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New and Innovative Approach to Ensuring Quality of Quarry Source Materials in Queensland Road Infrastructure Construction

Ajith Dissanayake

Technical Manager (Quarries and Construction Materials), Geotechnical Unit, Engineering and Technology Branch, QLD Department of Transport & Main Roads, Brisbane, Australia.

Peter Evans

Deputy Chief Engineer (Pavements Materials and Geotechnical), Engineering & Technology Branch, QLD Department of Transport & Main Roads, Brisbane, Australia.

ABSTRACT: The Queensland Department of Transport and Main Roads (TMR) manages a road network of 33,343km. Whether constructed of concrete, asphalt, modified, stabilised or gravel base, quarry sourced materials are widely used to provide the structural strength of these pavements. Accordingly, ensuring that these quarries are providing quality materials is of vital performance to TMR. Department currently spends over \$12 million annually on testing quarry material. The TMR Geotechnical Unit currently oversees 440 quarries that supply materials to TMR, Local Governments, and private industry, through its Quarry Registrations System (QRS). This paper discusses a new and innovative approach that TMR adopts to manage the quality of road construction quarry products. It also describes how test methods are applied to ensure adequate field performance, and how TMR has recently developed and implemented a sophisticated and practical system to allow quarries to self-assess their testing frequencies. QRS is already resulting in reduced testing costs for industry, which will ultimately flow on to reduce costs to government.

1 INTRODUCTION

The Queensland Department of Transport and Main Roads manages a road network of over 33,343km and associated infrastructure across the State of Queensland. The Department's heavily trafficked road pavements contain quarry-sourced materials. Quality management of construction, maintenance and rehabilitation of all pavements, and their surfacings, provides best value for the community. As the steward of this massive road network, the Department needs to ensure that these quarry materials are well managed, to avoid premature failure or reduced life of the pavements and their surfacings. Ensuring acceptable supply quality of pavement materials has always been a priority, and a major challenge, faced by State Road Authorities across Australia.

As part of Queensland's recent \$6.4 billion Flood Reconstruction program, approximately \$800 million worth of road construction quarry products have been produced and processed annually during that period. In Queensland, these paving materials are procured by Contractors from the 440 privately operated hard rock quarries and sand and gravel plants that produce crushed fine and coarse aggregates.

Each year it is estimated that \$12 million is spent on testing road construction quarry products supplied to the Department at different stages during construction. This constitutes approximately 1.5% of the total cost of supplying these materials. Through a process of stakeholder consultation, Quarry Industry operators identified that these costs may be reduced, particularly for well managed quarries. As part its drive for aggressive cost savings and value for money (VoM), the Department had a strong incentive to work with the Quarry Industry to review the testing requirements with a goal to generating cost savings without compromising quality.

Because the type and quality of paving and concrete materials varies markedly and widely throughout Queensland due to their source rock/material and product quality variations and associated risk issues (Figures 1, 2, 3, 4, 5 & 6), a robust, source/product-specific, risk-based, effective and efficient mechanism is required by the Department to manage the material risks presented. Additionally, many local governments utilise the Department's standard specification suite in procuring local roads.



Figure 1. An example of source rock variability - Partially melted/liquefied dolomitic limestone xenoliths (white patches) embedded within andesitic intrusions resulting processing and sorting difficulties.



Figure 2. An example of product variability for the same source rock - Requirements for specific soaking & screens in production process to separate poorly cemented labile deleterious and non-durable sandstone fragments from fine to quartzitic sand.



Figure 3. An example of poor quality basaltic cover (seal) aggregate exhibiting premature break down on a newly constructed pavement overlay. In this case, the count of moisture sensitive non-durable weak particles exceeds the specification limit.



Figure 4. An example of iron sulphide bearing regional metamorphic source rock showing scattered pods and vugs of gold-



en colour pyrite (FeS_2). Aerial oxidation of pyrite could result in adverse discoloration in aesthetic concrete & road surfaces. Figure 5. An example of aerial oxidation of pyrite (FeS_2) bearing asphalt aggregate on a road surface showing scattered and spotted rusty red brown discoloration.



Figure 6. Formation of jarosite ($\text{KFe}_3(\text{OH})_6(\text{SO}_4)_2$) with yellow band along the moisture front due to aerial oxidation of pyrite (FeS_2) in a stockpile of processed fine natural sand aggregate sourced from tidal sand deposit. This reveals the pres-

ence of potential acid sulfate condition in fine concrete aggregate.

2 MANAGEMENT OF QUARRY MATERIALS IN QLD

2.1 Background

The Department's specifications listed in Table 1 require that quarry products supplied to its road pavements and concrete infrastructure projects be registered in its Quarry Registration System (QRS). Registration is based on applying a well-developed process to assess the suitability of potential quarries for Departmental use. A small team of Departmental engineering geologists lead by the TMR Technical Manager (Quarries and Construction Materials) manages the QRS. To attain registration, quarries must conduct a series of laboratory tests following established TMR and Australian Standard test methods, and demonstrate that quarry materials can be produced to satisfy the material properties and engineering parameters established in TMR Technical Specifications. The respective road construction quarry products are registered in the TMR Quarry Database.

Table 1. TMR Technical Specifications impacted by TMR Quarry Registration System (QRS)

TMR Technical Specification	Technical Specification Title
MRTS05	Unbound Pavements
MRTS08	Plant-Mixed Stabilised Pavements Using Cement or Cementitious Blends
MRTS09	Plant-Mixed Pavements Layers Stabilised Using Foamed Bitumen
MRTS11	Sprayed Bituminous Surfacing
MRTS12	Sprayed Bituminous Emulsion Surfacing
MRTS13	Bituminous Slurry Surfacing
MRTS22	Supply of Cover Aggregate
MRTS30	Asphalt Pavements
MRTS39	Lean Mix Concrete Subbase for Pavements
MRTS40	Concrete Pavement Base
MRTS70	Concrete
MRTS101	Aggregates for Asphalt

2.2 Evolution of Specified Testing Frequency

Traditionally, contract Principals of individual road construction projects set their own testing frequencies, typically basing selection on historic practice and without up-to-date geological source or quarry production input. Consequently there were wide variations in testing frequencies between different quarries, and sometime for different projects for the same quarry. Depending on their risk appetite, some contract Principals also elected to invest heavily in testing, and others conducted minimal testing. In some cases this resulted in significantly disparate testing practices conducted in similar quarries.

The Management of the Queensland's Flood Reconstruction Program requested streamlining of testing in order to reduce the risk of delay to construction of a program within very tight delivery timelines. TMR convened a meeting of Flood Reconstruction Project Managers throughout Queensland, and negotiated a set of consistent testing frequencies for Flood Reconstruction Projects, for application across Queensland for all projects. These frequencies were then widely applied on flood recovered road construction work throughout Queensland.

However, this approach was not optimal as:

- it remained discretionary within the Departments specification and contract system

- it did not capture the ongoing data and analysis required to establish up-to-date testing regimes appropriate to the quarry-specific quality and risk.

the Quarry Industry identified the high financial cost of testing frequencies that were not aligned to risk and duplicated (often many times over) testing for the same material property for the same product of the same quarry.

In order to improve the specification of testing frequencies, the Department resolved to develop a system that removed these suboptimal factors from the QRS.

The Department consulted with the peak industry stakeholders representing the major quarries in Queensland throughout the review of the QRS. The Cement Concrete and Aggregates Association (CCAA) and Institute of Quarrying Australia (IQA) provided valuable input to assist the Department's geological, geotechnical, concrete and pavement materials technical experts to identify key risks and key variations, and to develop a workable system for quarry registration and utilisation of testing frequencies within TMR specifications.

2.3 The Department's Key Challenges

Department's fundamental challenges were as follows:

- How to apply different testing frequencies for different quarries, and still manage its risk?

- How to allow different frequencies fairly and with transparency, without claims of favouritism or bias?

- How to incorporate the Department's existing Quarry Registration System?

- How to gain Quarry Industry acceptance of the new system?

To address these challenges, collaborative consultation between the Department's technical leaders and Quarry Industry technical and operational experts commenced in mid-2013.

The Departmental and Quarry Industry working group identified the following key factors that influ-

ence the nomination of appropriate testing frequencies by individual quarries:

The type and properties of the quarry's source rocks,

The match between the source rock types and the TMR Technical Specification limits – for example some sources are in excess of required strengths,

The levels of management and technical and operational experience and expertise in managing production of quarry products, and

The robustness of the quality control measures demonstrated by the quarry in winning source rock and producing pavement products.

The agreed approach was to develop robust guidelines, which would allow the quarry's management to self-assess their own testing frequencies. The Department would retain its role to register the quarry where the TMR Manager (QRS) verifies or suggests amendments to the quarry self-assessments, and issues a QRS registration certificate accordingly. New contract provisions enable test frequencies to be applied consistently across all projects to which the quarry supplies pavement products.

2.4 Source Rock Test Properties

The QRS only applies to source rock/material testing, and Table 2 below summarises all relevant source rock/material property tests that are required by TMR Technical Specifications.

Table 2. All Relevant Source Rock/Material Property Tests for Coarse and Fine Aggregates in TMR Technical Specifications

Source Rock Property Test	Test Method/s
Petrographic Analysis	ASTM C295
Wet 10% Fines Value	AS1141.22 or Q205A/B
Wet/Dry Strength Variation	AS1141.22 or Q205C
Degradation Factor	Q208B
Particle Density (SSD)	AS1141.5/6.1 or Q214A/B
Water Absorption	AS1141.5/6.1 or Q214A/B
Bulk Density of Aggregate	AS1141.4
Soundness (Sodium Sulfate)	AS1141.24
Polish Aggregate Friction value	Q203
Weak Particles	AS1141.32
Crushed Particles	Q215
Methylene Blue Value (MBV)	AS1141.66
Sand equivalent	AS1289.3.7.1
Light Particles*	AS1141.31
Particle Size Distribution*	AS1141.11.1
Material Passing 75µm*	AS1141.12
Material Passing 2µm*	AS1141.13
Organic Impurities*	AS1141.34
Sugar Presence*	AS1141.35
Sulfate Content*	AS1012.20
Chloride Content*	AS1012.20

* Applicable to natural fine sand aggregate only

Pavement & concrete product testing is not included in the QRS as these material products that conform at the quarry may become segregated or

contaminated during subsequent handling, cartage or construction.

2.5 Quarry Registrations System Documents

The new QRS contains seven (7) separate documents:

QRS1 - Quarry Registration System Outline

QRS2 - Preparing a Quarry Assessment Report for a Hard Rock Quarry

QRS3 - Preparing a Quarry Assessment Report for a Natural Sand and/or Natural Gravel Quarry

QRS4 - Assigning Quarry Specific Testing Frequencies for Source Rock Tests

TMR Quarry Registration Application Form

Flowchart showing TMR Quarry Registration System

Process for assessing Quarry Specific Testing Frequencies (includes e-forms for interactive assessment spreadsheet)

These documents and a demonstration video (i.e. webinar) are all available on the TMR website at the following link:

<http://www.tmr.qld.gov.au/business-industry/Business-with-us/Approved-products-and-suppliers/Pavements-materials-and-geotechnical.aspx>

2.6 Application Process

As part of completing the application e-forms (i.e. interactive assessment spreadsheet), the Applicants address all attributes in order to satisfy the Department that they have control of their processes sufficient to allow the testing frequencies that they nominate.

The completed assessment spreadsheet, and accompanying substantiating documentation is submitted electronically to the TMR Manager (QRS) for processing. (An interactive assessment spreadsheet containing a worked example is available on the Department's website.)

2.7 TMR Administration of QRS Process

Upon receipt of an application, the TMR Manager (QRS) assesses the application. This includes inspecting quarry source and all nominated product stockpiles, reviewing of past performance and consulting the Department's construction project staff to obtain any updated information about recent operational and material performance.

The Manger (QRS) will either verify the submission or negotiate alternative testing frequencies with the Applicant. For successful Applicants, a QRS registration certificate is issued with an approved testing frequency schedule and the Department's

website updated to include the quarry as a registered supplier.

QRS registration certificates are valid for two years, but can (upon application) be upgraded six-monthly. However TMR can still modify testing frequencies at any time based on performance.

2.8 Future Enhancement of the QRS

The Department is about to conduct a 12-month review of the operation of the QRS in consultation with CCAA, IQA and Departmental technical and operational staff. As more information becomes available about the quality performance of individual quarries, potential exists to even further refine the process to achieve even greater cost savings. For example, work is well underway on a new Geographical Information System (GIS) system to allow public access to quarry registration data, and also to register their approvals through the Department's interactive mapping (iMAP)

2.9 Current Statuses of the QRS

The Department has been implementing the QRS since April 2015 and has already registered 80 quarries with approved testing frequency schedules.

4 CONCLUSIONS

The new Quarry Registration System (QRS) which was collaboratively developed between the Department and the Quarry Industry successfully delivered following main benefits:

It effectively addressed Quarry Industry concerns that excessive testing was resulting in increased costs which were being passed on to the Department's construction projects.

A set of guidelines which allows the quarry management to self-assess their own testing frequencies.

It allows the Department as well as Quarry Industry to concentrate testing resources to where risks are highest.

New contract provisions enable test frequencies to be applied consistently across all Queensland's road construction projects to which the quarry supplies pavement and concrete products.

Rewarding good performers through reduced testing costs. Testing frequency reductions of almost 90% have been realised in some cases with well managed quarries.

A preliminary estimate of cost savings is that overall quarry testing costs for Departmental projects will significantly be reduced by \$6 million per year.

3 ACKNOWLEDGEMENTS

The Authors are grateful to the Engineering and Technology Branch, Department of Transport and Main Roads, Queensland for their support and assistance in the preparation of this paper.

5 REFERENCES

- Cement Concrete & Aggregates Australia (2005). "Code of Practice – Testing Frequencies for Extractive Industry in Queensland", P8, September 2005.
- Dissanayake, A. & Evans, P. 2015. Latest Developments on TMR Quarry Registration System (QRS) and Incorporation into TMR Standard Specification Suit; *Innovation Driving Value; 16th APPA International Flexible Pavements Conference 2015, 10-11 September 2015*.
- Dissanayake, A. & Evans, P.A. 2015. Queensland Transport and Main Roads Department Quarry Registration System 511-514, *Geotechnics for Sustainable Development; Proc. intern. Conference on Geotechnical Engineering, ICGE-Colombo-2015, 10-11 August 2015*.
- Queensland Department of Transport and Main Roads. 2015. QRS1 - Quarry Registration System Outline, P12.
- Queensland Department of Transport and Main Roads. 2015. QRS2 - Preparing a Quarry Assessment Report for a Hard Rock Quarry, P12.
- Queensland Department of Transport and Main Roads. 2015. QRS3 - Preparing a Quarry Assessment Report for a Natural Sand and/or Natural Gravel Quarry, P8.
- Queensland Department of Transport and Main Roads. 2015. QRS4 - Assigning Quarry Specific Testing Frequencies for Source Rock Tests, P18.
- Queensland Department of Transport and Main Roads. 2013. TMR Technical Note 102: Selecting Testing Frequencies for Acceptance Sampling of Pavement Materials, P16.