and resulting floor collapse caused the garage to move in any direction. They wanted to verify that the exterior columns were still vertically aligned. They also wanted to know whether excessive settlement had occurred for the spread footings of the columns, and

whether rotation of the columns had occurred.

The surveyor's approach to this project was to effectively combine highly accurate conventional surveying with the highly efficient 3D laser scanning. Surveyors established the control points for the garage using conventional survey methods. Surveyors then identified the same control points in the scan data, and aligned the multiple scans with the control and with one another.

Acquisition Work Process

A Riegl LMS-Z360i scanner was used to capture 22 scans with 56 control points; a minimum of five control points was



Combined scan/orthophoto detail of floor of CAMC parking garage

used for each scan position. High-resolution digital photographs were captured at each scan position using the scanner's integrated camera. Survey control was achieved by measuring the position of the control targets using a Trimble 5600 Direct Reflex Robotic Total Station. The scanning took three days; the conventional survey of the control points required two days. The engineering team constructed a jig to locate column centers on the roof of the structure, and the position of these column centers was surveyed using the total station.

Post Processing

Riegl RiSCAN and InnovMetric's Polyworks were used to register the point cloud data and then to mesh the points for subsequent export of a DXF file to AutoCAD and MicroStation. Excel spreadsheets of the coordinates of the column bases determined from the scan data and the column tops determined from the total station data were generated. Post-processing of the scan data and subsequent generation of the 3D wireframe model took approximately four person-days.

Lessons Learned

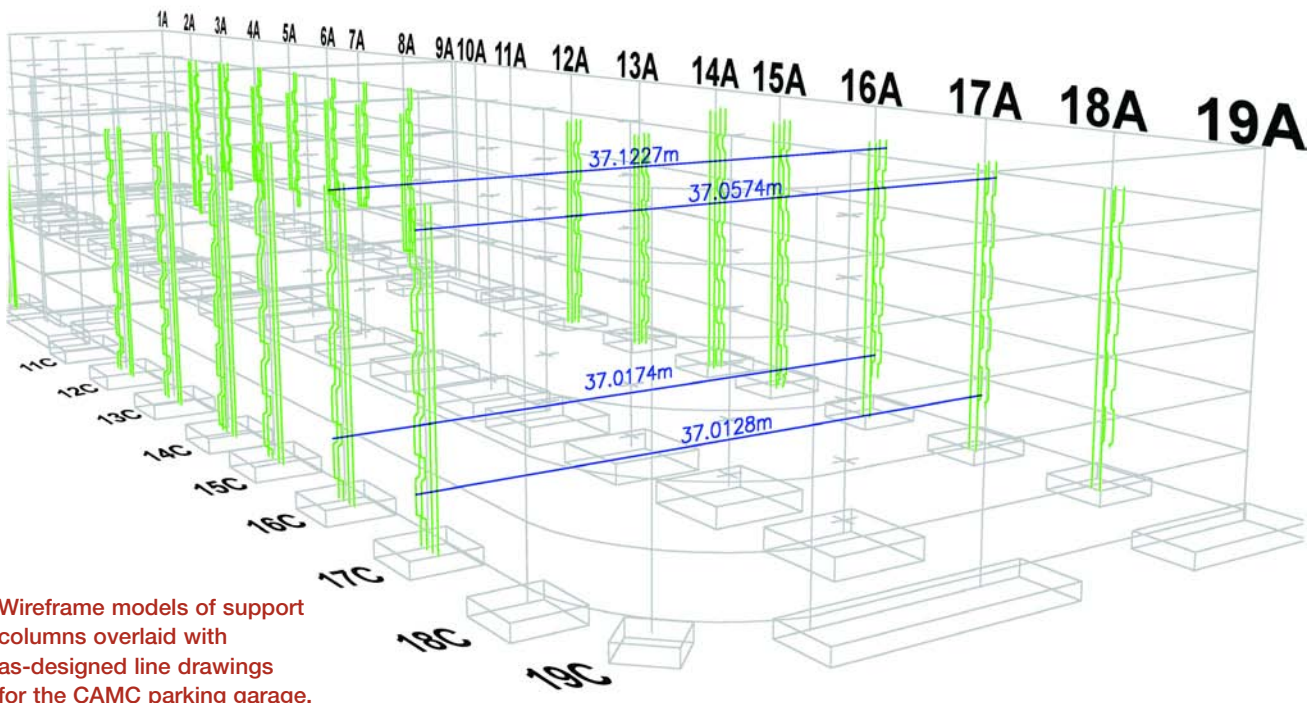
E.L. Robinson Engineering Co. made the following observations: The only way to gather enough data to produce a sufficiently detailed 3D model in the time available was to use laser scanning.

High-speed laser scanning combined with high-accuracy total station surveying can deliver engineering-grade data (6mm accuracy) suitable for failure mode investigation. Laser scanning allows safe and efficient data collection of areas difficult to reach with traditional surveying methods. Digital orthophotos together with conventional survey notes are valuable to office technicians for understanding building layout and features.

The survey data indicated no significant column displacement, lean, or twist. Following repairs and modifications to the garage based in part on the survey data, the garage was subsequently reopened. *AS*

All images courtesy of E.L. Robinson Engineering Co.

Tom Greaves is co-founder and a senior analyst of Spar Point Research LLC in Danvers, Massachusetts. Spar Point Research is a technology business research firm focused on terrestrial 3D laser scanning and related dimensional control technologies.



Wireframe models of support columns overlaid with as-designed line drawings for the CAMC parking garage.