Abstract  In order to construct 3D geospatial information about the terrain, current measurement using a total station, remote sensing, GNSS(GLOBAL Navigation Satellite System) have been used. However, ground survey and GNSS survey have time and economic disadvantages because they have to be surveyed directly in the field. In case of using aerial photographs and satellite images, these methods have the disadvantage that it is difficult to obtain the three-dimensional shape of the terrain. The terrestrial LiDAR can acquire 3D information of X, Y, Z coordinate and shape obtained by scanning innumerable laser pulses at densely spaced intervals on the surface of the object to be observed at high density, and the processing can also be automated. In this study, terrestrial LiDAR was used to analyze slope displacement. Study area slopes were selected and data were acquired using LiDAR in 2016 and 2017. Data processing has been used to generate slope cross section and slope data, and the overlay analysis of the generated data identifies slope displacements within 0.1 m and suggests the possibility of using slope LiDAR on land to manage slopes. If periodic data acquisition and analysis is performed in the future, the method using the terrestrial lidar will contribute to effective risk slope management.

Keywords: Geospatial Information, Light Detection And Ranging, Mesh, Pointcloud, Slope Displacement
1. Introduction

Recently, there have been frequent heavy rains due to climate change, and slope failure has occurred frequently, resulting in increasing life and property damage every year[1-2]. The slope failure is the most desirable method to find the cause of collapse in advance and to eliminate the cause and to take preventive measures, but finding the cause of collapse in advance requires economical and technological cost and technical force[3]. Also, when the slope collapse occurs, it is important to find a permanent recovery plan though the cause of the cause is important[4]. It is necessary to construct precise geospatial information about the slope in order to find the risk of collapse in advance, to analyze the cause after the collapse, or to establish a permanent recovery plan. The terrestrial LiDAR can acquire 3D geospatial information of the object, and it is increasingly used for slope topography survey, structural survey, current survey, cultural asset survey, shoreline change survey, volumetric survey, and tunnel survey[5-6].

In case of slope, quantitative interpretation method is needed to find risk beforehand or to establish cause analysis or recovery plan after collapse[7]. At this time, topographical information such as slope before collapse, slope after collapse, and section after slope after restoration are required, and ground survey data is also necessary. Especially, accurate geospatial information has a great influence on the accuracy of safety diagnosis. In this study, terrestrial LiDAR was used to obtain slope data and analyzed the applicability of LiDAR. Chapter 2 describes the data acquisition of the study site using Terrestrial LiDAR, and chapter 3 contains the data processing and analysis contents. Fig. 1 shows study flow.

2. Data Acquisition with Terrestrial LiDAR

Terrestrial LiDAR operates on the same principle as a total station with 3D laser scanning. The distance is measured by receiving a laser reflected in the near-infrared or visible light wavelength band, receiving the returning laser beam from the object, and measuring the horizontal and vertical angles of the laser beam simultaneously with distance measurement. Terrestrial LiDAR has a measurement speed of tens of thousands of points or more per second, whereas the conventional total station measures the point by adjusting the angle of the laser beam to a specific point to be measured.

Most terrestrial LiDARs currently in use use pulsed lasers. When pulses are used, the most common way to observe the distance is to measure the round-trip time of the laser pulse and multiply it by the speed of light, taking advantage of the time between the emission and reception of the pulse. The reciprocating time of the laser pulse can be expressed by Equation (1)[8].

$$T_L = \frac{2R}{C}$$

where, $R$ is distance between distance observer and ground surface, $C$ is speed of light. In Equation (1), the distance error is directly proportional to the time error, and is derived as in Equation (2)[8].

$$\Delta R = \frac{1}{2}c\Delta T_L$$

where, $\Delta R$ is resolution of distance, $\Delta T_L$ is resolution of time observation. In this study, slopes
located in Daejeon were selected as study sites for terrain slope data acquisition using terrestrial LiDAR. Fig. 2 shows one of target slope and Fig. 3 shows location of the study area.

In this study, data of study area were acquired in 2016 and 2017 using two types of terrestrial LiDAR. For the georeferencing of the acquired data, the control points were surveyed by the VRS (Virtual Reference Station) method, and the stations were moved and data were acquired to obtain the data of the entire area. Fig. 4 show terrestrial LiDAR[9][10].

<table>
<thead>
<tr>
<th>Point</th>
<th>X(m)</th>
<th>Y(m)</th>
<th>H(m)</th>
</tr>
</thead>
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<tr>
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<td>234988.752</td>
<td>71.726</td>
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<td>Control Point 3</td>
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<td>Control Point 4</td>
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<td>235438.81</td>
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<tr>
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<td>Control Point 14</td>
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<td>223670.525</td>
<td>246.056</td>
</tr>
</tbody>
</table>

Table 1. Coordinate of Control Points

Scanning was performed in 2016 and 2017 and the data was acquired in three stations. Fig. 5 shows the acquired data.
3. Data Processing and Analysis

Scanned data with terrestrial LiDAR were converted to las format pointcloud. Since the transformed pointcloud is the shape information without the actual coordinates, georeferencing is performed to the actual position using the coordinates of the control point. Fig. 6 shows data processing work flow.

To analyze the change in cross section, a mesh was created for the slope using data for 2016 and data for 2017. The variation of the slope was calculated by superimposing on the mesh and the result was shown visually. Figure 8 shows the mesh generated from the 2016 data, and Figure 9 shows the mesh generated from the 2017 data. Figure 10 shows the amount of change by mesh overlay.
Table 2 shows the displacement for the slopes of 2016 and 2017 as a result of the mesh overlap analysis for four slopes.

The section with the largest displacement was about 10 cm, which represented about 70% of the total slope displacement. The displacement of 0.6m or more was less than 1% of the total displacement. This seems to be vegetative displacement, and the effect of vegetation needs to be taken into account for this effect. As shown in the results of the analysis in 2016 and 2017, the slopes of the study site did not have large displacement. However, if the slope analysis using terrestrial LiDAR is performed periodically, it will be widely used as data for evaluating slope stability.

4. Conclusions

In this study, terrestrial LiDAR was used to acquire and analyze slope. The results of the study are as follows.

1. Data were collected using LiDAR in 2016 and 2017, and data processing enabled us to effectively generate georeferenced pointcloud data of slopes.

2. To analyze the displacement of the slope, the mesh was generated using the acquired data and the displacement were calculated by overlap analysis. The displacement of the slope of the study area was mostly less than 0.1m, which indicates that no significant displacement occurred on the slope from 2016 to 2017.
3. Overlap analysis of the generated data effectively identified slope displacements and suggested the possibility of using the terrestrial LiDAR for risk slope management.

4. In the future, if periodic data acquisition analysis is performed, it can contribute to improvement of slope stability.

References


