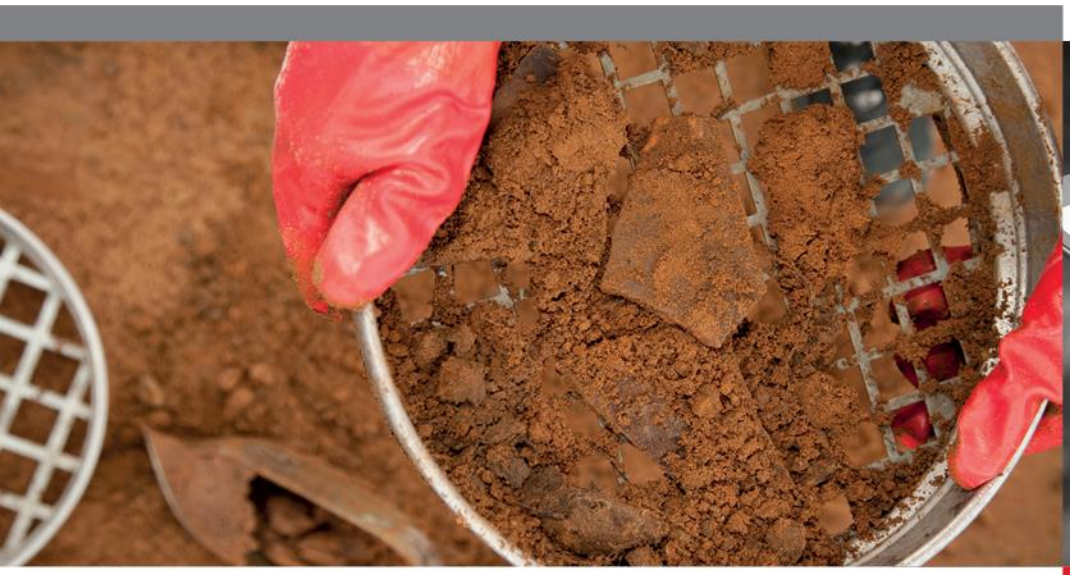

DFW Connector Project

Case Study

spectraqest®

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1 Project: DFW Connector, Texas, USA

Cost: US$1.02 billion
Owner: State of Texas
Head Contractor: NorthGate Constructors (a Kiewit and Zachry Constructors JV)
Construction Materials Testing: Professional Service Industries, Inc. (PSI, Inc.)
Website: www.DFWConnector.com

2 The Challenge

The DFW Connector is a $1.02bn publicly funded project to rebuild portions of four highways, two interchanges and five bridges. It is being designed and constructed by NorthGate Constructors, a joint venture between Fort Worth based Kiewit Texas Construction, L.P., and San Antonio based Zachry Construction Corporation.

The project is located north of DFW Airport, near the intersection of the area's four most populous counties. Incorporating state highways 114 and 121, and adjacent roads, the project site is a vital connection for the North Texas community. At the widest point along SH 114, between Texan Trail and International Parkway, the highway corridor will be 24 lanes wide.

On these very busy roads, minimizing traffic disruptions was imperative. This was achieved by building temporary pavements to shift traffic lanes and keeping all lanes open during peak travel times, as well as by minimizing overall construction time. To this end, the construction of the 8-mile initial phase of the project was expedited, with an expected construction time of around 4 years, rather than the usual 8-10 years for a project of similar scope.

An important aspect of achieving this was to minimize holdups during construction. This meant imposing test report turnaround times of 24 hours, which is an extremely tight timeframe, and one which most testing companies would find difficult to meet.

In addition, the funding bodies, including the Federal Highways Department, have an obligation to ensure the highest possible construction quality when spending $1.02 billion in public money. For this reason, they placed extremely stringent data collection and verification requirements on the testing companies.

Professional Services Industries, Inc. (PSI) was awarded the contract to provide Quality Acceptance Testing on this project. The following sections discuss how Spectra QEST's products were used by PSI to help meet the speed and quality objectives for materials testing and inspection on this vital project.

3 How the Challenge was Met

The testing process consists of the identification of testing to be undertaken, the allocation of that testing to a technician, the testing itself (both in the laboratory and in the field), the calculation and reporting of test results, and the distribution of the results to the relevant parties and systems. This process is often undertaken using disparate and highly manual systems. On this project, all of these steps were centralized on one very efficient, integrated system using Spectra QEST technologies and products.

Prior to the use of the QEST system, the assignment of work was undertaken manually, and communicated to the technicians at the end of each day via telephone, which would typically mean 2 hours on the phone for the dispatcher. Now, work orders are generated in QESTLab and assigned to the appropriate technician. A customized list of work to be undertaken then instantly appears on each technician's handheld device.

Without the QEST system, a field technician would record the results of field tests on paper worksheets. These would then be brought into the laboratory by each technician at the end of the day. A manual check was then undertaken to ensure that all the required worksheets had been received, after which the process of manual data entry would commence. This was a major bottle neck in achieving fast turnaround times, not only because the worksheets would not arrive until late in the day, but also because it would take the small team of data entry personnel considerable time to enter the data from around 40 field technicians. Missing or incorrect data could cause further delays while the field technician was contacted to clarify any discrepancies.

To appreciate the volume of test data in the DFW Connector project, consider that around 7,500 test reports were completed in a typical month (for example August '11), as follows:

- Roadway Daily Observation Report: 2559;
- Material Quantity Tracking Report: 1064;
- Aggregate/Soil Test Report: 721;
- Concrete Test Report: 677;
- External Test Report: 665;
- Field Density Report: 515;
- Reinforcing Steel Observation Report: 431;
- Field Particle Size Analysis Report: 208; and
- Other test reports: 780.

The results of these tests and inspections have a direct impact on the project as they form a critical part of the quality management process and are required to release hold points and allow construction to continue.

Figure 1. Field technicians using QESTField at the DFW Connector.

With the QEST system, data is entered in the field by the technician; test results are automatically calculated and are immediately available electronically in the laboratory. In addition, the technician is guided by the system to add all of the data correctly, significantly improving data quality.

Similar efficiency and quality improvements were also introduced in the laboratory.

The outcomes of these inspections and tests need to be reviewed/approved and provided to the appropriate stakeholders. These can be a contractor's representative or multiple representatives, the department of transport (TxDOT in this case) and any third party verification testing firm(s).

All this needs to happen in a timely manner. As mentioned previously, the DFW Connector project has a 24 hour report turnaround requirement from the completion of the test to the issue of a reviewed and endorsed test report.

The volume of test data to be managed and communicated is very significant in large road projects that require thousands of tests per month, and it is further amplified when the local Department of Transport requires test results, and often the intermediate measurements that go into these results, to be provided electronically to its systems for further analysis and QA purposes. Traditionally, the various stakeholders are given access to the Department's internal system where they manually re-enter quality data and upload test reports as appropriate.

In the DFW Connector project, this process was fully automated using the QEST system. With the press of a button, test reports and associated data are uploaded to a central portal, and stakeholders are notified that the reports are available. The reports and data are also automatically uploaded to the contractor's document management system, and to the Department of Transport's quality system.

The following sections discuss the various components of the QEST solution in more detail.

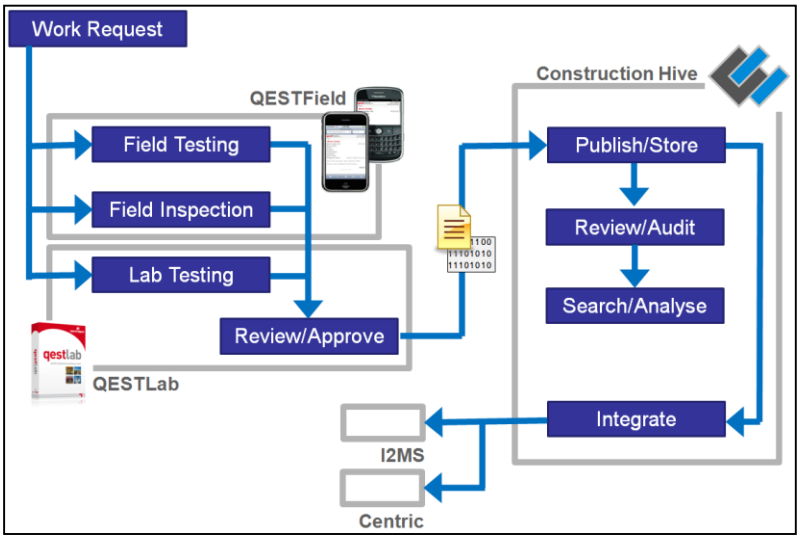


Figure 2. Workflow in the DFW Connector Project, and how the Spectra QEST products used (QESTField, QESTLab, Construction Hive) encompass various functions and contribute data to third party systems.

3.1 Laboratory Testing

QESTLab is the world's most powerful, most widely used and most commercially successful laboratory information management system (LIMS) specifically designed for the testing of construction materials. It caters for the testing of asphalt, bituminous materials, concrete, aggregates and soils – all in one system. The world's top five implementations of construction materials LIMS (in terms of numbers of laboratories using the system) all use QESTLab.

As is common with LIMS, the system manages all resources in the laboratory (personnel, security, tester competencies, equipment, calibrations, etc.) and all samples in the laboratory, supports the workflows as necessary and produces the laboratory's final product: reviewed and endorsed test reports. What is unique with QESTLab is that it explicitly supports over 500 different tests, common in construction materials testing, with fully functional electronic worksheets. Raw data go in the system once at the time of testing, calculations and verifications are performed in accordance with the relevant standards, and the review of test reports is electronic. The creation, issuing and distribution of test reports is automatic after they have been reviewed by appropriately authorized staff.

The system provided the project with a robust, auditable testing platform where all laboratory work is logged and is managed. The benefits such a system brings to the project are significant testing efficiency gains; better management of data, people and processes; standardization; and, in general, the ability to introduce and monitor best practice testing principles as they are described in ISO/IEC 17025:2005.

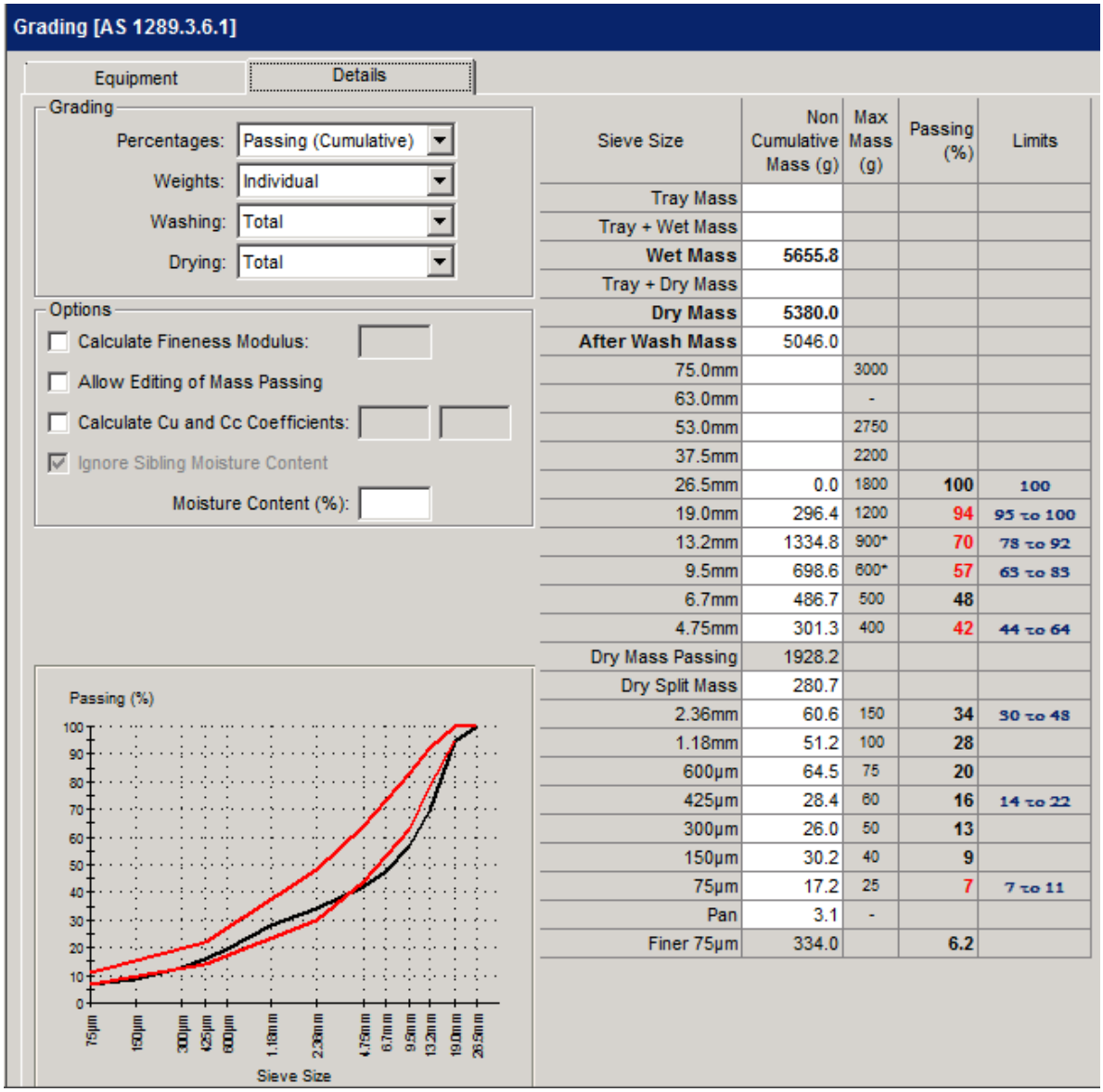
Further to the substantial benefits to the testing process, the use of QESTLab's extensive data mining abilities enables monitoring abilities for project staff that neither the contractor's document management system nor TxDOT's data analysis system allowed.

For example, the following management reports were developed:

- Concrete ACI 214 analysis. This report is generated weekly by the construction quality acceptance manager, the engineer in charge of quality acceptance, and is provided to the head contractor for tracking the performance of various concrete mixes.
- Concrete cylinder location reporting. There were problems with cylinders going missing in the field, in transit, and/or in the curing room. Reports were developed for the purpose of cross referencing what should be present in the curing room and what is actually there to avoid situations where missing cylinders were not discovered until far too late.
- Concrete performance reporting. An analysis was necessary on what percentage of structural concrete had fresh properties outside the given tolerances for the mix and what proportion of those also had high slump and air measurements. This was easily achieved with QESTLab whereas it would have taken days with paper, a spreadsheet, or the head contractor's quality management system.
- Failed density test reporting. A log of failing density tests was developed, to ensure all would be retested.

The system was also adapted to the specific needs of the project. For example, a custom field was included at the sample level to allow the reviewing engineer to enter an explanatory note against the sample if their stamp code was set to 'engineering decision' rather than 'pass'. A management report was created that searched for

these fields and showed the relevant ones for a date range. This allows the keeping of an engineering log directly within QESTLab, strongly tied to the tests in question, eliminating yet another separate paper system.



Sieve Size	Non Cumulative Mass (g)	Max Mass (g)	Passing (%)	Limits
Tray Mass				
Tray + Wet Mass				
Wet Mass	**5655.8**			
Tray + Dry Mass				
Dry Mass	**5380.0**			
After Wash Mass	5046.0			
75.0mm		3000		
63.0mm		-		
53.0mm		2750		
37.5mm		2200		
26.5mm	0.0	1800	**100**	100
19.0mm	296.4	1200	94	95 to 100
13.2mm	1334.8	900*	70	78 to 92
9.5mm	698.6	600*	57	63 to 83
6.7mm	486.7	500	**48**	
4.75mm	301.3	400	42	44 to 64
Dry Mass Passing	1928.2			
Dry Split Mass	280.7			
2.36mm	60.6	150	**34**	30 to 48
1.18mm	51.2	100	**28**	
600µm	64.5	75	**20**	
425µm	28.4	60	**16**	14 to 22
300µm	26.0	50	**13**	
150µm	30.2	40	**9**	
75µm	17.2	25	7	7 to 11
Pan	3.1	-		
Finer 75µm	334.0		**6.2**	

Figure 3. QESTLab ships with over 500 electronic worksheets. This is the Grading Test to AS1289.3.6.1.

The above solutions to very specific and very technical challenges in that project were possible due to the fact that the selected system collects all data relating to materials testing and is flexible enough to allow creative ways to present such data through the reporting functions it incorporates.

3.2 Field Testing and Inspection

QESTField is a bi-directional "always-on" system that connects the field testing staff with the laboratory and makes relevant laboratory information available to the field personnel. It allows work to be allocated to field technicians (around 40 in the case of the DFW Connector project), instructs them what to do and where and then makes it possible for them to enter all data they collect from the field in the laboratory database in real time. In the DFW Connector project QESTField was run on either consumer grade smart phones or on consumer grade tablets.

Figure 4. A PSI field technician using QESTField on an Android-based "smart phone" at the DFW Connector project.

Prior to the implementation of QESTField, the process for collecting and reviewing field data involved the following steps:

1. The field technician collects and records data on paper;
2. The paper notes are handed in to the laboratory;
3. A reviewer in the laboratory checks them initially;
4. A data entry person deciphers the information and enters it into a system, and
5. A project manager reviews the entered information and authorizes the production of a test report.

Following the adoption of QESTField the process changed to:

1. The field technician collects and records data on a tablet or smart phone;
2. A reviewer in the laboratory checks the data electronically in an efficient bulk review process using management reports; and
3. A project manager reviews the entered information and authorizes the production of a test report.

The two steps that are skipped are usually the most time consuming and the initial review is much quicker because reports can be generated to look for and highlight missing information (i.e. exception reporting) rather than having a staff member scan every paper report.

Some other advantages of using QESTField are:

- Real time work allocation. When work orders are created, they appear on the technician's device in real time.
- GPS support. QESTField allows the device to provide GPS coordinates for the place where the test takes place and logs this information along with the sample. Graphical presentation of test locations on maps is then possible.

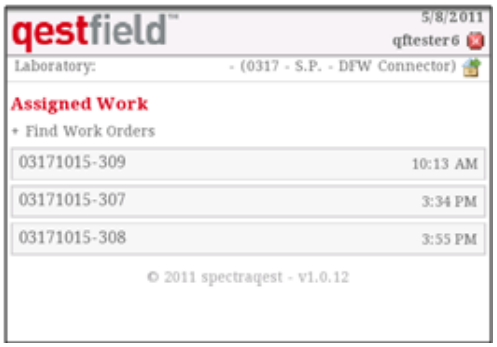


Figure 5. QESTField displays work orders in real time.

- No transcription errors. Data goes in once, at the point it is generated. All data manipulation and review takes place electronically after that point.
- Optimized for workflow. Data entry is broken up into pages that follow standard workflow for conducting the test.
- Support for controlled vocabulary lists (CVL's). Drop downs for pre-defined values are supported so that "Bridge 14" is always "Bridge 14" rather than "bridge14" or "bdg.#14" keeping data consistent and easier to report on. Also, testing staff no longer need to carry with them booklets containing the approved CVL's; the system contains all the necessary information.
- Better dissemination of information. Paper can only be in one place at any given time but many people can pull up an electronic copy of the same data simultaneously through management reports, etc.
- Laboratory data available in the field. In some instances, field staff need to refer to laboratory results in order to assess certain comparative values. For example, when assessing relative compaction, reference needs to be made to appropriate Maximum Dry Density (Proctor) values obtained in laboratory conditions. Technicians no longer need to carry with them lists of such laboratory results; appropriate laboratory results, relevant to the location they are testing, appear in lists in QESTField.

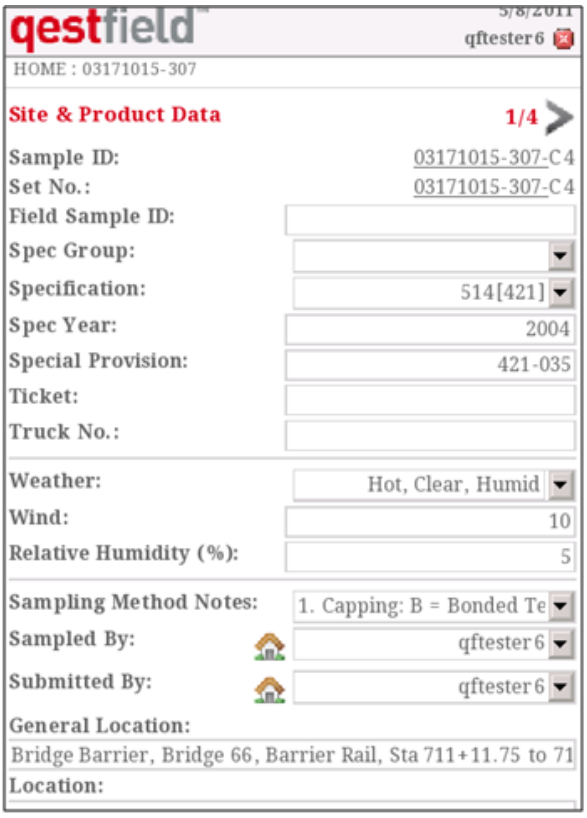


Figure 6. QESTField is optimized for workflow and supports CVLs.

- Calculation of test results by the computer, not by the field technician. QESTField includes all relevant calculations for the tests it supports making it easier and faster for the technician, while minimizing the possibility of human error.
- Samples registered at the point of collection. The laboratory knows, in real time, what samples to expect. Filters/reports are regularly run that help establish if anything is missing.

3.3 Report Distribution

The Construction Hive system is an online collaboration platform for stakeholders in the construction industry. Over 60,000 new test reports are published on Construction Hive every month.

In the DFW Connector project, the system allows the testing company to issue test reports to its customers electronically using cloud-based technologies and without the need to allow clients access to the testing company's internal laboratory system. It is much more powerful than sending PDF versions of the test reports via traditional means such as email, because it has the following additional features:

- Seamless publishing of test reports without manual intervention. The test report is converted from QESTLab to PDF automatically and is sent to Construction Hive without the user having to name, save, retrieve or e-mail a document.
- Multiple stakeholders are notified. The originating system (QESTLab) knows the appropriate stakeholders to notify when test reports become available for certain sections of the project. Construction Hive sends them a notification when new reports have been issued.
- Recipients can manage the notifications they receive. Test report recipients need not have their Inboxes flooded with test reports or even notifications. They can set how often they want to be notified (if there are test reports they need to see) and they can even set in their preferences to be notified immediately if there are failing results.
- Metadata accompany test reports. When QESTLab sends test reports to Construction Hive it sends metadata along with the PDF. This enables advanced functions such as analytics and reporting to take place in Construction Hive. It also makes it possible for a highly visual interface to be used where failures and other attributes are highlighted in lists and summary pages.
- Integration with third party systems. Due to the comprehensive metadata provided with the test reports, integrating with third party systems can be accomplished. Further information on this is provided in the next section.
- Powerful searching capabilities. The system allows users to search for test reports using advanced searching tools and utilizing the CVLs (Controlled Vocabulary Lists) used in the project.
- Google maps support. Because metadata (including GPS coordinates) travel with the test reports, Construction Hive can show test locations on Google Maps.
- Test report receipt is audited. The originating laboratory can audit which reports have been viewed, downloaded, printed, etc. and as such it can trace whether a test report has been used or not.
- Test report archiving. Reports are stored in Construction Hive for the duration of the project – and beyond, if required – providing an accessible and practical archiving service to all project stakeholders.

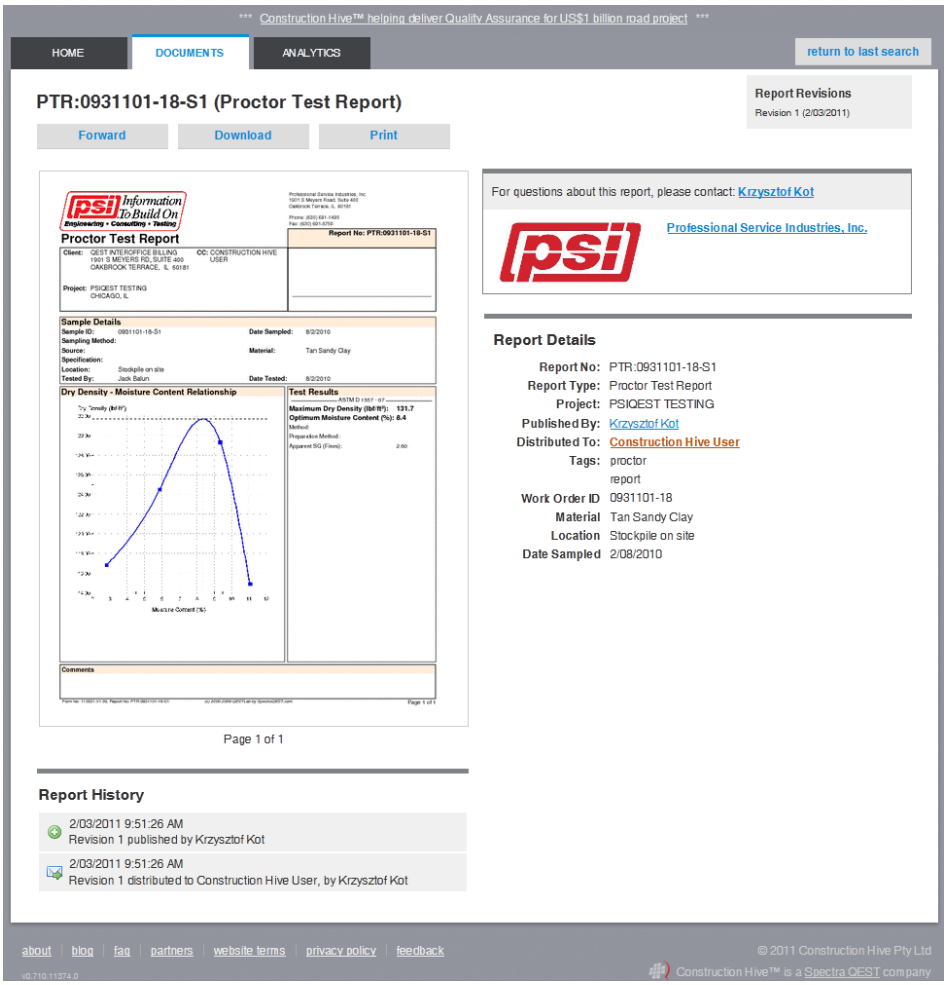


Figure 7. Construction Hive includes applications such as Documents and Analytics. This is an MDD (Proctor) Report.

3.4 Integration with Other Systems

3.4.1 I2MS

One of the requirements for successfully tendering for the DFW Connector project was to provide testing data electronically to I2MS – TxDOT's auditing system. I2MS is a particularly demanding system, not only requiring results from the various tests, but also requiring raw data to enable the Department to conduct detailed analysis on the data.

Some 48 test methods, represented in I2MS in 68 database tables, were necessary to be interfaced. In total, 688 fields from QESTLab and QESTField are electronically passed on to I2MS.

3.4.2 Centric

The Head Contractor's document management system is used for long term storage of all documentation associated with the project. Construction Hive pushes PDF copies of the test reports to Centric.

3.4.3 Test Equipment Integration

Due to the large volume of concrete testing on this project, QESTLab was interfaced directly with the compression machine testing the concrete cylinders for compressive strength.

3.5 Concluding Remarks

It is the first time in road building history that a fully integrated, electronic, quality platform, comprising of a fully functional construction materials testing LIMS, always connected mobile devices for the entry of field test information, and a web-based report publishing system with extended reporting and analytical abilities, has been used in a road project.

The solution also integrates with other systems that the various stakeholders employ to monitor and manage the quality of the materials and the workmanship for the project.

This application of Australian technology to provide rapid, high quality data is expected to heavily influence how quality data for large road projects are collected and managed in the future.

4 Industry and Media Recognition

There has been significant interest in this technology both from a commercial point of view as well as from an innovation point of view. As mentioned earlier, it is the first time in road building history that a fully integrated, electronic, quality platform has been used in a road project comprising of a fully functional construction materials testing LIMS, always connected mobile devices for the entry of field test information, and a web-based report publishing system with extended reporting and analytical abilities.

Engineers Australia, the official publication of the association that represents the engineering profession in Australia, published an excellent article on the project and the technology used in the November 2011 edition.

Sam Swan, TxDOT Project Manager of the DFW Connector Project, has been honored by the White House as a Champion of Change. During his acceptance speech Mr. Swan mentioned electronic field data collection as one of the many innovations used in this project.

PSI, Inc. won the 2013 Gold Medal for Innovation by the American Council of Engineering Companies (ACEC), Texas Branch, for using the QEST Quality Platform in the DFW Connector Project.

PSI has also produced a video proudly showcasing the use of their "PSIQEST" system: their own adaptation of the QEST Quality Platform, integrated with other systems the company uses. PSI has been the first major testing company in the world to use the technology.

4.1 Awards

On 8th August, 2013, Spectra QEST was the national winner of the prestigious iAwards in the Industrial Category for creating and successfully implementing the QEST Quality Platform in the DFW Connector Project.

Over 19 years, the iAwards has become the premier technology awards platform in Australia delivering the most comprehensive awards program which recognizes the achievements and innovation made in ICT across all facets of the economy.

Spectra QEST's success at the national level follows its win at the South Australian state level on 19th June, 2013.

Spectra QEST also represented Australia at the 2013 Asia Pacific Information and Communications Technology Alliance (APICTA) Awards in Hong Kong.

Figure 8. Federal Minister The Hon Kate Lundy, Spectra QEST Directors Mr. Stephan Mavrakis and Dr. Manfred Sautner, and Mr. Bob Cupitt, Principal at BusinessBC, at the iAwards Presentation Ceremony.

In addition to the recognition Spectra QEST received for its technical achievements through the iAwards, the company has also been honored for its commercial success by winning the Business SA 2013 Export Awards in the Information Communications Technology category. These awards celebrate exporting excellence in South Australia, recognizing companies for their innovation and success in industry and export.

The award was presented on the 11th of October 2013 by Mr. Nigel McBride, Business SA Chief Executive Officer, who said, "These Business SA Export Awards highlight our local innovative and internationally competitive companies based right here in South Australia, emphasizing our ability to compete on a global stage."

The award presentation was attended by the Governor of South Australia, His Excellency Rear Admiral Kevin Scarce, the Premier of South Australia, Mr. Jay Weatherill MP, the Leader of the Opposition, Mr. Steven Marshall MP and the Adelaide Lord Mayor, Mr. Stephen Yarwood.

Spectra QEST also represented South Australia at the 51st Australian Export Awards.

4.2 More Information

Additional information can be obtained by contacting Spectra QEST's Australian- or American-based sales staff sales@spectraqest.com.

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