Concluding Remarks

- Expensive not always the best
  - The Ugly Duckling can become a Beautiful Swan

- Beneficial for a piling specialist to be able to offer a wide range of solutions
  - Flexibility is the key to success

Session 6: Case Histories

(Tuesday Afternoon, 6 June 2000, 2 hours)

Objectives of Session: Versatile collection of implemented micropile cases

Chairman: Prof. Fred H. Kulhawy Technical Secretary: Mr. Gary Weinstein

Chairman Remarks:

A summary statement was made by the chairman for this session: "We have great construction information, but not so great geotechnical information". It was stated that we need three important things: (a) a broad and detailed database of different construction technology and equipment, correlated to micropile performance data, (b) well-documented and well-instrumented load tests to FAILURE!, and (c) data on performance of different micropiles under various field applications. All of these should be available in an accessible repository!

Regional Presentations:

1. Rolf Mattson (Europe)
Mr. Mattson made a presentation that included information on the Ischebeck Titan anchors, specifically incorporating the Titan 103/78 bars for a large bridge retrofit. A clarification of the classification of micropiles in North Europe and Finland also was made. A summary statement was made that "Commercial/economic interests should be secondary to the primary mission of IWM."

2. Prof. Fusanori Miura (Japan)
Professor Miura made a presentation on different types of micropile applications in Japan, which included retaining wall foundations, tunnel reinforcement, underpinning of existing abutments, and protection of existing structures. A point was made that structural reinforcement applications have approached the number of in-situ reinforcement applications in the last two years. These structural reinforcement applications are ranked as follows in numbers completed: (a) retaining walls, (b) tunnels, (c) other applications, and (d) bridges. Studies presented in Ube included small model, in-situ, and centrifuge tests, case studies, element tests, stability analyses, and dynamic response analyses.

3. Dr. Donald Bruce (U. S. A.)
Dr. Bruce presented the results of full-scale field tests on single micropiles and networks of Titan and Expanded Body micropiles. Twenty-eight Titan micropiles were installed in six groups/networks, plus six individual vertical ones, and four EB micropiles were installed vertically. All were in typically medium dense, medium to fine sand. Ultimate bond values for the vertical micropiles was in the range of 21 - 27 psi, and the capacity of the EB micropiles was proportional to its inflated cross-section. For the group tests, the following was found: (a) reticulated groups were stiffer than vertical groups, (b) oblique loading resulted in less stiff response, (c) stiffness increased with increasing number in the group and with reticulation, and (d) for group tensile testing, small groups (2-pile and reticulated 4-pile) behaved essentially as the sum of individual piles, but large groups (vertical 4-pile and two 8-pile groups) behaved as large soil-pile "blocks" with capacity defined by the perimeter of the block. During discussion, Prof. Juran noted that, in centrifuge tests, he also observed larger stiffness when the piles were inclined.

Special Presentations:

1. Mr. Henrik Holmberg
Mr. Holmberg presented a case history of a Turku apartment house, built in the 1950s on timber piles, with 200 - 500 mm of clay through moraine and then continuing to bedrock. The building has already settled 65 mm, and it continues to settle at 2 - 3 mm per year. To solve this problem, new Rautaruukki piles were driven through existing timber piles. [Note: welding connections on site was nearly impossible.] Piles were installed to the moraine layer with a pile working load of 900 kN. They were driven and then grouted & jacked in place. Where resistance was encountered, drilling was conducted to penetrate existing piles with a special wood drill bit.

2. Mr. Harri Vehmas

Mr. Vehmas presented a Turku underpinning project for a private house. They would drive piles to hard layers and then heat the pile electrically to make a continuous connection. After jacking, driving, and drilling, the system would be tested. Advantages included straight and quick drilling and driving with no disturbance.

3. *Mr. Flor De Cock*

Mr. De Cock presented a project that involved underpinning of a silo-building. Eight buildings within one larger building, built in 1980 in Luxemborg, were underpinned with a jet grouting technique. Total settlement was 100 - 350 mm throughout the building. Soil investigation showed weathered marl and stiff clays. The tilting of the building was due to construction and not poor soil conditions, and the steel deformation characteristics governed design.

4. *Jean-Ghislain LaFonta*

Mr. LaFonta presented real-time monitoring of H piles in a very sensitive building using laser leveling techniques. The problem with the original construction was that the large diameter bored piles were constructed shorter than required. The end result was that 116 out of 128 piles were in need of repair. The proposed solution was 402 new piles inserted 10 m into the rock, through the moraine layer that the original piles were resting on. A series of laser levels and reflective prisms were mounted in the area to monitor accuracy of construction.

5. *Paul Woodfield*

Mr. Woodfield presented "The Good, the Bad, and the Ugly" of various underpinning projects in the UK.
(a) The "Good" project was a traditional masonry building in which stabilization was previously attempted in 1990, but then it experienced additional settlement in 1998. Further site investigations revealed various problems, which included 26 m of loose fill interspersed with massive sandstone boulders. There was also a very high water table, limited headroom, site restrictions, and two adjacent buildings that would impact the construction technique. The solution was to core through an existing 700 mm slab and install 70 ODS drilled piles in 16 weeks.
(b) The "Bad" project was a house using precast segmental (glued) piles for the original construction. After a few months, the house began to settle on one side, which was followed by equal settlement on the other side. When the settlement had stopped, the building was level but approximately 2 m lower. Problems encountered were the existing soil conditions, which included 9 m of peat over 3 m of very soft clay, in addition to high water table and difficult access conditions. The solution was to install 20 steel-cased bottom-driven piles installed to a depth of 17 m to dense sand and gravel layers.
(c) The "Ugly" project was the Float Viaduct, a four span bridge over the River Clyde, in which the foundations were constructed under the live bridge. Problems encountered were river flooding, limited headroom, difficult access, and ground problems. The solution was to install 250 new piles to a depth of 15 - 28 m.
Overall conclusions were that the most expensive solution is not always the best and that flexibility in piling is the key to success.

6. *Renato Fiorotto*

Mr. Fiorotto presented various designs, uses, and construction techniques that can be used with micropiles. These included embankment stabilization, earth retaining structures, new ramps off existing highway, and forepoling in tunnels.