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Geotechnical Data Management of the New Doha International Airport Platform Reclamation

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ABSTRACT

The Platform Reclamation and Armoured Revetment project of the New Doha International Airport (NDIA) involved a large variety and quantity of geotechnical in situ testing, laboratory testing, and monitoring. All geotechnical data was managed, calculated, validated, screened, analysed and reported by one Geotechnical Database Management System (GDMS). In addition to periodic paper and PDF reports, electronic data was automatically provided to the client daily in AGS 3.1 Format. The GDMS was developed by personnel based both on and off site using off-the-shelf software and custom add-ons; having a developer with geotechnical knowledge on site working along side the end-users improved the quality and speed of the system delivery - this was integral to the success of the project. The all-in-one system minimised data errors and streamlined the entire data process, which improved data quality, presentation and reporting time.

1 INTRODUCTION

The New Doha International Airport (NDIA) Platform Reclamation and Armoured Revetment is one of the largest reclamation projects undertaken to date. The platform has an area of 22 to 23 km² and required a net fill quantity in excess of 60 million m³, of which over 80% was reclaimed from the sea, involving dredging of limestone rock and offshore sands from borrow areas. Hydraulic reclamation works commenced in January 2005 and were completed by mid October 2006, whereas the related dry fill works were scheduled for completion in July-August 2007.

The works are realised for the State of Qatar represented by the Steering Committee New Doha International Airport (Client). The Steering Committee appointed Overseas Bechtel Incorporated (OBI) as Engineer. The Platform Reclamation and Armoured Revetment contract package was awarded to the Joint Venture NDIA consisting of Qatar Dredging Company from Qatar, Dredging International from Belgium, Boskalis Westminster from the Netherlands, and Great Lakes Dredge & Dock Company from the USA.

A significant quantity and variety of geotechnical testing and monitoring was specified in the contract's Technical Specifications. This included some 11 lab test types, 7 in situ test types and 5 monitoring types. It was initially estimated that 30,000 to 35,000 tests of all types would have to be done. The contractor was requested to implement a Geotechnical Data Management System (GDMS) and submit AGS 3.1 Format (AGS UK 2005) data on a daily basis for newly collected data, in addition to the periodic printed/PDF reporting for area handovers.

After investigating a number of commercially available GDMS and taking into consideration the development of a fully customised tailor made solution, the contractor selected a commercially available GDMS with customisation.

Ultimately more than 240 MB of data, 7,700 test locations, 13,200 lab tests, 12,500 field tests and 136 instruments with 2 years of readings were stored in the GDMS.

2 TECHNOLOGY EMPLOYED

The GDMS was developed using gINT Professional (commercially available GDMS) and Microsoft .NET technology. The commercially available GDMS was the primary user interface and reporting engine using a Jet/Access database backend. .NET was used in conjunction with the commercially available GDMS' object model to develop the database calculations and other non-native functionality (i.e. functionality that is not standard in the commercially available GDMS software).

In order to keep file size down the project was split (mostly) geographically into 10 database files. Ultimately the Contractor's system was run using Windows Terminal Services, in order to overcome the data access speed issues. At that time the selected commercially available GDMS did not natively support a more robust database format. However, the advantages of the selected commercially available GDMS outweighed this disadvantage.

The GDMS was developed and supported by personnel based in USA, UK, Australia, and on site in Qatar. A significant amount of the development was done on site by a developer with geotechnical knowledge; this was integral to the success of the software project.

3 TYPES OF DATA

There are four main types of data related to geotechnical field and laboratory data (DIGGS Committee, 2006):

1. Metadata about the test (includes the testing standard procedure designation followed)
2. Testing data and parameters derived from the test
3. Raw data from the test from which the parameters can be derived
4. Calibration data

The GDMS stored all of these data types, and calculated or manipulated the test parameters based on the raw data, metadata and calibration data. The advantages of this type of system included:

1. Data is entered only once which minimises the risk of transcription errors
2. Negates the need to import data calculated by a second software application (e.g. Excel)
3. It gives more confidence in the correctness of the calculations, as opposed to numerous individual spreadsheet files.

4 EXECUTION OF WORK AND TEST TYPES

The Contractor's reclamation and dredging operations were continuous 24 hours a day and 7 days a week throughout the execution period. The on-site geotechnical laboratory at the NDIA was organized to be operational during the same hours to optimise the feedback of geotechnical results.

Most tests were carried out to British Standard, otherwise ASTM standards were used. Table 1 summarises the data types and quantity of testing.

5 GENERAL FEATURES

5.1 Data entry

All basic data was entered directly into the GDMS native interface. This included primary data entry of field and lab data not recorded by a data logger. Many timesaving automated tasks were implemented such as pre-populating tables with depths or predictable readings before the data was entered.

5.2 Data validation

Many lab test standards define limits and accuracy that the data should comply with. For example the PSD tests should always decrease in percent passing as the particle size decreases, and check sums at various parts of the test must meet set differences. These checks were done as part of the custom calculations and reported to the user.

Table 1: Test Types and Number

Group	Test Type	Approx Number
Laboratory	Moisture content	6233
	Lab density	0
	Atterberg	1477
	Sieve (wet and dry)	3759
	Hydrometer	0
	Particle density	5
	Dry density - moisture content relationship	977
	CBR	205
	Min and max density by vibratory table	577
	Shear box	0
	Point Load Index	0
In situ	CPT	1620
	Zone load tests (ZLT)	69
	In situ density (sand replacement)	4111
	In situ CBR	1300
	Dynamic probe penetrometer	1208
	Test pit	4152
	Borehole	30
Monitoring	Settlement markers	105
	Rod settlement gauge	11
	Deep datum	9
	Standpipe piezometers	21
	Magnetic extensometers	17

5.3 Component descriptions

A soil component description model to British Standard was used for all test pit and borehole material description. As described in Caronna and Wade (2005) this was implemented to enforce consistency of the descriptions and improved validation.

5.4 Specification checks

Specification requirements related to each field and lab test for the numerous fill types were stored in the database. “On Save” each test result was compared to the relevant specification requirement and a pass or fail assigned. The acceptability of each result could be instantly viewed after data entry and was displayed on reports.

5.5 Data security and approval

One of the Contractor’s major concerns was the possibility that unapproved data may be provided to the Engineer by electronic means (AGS or database copy). In addition they wanted to ensure that once data was approved it could not be changed by subsequent users. A security system was implemented that incorporated the following aspects:

1. Each Hole ID and lab test was assigned a Status (0 unchecked to 3 for client export). A test pit log set to Status 3 would be exported, but a PSD for that test pit at status 1 would not be exported.
2. Each user of the database was registered in the GDMS and assigned to a security group. Administrators could use any function and edit status or data, whereas the lab data entry group could not change Status ≥ 2 data and didn’t have access to some native and custom functions.
3. Time-saving tools were developed to help the Contractor’s engineers’ approve data for hand over areas.

5.6 Surfaces and original ground elevation calculation

An important issue relating to the CPTs was to know the original ground elevation (in survey) at each CPT location. This allowed the engineers to accurately know which material the test was done

through, either natural ground or dredged material. The GDMS was customised to import large surface files and on command interpolate the original ground elevation at each Hole ID location.

5.7 Maps and backing data

On a daily basis the Contractor's engineers and technicians created maps using the GDMS. DXF backing data was imported into the system and was used in the GIS interface and on printed maps (Figure 1).

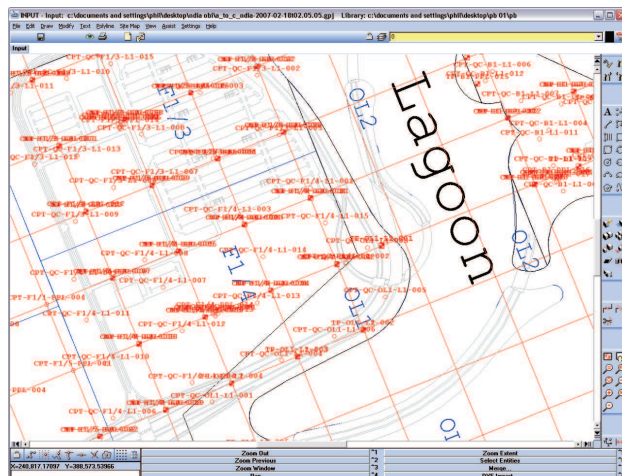


Figure 1: GIS map interface

5.8 Fence diagrams (sections)

Sub surface sections (fence reports) were produced displaying CPT data, in situ density, and surfaces. These proved particularly useful when investigating the testing data below specific structures.

5.9 Automatic lab sample soil descriptions to British Standard

The GDMS has native functions to classify and describe soils based on the PSD and Atterberg results; this was used to describe some lab samples for reporting purposes.

5.10 Data import

Both native and custom import functions were used to efficiently import the following data types:

1. CPT Gorilla! ASCII files - a propriety CPT data file format produced by the CPT equipment
2. Zone Load Test data logger ASCII files
3. Excel for many purposes e.g. survey data

5.11 Standard reporting

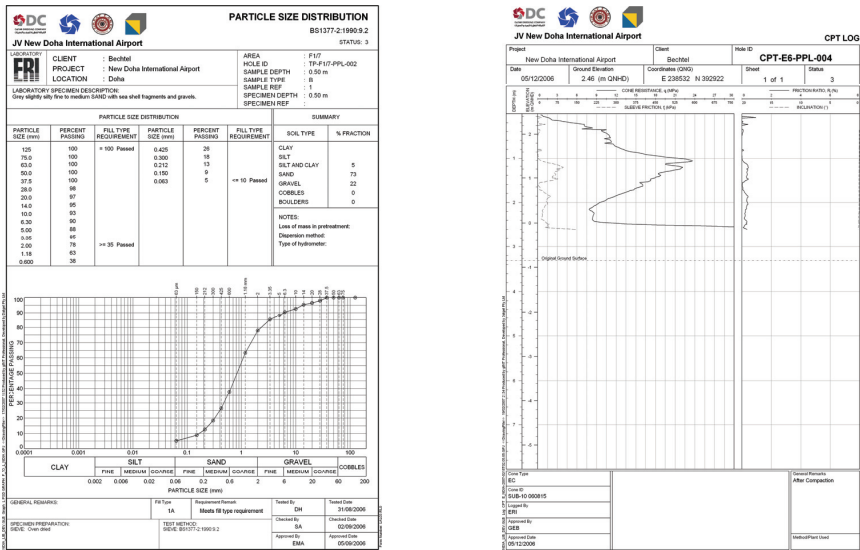
The GDMS was used for all standard reporting (Figure 2). This included individual lab and in situ test reports, instrumentation installations, monitoring time related data, and standard summary/analysis. All reports were exported to PDF or printed in colour and black & white. Following is a summary of the report types and scope:

1. Log reports (6) - test pit, borehole, CPT, well, extensometer (displacement with geology)
2. Fence/sections (5) - showing surfaces, CPT data and in-situ density results
3. Graphs (43) - lab tests, CPT summaries, lab and in situ test summaries, monitoring time graphs
4. Histograms (2) - percent fines and dry density
5. Table reports (21) - monitoring data, lab and in situ test data and summaries

- 6. Other reports (10) - all data groups
- 7. Site Maps (7) - standard and ad hoc line maps with CAD backing data

A native feature of the GDMS is filtering at output time. This allowed the users to limit the data output, for example the users only printed data in a certain site area and tested in a certain data range. They also used the range filter to only print lab test data in certain soil types defined on the geology table.

The GDMS has scripting functionality which has ability to record a series of reports to output; this was used to automate repetitious tasks and periodic reporting such as hand over area and monthly monitoring reporting.



5.12 Ad hoc analysis and reporting

In addition to the standard reporting of individual tests, summaries in both tabular and graphical form were required. These were presented using the GDMS, and in some situations practical interpretations were initially developed by means of the Excel export function in the GDMS, and once they had proven to be useful, tailored queries were developed to by-pass the use of two programs. Examples of where the GDMS’s reporting and analysis power was outstanding include the optimization of the compaction process (Avsar et al 2006) and in-situ mixing of silt with dune sand.

5.13 Electronic data for Client

The Contractor was required to provide the Engineer with electronic data on a daily basis, this system consisted of:

- 1. The AGS Creator, an executable program that calls the GDMS using scripts to repair and compact the live database files, export database files and AGS files containing only the data approved and in the case of the AGS file only data that was approved in the previous 24 hours, and record what it exported for quality assurance purposes.
- 2. Geotechnical Data Viewer, a custom application for the Client to query and view GDMS reports on the fly.

6 LESSONS LEARNED

As this was the principal author’s first project of this magnitude, many lessons were learned, both technical and managerial.

1. A comprehensive system like this takes a long time to develop, debug, maintain and support. Even after 2 years new issues arose that required changes to the code.
2. Run structured training courses that include all users. Follow up with web based training for those who missed the face to face training.
3. Internet based communication such as VoIP (voice over Internet Protocol) and web meeting services are useful and cost effective to supporting distant projects.
4. Documentation is important and useful to both users and developers particularly on long projects where personnel change over time. Comprehensive documentation was not part of the original scope, but was ultimately written.
5. A more robust database backend was required.
6. As the focus must be useability for all, one should listen to all users when designing and developing the system.

From a Client/Engineer perspective, specifying such a system enabled tight control of a data set of high quality to be demonstrated. The data set can be used for interrogation and determination of anomalous results. For projects of significant magnitude like NDIA, consideration should be given to institutionalisation of electronic data, which can then be manipulated as required for Quality Assurance purposes and future design requirements.

7 CONCLUSIONS

The JV NDIA Geotechnical Data Management System successfully fulfilled its aim of managing, calculating, reporting and transferring the large amount of geotechnical data in a timely and structured way. It also succeeded in its secondary aim to reduce the data management burden on the Contractor's engineers so they could concentrate on the technical and management aspects of the project.

Geotechnical data, especially substantial amounts of it, is only useful when it finds its way back into the field through the construction departments. This is essential to contribute to the execution of the Works. The GDMS has not only proven itself a useful tool for getting the data back in the field in a workable manner, it also has proven to be a necessity to report on a timely basis in a fast pace environment.

The ability to process data generated in the field in a timely manner, to allow all parties (Contractor and Engineer) access to the data set and to permit interrogation of that data set at any time for Quality Assurance purposes, would not have been possible without such a Geotechnical Data Management System. It should be noted that at the peak of construction, reclamation was at a rate of well above 4 Million m³ per month and geotechnical follow up had to keep up with this pace for a timely and on line reporting.

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