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Virginia Transportation Research Council

research report

Implementation of gINT Software at the Virginia Department of Transportation

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16. Abstract

A set of software tools was developed to enable staff of the Virginia Department of Transportation (VDOT) and consultants to streamline processing of subsurface exploration data. Built around the gINT program (geotechnical database and graphics package), these tools allow generation of various geotechnical outputs with a high degree of uniformity. Capabilities include data export to GEOPAK and MicroStation, including automated post-processing, resulting in final drawings conforming to VDOT office practice.

In this project, various macros and configuration files were assembled into a single installation file, allowing users to configure their workstation quickly for VDOT projects. The system has already been implemented at VDOT. The install program can be downloaded from the website of VDOT's Materials Division at http://www.virginiadot.org/business/materials-download-docs.asp. A detailed instruction manual is also posted, providing step-by-step directions. The use of this software significantly reduces borehole log preparation time and ensures consistency of output, the latter resulting in a higher quality end product.

It is estimated that a VDOT geologist saves approximately 2 full days of work per typical bridge project when using this software, which translates into an approximate cost savings of $600 per bridge. Truly significant savings can be realized over a longer period of time. In the past, some VDOT borehole logs generated manually on paper were not readily accessible after project completion. As a consequence, when new projects were proposed in the vicinity of existing roads and structures, the subsurface information was lacking, necessitating additional exploration, often at great expense. For example, it is estimated that many over water drilling projects can cost approximately $10,000 per day. The software developed through this project will also allow an improved archiving process, thus providing better information regarding local subsurface conditions. It will also help determine if additional boreholes are necessary. Finally, it will allow sharing of subsurface data with consultants and contractors.

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Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation and
the University of Virginia since 1948)

In Cooperation with the U.S. Department of Transportation
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DISCLAIMER

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INTRODUCTION

Geotechnical site investigations are routinely conducted for various transportation projects in order to obtain relevant subsurface data. Typically, the process involves drilling boreholes and collecting information on the type and nature of the material encountered. Large volumes of records are generated, necessitating an effective data management system. In most cases, the geotechnical work needs to be completed before the final design can begin. Timely preparation of reports and logs of subsurface exploration is essential. There is also a need to archive subsurface data for potential future use. Substantial cost savings can be realized if "old" data are available and accessible when at some future date a nearby "new" project is proposed.

PURPOSE AND SCOPE

The purpose of this project was to develop a set of software tools that would enable staff of the Virginia Department of Transportation (VDOT) and consultants to streamline the process of generating and archiving geotechnical data. The essential element in this process is uniformity. Uniformity ensures that the type of data collected and the manner of data presentation are the same for every road and bridge project undertaken by VDOT, anywhere in Virginia. The resulting process is transparent in terms of the expected output and enforces data consistency. It also lends itself to an automated task of data archiving and retrieval.

This project was limited in scope to the development of software for processing data collected by drilling and sampling boreholes in accordance with ASTM D 1586-08, Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils,[1] and soundings conducted in accordance with ASTM D 3441-05, Standard Test Method for Mechanical Cone Penetration Tests [CPT] of Soil..[2]

METHODOLOGY

The main requirement, as identified by VDOT, for subsurface data management software is to "input data only once" and "output data in a multitude of report formats." Effectively, satisfying the requirement requires a database tool that is tailored to geotechnical applications. The user who provides input is typically a geologist or a geotechnical engineer. The software must be designed to make his or her task of compiling and presenting subsurface data fairly quick and efficient without the need to deal in the operational complexities associated with many sophisticated database programs.

VDOT joined a growing number of leading consultants, contractors, and government agencies in selecting commercially available gINT database software as the mainstay for geotechnical data manipulation.[3] The system incorporates data entry in the MS Access format and provides for a wide range of output reports. A powerful relational database allows flexibility and control over the design of data entry formats, report formats, and Structured Query Language (SQL) queries. gINT Software has been in business for approximately 20 years.

It is important to recognize that gINT software is not a tool that works “out of the box.” It offers functionality that needs to be adapted, harnessed, and customized by programming various components, such as the type of data entry structure, layout and content of final reports, processing of numerical calculations, and structuring of queries. All these components must interact effectively to deliver the final product. In essence, gINT database software offers a framework upon which the geotechnical data management system is structured by a user.

The first step in adapting gINT software to VDOT business needs involved deciding on the type of field data that must be collected on a typical project. Personnel of VDOT’s Materials Division and VDOT’s Structures & Bridge Division in conjunction with district geologists jointly arrived at a list of elements that would form a core of the data entry structure. The underlying philosophy was to specify the absolute minimum number of required inputs, rather than attempting to collect data on all possible field situations. Subsequently, customized data entry templates were developed for SPT boreholes and CPT soundings. ASTM D 2488 (Standard Practice for Description and Identification of Soils) was followed for creating a list of soil group symbols.[4]

It was also recognized that there is frequently a need to access various data elements for project monitoring and accounting purposes. Consequently, a number of SQL queries were developed to allow quick automated reporting of the total length of subsurface drilling on a given project and to account separately for the extent of soil sampling and rock core drilling.

The next step involved the number and format of required output log reports. There are many effective ways to present subsurface data, as geotechnical reports received from various consultants would attest. VDOT personnel jointly decided on the layout and the composition of each output report. It was decided that VDOT should have the capability of outputting a single SPT log (8.5- by 11-in page size), single CPT log, multiple (composite) SPT logs on a single sheet of full-size or half-size drawings, and multiple CPT logs. In addition, a number of “fence diagram” output reports (full-size or half-size drawings) designed to allow subsurface cross sections between individual borings were developed.

As the functionality of gINT evolved to address VDOT’s needs, the issue of interoperability became important. VDOT, as with any large public agency, uses various software packages in the process of creating design drawings. The primary drafting package is MicroStation, recently supplemented by GEOPAK. Since most road and bridge plans are prepared with these programs, a set of customized macros was developed through this project to allow gINT users to interact, exchange, and post-process data. Another set of macros and configuration files was developed to interface gINT with Trimble GeoXT GPS units used by district geologists to collect position data.

RESULTS

Figure 1 is a flowchart of the geotechnical data processing system developed in this study. It includes gINT software as the main processing component, with field data entered manually by a user and location coordinates fed electronically from a GPS device. Output reports include single logs, composite logs, and fence diagrams. These reports can be exported into MicroStation for automated post-processing and inclusion into a set of design drawings on a given project. Geotechnical data can also be exported to GEOPAK for further processing.

All customized software components were integrated into a single installation program named “vdot.exe.” This is a self-extracting executable program that copies various component files to appropriate folders. It is designed for users who already have gINT and MicroStation

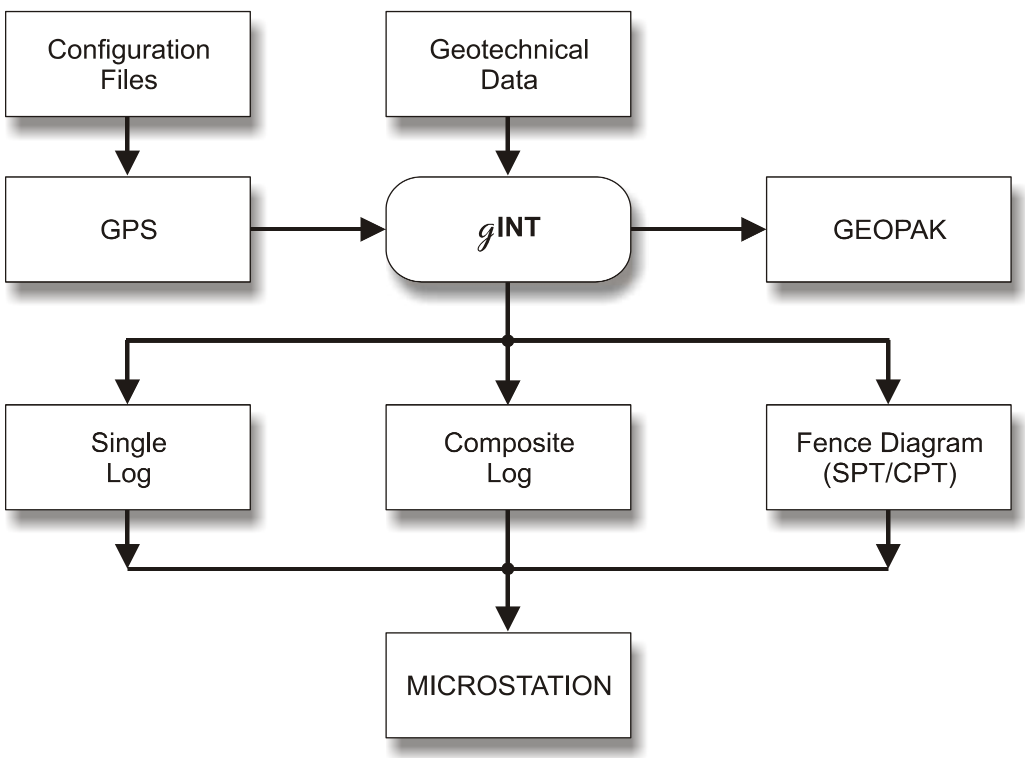

Figure 1. Geotechnical Data Processing at VDOT

installed on their computers. The program was created with NSIS (Nullsoft Scriptable Install System) open source software.

The system has already been implemented at VDOT. The install program can be downloaded from the website of VDOT's Materials Division at http://www.virginiadot.org/business/materials-download-docs.asp. It is listed as GEOXT, GINT, MicroStation, and GEOPAK Integrator. A detailed instruction manual is also posted, providing step-by-step directions. Currently, the use of this program is required by VDOT's Materials Division on all VDOT geotechnical projects. Sample output reports are provided in the Appendix.

DISCUSSION

In the not too distant past, a geologist would manually prepare the borehole logs in a hardbound 4.5- by 7-in log book that would be loaned to a draftsman for preparation of the Mylar sheet to be incorporated with the bridge construction plans. Assuming that a bridge project involved four to six boreholes, the procedure would require about 2 days work for the geologist and then for the skilled draftsman.

Comparing that scenario with the present, the geologist spends marginally less time entering data, but the resulting material is instantly available for multiple forms of presentation without the need for a draftsman. The step of exporting data from gINT to MicroStation is automated, greatly reducing the amount of time needed to complete the final drawing. A macro automatically turns imported gINT data into a final MicroStation drawing conforming to VDOT standards within seconds. Further, all output reports are accessible for electronic transmission and storage. The use of customized software developed through this project has resulted in standardization and a high-quality flexible end product that can be effectively re-used.

Since gINT software is based on the Access database format, it easily lends itself to GIS applications. Efforts currently under way at VDOT include development of a robust Geotechnical Database Management System (GDBMS) that combines elements of gINT with ArcIMS and offers a web-based access.[5] The GDBMS server dynamically creates user-defined logs and fence diagrams. It interfaces with the existing report structure without the need for additional processing of gINT project files. The system allows VDOT personnel and consultants quick access to the geotechnical data. This is especially important for projects under the Public-Private Transportation Act or design/build projects.

CONCLUSIONS

- *The customized set of macros and configuration files developed in this study to tailor gINT functionality for VDOT applications allows interoperability with MicroStation and GEOPAK.*

- *The software developed in this project has been implemented at VDOT, and its use is required by VDOT's Materials Division on all geotechnical projects.*

RECOMMENDATIONS

1. *VDOT' Materials Division should ensure the use of customized gINT software on all subsurface explorations projects.*

2. *The Virginia Transportation Research Council should maintain and further develop customized output reports for gINT. One possible future application may be laboratory geotechnical test results that can be linked to the appropriate borings in the GDBMS environment.*

3. *The Virginia Transportation Research Council should continue efforts to develop a robust GDBMS combining gINT with ArcIMS and offering web-based access to VDOT personnel and consultants.*

COSTS AND BENEFITS ASSESSMENT

The most obvious benefit of using the software package developed in this project is the time savings realized in subsurface data preparation. Various tasks are now automated, allowing a user to generate final output quickly in accordance with VDOT office practice. It is estimated that a VDOT geologist saves approximately 2 full days of work per typical bridge project when using this software, which translates into an approximate cost savings of $600 per bridge. In addition, output consistency is ensured, resulting in a higher quality end product.

Truly significant savings can be realized over a longer period of time. In the past, some VDOT borehole logs generated manually on paper were not readily accessible after project completion. As a consequence, when new projects were proposed in the vicinity of existing roads and structures, the subsurface information was lacking, necessitating additional exploration, often at great expense. For example, it is estimated that many over water drilling projects can cost approximately $10,000 per day. Over time, VDOT has collated an impressive marine geotechnical database in the Hampton Roads District. The software developed through this project will also allow an improved archiving process, thus providing better information regarding local subsurface conditions. It will also help determine if additional boreholes are necessary. Finally, it will allow sharing of subsurface data with consultants and contractors.

ACKNOWLEDGMENTS

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APPENDIX

EXAMPLES OF SUBSURFACE DATA PRESENTATION

Virginia Department of Transportation

VDOT

PROJECT #: 0050-053-119, C501
LOCATION: LOUDOUN COUNTY
STRUCTURE:

06BH-236

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STATION: 1105+00
OFFSET: 60 ft LT
LATITUDE: 38.963860 °N
LONGITUDE: 77.608141 °W
SURFACE ELEVATION: 357.9 ft
COORD. DATUM: NAD 83

Date(s) Drilled: 7-7-06 - 7-10-06
Drilling Method(s): 2.25" HSA
SPT Method: Automatic
Other Test(s): NW Coring
Driller: D. Finks
Logger: P. Coates

GROUND WATER
NOT ENCOUNTERED DURING DRILLING
STABILIZED AT: 11.8 ft (346.1ft ELEV.) AFTER 140 HRS

FIELD DATA

SOIL

SAMPLE INTERVAL (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	MOISTURE CONTENT (%)
0 - 2	0 1 1	27.8
2 - 4	2 3 2	25.1
4 - 6	3 7 9	15.5
6 - 8	6 17 30	9.8
8 - 8.75	35 50/3"	10.1
10 - 10.3	50/4"	11.6

ROCK

SAMPLE INTERVAL (ft)	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION
13.6 - 16.1	100	92
16.1 - 21.1	100	39
21.1 - 26.1	100	17
26.1 - 31.1	100	0

FIELD DESCRIPTION OF STRATA

0.0 / 357.9
Topsoil **TOPS**

0.3 / 357.6
Brown fine sandy lean CLAY, trace wood debris, soft, moist, FILL (CL) **FL**
-- firm with thin viens of grey clay below 2'

4.0 / 353.9
Brown f-c sandy lean CLAY, trace fine rock fragments, very stiff, moist, FILL (CL) **FL**

6.5 / 351.4
Reddish brown f-c sandy SILT with fine, thin, friable, rock fragments, micaceous, very hard, dry, (highly weathered SILTSTONE) (ML) **ML**

-- augers grinding in rock 10' to 13.6'

-- Auger Refusal at 13.6'

13.6 / 344.3
Slightly weathered, moderately hard, massive, highly jointed (open and healed, 40° to 60°), grey fine grained calcareous SANDSTONE, thin calcite stringers throughout; mild reaction to dilute HCl in all specimens **SST**

14.6 / 343.3
Moderately weathered, moderately hard, thin bedded, highly jointed (open and healed, 40° to 60°), grey to red brown, calcareous SILTSTONE, thin calcite stringers throughout; mild to moderate reaction to dilute HCl in all specimens **SLS**
-- soft and highly weathered from 17.9' to 19.3'
-- thin interbedded layers of fine SANDSTONE from 19.3' to 19.8'

-- moderately hard and highly weathered from 19.3' to 31.1'

-- healed vertical joint (+/- 85°) in core from 28.7' to 31.0'

Coring Terminated at 31.1 ft.

REMARKS: RIG TYPE: CME 550 ATV.
SPT sample tube was driven through four 6-inch intervals where 24 inches of penetration was possible; hammer blows through only the first three intervals are shown for clarity.

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06BH-236

SPT_LOG:0050GILBERTSCORNERSOILSURVEY.GPJ;8.1.023;050108;5/13/08

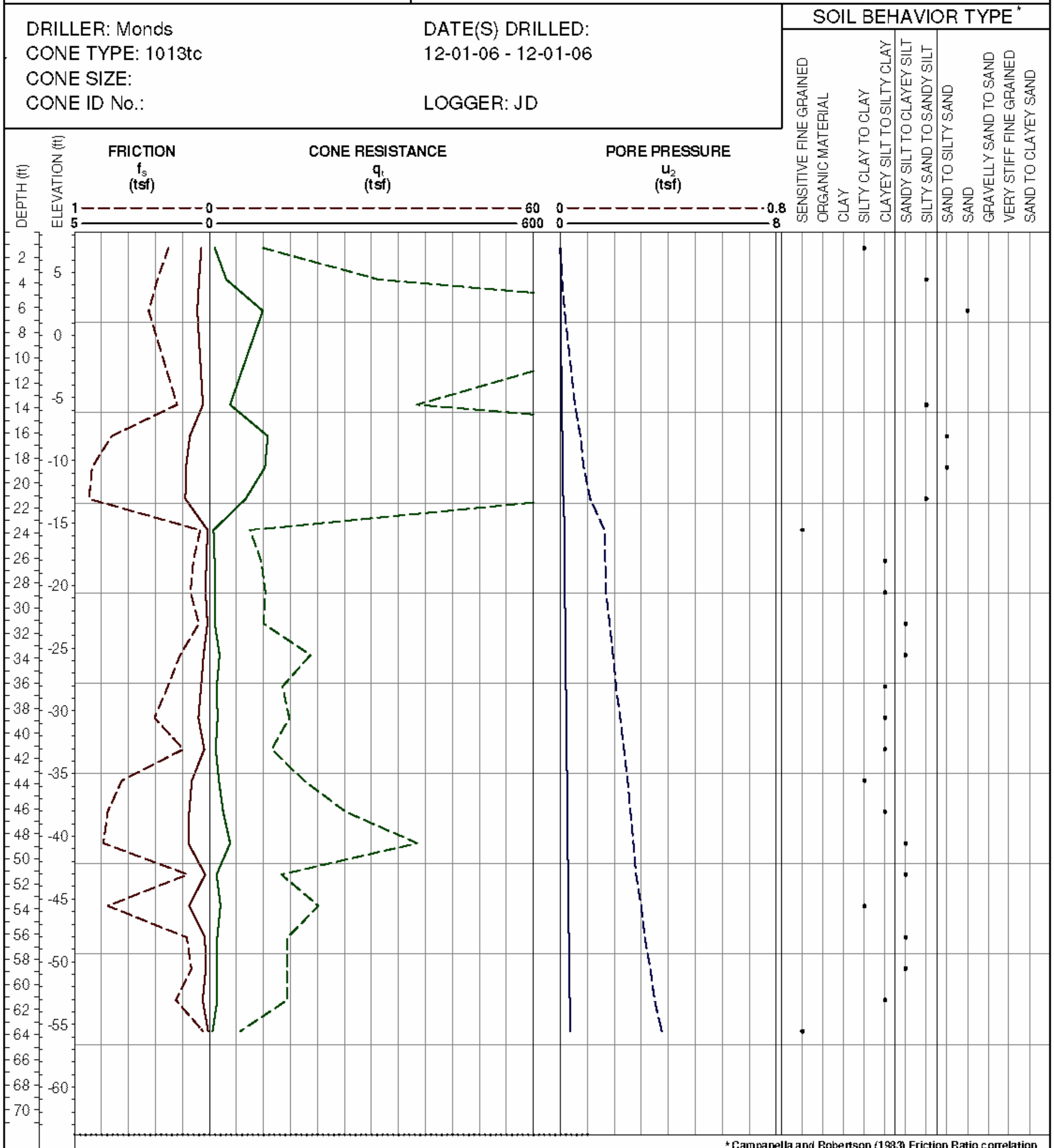
CONE PENETROMETER TEST LOG

Virginia Department of Transportation VDOT	PROJECT #: 0064-131-F11, PE105 LOCATION: I-64 (WB) Soundwall	CPT-87 PAGE 1 OF 1
	STATION: 10+88 LATITUDE: 36.757844 °N SURFACE ELEVATION: 8.2 BENCHMARK LOCATION:	OFFSET: 16 ft LT of centerline LONGITUDE: 76.277236 °W COORD. DATUM: NAD 83

DRILLER: Monds
CONE TYPE: 1013tc
CONE SIZE:
CONE ID No.:

DATE(S) DRILLED:
12-01-06 - 12-01-06

LOGGER: JD



REMARKS:
PPMS ID: 00076725

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CPT_LOG:0064_131_F11_PE105.GPJ;8.1.018;050307;8/7/07