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National Geotechnical Experimentation Sites (NGES)

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SYNOPSIS The cost of and time required for site characterization in preparation for field experimentation often exceeds the cost and time of performing the experiment. For this reason alone, there is a need for well characterized field experimentation sites. The additional advantage of being able to compare measurements of soil and rock parameters by new methods with measurements of the same parameters by other methods in well known materials is very beneficial to the geotechnical community. Finally, the need to perform full scale earth structure experiments dictates a need for well characterized and user friendly sites where large experiments can be performed. Through the sponsorship of NSF and FHWA, well characterized experimentation fields of this kind now exist at the National Geotechnical Experimentation Sites.

INTRODUCTION

Anyone who has experienced the process of site preparation and site characterization for field experiments shares the knowledge that a substantial amount of time and resources must be devoted to this phase of research. Often the cost of site characterization exceeds the cost of other operations associated with the research. For these reasons alone there is strong justification for development of experimentation sites which have been thoroughly characterized and which have been made user-friendly. It is also widely recognized, nowadays, that full-scale model or prototype tests are extremely valuable in geotechnical engineering, and well characterized sites are necessary for these tests.

For the above reasons, it became evident during the past decade to many geotechnical engineers that easy access by investigators to well-characterized field sites would be of enormous benefit. These sites could be used to evaluate new techniques of soil improvement, new methods of soil testing, new methods of foundation and earth structure construction, as well as other activities not yet defined. Completely documented field sites with a public database containing results of previous tests and site characteristics could also provide appropriate locations for the installation of permanent instrumentation for measurement of site response during earthquakes and other mass movement phenomena where appropriate.

Sites like this exist in other countries like Canada, Brazil, United Kingdom, France, Italy, Japan, and Norway. These sites have promoted cooperation and exchange of information between public agencies, universities and private sector groups in a cost effective way.

CREATION OF NATIONAL GEOTECHNICAL EXPERIMENTATION SITES

Two workshops sponsored by NSF and FHWA identified and quantified the need for a system of multiple-user geotechnical experimentation sites (Benoit and de Alba, 1988 & 1991). As a result of these workshops, the National Geotechnical Experimentation Sites (NGES) system was established in November 1992 and is in operation.

The NGES system consists of five sites which receive funding for database creation and up-dating, site improvements, and site management for multiple users; and 34 sites which are included in the system and described in the NGES Catalog (Benoit and de Alba, 1993) but which have received no funding.

The NGES sites are overseen by a self-sustaining Management Board of eight members who direct the activities of the System Manager, currently, R.D. Woods (University of Michigan). The principal investigators for the NSF/FHWA NGES Project are Professors J. Benoit and P.A. de Alba of the University of New Hampshire. The data base management and site subcontract management is the responsibility of the principal investigators.

The initial 40 NGES sites were selected from a group of about eighty sites, each of which was presented by a sponsor. Three categories of sites were established for the sites in the system: Level I sites receive the highest level of funding for site improvements and user-friendly activities, Level II sites receive some funding, and Level III sites are listed in the NGES Catalog and are included in the data base do not receive any NSF/FHWA funds at this time.

Funding provided to the NGES sites up to now has been used to establish and keep up-to-date the databases, bring the sites up to a

high level of geotechnical characterization, to make the sites user-friendly, and to provide continuity of management with the attendant preservation of all valuable data. All NGES sites are available to any interested and qualified individual, entity, or university. NGES site users are expected to provide their own funding for specific experiments and/or tests through traditional funding sources or self funding in the case of industrial users. NGES Sites are not in a position to provide funding for research at their sites by outside users.

In the future, site managers may have to make a charge for site usage to provide for maintenance and further upgrading. This charge, if any, will be nominal for all users. Potential NGES site users are encouraged to contact the Site Manager early in the planning for any use of that site.

The Level I sites are: *Treasure Island Naval Station*, San Francisco, California and Texas A & M University, *Riverside Campus*, College Station, Texas. The Level II sites are: *University of Houston*, Houston, Texas; *Northwestern University*, Evanston, Illinois; and *University of Massachusetts*, Amherst, Massachusetts. The Level III sites are distributed over the entire continental United States.

In the following sections the salient features of the Levels I & II sites are presented and their managers are identified so potential users might become familiar with the NGES system. Interested users are also encouraged to obtain a floppy disk version of the databases of all the NGES sites by contacting Prof. J. Benoit at the University of New Hampshire; phone (603) 862-1419.

LEVEL I SITES

Treasure Island Naval Station

Site Owner: U.S. Navy
Site Manager: J.R. Faris (415) 244-3451
Catalog ID: CATIFS

The Treasure Island Site is located in San Francisco Bay and is owned by the U.S. Navy. Although Treasure Island is scheduled to be removed from the Navy's active facilities, control will very likely remain in the public sector for at least the next ten years. Because of the strategic location and characteristics of this site, it was judged well worth the small risk of future loss of access to include Treasure Island in the highest level of NGES sites for the near term.

Treasure Island an artificial island with an area of 162 hectares formed by dumping hydraulic fill on a shoal adjacent to the large rock outcrop known as Yerba Buena Island in San Francisco Bay. The composition and consistency of the hydraulic fill varies across the island, but it is basically loose, fine to medium, silty sand, with occasional clayey zones. There are improved areas on the island, where vibrofloation and compaction piles were used to densify the fill. Treasure Island experienced lateral spreading and sand boils, Fig. 1, in unimproved areas during the Loma Prieta Earthquake in 1989.

FIGURE 1 - Sand Boils Due to Liquefaction on Treasure Island

Seismologically, Treasure Island is located roughly midway between the Peninsula segment of the San Andreas Fault to the West and the Northern segment of the Hayward Fault to the East. An earthquake of magnitude greater than or equal to 7.0 on the Richter Scale is expected on one of these faults within the next thirty years with an aggregate probability greater than 50%. Intensity at Treasure Island is predicted to be MM VIII for either of these events.

Fire Station #1 is designated the NGES Site on Treasure Island, Fig. 2. An area of about 0.2 hectare around the fire station is available for experimentation. This is a quasi-free field location being a vacant lot associated with the two-story, wood frame structure of the fire station. There was existing at this site before the creation of NGES system a deep accelerometer array funded by the NSF Earthquake Hazard Mitigation Program in collaboration with the Strong Motion Instrumentation Program of the California Division of Mines and Geology, CDMG. Also, CDMG already had a surface instrument at this site which recorded motion during the Loma Prieta event.

A total of five additional accelerometers have been installed in a deep borehole to rock: one at bedrock and four at locations in the soil profile. P & S wave velocity logging has been performed,throughout the depth of the deep borehole and crosshole seismic data exists for shallower depths.

In addition, eight piezometers have been installed at various depths in the hydraulic fill and one inclinometer tube is available to indicate horizontal displacements. An extensive collection of other geotechnical data is available based on previous investigations. The general profile with some geotechnical data is presented in Fig. 3.

FIGURE 2 - Fire Station Site on Treasure Island

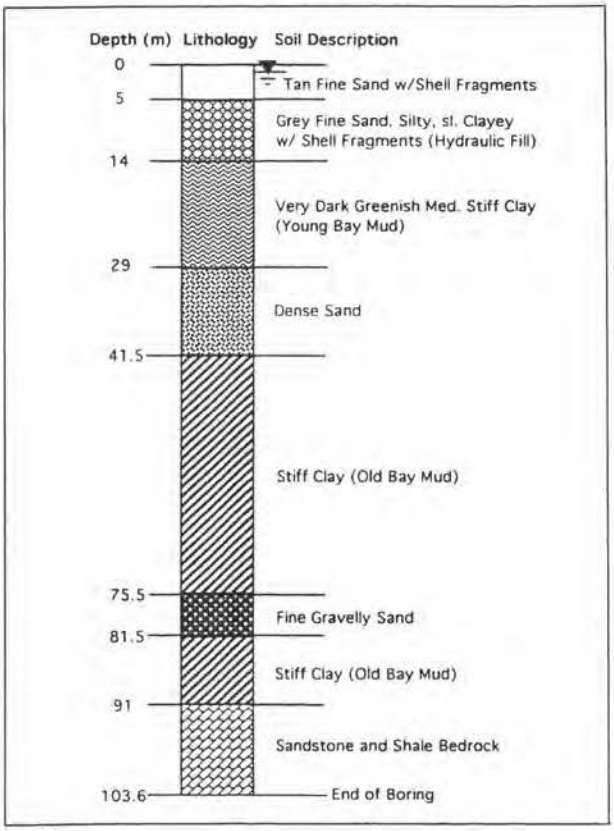

FIGURE 3 - Soil Profile at Treasure Island Site

Future plans call for updated topographic surveying, detailed refraction/reflection profiling to identify top of rock, and additional SPT's to characterize select areas of the island. Instrumentation of a site on the island where ground improvement techniques were used is also envisaged.

Texas A & M University, Riverside Campus

Site Owner: Texas A & M University
Site Manager: J.-L. Briaud (409) 845-3736
Catalog ID's: TXAMCLAY & TXAMSAND

The Texas A & M University NGES Site, Fig.4, actually consists of two sub-sites, one predominantly clay and one predominantly sand, Fig. 5. Both are located on the Riverside Campus of TAMU in College Station, Texas. Both sub-sites are part of a former U.S. Army Airfield and have ample space for future expansion as needed. These sites have been set aside for geotechnical testing since the late 1970's. Many organization both within and outside of the TAMU system have used this site.

TAMU Clay Sub-Site

The clay sub-site covers about 0.7 hectare at the southwest end of the NE-SW runway. The clays at this site are representative of the Middle Eocene Age marine and non-marine Claiborne Group sediments. These sediments were deposited by a major transgression of the seas followed by repeated marine regressions and transgressions, finally ending with a major regression. The deposit consists of three horizons including a stiff to very stiff clay from the surface to a depth of 6.5 m, a very stiff to hard clay from 6.5 to 12.2 m and a very hard clay or clay shale from 12.2 m and below. The ground water is at about 6 m below surface. A simple profile of this sub-site is presented in Fig. 5.

Previous studies at this site started with tests on horizontally loaded drilled shafts by the Texas Highway Department in the late 1970's. Other shallow and deep foundation studies, retaining wall behavior studies, and in situ testing studies have been performed in the intervening years. Figure 6 shows a pile load test and is an example of TAMU Clay Site activities.

FIGURE 4 - NGES Site Sign, TAMU

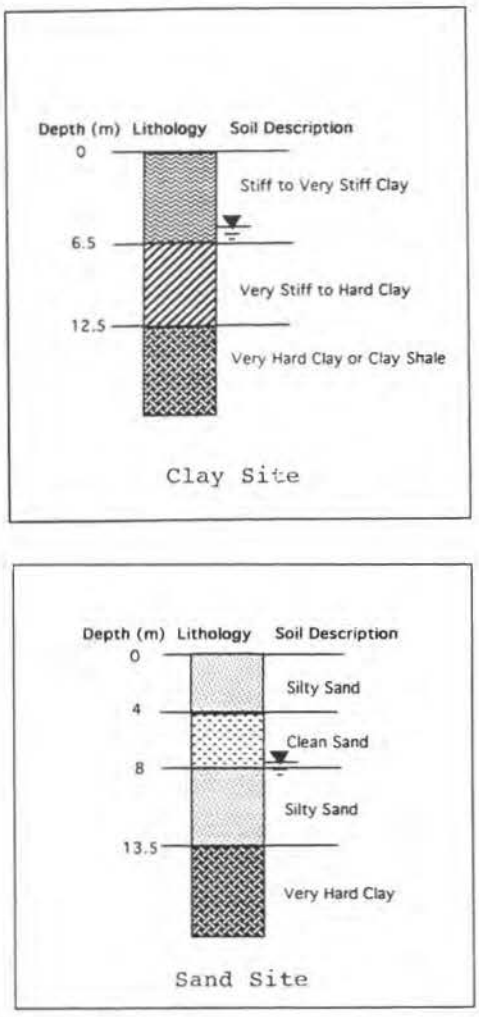

FIGURE 5 - Soil Profiles for TAMU Sites

Improvements at this site has been in the form of providing electrical power and water at the site. New topographic and planimetric maps were drawn and a Geodetic Benchmark was installed according to NOAA specifications. Additionally, the substantial data already collected at this site have been incorporated in the NGES database and also published as part of a separate extensive report (Marcontell and Briaud, 1994).

TAMU Sand Sub-Site

The sand sub-site consists of the Lakeland-Derby deep sands which were derived from excessively drained soils of the coastal plain uplands. These sands are quartz-rich, have high permeability and are vulnerable to wind and water erosion. The profile consists of two silty sand layers separated by a 4 m thick clean sand, Fig. 5. The water table is at a depth of about 8 m, near the bottom of the clean sand. Under the sands is a very hard clay.

Two substantial full-scale soils structure experiments have been performed at this site. The first consisted of a 70m long by 5m high embankment passing over a full-size, instrumented culvert. The second consisted of an instrumented, 60m long and 8m high tied-back, ground-anchored, wall, Fig. 7. Many in situ tests were performed in connection with these full-scale structures including pressuremeter and seismic velocity measurements.

This sub-site was also the location of the SETTLEMENT 1994 Prediction Symposium for Spread Footings on Sand sponsored by the Federal Highway Administration and held in conjunction with the ASCE Geotechnical Engineering Division Specialty Conference on the prediction of Vertical and Horizontal Deformations for Foundations and Embankments over sand. Considerable new characterization data were collected for this settlement event in the area shown in Fig. 8. A full scale footing load test shown in Fig. 9.

FIGURE 6 - Pile Load Tests, TAMU Clay Site

FIGURE 7 - Tied-Back Retaining Wall Experiment

FIGURE 8 - Sand Site for Spread Footing Tests

FIGURE 9 - Load Test on Spread Footing, TAMU

Improvements to this site after joining the NGES system have consisted of providing a portable office at the site, performing a topographic survey, and installation of a Geodetic Bench Mark according to NOAA specifications. Previous data collected at this site was included in the TAMU report (Marcontell and Briaud, 1994) on previous experience and was incorporated in the NGES data base for this site.

LEVEL II SITES

University of Houston

Site Owner: University of Houston
Site Manager: M.W. O'Neill (713) 743-4252
Catalog ID: TXHOUSTO

This site, Fig. 10, on the main campus of the University of Houston in Houston, Texas covers an area of about 0.4 hectare. Subsurface conditions consist of alternating layers of overconsolidated clay and silt with ground water at a depth of about 2.1 m. Figure 11 presents a basic profile of the soils at this site.

FIGURE 10 - University of Houston, NGES Site

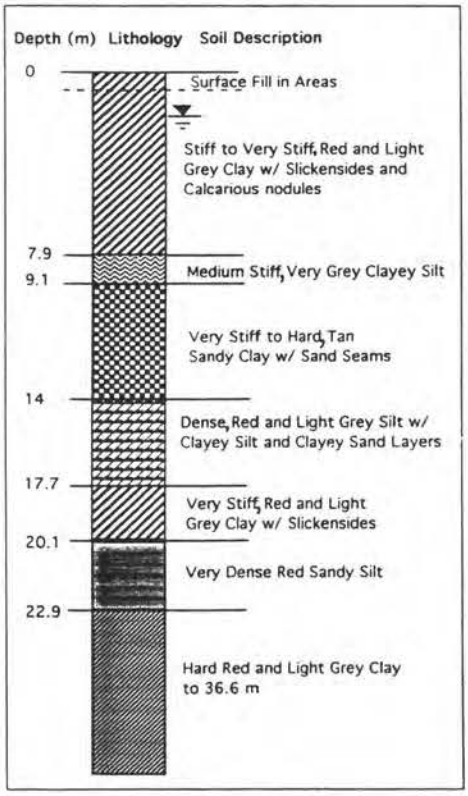

FIGURE 11 - Soil Profile, Houston Site

Some of the new data developed for this site after joining the NGES system have been: establishment of baselines for locating future activities relative to previous studies, and new soil data was acquired with the help of Fugro Geosciences. This new data consists of 4 Marchetti Dilatometer soundings with 4 tests in each boring and 3 CPTU tests with dissipation testing in three soundings.

Previous characterization of the site has been extensive and consists of several borings from which samples have been retrieved and subjected to various laboratory tests, SPT, CPT, pressuremeter, crosshole shear wave velocity, electrical logging, vane shear, and stepped-blade testing. These characterization efforts have been performed to support various studies on prototype foundations including: dynamic axial and lateral loading of single piles, drilled shafts (Fig. 12) and pile groups, compressional static behavior of pile groups, uplift of drilled shafts, behavior of unreinforced underreamed footings, behavior of piles during driving, capacity enhancement of drilled shafts using expansive concrete, and capacity of eccentrically loaded pin piles.

FIGURE 12 - Drilled Pier, Lateral Load Test

Northwestern University

Site Owner: Northwestern University
Site Manager: R.J. Finno (708) 491-5885
Catalog ID: ILNWULAK

This site along the Lake Michigan waterfront on the Campus of Northwestern University, Evanston, Illinois, consists of a 0.6 hectare part of the sand filled area constructed in 1966 to increase the area of the university campus.

The geology of the area is dominated by the glacial advances and retreats during the Wisconsin Stage of glaciation. The repetitive process of advance and retreat of glaciers were marked by terminal moraines and left readily identifiable strata consisting primarily of cohesive soils. The complex ice margins were deposited underwater when Lake Chicago was 18 m higher than the current level of Lake Michigan. The fine sand fill extends to a depth of 7-8.5 m and was deposited by bottom-dumping from barges up to lake level. Then the sand was removed from barges by clamshell buckets and spread with bulldozers without special densification to bring the elevation up to current level. Figure 13 shows a profile of this site.

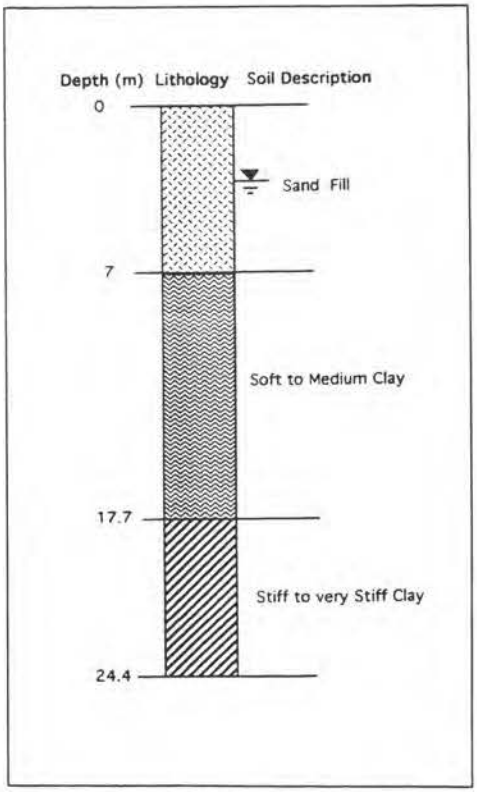

FIGURE 13 - Northwestern University, Lake-Fill Site Profile

FIGURE 14 - Pile Driver at Northwestern Site

Extensive site characterization was performed at this site in preparation for the 1989 ASCE Geotechnical Congress, at which a pile load prediction event was held. Four test piles and nine anchor piles were installed for this prediction event, Fig. 14. Available in situ data includes SPT, CPT, uCPT, DMT, and PMT measurements. Furthermore, laboratory data include index tests; mineralogy; consolidation; and UU, and CK_oU TXC and TXE triaxial tests.

Work done for this site after being selected as an NGES site has included preparing the site data for the NGES database and drilling a sample boring to obtain specimens for further laboratory testing. The new boring was 27.1m deep. Split spoon samples were obtained in the sand and 76.2 mm diameter thin wall tubes were pushed in the clays.

University of Massachusetts

Site Owner: University of Massachusetts
Site Manager: A.J.Lutenegger
(413) 545-2508
Catalog ID: MAUMASSA

This site consists of an area of about 1.2 hectares on the campus of the University of Massachusetts in Amherst, Massachusetts. The site has been used for about 5 years for research on in situ testing and behavior of deep foundations.

On the site is one research/support building with an office, restroom, machine shop with tools, and a small storage building. Electricity and water are also available at the site.

Site geology is dominated by lacustrine varved clay deposits of Glacial Lake Hitchcock of the late Pleistocene, early Holocene age when an ice dam formed in northern Connecticut. The deposits at the site generally are in the age range of 10,000 - 8,000 years old. A considerable body of field testing data from a variety of tools is available including CPTO, seismic cone, DMT, PMT, BST and FVT, as well as the results of a number of deep foundation tests, and laboratory tests including index tests, CIUC triaxial, consolidation, hydraulic conductivity, direct simple shear, and direct shear box.

The maximum depth of exploration on the site is about 24.4 m, however, nearby borings allow estimation of the entire profile at the site. The upper meter consists of cohesive fill and this is underlain by about 36.6 m of lacustrine clay of the glacial Lake Hitchcock. The upper 7.6-9.1 m of this clay is an overconsolidated crust, while the remainder is lightly to normally consolidated. Figure 15 shows a simplified profile of this site.

Model pile load tests, and small diameter pile uplift tests are continuing, while anchor shafts were installed for future pile load tests. The next scheduled improvements for this site include exploring the possibility of increasing the area of the site by annexing a nearby parcel of land, testing to establish in situ stress conditions, and additional laboratory undrained shear strength testing.

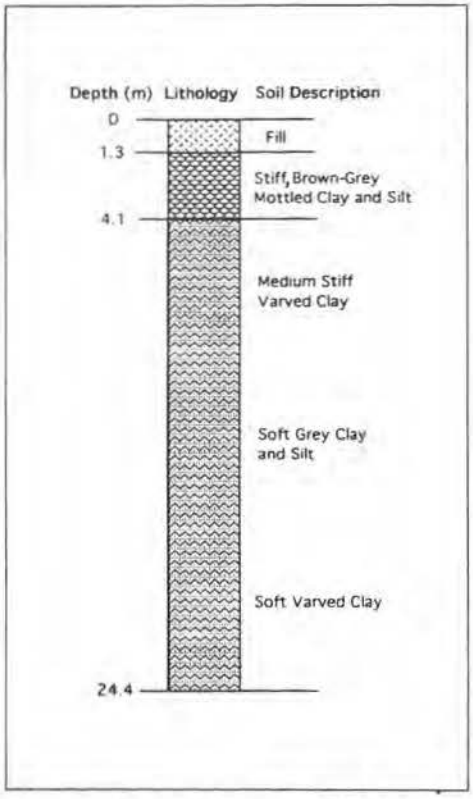

FIGURE 15 - Soil Profile at UMASS, NGES Site

The first effort after joining the NGES sites was to compile existing laboratory and field data and enter same into NGES database. All existing test locations were surveyed, standpipe piezometers were installed at depths of 28, 15, and 18 meters, Fig. 16, pneumatic piezometers were installed at 15, 17 and 24 meters to supplement existing piezometers and thermocouples were installed throughout the upper 4.6 m. An 24.4 m deep wash boring was conducted from which 76.2 mm diameter fixed piston samples were obtained at 1.5 m intervals for laboratory tests. A shallow boring was performed to obtain continuous samples with a Laval sampler for future laboratory tests. Push-in piezometers were installed at 12.2, 15.2, and 18.3 meters for horizontal permeability (K_H) and hydraulic fracture tests.

FIGURE 16 - Installation of Pneumatic Piezometers at UMASS Site

CONCLUSIONS

A resource is available to geotechnical engineers for testing new ideas for earthworks construction, in situ measurement of earth parameters, and long term measurement of ground behavior. The NGES sites are available to all interested users, government, university and private sector. The well-characterized NGES sites should encourage a variety of field experiments which should lead to better, safer and more economical earth structures.

Any interested engineer is encouraged to obtain a floppy disk version of the NGES Database from Prof. Jean Benoit, University of New Hampshire.

ACKNOWLEDGEMENT

The National Science Foundation, Directorate for Engineering; Geomechanical, Geotechnical & Geo-Environmental Systems Program, and the Federal Highway Administration, Office of Engineering and Highway Operations Research, Materials Division have provided the funds to initiate the National Geotechnical Experimentation Sites. The cooperation of these agencies in jointly funding these sites represents a welcome development in the funding of geotechnical research. This is greatly appreciated by the geotechnical community.

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