SLOPE STABILIZATION BY MICROPILES: CASES STUDY IN NORTHWESTERN TUNISIA

S. Khediri, S. Haffoudhi, K. Zaghouani

Selma Khediri, Krakow, June 2014
I. **INTRODUCTION**

*Exceptional event in 2012 in Northwestern Tunisia:*

Uncommon heavy rainy episodes

↓

Landslides in the mountainous regions

↓

Substantial damages: *broken roads, homes, isolated communities*

*Risk increased of human losses*

↓

**RAPID AND EFFICIENT ACTIONS**

*(expertise study, geotechnical investigations, solutions)*
II. SOME CASES

Photo 1: Reactivated old landslide

Photo 2: Landslide: prefailure state
II. SOME CASES

Photo 3: Landslide: occurred failure

Photo 4: Reactivated old landslide

TOTAL : 30 RECORDED LANDSLIDES
III. GEOLOGICAL CONTEXT

**Soils involved**

**Bedrock**: mainly hard marls, compact claystones, sandstone,

**Upper layers**: filling, scree and plastic clays, lying on steep slope profiles

(Ple*, E: pressuremeter parameters)

(low to medium mechanical characteristics)
III. SOLUTIONS

Emergency solutions

Case Photo N°2: Prefailure state

- Soften the slope
- Soil nailing: rows of nails and micropiles, drainage system

Micropiles type III (C): in duets, D 150 mm, steel bar D 73 mm
III. SOLUTIONS

Long term solutions

5 options highlighted in the expertise study

- 5 options involving flexible and rigid structures, associated to earthworks (reprofiling and slope softening)

- Implemented option:
  mostly stabilization by rigid elements coupled with earthworks and drainage actions:

Reinforced retaining walls, founded on duets of micropiles + deep and shallow drainage actions (subhorizontal drains + draining material behind the walls, in the slope)

Selma Khediri, Krakow, June 2014
III. SOLUTIONS

Case Photo N°2: Soil profile: situation after the landslide

Mechanical characteristics:

<table>
<thead>
<tr>
<th>Layer</th>
<th>$\gamma_h$ (KN/m$^3$)</th>
<th>C (KPa)</th>
<th>$\phi$ (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filling</td>
<td>19</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Scree</td>
<td>18</td>
<td>71</td>
<td>28</td>
</tr>
<tr>
<td>Compact Clay</td>
<td>19</td>
<td>117</td>
<td>26</td>
</tr>
<tr>
<td>F. Claystone</td>
<td>20</td>
<td>107</td>
<td>27</td>
</tr>
</tbody>
</table>

Selma Khediri, Krakow, June 2014
III. SOLUTIONS

Filter material

Concrete wall

Anchors

Nails HA 32

Micropiles D150 mm vertical and inclined 20°
III. SOLUTIONS
III. SOLUTIONS

Mpile: D150 mm, L=12 m – 15 m, tubular bars D73 mm

Selma Khediri, Krakow, June 2014
III. CALCULATION AND CONTROLS

CALCULATION:

- *French standard « Fascicule 62 »*: calculation of micropiles admissible bearing capacities, based on pressuremeter data (Software FOXTA)
- *Common standard methods for slope stability calculation*: Bishop method (Software TALREN), and also *Finite Element calculation* (Software PLAXIS 2D)

CONTROLS:

- *Ongoing work control on site*
- *Tensile tests: loaded to 2*Qs*
OTHER MICROPILE USE IN TUNISIA

Many other fields for micropiles use in Tunisia:
- Underpinning work on existing foundations (reservoirs, old constructions, ....)
- Deep foundations for new constructions:
  - Pylons, storage tanks, industrial and residential buildings
  - Berlin walls

Selma Khediri, Krakow, June 2014