The 2024 World Congress on
Advances in Civil, Environmental, & Materials Research (ACEM24)
19-22, August, 2024, The K hotel, Seoul, Korea

Use of terrestrial LiDAR to capture potential displacements of mechanically stabilized earth retaining walls

Marcel Maghiar[1)], *Gustavo Maldonado[1)], Soonkie Nam[2)]
Tanvir Ahmed[3)], Md. Mehrab Hossain[4)], and Shakil Ahmed[4)]

[1)-4)] *Department of Civil Engineering & Construction, Georgia Southern University, Statesboro, Georgia, USA*
[*, 1)] gmaldonado@georgiasoutern.edu

ABSTRACT

This work considers the use of terrestrial light detection and ranging (T-LiDAR) techniques as a non-destructive, non-contact mean to detect potential displacements in deteriorating mechanically stabilized retaining walls (MSEWs). These walls use resistance between backfill materials and reinforcements and have become ubiquitous due to their economy and stability. They were first introduced in the USA in 1972 and numerous of them are now built every year. However, a study by Tarawneh and Siddiqi (2014), which examined 339 MSEWs in Ohio, revealed that different problems may affect these walls, with as many as 95% suffering from either cosmetic or structural problems. As these structures age, their chance of deterioration arises, and the severity of their problems increases. The Georgia Department of Transportation (GDOT) employs these walls in numerous of its bridges and needs to investigate their aging problems during their life span and maintenance period, so proper inspection protocols can be generated. Our team works closely with GDOT on this issue. In this regard, to capture potential undesirable wall displacements, we investigated the use of a Leica Geosystems' laser scanner, ScanStation C10, to generate virtual, 3D, point-cloud models that capture the existing spatial configurations of these walls. The idea is to fully scan a given MSEW at different times, and generate similar 3D models at each time, to compare them for potential detection of wall displacements between those modeling events. The magnitude of the wall displacements that can be captured via laser scanning depends on the accuracy attained in their resulting point-cloud models. This leads to the main objective of this work which is to determine the relative accuracy of the resulting virtual, 3D, point-cloud models of MSEWs, produced by two different registration/scan-stitching techniques, the target-based (TB) and visual-aligned (VA) approaches, with respect to classical field measurements via a slow, but accurate, one-second, robotic total station (RTS) instrument. This RTS instrument is more accurate

---

[1)] Professor
[2)] Associate Professor
[3)] Former Graduate Student
[4)] Graduate Student

than currently available scanners and serves as benchmark, but it only acquires the position of one point at a time, versus 50,000 points per second captured by the less accurate, twelve-second, C10 scanner. The mentioned two registration procedures were selected to be compared because differences in their relative accuracies have already been reported by Maldonado et al. (2024) for a different type of project. That work involved 34 consecutive scans, covering 1.4 hectares. The location of those 34 scans followed a closed path with spatial superposition occurring only between close neighboring scans. Conversely, the current study involved smaller areas (0.23 and 0.38 ha) requiring only 6 scans per bridge. All 6 scans presented substantial superposition among all of them. Two bridges were considered, and each included 2 MSEWs, one at each abutment. A total of 6 check points (CPs) were marked on each wall. Each CP consisted of a 15cm-diameter, black-and-white sticker. The coordinates of all CPs were extracted from the resulting 2 point-cloud models, based on the TB and VA approaches. Those coordinates were compared against the ones measured in the field via the RTS instrument. Also, for each bridge, 66 non-repeated distances were measured between its 12 CPs (6 per wall). The discrepancy results are presented in Table 1.

Table 1: Relative error comparison, TB approach vs RTS, and VA approach vs RTS.

Bridge Name	Area (ha)	Comparison Type	Positions of 12 Check Points		66 Distances
			Mean Abs Error	RMSE	RMSE
1-Crossgate	0.23	TB vs RTS	19 mm	23 mm	5 mm
		VA vs RTS	18 mm	22 mm	4 mm
2-Old River Road	0.38	TB vs RTS	9 mm	10 mm	8 mm
		VA vs RTS	7 mm	7 mm	5 mm

RMSE: Root Mean Square Error

In this case, both registration approaches, TB, and VA, show similar discrepancies with respect to the RTS instrument. That is, both TB and VA schemes could be employed to capture displacements ≥~25 mm (≥~1 inch). This contrasts Maldonado et al.’s previous results, where the TB approach was 3 to 4 times more accurate than the VA one. The authors understand that the current reduced discrepancies are because each involved scan, out of 6 per bridge, presented high spatial superposition among all of them.

REFERENCES

Maldonado, G. M., Maghiar, M., and Loyed, W. A. (2024). “Spatial and Distance Discrepancies in Target-Based and Visual-Aligned LiDAR Models.” ASC 2024 60th Annual ASC International Conference, *Epic Series in Built Environment,* 5, 505-513.

Tarawneh, B., and Siddiqi, J. (2014)."Performance issues of mechanically stabilized earth wall supporting bridge abutment." Proceeding of the 8th International Conference on Engineering and Technology Research, Dubai, United Arab Emirates.