Ultra High Capacity and Totally Removable Tiebacks

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The installation of a multiple of individual anchor tendons within a single tieback borehole is gaining popularity on a world-wide basis.

Each individual tendon is referred to as a “unit anchor”, and each unit anchor has its own short fixed length (8’ – 15’). As many as seven units may be installed in a single borehole with unit fixed lengths at staggered locations. The principle is applied to permanent anchors, temporary anchors and removable anchors (See Figure 1).

Since each unit anchor also has its own free length, and hence, its own load extension characteristics, each unit requires its own hydraulic ram which is seated on the communal bearing plate during testing. Each ram is coupled via a manifold to the high pressure (10,000 psi) hydraulic power pack. This system ensures that each ram and each unit are subjected to the same synchronized load application during all loading stages. Each individual unit exhibits its own performance behavior characteristics throughout loading, and testing results are compared to conventional acceptance test requirements.

It is widely acknowledged that for tensile anchors with long fixed lengths (30’ to 40’), the elastic properties of the tendon strongly influence the load transfer. The elastic incompatibility between the tendon and the grouted ground generally results in debonding progressing along the grout/soil interface as load is increased (Figure 2). This phenomenon prevents the simultaneous mobilization of the ultimate bond stress along the whole fixed length and leads to inefficient utilization of the available soil strength. This load loss effect has been quantified as an “efficiency factor,” which is used in design to account for very short fixed lengths that mobilize the full available bond (“skin friction”), and the long fixed length mobilize only a percentage of that bond. As a result, the simultaneous loading of multiple short, fixed length units in a single normal size diameter bore hole (5” to 7”) can, in total, achieve a considerable increase in pull out capacity over that of a conventional tieback anchor with the same total fixed length. Each additional unit anchor provides a proportional increase in anchor capacity, such that efficient total fixed lengths up to 60’ have been used. A recently tested soil anchor with four units each with 10 foot lengths, (totalling 40’), has achieved an enormous load of 1100 kips prior to failure of an individual unit.

Unit anchors may be designed and founded in differing strata - an exclusive feature and a beneficial characteristic of the system. This promotes the system’s use in layered soil strata, which are typically difficult for designing conventional tiebacks. Each unit fixed length is designed on the basis of the known or anticipated bond stresses at the grout to soil interface in the encountered strata. These bond capacities are typically higher in granular materials and lower in cohesive strata. This multiple short length load transfer approach promotes a relatively uniform distribution of load along the overall fixed length in all strata. This contrasts with the uneven load distribution known to be exhibited along the fixed lengths (continued on page 36)
of conventional tiebacks. In addition to capacities being achieved, creep losses demonstrated by multiple unit tiebacks are generally considerably lower than those of conventional tiebacks. In addition to capacities being achieved, creep losses demonstrated by multiple unit tiebacks are generally considerably lower than those of conventional tiebacks.

The Single Bore Multiple Anchor System ("SBMA") system has been utilized extensively in the UK, Ireland, Austria and Singapore (over 35,000 high load anchors) and is gaining popularity in Australia, New Zealand and Spain. The system has been used twice in the USA:

- At Natchez, Mississippi where the tieback capacity of the multiple unit anchor far exceeded that achieved by conventional tiebacks in very fine silt ("loess"). Tiebacks were installed by Haywood Baker, Inc.*, and tendons were provided by Lang Tendons Inc.*
- At Hodenpyl Dam, Michigan, previously installed conventional tiebacks apparently exhibited high creep losses resulting in unacceptable wall movement. A post grouted SBMA was tested to 2.7 times the design load without reaching failure. Production multiple unit anchors were installed in 2002 and are being monitored annually. Tiebacks were installed by Gerace CC Inc., tendons were supplied by Lang Tendons Inc.

*Geotechnica and Geosystems designed the Hodenpyl project and the geotechnical engineer and reviewer was Schnabel.

In addition to permanent "double protected" or temporary "SBMA", fully removable multiple anchors are also available, and demonstrate the same ultra high performance characteristics. This system, also patented, utilizes a multiple of looped, fully sheathed strands in a single bore hole (Photo 1) and can guarantee (continued on page 38)
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removal of the entire length of the multiple of tendons after destressing. Removability is becoming mandatory for temporary tiebacks installed in several major cities: Berlin, London, Edinburgh, Manchester, Hong Kong, Perth and Singapore (Photo 2).

Ultra high capacity? The following capacities have been demonstrated in over 70 investigation anchors in differing soil strata over a 10 year period in various countries:

- 350 tons (800 kips)

When preliminary or sacrificial anchors are tested to failure, ultimate grout/soil bond stress is recorded for each individual SBMA and an extraordinarily wide database is thereby collected for tieback design in a host of different soil conditions.

The provision of ultra high capacity (up to twice that of conventional

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anchors in controlled conditions) ensures that the use of this system can reduce the number of tiebacks, in a deep excavation with multiple rows of ties, by as much as half. This inevitably provides considerable direct financial benefits plus a time savings. A three month time savings was achieved in a deep excavation in Hong Kong when 500 SBMAs each with 450 kips design load were installed and removed during construction.

For further information see: www.TheAnchorman.com  
www.SBMASystems.com  
Tony Barley and Mary Ellen Bruce are ADSC Technical Affiliate Members. Mary Ellen serves as the Secretariat for the International Society on Micropiles (ISM). (Editor)

*Indicates ADSC Members.

Photo 2: Over 2500 high capacity SBMA-type Removable Anchor Tiebacks have been installed in Singapore where complete tendon removal is mandatory.