0002 ONLINE SENSOR PLATFORM FOR EARTH SLOPE RESILIENCE IN THAILAND

45. RESILIENCE AND INNOVATION OF EARTH STRUCTURES TO NATURAL HAZARDS

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ABSTRACT

- Highway slope failure and erosion are becoming more severe due to climate change and increasing infrastructure development.
- The online sensor platform was developed for early warning and evaluating performance of bioengineered slopes in this study.
- A series of online monitoring sensor and field instrumentation were deployed at four test sections along the national highways' cut and fill slopes in the Northern Thailand.

1. SOIL BIOENGINEERING TECHNOLOGY AND SLOPE MONITORING SYSTEM

1.1 Soil Bioengineering Technology

The **soil bioengineering technique** for road slope engineering in Thailand involves the utilization of various plant materials together with both **permanent structures** and **temporary biodegradable structures**. These materials function together and supplement each other as Figure 1.

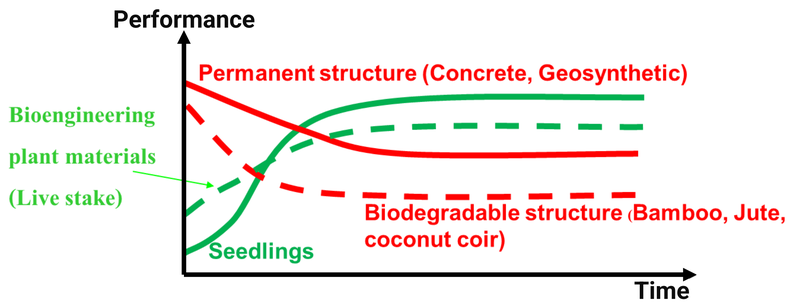


Figure 1 - Conceptual performance of bioengineering technique using plant materials and engineering structures

Three main bioengineering slope covers

a) Vetiver system (VS) with bamboo fence,
b) Erosion control blanket (ECB) with erosion control log (ECL)
c) Capillary barrier system (CBS) as Figure 2.

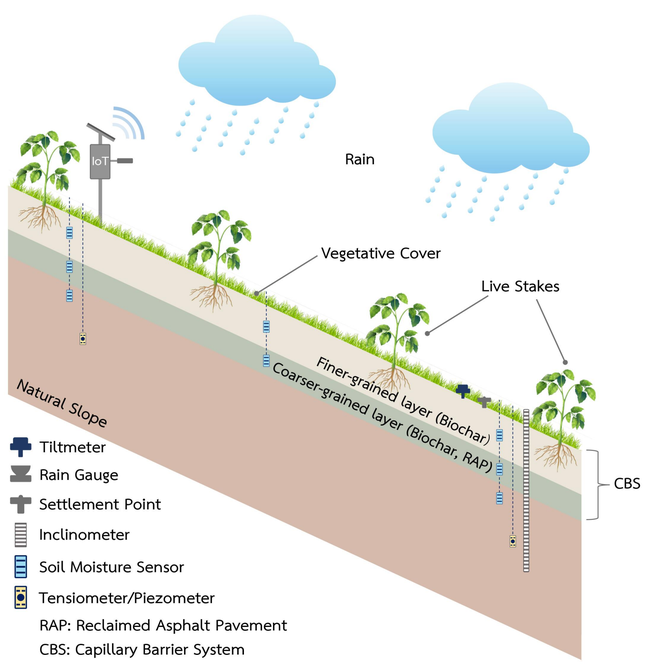


Figure 2 - Capillary barrier system (CBS) and field instrumentations

1.2 Slope Monitoring System

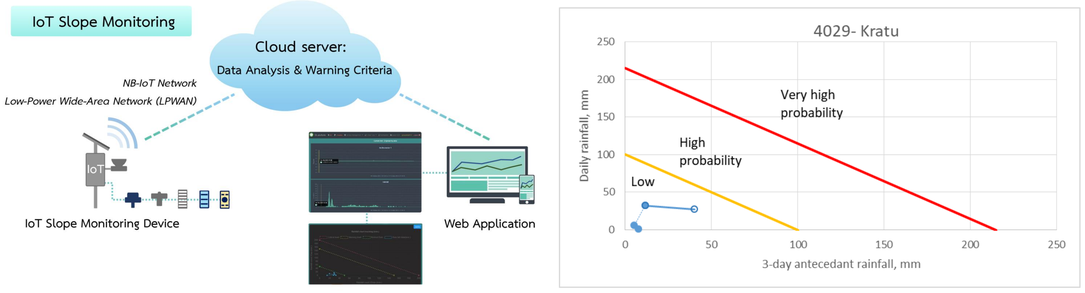


Figure 3 a - Internet of Things (IoT) slope monitoring system
b - Typical rainfall envelope used to estimate the slope failure probability

2. EXPERIMENTAL SITES FOR ONLINE MONITORING

Table 1 - Summary of the bioengineering techniques used in these four test sections

Test section ID		Location	Type	Details	Geological material
1	1a	Highway no.1192 at km post 11+500	Back slope (Cut)	• Screw pile and flapped soil bags for toe stabilization. • 3 types of soil cover, a) Vetiver system, b) Erosion control blanket/log, c) Capillary barrier with biochar-soil for fine-grained layer and recycled asphalt aggregate (RAA) for coarse grain layer	• Granitic soil with severe erosion problem
	1b		Side slope (Fill)	• Screw pile • Vegetated flapped soil bags • Vetiver grass system	
2		Highway no.118 at km post 46+700	Back slope (Cut)	• Same as 1a except that the coarse grain biochar was used instead of RAA	• Granitic soil with severe erosion problem
3		Highway no.21 at km post 324+151	Side slope (Fill)	• Same as 1b	• Colluvium soil in sedimentary rock and recurring water channel
4		Highway no.21 at km post 329+700	Back slope (Cut)	• Same as 1a except that the coarse grain biochar was used instead of RAA	• Colluvium soil (Old landslide) in sedimentary rock

Figure 4 - Four test sections

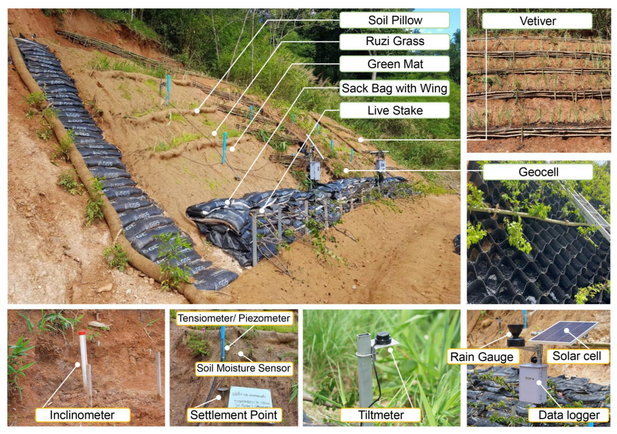


Figure 5 - Photographs of test section 4.

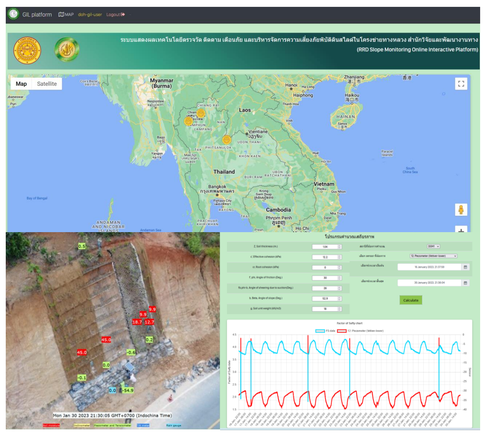
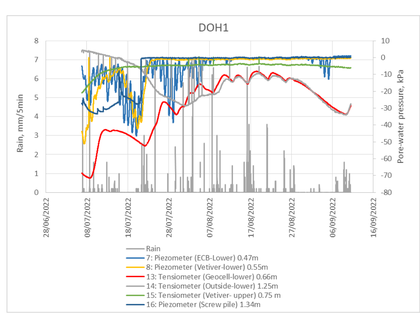


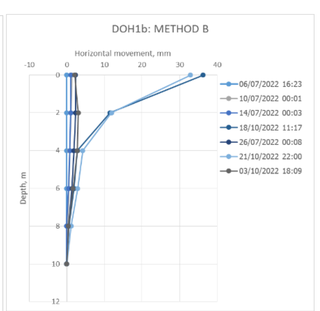
Figure 6 - RRD slope monitoring online interactive platform

3. RESULTS AND DISCUSSION

The performance and effectiveness of various vegetative and CBS slope cover installed at four experimental sites were investigated and compared based on the field monitoring results and the unsaturated soil mechanics principle.



Pore-water pressure, soil moisture and rainfall results (1a)



In-place inclinometer results (1b)

Figure 7 - Typical results

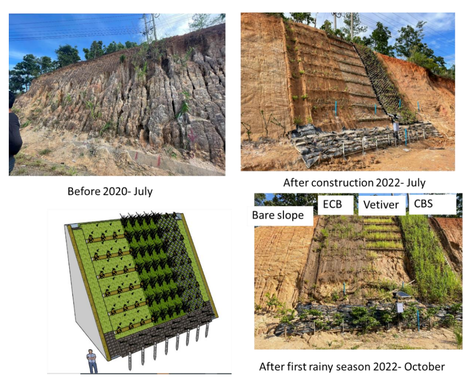


Figure 8 - Visual appearance of the different treatments of the section at various stages (1a)

4. CONCLUSIONS AND RECOMMENDATIONS

- An implementation of **nature-based solution** such as vegetative cover, capillary barrier system, bio-engineering stabilization can represent the state-of-the-art solution in terms of cost, resiliency, sustainability, environmental-friendly, and aesthetics for future green growth development of highway network.
- **Bio-engineering stabilization** provided sound engineering practices in conjunction with integrated ecological principles for slope resiliency and sustainability.
- **Real-time** data-driven decision making through the **online sensor platform** provided good supportive and advantageous evidence for the advancement in slope resilience and sustainable mitigation with respect to the increase and the faster recovery of factor of safety during prolonged and/or intense rainfall during the extreme events.