FIG Working Week 2007, Hong Kong

Monitoring Slope Failure at Kadoorie Agricultural Research Centre with a 3D Laser Scanner

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Background

- **A loosely compacted fill slope with an angle of 33˚ was constructed at the Kadoorie Agricultural Research Centre of The University of Hong Kong**
- **The slope was installed with soil nails and brought to failure by subjecting to surcharge at the slope crest, rise in groundwater table and precipitation**
- **Heavy instrumentation comprised in-place inclinometer, vibrating wire piezometers, vibrating wire extensometer, earth pressure cell and strain gauges along soil nails to study the failure mechanism and behavior of the soil nails in loosely compacted fill slope**
- **Slope Height = 4.75m and Width = 9m**
- **Constructed by end-tipping method and resulted in a loose state with an initial dry density of 70% of the maximum dry density.**

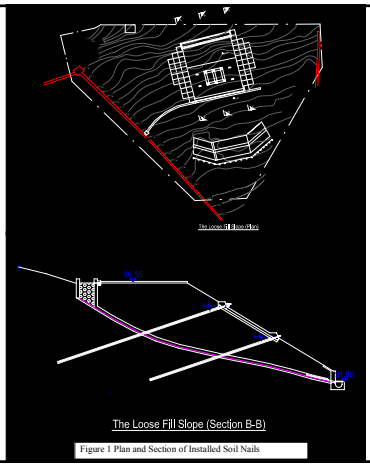
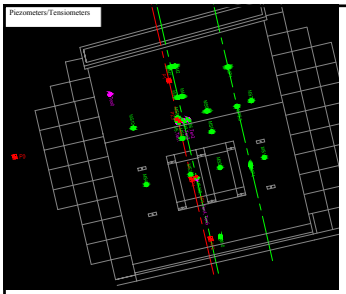
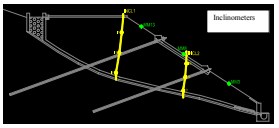
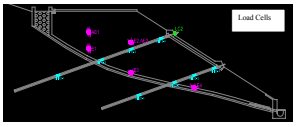


Figure 1 Plan and Section of Installed Soil Nails

- Two rows of grouted nails were installed at a grid of 1.5m x 1.5m
- Inclination of 20˚ from the horizontal
- Holes diameter = 100mm
- Nail lengths 8m and 6m
- 25mm diameter steel ribbed bar was grouted

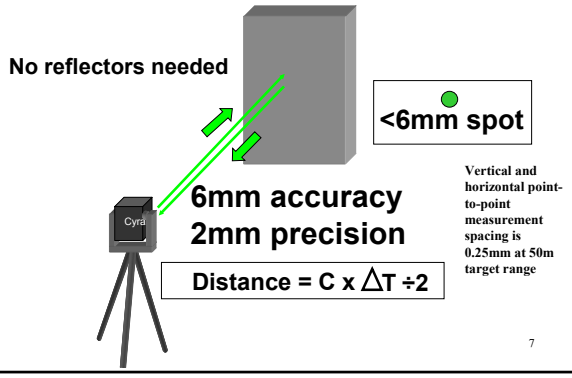






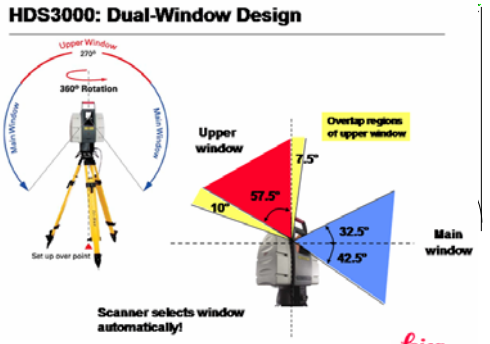
This paper focuses on the use of 3D laser scanner in capturing the formation of cracks and surface movement during the failure

Pulsed laser (time-of-flight)



Vertical and horizontal point-to-point measurement spacing is 0.25mm at 50m target range

Large volume of space per scan

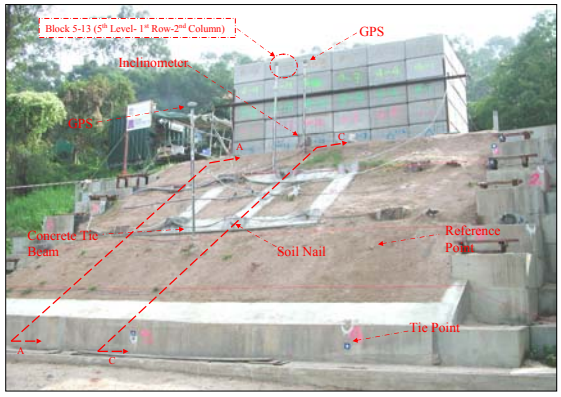


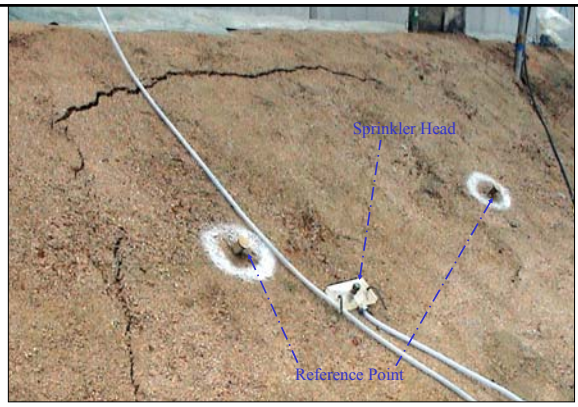
Typical scan for 1 million point: 20 minutes

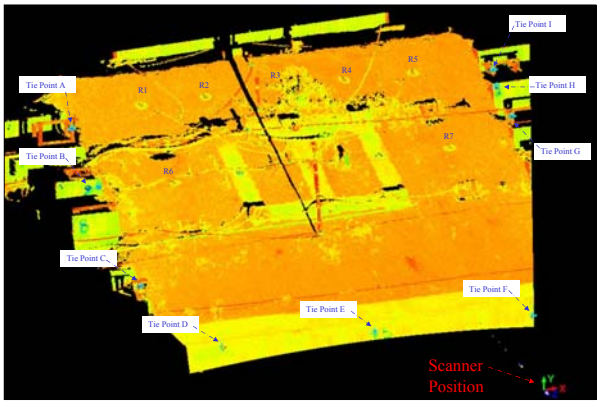
HDS3000 Complete System

A typical complete system includes…

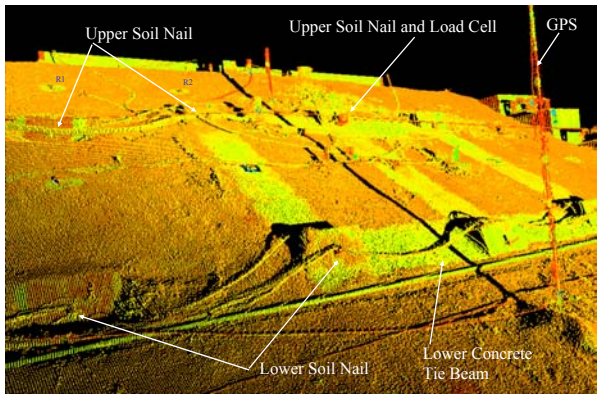
- Scan Head
- Tribrach
- Tripod
- Ethernet and Power cable
- 2 Batteries (1 shown)
- Laptop
- Shipping cases (1 pictured)



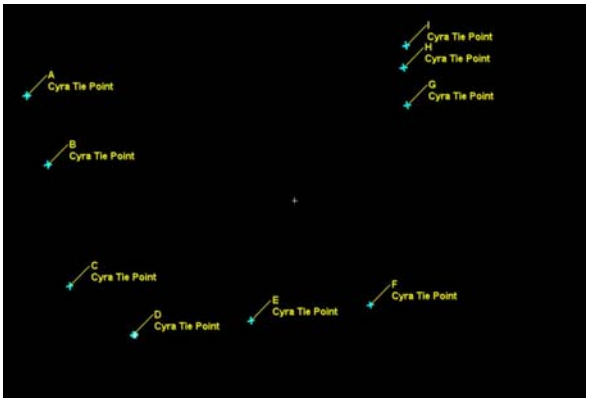




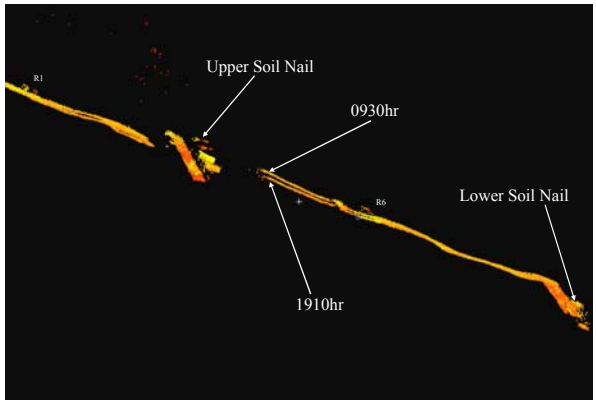
Overall View at 0930 hr



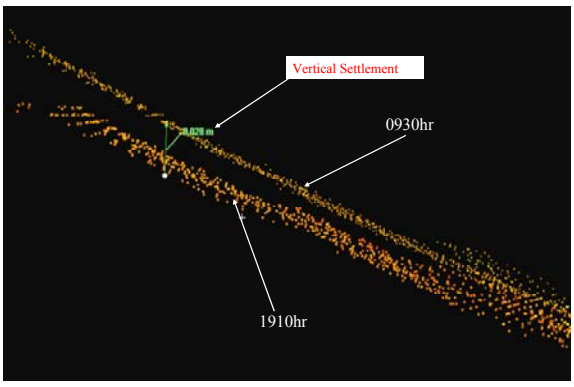
Close-up View at 0930 hr



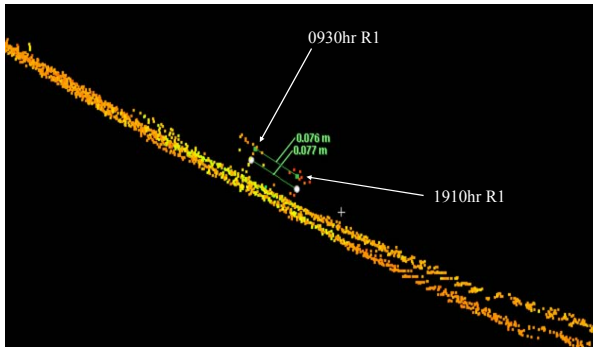
Tie Points for Registration



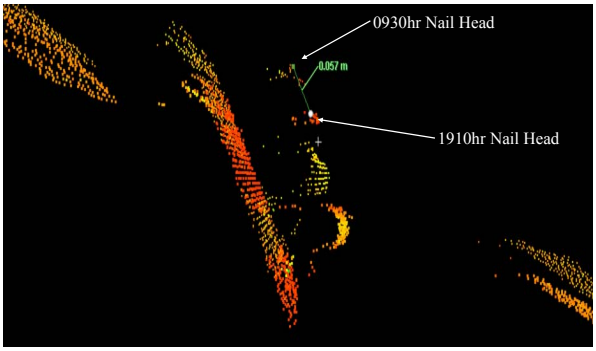
Section A-A



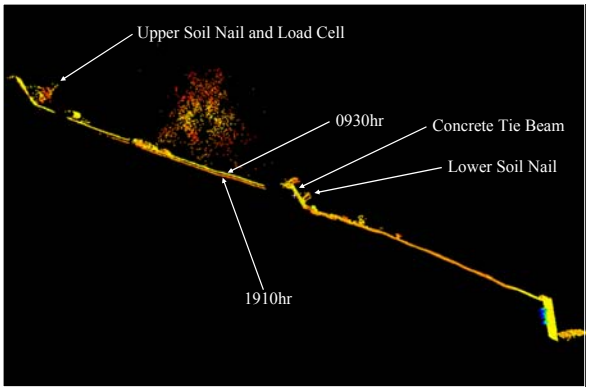
Section A-A (Close-up View between Upper Soil Nail and R6)



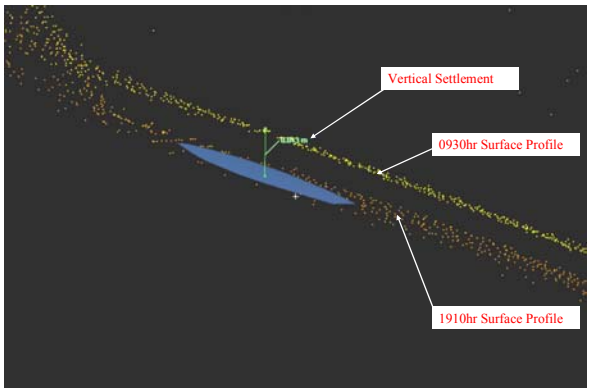
Section A-A (Movement at R1 above Upper Soil Nail)



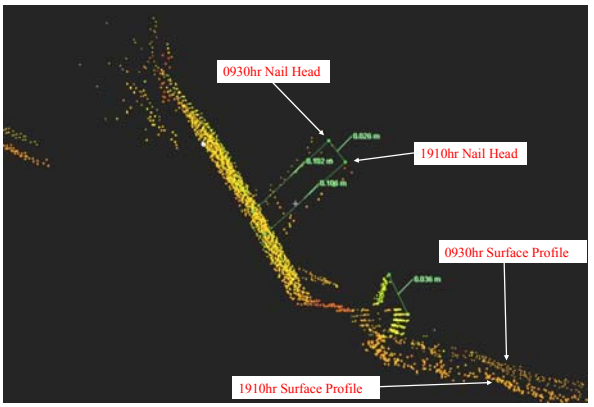
Section A-A (Movement at Upper Soil Nail Head)



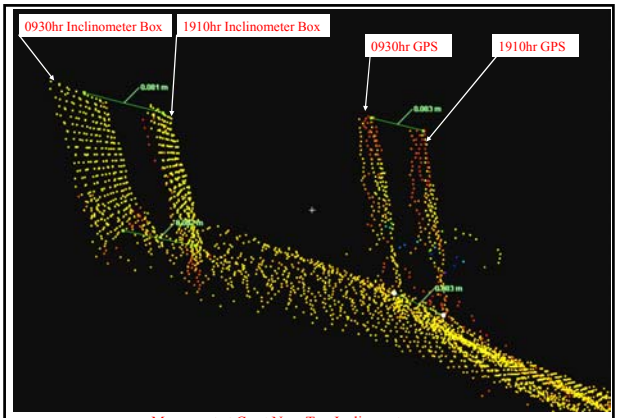
Section C-C



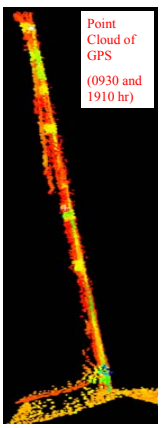
Section C-C (Close-up View above Lower Soil Nail Head)

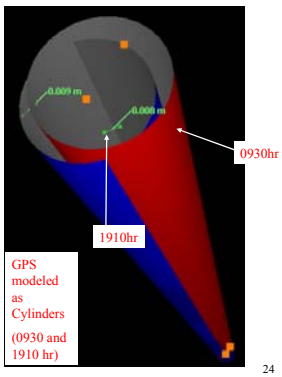


Section C-C (Close-up View of Lower Soil Nail Head)



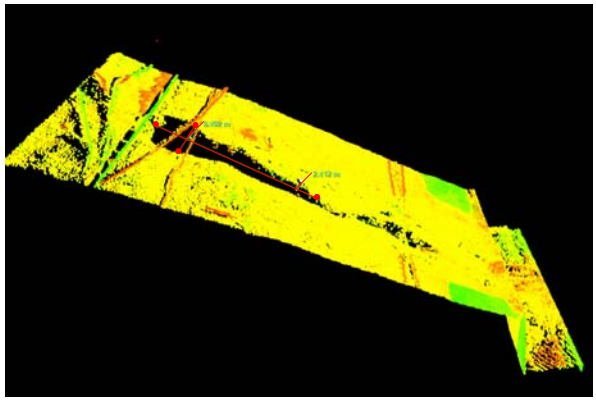
Movement at Crest Near Top Inclinometer Position (Close-up View of Section C-C)



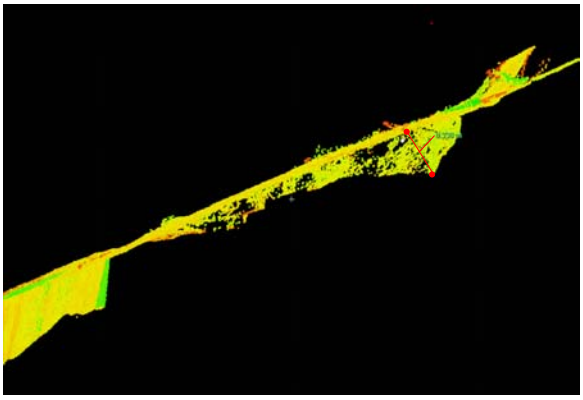


Close-up View of GPS (centerline movement 8mm)

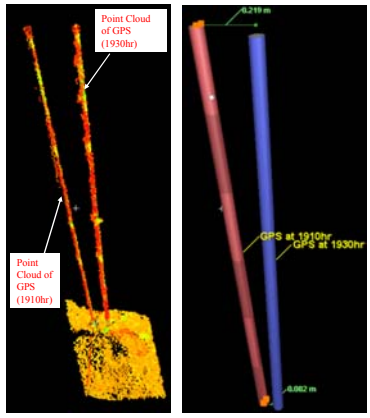
25



Wash Out Observed at 1910 hr (width=0.402m, length=2.412m) 26



Wash Out Scar at 1910 hr (maximum depth=0.338m) 27



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Close-up View of GPS (movement between 1910hr and 1930hr)

4 Dec. 02

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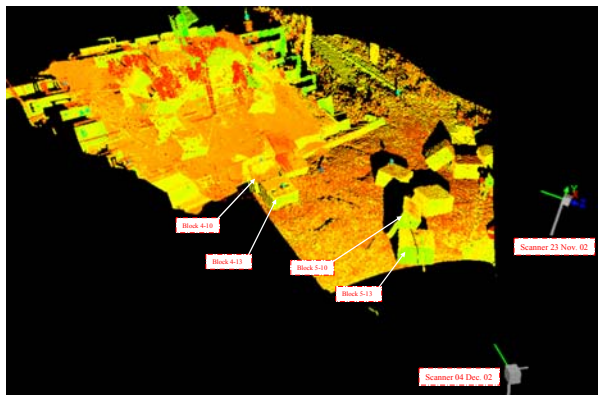
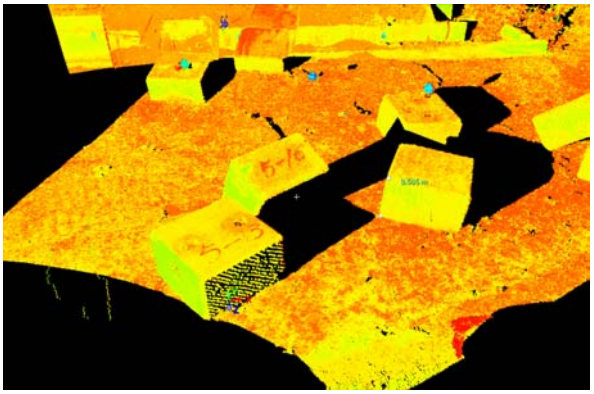
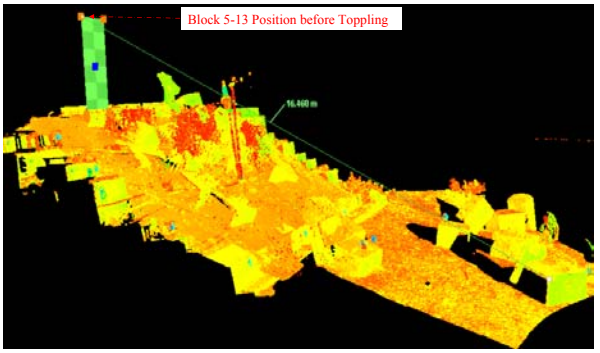
Surcharge Blocks Toppled After Significant Slope Movement



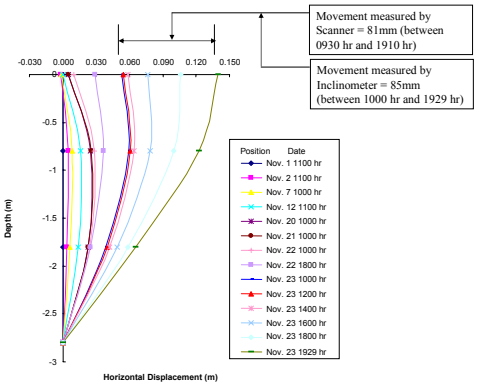
Merging Images from Scan on 23 Nov. 02 (1930hr-after toppled) and 04 Dec. 02 (detailed scan at toe) 30



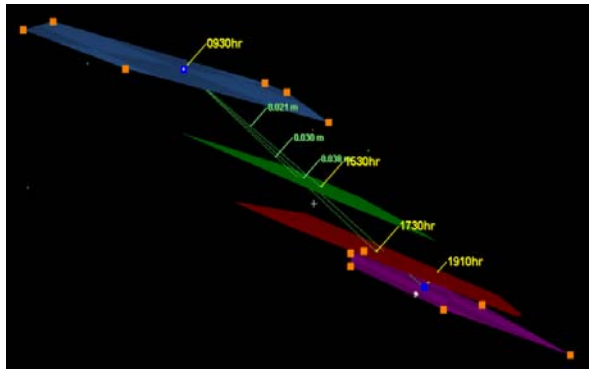
Close-up view of Block 5-10, 5-13 (04 Dec. 02)



Travel Distance of Block 5-13



Inclinometer at Crest of Slope (Horizontal Displacement against Time)



Movement of Reference Point R6 against Time (0930hr, 1530 hr, 1730 hr and 1910 hr)

Conclusions:

• Slope movement can be monitored using the latest 3D laser scanning technology

• By overlapping the point cloud generated from the scanner at different time intervals, the surface movement of the slope can be accurately recorded without the need of physically accessing the slope surface

• Can safely and quickly record the movement and dimension of washout and cracks, advantages over conventional survey method when the slope reaches failure

• Scanner reading agrees very well with that from conventional inclinometer reading at the surface

• Point cloud can be easily modeled into geometrical shape for further rendering