Technical Audit of Select Tonga Transport Sector Consolidation Project – Final Audit Report

General Routine and Periodic Maintenance Contract Works

Prepared for DFAT
April 2014

Abbreviations and Acronyms

DFAT	Department of Foreign Affairs and Trade (Australia)
km	kilometres
kN	Kilo Newtons
MoI	Ministry of Infrastructure (Tonga)
MPa	Mega Pascals
PECG	Pacific Engineering Consultant Group
PM	Project Manager
PMR	Project Manager's Representative
TOP	Tongan Pa'Anga (Currency of Tonga)
TSCP	Transport Sector Consolidation Project
Vpd	Vehicles per day

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1 Executive Summary

1.1 Background

The Transport Sector Consolidation Project (TSCP) in Tonga, led by the World Bank and co-financed by the Australian Government, commenced in 2008 with expected completion in 2014/15. One of its objectives is to strengthen greater domestic capacity for road rehabilitation and maintenance.

The periodic and routine road maintenance has been previously undertaken by the Ministry of Infrastructure, Tonga (MoI) using direct labour. However prior to 2012 there was a period of about four years when minimal road maintenance was undertaken due to lack of capacity within the MoI. In 2012, to support and strengthen greater domestic capacity, the periodic and routine road maintenance were outsourced to local contractors, with a total of four periodic maintenance contracts and seven routine maintenance contracts awarded.

As a result of this outsourcing, the MoI's role changed from the implementer to purchaser / project manager. The local contractors who emerged from this process were largely new to contracting and road maintenance and a series of training sessions were held to uplift their skills with the expectation of improving contractor performance.

In 2007, the only quarry (Aho'nonou Quarry) in Tongatapu that provided aggregate suitable for spray sealing, the primary periodic maintenance activity, ceased its operations, leaving other quarries with lesser quality materials as aggregate sources for road maintenance. (At the time of the Audit, measures initiated by the MoI were underway to re-open Aho'nonou Quarry). To overcome this constraint, a relatively new technology, Otta Seal, was adopted in lieu of spray seals, as it required lesser quality (strength) aggregates than spray seals. Developed in Norway in the mid-1960s, Otta Seal has been used in several countries including Botswana and Kenya. Whilst similar to spray sealing, it uses a softer bitumen binder and crushed aggregate with a range of sizes, instead of single sized aggregate used in spray sealing.

1.2 Audit Objectives

The Department of Foreign Affairs and Trade (DFAT) commissioned this Technical Audit in February 2014, to assess contract compliance of a select package of general routine and periodic road maintenance contracts, in order to evaluate the effectiveness of the contractors in complying with contract specifications, as well as the effectiveness of project supervision processes and supervision teams in assuring contractor compliance to contract specifications.

The Technical Audit will also be used to inform the joint evaluation of the TSCP by the World Bank and the Australian Government in consultation with the Government of Tonga, which was underway at the time of the Audit.

1.3 Audit Methodology

The Technical Audit was conducted from 17–22 March 2014, and all the four periodic maintenance contracts and three out of the seven routine maintenance contracts were assessed. As all contracts had been completed in 2013 there were no maintenance activities occurring at the time of the Audit, therefore the assessment was based on: review of contract documents and records including materials test results; inspection of work done under the contracts; and, interviews with the supervision teams and contractors.

1.4 Audit Findings

1.4.1 Periodic Maintenance

Product: The Otta seals, 6–12 months old at the time of inspection, were performing generally well with no signs of major failure or distress. However some localised deficiencies included: excess bitumen on surface at some intersections; excess bitumen / uneven surface at some transverse joints between spray runs; excess thickness in some middle sections due to overlap of sealing of the two lanes; and, apparent excess

bitumen on some sections of wheel paths. The project supervision team is aware of these deficiencies, and intends to assess options to rectify some of the higher risk ones.

Process: Records were available on repair of defects and surface preparation prior to sealing; and this was best documented in the last contract using 'Maintenance Survey Forms'. In the two initial contracts, the contractor was slow to respond or did not respond to supervision team requests for required certifications and test results, however the contractor response improved in the two later contracts. Bitumen spray rates were available for each spray run in all contracts, and were generally close to specified, with some large variations occurring in first two contracts, and no major variations in two later contracts. Despite repeated requests from MoI, bitumen sprayer calibration certificates were not provided by contractors due to difficulties in getting them, and an improvised assurance mechanism was approved in lieu for the two later contracts. Required aggregate test results records not available were:

> aggregate strength for first two contracts; and

> aggregate wet / dry strength ratio for all contracts.

Also, test results from past studies had been used for aggregate water absorption ratio.

Specification: The Contract Specification was generally adequate for the scope of work, the main deficiencies being: not specifying frequencies for aggregate testing, and not specifying bitumen spray temperatures. However the supervision team imposed aggregate testing frequency on the two later contracts. Testing frequencies are stipulated in the current (Year 2) contract specifications.

Project Supervision: The Project Supervision Team consisted of MoI staff, assisted by a Supervision Consultant with some contractual delegations, and supported by TSCP. Evidence indicated that most technical directives to contractors were from MoI, even though the Supervision Consultant had delegated authority for many of them. Product non-conformances (e.g. low bitumen spray rates) were dealt through Exception Reports; sometimes resulting in payment deductions, however the close out of these non-conformances was not traceable. Three types of daily records / checklists have been used in supervision of Otta seals, which require streamlining.

1.4.2 Routine Maintenance

Procurement: In November 2012, seven contracts were awarded for routine maintenance: four in Tongatapu; and, one each in 'Eua, Ha'apai, and Vava'u (Year 1 Contracts). Due to delays in contractors mobilising, the commencement date was postponed to January 2013. There were further delays in scoping work and issuing work orders by the supervision teams, and actual work commenced only in March 2013. Also, the contract completion dates were brought forward to September 2013, with the intention of accelerating TSCP funded routine maintenance. In addition, there were delays in procuring the next round of routine maintenance contracts, which were being awarded at the time of the Audit in March 2014. In this six-month gap between routine maintenance contracts (October 2013 to March 2014), some of the urgent routine maintenance work has been undertaken by MoI minor contracts, also the wet season ending in March could hinder effective pothole repair. Nevertheless this large time gap between routine maintenance contracts is an undesirable outcome detrimental to road safety and asset preservation.

Planning, monitoring and payment: These activities have been well documented. The work was scoped using Maintenance Survey Forms; work orders with activity quantities based this scope issued to contractors monthly; and the work monitored and approved for payment based on the initial / amended scope of work completed.

Quality Control: The contracts stipulated a work method for pothole patching, however did not require materials testing. (The current Year 2 contracts require testing aggregate used for pothole patching). In two of the contracts, a variation order was issued to replace about 1,000 existing damaged drain covers in the Nuku'alofa town area (constructed previously by others). The concrete used for these precast drain covers required testing for concrete strength (25MPa), however any such test results were not sighted during the Audit..

1.4.3 Materials Testing Laboratory

The Laboratory contained test equipment and Australian Standards Test Methods required for aggregate and concrete testing under periodic maintenance contracts. However copies of test results undertaken for periodic maintenance contracts were not available, and said to be kept on relevant project files. Calibration certificates for test equipment were not on file, except for a calibration test for density of sand used for field density testing, however calibration stickers dated August 2012 were on all the four compression testing machines. Testing could not be witnessed as there were no tests being undertaken due to absence of road maintenance activities.

In the interviews held, material testing was identified as a key area requiring improvement by MoI staff, TSCP staff, and several contractors.

1.5 Recommendations

For implementation within the current TSCP

1. Assess the Otta Seal sections constructed in Year 1 contracts and determine aggregate grading and source of better performing sections, for adoption in Year 2 Otta seals for improving performance.
2. Minimise the use of double Otta seals and, the use of hand lance for bitumen spraying by implementing Year 2 Specification, to prevent excess bitumen on surface.
3. Undertake increased supervision and implement Year 2 Specification on the construction of transverse and longitudinal joints between spray runs, to prevent surface defects and excess seal thickness.
4. Undertake appropriate testing to determine adequacy of skid resistance on sections of wheel paths with apparent excess bitumen.
5. Assess the possibility of better utilising the Supervision Consultant by allowing greater involvement within the delegated authorities of periodic maintenance contracts.
6. Improve traceability of non-conformance management by maintaining a register to record: agreed dispositions; implementation of dispositions; and, action to prevent recurrence.
7. Streamline the Otta seal supervision checklist / daily record by combining the three pro forma currently used into one. Include a check for bitumen blending on site to ensure that required consistency is achieved by circulating for 1 hour.
8. Consider the use of Maintenance Survey Forms for scoping and payment of surface preparation work prior to Otta sealing.
9. Assist the contractors in obtaining Bitumen Sprayer Certificates, by commissioning a specialist for all contracts, and deducting the cost from the relevant Provisional Sum item in Year 2 periodic maintenance contracts.
10. Undertake aggregate testing for each nominated quarry for Year 2 Contracts, for wet / dry strength, flakiness, and water absorption ratio.
11. Assist the contractors in sampling and testing of aggregate grading prior to and during sealing.
12. In Contract Specifications or as a directive to contractors, provide a bitumen spray temperature range for Year 2 Otta sealing, after deciding the bitumen grade achieved through specified blending process.
13. Undertake aggregate testing as per Year 2 Contract Specifications for pothole patching, to provide assurance on the quality of materials used.
14. Undertake concrete strength testing as per Year 2 Contract Specifications for the drain covers to be supplied under Hihifo and Nuku'alofa District routine maintenance contracts.
15. Undertake a structural design and stipulate a procedure for pre-casting and placing drain covers in Year 2 Contracts, taking into account the marine environment and the potential occasional vehicle loading due to proximity to traffic.

16. Maintain a proper document control system including equipment calibration records in the Materials Testing Lab.
17. Maintain a register of all the tests undertaken with copies of test results in the Lab, as a backup for quality assurance of periodic and routine maintenance contracts.

For implementation in a future phase of TSCP

1. Minimise the time gap between routine maintenance contracts by timely procurement of contracts and providing adequate quantities to cover routine maintenance activities for the full duration of contracts.
2. Consider options for longer term routine maintenance contracts of up to two or three years, or annual contracts with provision for one- or two-year extensions subject to satisfactory performance, to prevent large time gaps between contracts.
3. Consider the submission of product quality verification by Contractor as a prerequisite for progress payments, in order to improve quality management.
4. Seek information on failure modes and maintenance needs of Otta Seals constructed in other countries, in order to develop a maintenance regime for Otta seals in Tonga.
5. Consider long term monitoring and evaluation of the performance of Otta seals, using methodology in the World Bank document *Guidelines for Performance Monitoring Otta seal resurfacings in the Pacific Island Countries* (September 2011).
6. Provide additional competent staff to improve management and verification of materials testing in the Lab, with relevant training as required.
7. Consider conducting training courses or refresher courses on contracting and road maintenance on a periodic basis to maintain and improve contractors' skills and competencies.

1.6 Conclusion

In periodic maintenance, in the context of application of a new technology by contractors new to contracting and road maintenance supervised by a relatively new contract management team, the product delivered, the Otta seal, is generally performing well. However, major improvements are required in the delivery process, mainly in materials testing and record keeping. Improvements were evident between the first two and the latter two contracts; however it is too early to conclude whether it is a trend or the different performances between contractors.

The planning, monitoring and payment for routine maintenance was in a controlled environment, however the large time gap between routine maintenance contracts is detrimental to road safety and road asset preservation.

2 Audit Methodology

The Audit was undertaken as per the requirements of the Service Order No. 65697/1 of DFAT that included Audit Terms of Reference. An Audit Plan was prepared as per these requirements, and the approved Audit Plan is in Annex 1.

2.1 Audit Fieldwork

The Technical Audit was conducted from 17–22 March 2014, with briefing sessions to DFAT, MoI on 24 March, and Ministry of Finance, TSCP, and the World Bank Review Team on 25 March. All four periodic maintenance contracts and three out of the seven routine maintenance contracts awarded in 2012 were reviewed, as listed in Table 1.

Table 1 Periodic Maintenance Contracts

Contract #	Contractor	Initial Value (TOP)	Final Value (TOP)	Contract Period	Period – Otta Seal	Road	Length (km)
C6.1.1	Vava'u	474,560	488,269	Feb 12 – Feb 13	Jul 12 – Feb 13	Folaha, Sipu	2.5, 0.8
C6.1.2	Vava'u	593,918	593,918	Sep 12 – Apr 13	Nov 12 – Apr 13	Puke, Holoipepe, Hihifo	0.5, 2.4, 0.5
C6.1.3	BB	807,196	927,633	Sep 12 – Jul 13	May 13 – Jul 13	Longoteme, Fonongahina, Puke	1.9, 1.9, 0.5
C6.1.4	Tafolo (Otta seal by BB)	527,810	583,393	Oct 12 – Sep 13	May13 – Sep 13	Hufangalupe	3.9
Total		**2,403,484**	**2,593,213**				**14.9**

Table 2 General Routine Maintenance Contracts

Contract #	Contractor	Initial Value (TOP)	Final Value (TOP)	Period	District
C7.1.1	Petani Quarry	193,097	193,097	Jan 12 – Sep 12	Eua
C7.1.4	Five Star Construction	149,898	149,898	Jan 12 – Sep 12	Hihifo
C7.1.5	Five Star Construction	150,890	163,908	Jan 12 – Sep 12	Nuku'alofa
Total		**493,885**	**506,903**		

Note: For ease of reference, all of the above Contracts will be referred to as Year 1 Contracts. The contracts that were being awarded at the time of the Audit will be referred to as Year 2 Contracts.

As all the contracts had been completed in 2013 there was no maintenance activities occurring at the time of the Audit, therefore the assessment was based on:

1. Review of contract documents and records including materials test results. Annex 2 provides a list of the documents and records reviewed, grouped by the relevant Audit Finding.
2. Inspection of work done under the contracts. Inspection of Periodic Maintenance works (Otta Seals) were undertaken on 19 and 22 March. Inspections of General Routine Maintenance works were undertaken on: 20 March (Nuku'alofa and Hihifo Districts); and, 21 March ('Eua District). Selected photographs from these inspections have been included in the Report where relevant.

3. Interviews with relevant personnel of MoI including the project supervision teams, TSCP, Contractors, and a quarry manager that supplied aggregate for Otta seals. Annex 3 provides a list of interviews undertaken.

The Audit had provisions for undertaking materials testing, however as there were no maintenance activities being undertaken at the time of the audit, the only meaningful tests that could be undertaken were on: aggregate strength, flakiness, and water absorption ratio, for aggregates from Nissi Quarry. This could not be undertaken due to lack of time.

2.2 Reporting and Response Management

Audit reporting consists of following stages:

1. Initial End of Field Audit Report – Preliminary Observations and Findings. This was provided to DFAT on 24 March, and tabled at a de-briefing session on 25 March to representatives of MoI, Ministry of Finance, TSCP, and the World Bank Review Team.
2. Draft Audit Report issued to Key Stakeholders with a comment period of 2 weeks.
3. Final Audit Report, (this report) after incorporation of Key Stakeholder comments as necessary.

A comments and response matrix to track comments from stakeholders and response provided by Auditor is in Annex 4.

3 Audit Findings

3.1 Periodic Maintenance Contracts

Finding 3.1.1: Otta seals were performing reasonably well after 6–12 months in service with no major failures, however with some localised deficiencies.

Observations

Inspections of Otta Seals undertaken on 19 and 22 March revealed that:

1. All the roads sealed were generally in reasonable condition, with no signs of major failures or distress, however with some localised deficiencies. Spot measurements at several locations indicated crossfalls and width generally complying with the drawings.
2. The best surface texture, with least localised deficiencies was the first Otta seal constructed on Folaha Road using aggregates from Malopo quarry that fitted an Open Grading envelope. This is contrary to Section 8.3 of *A Guide to the Use of Otta Seals (1999)* by Norwegian Public Roads Administration (Otta Seal Guide), which specifies Open Grading only for low traffic volumes of less than 100 vehicles per day (vpd). Even though reliable traffic counts were not available, the general opinion of the Supervision Team was that all the Year 1 Otta sealed roads carried more than 100vpd.
3. The Otta Seal Guide (1999), and a conference paper *Otta Seals: A Surfacing Solution in Developing Regions (November 2012)* by AT Visser, provides some information on the performance of Otta seals constructed in several countries, however, more information is required on failure modes and maintenance needs, in order to develop a forward maintenance program for Otta seals in Tonga.
4. Localised deficiencies that need to be addressed in future construction and maintenance were:
   (a) **Excess bitumen on surface at some intersections:** The excess bitumen at some intersections were due to either: double Otta seals applied to take the additional stresses of turning traffic; and / or, bitumen application using hand lances to wing sections where rate could not be controlled. The loss of traction due to excess bitumen is not considered a major traffic hazard due to lower speeds at intersections; however the Project Supervision team intended to rectify this by an appropriate treatment. The bitumen bubbles observed in hot weather at one of the locations indicates that the

Otta seal may not be fully cured, which facilitates treatments such as blinding with sand or small aggregate.

(b) **Excess bitumen / uneven surface at some of the transverse joints:** The Roads Adviser stated that in spite of using end of spray run protective strips to avoid spray overlaps, the stop start operations sometimes let out excess bitumen.

(c) **Excess thickness along longitudinal joint:** Caused by overlap of the seals of each lane at the middle. This excess thickness is more pronounced in some early road sections (e.g. Folaha, 12 months old) and hardly noticeable in some later sections (e.g. Hufangalupe, six months). At worst locations this is about 15mm thick by 150mm wide. Year 2 Contracts include a work method for longitudinal joints to prevent this construction deficiency.

(d) **Apparent excess bitumen on wheel paths:** On some heavier trafficked roads, wheel paths appeared to bleed when viewed from a vehicle (e.g. Fononghina Rd). However on closer inspection, an aggregate matrix was visible flush with the surface. Whether this texture is sufficient to provide required skid resistance needs to be substantiated by appropriate tests such as the texture depth test by sand patch method; or, pendulum skid resistance tester.

Recommendations

1. Assess the Otta Seal sections constructed in Year 1 contracts and determine aggregate grading and source of better performing sections, for adoption in future Otta seals for improving performance.
2. Minimise the use of double Otta seals and, the use of hand lance for bitumen spraying by implementing Year 2 Specification, to prevent excess bitumen on surface.
3. Undertake increased supervision and implement Year 2 Specification on the construction of transverse and longitudinal joints between spray runs, to prevent surface defects and excess seal thickness.
4. Undertake appropriate testing to determine adequacy of skid resistance on sections of wheel paths with apparent excess bitumen.
5. Seek information on failure modes and maintenance needs of Otta Seals constructed in other countries, in order to develop a maintenance regime for Otta seals in Tonga.
6. Consider long-term monitoring and evaluation of the performance of Otta seals, using methodology in the World Bank document *Guidelines for Performance Monitoring Otta seal resurfacings in the Pacific Island Countries* (September 2011).

Evidence

Following is some photographic evidence to support above observations:

Figure 1 **Pilot Otta Seal on Folaha Road with the best surface texture after 12 months of traffic**

Figure 2 Excess bitumen at Fononga hina Road and Liku Road intersection

Excess bitumen

Bitumen bubbles on a warm day (same location)

Figure 3 Stop-Start (Transverse) Joint Holoipepe Rd and Seal overlap at middle – Folaha Rd

Figure 4 Apparent bleeding on wheel paths – Fononga hina Road

View from a vehicle

Closer view of wheel path

Finding 3.1.2: Quality management processes used in Otta Seal construction require improvements, particularly in materials testing and document control.

Observations

Review of quality records of the four Periodic Maintenance Contracts revealed that:

1. The Project Supervision Team consisted of MoI staff, assisted by a Supervision Consultant, Pacific Engineering Consultant Group (PECG), and supported by TSCP. Most quality related directives to contractors were issued by MoI Project Manager (PM) and Project Manager's Representative (PMR).

Letters of Delegation issued by PM to each Contractor stated PECG's contractual authorities which included: *Check work and notify defects, including approval of materials; and, Issue instructions, but only to the extent covered by these delegated authorities,* however very few instructions have been issued by PECG .

2. Product non-conformances were managed through Exception Reports raised by PECG to contractors, and altogether four Exception Reports were sighted for C6.1.1 and C6.1.2, mainly on bitumen spray rates. Two of these Exception Reports were used by MoI to stop payment for some sections of Otta seal; and it was stated that these sections were subsequently re-sealed, however there were no records to substantiate the re-sealing. The agreed dispositions, their implementation, and action to prevent recurrence of the non-conformances were not traceable.

3. Three types of daily checklists / daily records for Otta Seal supervision work were sighted, two from MoI and one from PECG, containing similar information. PECG has prepared a *Road Construction Supervision Manual* (May 2012), which contained its Checklist.

4. **Surface preparation prior to Otta sealing:** All the contracts had provision for surface preparation prior to sealing, including pay items in the Schedule of Rates. These included: verge clearing, pothole patching / edge break repair, and surface preparation. Records of surface preparation prior to Otta seal were available for all contracts, in the form of progress claims and variations. Best documented was for C6.1.4 in the form of a Revised Project Scope (due to change of contractors) where all potholes and edge breaks were documented in 'Maintenance Survey Forms' with a price request to Contractor.

5. **Test Certificates / Test Results required prior to sealing:** The Contract Specifications required following certifications and test results prior to commencement of sealing:

   (a) **Bitumen Certificates:** After several requests from PM and PMR, the contractor for C6.1.1 and C6.1.2, Vava'u Construction, submitted the Bitumen Certificate under C6.1.2. The Certificate was dated 13/03/12; 8 months prior to sealing, however an email from the supplier stated that it was applicable for bitumen batch delivered to Vava'u Construction. For C6.1.3 and C6.1.4, BB Construction provided a Bitumen Certificate of Quality dated 15/11/12. Both Certificates showed compliance to AS2008 Specification for Class 170 bitumen. Correspondence between supplier and PM / TSCP, and also the Auditor's interview with BB Construction indicated that the small size of bitumen orders contributed to not getting timely bitumen certificates.

   (b) **Bitumen sprayer calibration certificates:** PM and PMR made several requests for bitumen sprayer certificate from both contractors. As this was not received in C6.1.1, C6.1.2, the PM waived this requirement for C6.1.3, C6.1.4 (BB Construction), subject to contractor making available: a) a Spray Chart correlating road speed and pump output to reflect target spray rates; b) dip stick measurements; c) temperature gauges at spray pump and for heating. BB Construction fulfilled this requirement. At the interview with BB Construction, the contractor stated that the bitumen sprayer vendor promised to send calibration certificate when he bought the sprayer from New Zealand, however this promise was not fulfilled despite repeated requests. Year 2 Periodic Contracts has a Specification requirement that mandates bitumen sprayer calibration certificate, and a Provisional Sum to pay for its cost. This should provide the necessary incentive for contractors to comply with this requirement.

   (c) **Aggregate Strength:** Otta seal specification requires minimum aggregate strengths of 90kN for less than 100vpd and 110kN for 100vpd or more. For contracts C6.1.1 and C6.1.2 there were no records available for aggregate strength results, even though aggregate was sourced from a previously tested quarry (Malapo). For contracts C6.1.3 and C6.1.4, a test result was available for each contract; and the strengths 100kN (C6.1.3) and 108kN (C6.1.4), both from Nissi Quarry, were lower than the 110kN specified for 100vpd or more.

   (d) **Aggregate Wet / Dry strength ratio:** Specification requires minimum wet / dry strength ratios of: 0.60 for less than 100vpd; and, 0.75 for 100vpd or more. No test results were available for wet / dry strength ratios.

(e) **Aggregate Water Absorption Ratio:** Specification requires bitumen spray rate to be increased by 0.3 litre/m2 for water absorption ratios of 2% or more. Water absorption tests were not undertaken; however results from a study undertaken in 1993 on quarries in Tongatapu and Vava'u were used as the basis to decide on a water absorption rate of more than 2%. (British Geological Survey Technical Report WC/92/23 states a range of water absorption ratios from 2.1% for Ahononou Quarry to 8.1% for Malopo Quarry)

(f) **Particle size distribution (Aggregate grading):** Four grading envelopes were available for the combined aggregate grading: Dense; Medium; Open; and, Open Modified / Open Overby. Otta Seal Guide stated preferred grading as Medium or Dense, with Dense recommended for more than 1000vpd. For C6.1.1 and C6.1.2, three aggregate grading test results were available, one outside Open grading envelope and rejected by the PM. Of the other two aggregate gradings, which were close to Open Overby grading envelope, there is no record of which one was approved for use. For C6.1.3 and C6.1.4, aggregate grading tests were undertaken for each 100m3 stockpile.

6. Surveillance / Tests required during sealing

(a) **Bitumen spray rates:** Daily bitumen spray records were available for all contracts, for total lengths of the contracts. The spray record included for each run: length, width, area, temperature, start and end bitumen volumes, bitumen rate (hot), time, pump speed, and truck rpm. For C6.1.1 and C6.1.2 most spray rates were close to the specified rate of 2 to 2.2l/m^2, generally between 1.8 and 2.4. Exception to this included: four runs with low rates – 1.3 to 1.5 l/m^2, which were identified as non-conforming and rejected by the PM, and two runs with high rates, exceeding 3 l/m^2 – both last runs for the day. Subsequent field visits revealed that some of the low rate rejected sections, where contractor applied a second coat to make it conforming, had excess bitumen on the surface, whilst the areas with high rates did not show up as having excess bitumen on surface. For C6.1.3 and C6.1.4, the bitumen spray rates were generally around 2 l/m^2 specified, with no large variations.

(b) **Bitumen storage and spray temperatures:** Temperatures recorded in Daily spray records varied between 130°C to 170°C, which is in the range specified in Section 6.5 of Otta Seal Guide for MC3000 bitumen. It is noted that Year 1 or Year 2 Periodic Maintenance Contracts did not specify bitumen spray temperatures in Otta seal Specification, even though there were bitumen spray temperatures specified for other bitumen types in General Specifications of the Contracts. The temperatures at which bitumen was stored could not be verified, as there was no bituminous sealing during the audit and no records relevant to that aspect were available.

(c) **Aggregate spread rates:** Specifications provide ranges for aggregate application rates for open, medium and dense gradings, however there is no requirement to test the rates; the only requirement being that there be surplus amounts for initial curing period of the seal.

(d) **Bitumen blending:** Specification requires Class 170 bitumen to be blended with a 3% softener (engine oil) and a 6% cutter (kerosene), and the mix to be circulated for one hour to get consistency. The daily checklist filled by field supervisors does not have a check to verify that bitumen blend was circulated for 1hr as specified.

7. Adequacy of Contract Specification in relation to Otta Seal quality management

Year 1 Contract Specifications did not stipulate a testing frequency for aggregate testing; however the PM imposed a frequency of one test per 100m^3 for aggregate grading on C6.1.3 and C6.1.4. Year 2 Periodic Contracts address this deficiency, and a testing frequency of one per 100m^3 has been included for Otta seal aggregates for: aggregate wet / dry strength, grading, flakiness, and water absorption. This frequency may seem excessive for the tests other than grading, however as most contracts are about 2–3km in length, thus requiring about 200–300m^3 aggregate, it will require only about 2–3 tests per contract.

Both Year 1 and Year 2 Contracts did not specify bitumen spray temperatures in Otta seal Specification, even though there were bitumen spray temperatures specified for other bitumen types in General Specifications. This is considered a major inadequacy.

Recommendations

1. Assess the possibility of better utilising the Supervision Consultant by allowing greater involvement within the delegated authorities.
2. Improve traceability of non-conformance management by maintaining a register to record: agreed dispositions; implementation of dispositions; and, action to prevent recurrence.
3. Streamline the Otta seal supervision checklist / daily record by combining the three pro forma currently used into one. Include a check for bitumen blending on site to ensure that required consistency is achieved by circulating for one hour.
4. Consider the use of Maintenance Survey Forms for scoping and payment of surface preparation work prior to Otta sealing.
5. Assist the contractors in obtaining Bitumen Sprayer Certificates, by commissioning a specialist for all contracts, and deducting the cost from the relevant Provisional Sum item.
6. Undertake aggregate testing for each nominated quarry for Year 2 Contracts, for wet / dry strength, flakiness, and water absorption ratio.
7. Assist the contractors in sampling and testing of aggregate grading prior to and during sealing.
8. In Contract Specifications or as a directive to contractors, provide a bitumen spray temperature range for Year 2 Otta sealing, after deciding the bitumen grade achieved through specified blending process.
9. Consider the submission of product quality verification by Contractor as a prerequisite for progress payments, in order to improve quality management.

Evidence

Refer to Annex 3 of the Report for a list of documentary evidence.

3.2 General Routine Maintenance Contracts

Finding 3.2.1: Planning, monitoring and payment for routine maintenance have been well documented indicating a controlled and traceable process, except for not undertaking some required concrete strength tests. The excessive time gap between procurement of routine maintenance contracts is detrimental to road safety and road asset preservation.

Observations

Review of quality records of the three selected General Routine Maintenance Contracts, and inspection of the routine pavement maintenance undertaken under the contracts revealed the following:

1. **Planning, monitoring, and payment:** Routine maintenance activities were planned, monitored, and paid based on a work order / progress payment system. This involved: Maintenance Survey Forms to scope potholes, edge breaks, verge reduction, and drain clearing; issue of monthly work orders summing up quantities from above Forms; monitoring and approving the work done based on the work order quantities; and, progress payment for approved quantities. Site visits to the three Districts revealed that the routine work for the first quarter of Year 2 contracts, being awarded at the time of the audit, was already scoped in two of the Districts.
2. **Quality Control:**
   (a) Pothole patching: The MoI Routine Maintenance Manual formed part of the Year 1 Contract documents. In addition, the PM issued to Contractors the work practices for pothole repair, an extract from the Manual. In the interviews, Contractors and Supervision staff showed awareness of this work practice and they advised that it was followed. Supervision staff also advised that aggregates were from tested and approved quarries; however there were no records to substantiate that. Aggregate testing is not a specification requirement in Year 1 contracts, however it is a requirement in Year 2 contracts, and its implementation should improve quality assurance of the

materials used in pothole patching. From the site inspections of the three Districts: Nuku'alofa, Hihifo, and 'Eua, there was no evidence of failed or re-patched pothole patches, however there were areas where new potholes were forming in the vicinity of previous pothole patches.

(b) Concrete testing for drain covers: In C7.1.4 and C7.1.5, 3 Variation Orders were issued to replace 1,063 existing damaged drain covers in the Nuku'alofa town area (constructed previously by others). The PM issued instructions on their design and concrete strength (25MPa). The concrete used for pre-casting these drain covers were required to be tested, however no such test results were sighted during the Audit. Year 2 contracts for these Districts require supply and installation of more drain covers, and also a testing requirement for concrete. It would be prudent to check the structural design of these drain covers due to the marine environment, and possible occasional vehicle loading due to proximity to traffic.

3. **Procurement:** In November 2012, seven contracts were awarded for routine maintenance: four in Tongatapu; and, one each in 'Eua, Ha'apai, and Vava'u. Due to delays in contractors mobilising, the commencement date was postponed to January 2013. There were further delays in scoping work and issuing work orders by the supervision teams, and actual work commenced only in March 2013. As the contract quantities were being completed before scheduled times, contract completion dates were brought forward to September 2013. There were delays in procuring the next round of routine maintenance contracts, which were being awarded at the time of the Audit, March 2014, with work expected to commence in April 2014. In this six-month gap between routine maintenance contracts (October 2013 to March 2014), some of the urgent work has been undertaken by MoI minor contracts, also the wet season ending in March could hinder effective pothole repair. Nevertheless this large time gap between routine maintenance contracts is an undesirable outcome detrimental to road safety and asset preservation, and the site inspections indicated reduced sight distance due to vegetation growth in some road sections. Options available to prevent large time gaps between routine maintenance contracts is to increase contract durations from 12 months to 2–3 years, or annual contracts with provision for one- or two-year extensions subject to satisfactory performance.

Recommendations

1. Undertake aggregate testing as per Year 2 Contract Specifications for pothole patching, to provide assurance on the quality of materials used.
2. Undertake concrete strength testing as per Year 2 Contract Specifications for the drain covers to be supplied under Hihifo and Nuku'alofa District contracts.
3. Minimise the time gap between routine maintenance contracts by timely procurement of contracts and providing adequate quantities to cover routine maintenance activities for the full duration of contracts.
4. Consider options for longer term routine maintenance contracts of up to two or three years, or annual contracts with provision for one- or two-year extensions subject to satisfactory performance, to prevent large time gaps between contracts.
5. Undertake a structural design and stipulate a procedure for pre-casting and placing drain covers in Year 2 Contracts, taking into account the marine environment and the potential occasional vehicle loading due to proximity to traffic.

Evidence

Refer to Annex 3 of the Report for a list of documentary evidence, and also following photographs taken during site inspections.

Figure 5 Pothole Patches on Hihifo Road and Pothole patches on 'Eua District

3.3 Materials Testing Laboratory

Finding 3.3.1: Materials Testing Laboratory was equipped to undertake materials testing required under periodic and routine maintenance contracts, however improvements are required in: record keeping; and, additional competent staff for management and verification of testing.

Observations

An inspection and records review of the Materials Testing Lab at MoI was undertaken on 20 March 2014, and following were observed:

1. **Documents and records:** Forty-one Australian Standards and three British Standards were in the Lab for testing of: cement; bitumen; bituminous mixes; Soils and Gravels; Aggregates; and, Concrete. These covered all the test methods (and more) required under the periodic and routine maintenance contracts. Copies of test results undertaken have not been kept in the Lab (originals given to requesting party) except for some field density test results undertaken for a Chinese contractor.
2. **Equipment:** The tools and equipment for tests required in periodic maintenance contracts were available including: sieves and a riffler for grading; two compression testing machines for aggregate strength, concrete crushing, and California Bearing Ration; slump cone and moulds for concrete testing; moulds for California Bearing Ration and aggregate strength; equipment for Atterberg limits; field density testing equipment by sand replacement method; coring machine (100mm diameter) suitable for shallow cores (such as pavements).
3. **Equipment Calibration:** A record was available for calibrating the sand used for field density tests. (sand density). There were no calibration records for equipment on file; however calibration stickers dated August 2012 were on four compression testing machines.

Testing could not be witnessed during the Audit, as there were no maintenance activities in progress. The Audit had provisions for undertaking materials testing, however the only meaningful tests that could be undertaken were aggregate wet dry strength and water absorption ratio test for aggregates from Nissi Quarry. This could not be undertaken due to lack of time.

Recommendations

1. Maintain a proper document control system including equipment calibration records in the Materials Lab.
2. Consider maintaining a register of all the tests undertaken with copies of test results in the Materials Lab, as a backup for quality assurance of periodic and routine maintenance contracts.
3. Provide additional competent staff to improve management and verification of materials testing in the Lab, with relevant training as required.

3.4 Interviews with Contractors

Finding 3.4.1: In the interviews with contractors, common positives raised were assistance from Supervision teams and training received, and a common negative was difficulties faced with materials testing.

On 18 March 2014, interviews were held with seven contractors who have worked / or intend to work on periodic or routine maintenance contracts. These included:

1.	BB Construction	Periodic Maintenance Contracts C6.1.3, C6.1.4
2.	Five Star Construction	Routine Maintenance Contracts for all four Districts of Tongatapu
3.	Veisiale Construction	Routine Maintenance Contracts for Vava'u District
4.	Petani Quarry	Routine Maintenance Contracts for 'Eua District
5.	Gateos Expert Painting	Road Signs and Markings, Ha'apai

Of the other two contractors, Toa Construction has been awarded a Year 2 Routine Maintenance Contract, while Matangi Civil Works was yet to win a contract.

Some common positives out of the interviews were:

> Directives from Supervision team assisted planning and implementation of work. (This is reflected in a feedback letter from BB Construction dated 13.03.14 to MoI, thanking for MoI's Contractor Performance Evaluation Report, and providing professional advice and supervision).

> Training received very valuable, particularly knowing 'why' something should / should not be done gives better appreciation. Some suggested periodic refresher courses.

A common negative was the delays experienced in materials testing, in terms of time taken, as well as some tests not undertaken (e.g. concrete tests for drain covers in C7.1.4, C7.1.5)

3.4.1 Recommendation

1. Consider conducting training courses or refresher courses on contracting and road maintenance on a periodic basis to maintain and improve contractors' skills and competencies.

ANNEX 1: APPROVED AUDIT PLAN

Audit Plan - Final

Technical Audit of Select Tonga Transport Sector Consolidation Project (TSCP)

General Routine and Periodic Maintenance Contract Works

1. Audit Objectives

To review contract compliance of a select package of contracts of the general routine and periodic road maintenance components of TSCP, and to assess:

1. Effectiveness of contractors' quality control and project construction procedures for compliance with contract specifications and drawings or acceptable technical standards where details not covered in the contract documents.
2. Effectiveness of project supervision processes and project supervision team(s) in assuring contractor compliance with contract specifications and drawings.

Any recommendations from the audit will be aimed at identifying improvements to procedures, systems, and resources related to road maintenance quality assurance and contract supervision.

2. Audit Criteria

Audit Criteria are reasonable and attainable standards of performance that represent rules or principles for testing during the audit process. In line with the above Audit Objectives, the criteria for this Technical Audit are:

1. Contractors' quality control and project construction procedures comply with contract specifications and drawings or acceptable technical standards.
2. Project supervision processes and project supervision team(s) effectively assure contractor compliance with contract specifications and drawings.

3. Audit Scope

The audit will review the contracts listed in ***Table 1***, as stipulated in Section 3.8 of the Department of Foreign Affairs and Trade (DFAT) Service Order ***(Annexure A).*** However, depending on the road maintenance activities being undertaken during the Audit Fieldwork period, the Auditor may choose other similar contracts for auditing subject to DFAT approval.

Table 1 – List of contracts for review

Contract No.	Type	Location	Value (TOP)	Contractor
Contract A – C6.1.3	Periodic	Nuku'alofa	807,196.50	BB Construction
Contract B – C6.1.4	Periodic	Nuku'alofa	527,810.49	Tafolo Construction (Work completed by BB Construction as Tafolo went into receivership)
Contract C –C7.1.1	Routine	'Eua	191,166.52	Petani Quarry
Contract D –C7.1.4	Routine	Hihifo	141,773.00	Five Star Construction
Contract E – C7.1.5	Routine	Nuku'alofa	150,890.00	Five Star Construction

4. Key Stakeholders

Following Key stakeholders have been recommended for consultation in Section 3.10 of the DFAT Service Order ***(Annexure A)***:

1. DFAT and World Bank representatives
2. Representatives from the Government of Tonga Ministry of Infrastructure (MoI) including Land Transport Division

3. TSCP Project team
4. Contractors
5. Design and Supervision Consultant (local)

Additional stakeholders may be identified and consulted (subject to DFAT concurrence) during the audit process.

5. Exclusions

The audit excludes cost and time management aspects of the contracts reviewed.

6. Constraints

Following are potential constraints that may need to be addressed in achieving audit objectives:

1. Non availability of quality records with contractors and project supervision teams due to lack of understanding or experience of relevant personnel in quality systems.
2. General routine and periodic maintenance activities not occurring during Auditor's site visits.
3. Inability to undertake verification tests required by the Auditor in materials testing laboratories due to lack of certified equipment / skilled operators.

7. Reference Documentation

Reference Documents reviewed in audit planning includes DFAT material provided, as listed in Section 9.1 of the DFAT Service Order. ***(Annexure A)***

In addition, following documents are considered to be the governing documents for the purpose of this audit (even though some are in draft form), and will be referenced during the audit for compliance assessment of contractors and project supervision team activities:

1. Routine Road Maintenance Manual, Ministry of Transport, March 2012.
2. Maintenance Manual for Roads in Tonga, Ministry of Transport, March 2012.
3. Ministry of Transport Specifications forming part of the Periodic Road Maintenance Contracts MOI/LAD/C6.1.3 and MOI/LAD/C.6.1.4.
4. Contracts Administration Manual – Minor and Major Works, Ministry of Infrastructure, August 2012.
5. Guidelines for Performance Monitoring Otta Seal Resurfacings in the Pacific Island Countries, World Bank, Sep 2011.
6. Otta Seal Monitoring Program, Ministry of Transport, June 2012.
7. Training in the Design, Construction and Maintenance of Otta Seals, Ministry of Transport, January 2012.
8. Road Design Specifications and Standards, Ministry of Transport, April 2012.

8. Time Management

Following milestones are intended to be met for the audit process:

#	Milestone	Date
1	Consultation with DFAT on Draft Audit Plan	12.03.14
2	Audit Plan - Finalisation	14.03.14
3	Commence Fieldwork including stakeholder consultation	17.03.14
4	Complete Fieldwork	22.03.14
5	Initial End of Fieldwork Audit Report	24.03.14
6	Draft Audit Report	07.04.14
7	Final Audit Report (based on 2 weeks for DFAT response to Draft Report)	28.04.14

9. Audit Methodology

9.1 Stakeholder consultation

Stakeholders identified in Section 3 of the Audit Plan will be consulted during the audit. A draft meeting schedule has been prepared by the Second Secretary (Development Cooperation), Tonga, DFAT. ***(Annexure B).*** This will be finalised closer to the date of audit fieldwork. The main objectives of stakeholder consultation are:

1. Brief on the objectives and scope of the Technical Audit, including the time and cost management exclusions from the audit.
2. Seek their views / inputs on the technical performance of road maintenance contractors, identify persistent non-compliances, etc.

9.2 Review of quality documents and records

Quality documents and quality records on the general routine and periodic maintenance activities, held by the project supervision team and the contractors listed in Table 1 will be reviewed to assess compliance to contract specifications and drawings / acceptable technical standards.

9.3 Field inspections

Field inspections will be undertaken on the activities of contactors listed in ***Table 1.*** The activities / activity groups to be inspected, and the documents providing specifications for compliance, in addition to the MoI Specifications which form part of the Periodic Road Maintenance Contracts, are listed in ***Table 2.***

Table 2 is only a guide for field inspections, and this will be supplemented by: the Auditor's engineering judgement; stakeholder comments; interviews with field supervisors; verification testing where necessary; and, other relevant observations.

Table 2: Activities / Activity Groups for field inspection

#	Activity / Activity Group	Specifications for compliance (Relevant Sections from Document no. from Section 7 above)
Periodic Maintenance		
1	Pothole / edge break repairs	Section 4.7 of Doc No. 1 Section 4.5 of Doc No.2
2	Pavement rehabilitation	Section 3 of Doc No. 3
3.	Otta seal	Section 15 of Doc No. 3 Doc No. 5, also Doc Nos. 6, 7 as required
General Routine Maintenance		
1.	Drainage maintenance (culverts, side drains)	Sections 4.1 to 4.5 of Doc No. 1
2.	Vegetation control, rubbish removal	Section 4.9.1 of Doc No. 1
3.	Shoulder maintenance	Section 4.6 of Doc No. 1
4.	Repairs on bituminous paved roads (potholes, edge breaks, heavy patching)	Section 4.7 of Doc No. 1 Section 4.5 of Doc No.2
5.	Repairs on unpaved roads (potholes, heavy patching)	Section 4.8 of Doc No. 1
6.	Patrol Grading, Team Grading	Sections 3.6, 3.7 of Doc No. 2
7.	Maintenance of signs, road markings	Section 4.9.2 of Doc No. 1

9.4 Verification Testing

Verification testing, under the provisions of Section 6.4.c of the DFAT Service Order ***(Annexure A),*** will be undertaken in following circumstances:

1. Where a critical test has not been performed or test results not available on a key activity / product that in the Auditor's opinion is deficient.
2. Where the available test results on a key activity / product is, in the Auditor's opinion, erroneous.

9.5 Documentary Evidence

The documentary evidence to support the findings of this Audit will consist of:

1. Evidence obtained in the review of documents and records of Section 9.2 above.
2. Photographic evidence obtained from Field inspections of Section 9.3 above.
3. Results obtained from Verification Testing in Section 9.4 above.

10. Audit Reporting

Audit reporting will be undertaken as per the requirements of Section 4 of the DFAT Service Order ***(Annexure A),*** in the 3 stages of: Initial End of Field Audit Report (3-4 pages); Draft Audit Report; and, Final Audit Report.

Subject to DFAT approval, the Audit Reports will be presented in following structure:

1. Audit Criteria
2. Findings under each Audit Criterion
3. For each Finding: Observations, Evidence, Audit Opinion, and Recommendations (where required).
4. Each Recommendation will have a Responsible Person / Party for action, and a time frame for implementation.

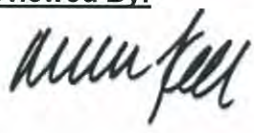
11. Approvals

Prepared By:

.....

Roy Abeygoonawardana
Auditor / Independent Contractor to
Cardno Emerging Markets (Australia) Pty Ltd

Reviewed By:



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Richard Kell
Director
Cardno International Pty Ltd

Approved By:

.....

Peter Kelly
Pacific Infrastructure Advisor
Department of Foreign Affairs and Trade

Annexure A

Department of Foreign Affairs and Trade Services Order No. 65697/1 for the Technical Audit of Select Tonga Transport Sector Consolidation Project General and Routine Maintenance Contract Works (Tonga).

Annexure B

(Draft) Meeting Schedule for Audit Fieldwork

(To be finalised prior to Audit Fieldwork)

Road Audit for the Transport Sector Consolidation Project (TSCP) - Tonga

Time	Activities	Participants	Venue
	Briefing with the World Bank (WB) via teleconference	Chris Bennett Megan Schlotjes Saia Faletau	Australian High Commission (AHC)
	Meeting with the TSCP team	Lawrie Carlson, TSCP team, and land transport division	Ministry of Infrastructure (MoI) – O.G. Sanft Building
	Meeting with the Aid and Project Management Division (courtesy call)		Tonga Development Bank building
	Meeting with the CEO, MoI	Ringo Fa'oliu	MoI - Vaololoa
	Meeting with local contractors		
	Meeting with the design and supervision consultant (local)		
Day trip 22 March	Site Visits (hosted by the Land Transport Division, including roads and lab)		
Day trip	Travel to the Outer-Islands ('Eua?): • Meet with local contractors • Site visits		
24 March	Debrief with the TSCP evaluation team, and broader stakeholders		

ANNEX 2: LIST OF DOCUMENTARY EVIDENCE

Annex 2: List of Documentary Evidence

#	Document / Record (Author, Recipient, Date)	Title / Key contents relevant to Finding
Finding 3.1.2 – Supervision Consultant		
1	C6.1.2 – Letter from PM (MoI) to Vava'u Construction dated 17.10.12	Letter of Delegation of Powers to Project Manager's Representative and Supervision Consultant, PECG. (Similar letters sighted for all other Year 1 Periodic Contracts)
Finding 3.1.2 – Directives from Supervision Team to Contractor		
2	C6.1.1 – Instructions from PECG to Vava'u Construction. Instruction 2 dated 19.07.12; Instruction 5 dated 10.08.12.	Instruction 2 – bitumen and aggregate application rates, blending of bitumen, need for second roller; Instruction 5 – Checklist to be completed for Otta Seals.
3	C6.1.1 – Letter from PMR (MoI) to Vava'u Construction dated 22.10.12	Post Construction Care (after care) pursuant to Cl 15.5.4 of Otta Seal Specification. Emphasis on rolling for first three days, monitoring for 2–3 weeks, sweeping excess aggregate on fourth week.
4	C6.1.2 – Letter from PMR (MoI) to Vava'u Construction dated 06.11.12	Emphasis on Contract Submissions – Health and Safety Plan, and Quality Management Plan.
5	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 07.11.12	Emphasis on Contract Specifications Clauses: 15.5 – construction methodology, equipment required; 1.16.5 – Materials testing frequency; 1.16.4, 1.16.5 – responsibility and payments for testing.
6	C6.1.3 – Email from Technical Adviser (Roads) TSCP to Supervision Team dated 01.11.12	Providing a Generic Quality Management Plan containing technical procedures, method statements, and checklists.
Finding 3.1.2 – Exception Reports		
7	C6.1.1 – Letter from PMR (MoI) to Vava'u Construction dated 20.0213.	Review of work on Sipu Road – non-conforming Otta seal work on 12.02.13. Bitumen spray rates lower than specified (1.94 and 1.41 l/m^2).
8	C6.1.2 – Issue of Exception Report No. 4 from PECG to Vava'u Construction dated 27.11.12	For non-conforming works on 27.11.12 re. Bitumen spray rates lower than specified (1.3 and 1.65 l/m^2) , and bitumen sprayer not in good mechanical condition.
Finding 3.1.2 – Surface preparation for Otta seals		
9	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 12.02.12	Revised Project Scope containing the scope and quantities for pothole and edge break repairs using Maintenance Survey Forms. (due to change of Contractors from Tafolo to BB Construction).
Finding 3.1.2 – Bitumen Certificate of Quality		
10	C6.1.1 – Letter from PM (MoI) to Vava'u Construction dated 16.10.12	Request for Bitumen Certificate pursuant to Cl 1.16.5 of Contract Specification.
11	Email from Vava'u Construction dated 28.11.12 to PM submitting Bitumen Certificate (dated 13.03.12)	Test results for bitumen sampled 13.03.13, compliant to AS2008 Specification for Class 170.
12	C6.1.3 – Letter from PM (MoI) to BB Construction dated 17.11.12	Query on validity of Bitumen Certificate submitted on 17.11.12 re. no reference batch no., a lab result and not a Certificate.
13	Email correspondence between Bruce Jackson (TSCP) and bitumen supplier (Technix) dated 20.11.12, 23.11.12	Technix substantiating that document submitted was a Certificate relevant to bitumen supplied.
Finding 3.1.2 – Bitumen Sprayer Certificate		
14	C6.1.3 – Letter from PM (MoI) to BB Construction dated 28.02.13	Request for Bitumen Sprayer Certificate pursuant to Cl 5.3.3. of General Specifications.
15	C6.1.3 – Letter from PM (MoI) to BB Construction dated 28.02.13	Request for Bitumen Sprayer Certificate pursuant to Cl 5.3.3. of General Specifications.
16	C6.1.3 – Letter from PM (MoI) to BB Construction dated 11.03.13	Request for Bitumen Sprayer Certificate pursuant to Cl 5.3.3. of General Specifications.
17	C6.1.3 – Letter from PM (MoI) to BB Construction dated 09.04.13	Review of Sprayer Certificate requirement and approval to proceed based on maintaining a Spray Chart.
18	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 24.05.13	Approval of BB Construction's Bitumen Sprayer and Bitumen Heating Kettle for use.
Finding 3.1.2 – Supervision Consultant		
19	C6.1.2 – Letter from PM (MoI) to Vava'u Construction dated 17.10.12	Letter of Delegation of Powers to Project Manager's Representative and Supervision Consultant, PECG. (Similar letters sighted for all other Periodic Contracts)
Finding 3.1.2 – Aggregate Water Absorption Ratio		
20	British Geological Survey Technical Report WC/93/23 'The Limestone Resources of Tongatapu and Vava'u – Kingdom of Tonga'(1993)	Table 5 lists following material properties from nine quarries in Tongatapu: Water Absorption, Relative Density, Flakiness. Lowest water absorption Aho'nonou Quarry 2.1%, Highest Malopo Quarry 8.1%.

#	Document / Record (Author, Recipient, Date)	Title / Key contents relevant to Finding
Finding 3.1.2 – Aggregate Strength and Grading Approvals		
21	C6.1.1 – Instruction 4 from PECG to Vava'u Construction dated 26.07.12.	Rejecting aggregate grading proposed by Test Nos. 16, 45, 55.
22	C6.1.1 – Letter from PECG to Vava'u Construction dated 30.04.12.	Rejection of combined aggregate grading proposed by Vava'u Construction.
23	C6.1.1, C6.1.2 – Email correspondence from Technical Adviser (Roads) TSCP to Supervision Team between 18.03.13 and 17.04.13	Concerns on the aggregate grading test results no. 75 and 76 for Vava'u Construction – that they are not within Dense Grading envelope, but more on Open grading envelope.
24	C6.1.3 – Letter from PM (MoI) to BB Construction dated 17.04.13	Advice on the aggregate strength and grading results submitted by Contractor for Royco Quarry (not approved) and Malopo Quarry (approved).
25	C6.1.3 – Letter from PM (MoI) to BB Construction dated 17.06.13	Approval of aggregate strength (Test Sample 102 – 100KN for 10% Fines), aggregate grading (Test Sample 101) for Lot No.1 stockpile at Nissi Quarry
26	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 24.09.13	Approval of aggregate strength (Test Sample 204 – 100KN for 10% Fines), aggregate grading (Test Sample 205) for Lot No.1 stockpile at Nissi Quarry
27	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 30.09.13	Approval of aggregate grading for Lot No.2 stockpile at Nissi Quarry (Test Sample 206)
28	C6.1.4 – Letter from PM (MoI) to Tafolo Group dated 08.10.13	Approval of aggregate grading for Lot No.3 stockpile at Nissi Quarry (Test Sample 209)
Finding 3.1.2 – Bitumen Spray Rates		
28	Daily Bitumen Spray Sheets were sighted for all the road lengths of Otta Seals conducted under Year 1 contracts, in the Progress Reports submitted by PECG.	The Daily Bitumen Spray Sheets contained: Road name, date, Start and End times, Spray No., width, length, area, temperature, start and end volumes, litres used, bitumen rate, remarks.
Finding 3.2.1 – General Routine Maintenance – Pothole patching work practice		
29	C7.1.1 – Letter from PM (MoI) to Petani Quarry dated 02.07.13	Confirmation of Work Practices for Pothole Repair on Paved Roads – Section 4.7.2 of the Routine Road Maintenance Manual. (similar letters sighted for C7.1.4, C7.1.5)
Finding 3.2.1 – General Routine Maintenance – Revision of Contract Start Date		
30	C7.1.1 – Variation Order No.1 from PM (MoI) to Petani Quarry dated 20.12.12	Start date for contract revised from 28.11.12 to 01.01.13. (similar letters sighted for C7.1.4, C7.1.5)
Finding 3.2.1 – General Routine Maintenance – Concrete Drain Covers		
31	C7.1.4 – Letter from PM (MoI) to Five Star Construction dated 12.02.13.	Request for Price for supply and place for replacement of damaged drain covers. Size 500mm x 430mm x 100mm. Y12 reinforcement four bars each way. 25 Mpa Concrete.
32	C7.1.4 – Variation Order Nos 2 and 4 from PM (MoI) to Five Star Construction dated 25.02.13, and 18.06.13 respectively.	Variation Order No.2 for 275 concrete lids for open drains (TOP 9,625), and Variation Order No. 4 for 300 lids (TOP 10,500).
33	C7.1.5 – Variation Order No 4 from PM (MoI) to Five Star Construction dated 18.07.13.	Variation Order No.4 for 488 concrete lids for drains (TOP 17,080).
Finding 3.3.1 – Material Testing Laboratory		
34	Australian and British Standards Test Methods kept in Lab	Australian and British Standards held: one for cement testing; four for bitumen testing; one for bitumen mixes; 17 for soils and gravels; 12 for aggregates and gravels; and eight for concrete. Total 43.
Finding 3.4.1 – Positive feedback from Contractors		
35	BB Construction to MoI on Performance Evaluation MoI_LAD_C6.1.3, dated 13.03.14	The letter thanks to MoI for the Performance Report, and providing professional advice and supervision to meet the key deliverables.

ANNEX 3: DISCUSSIONS AND INTERVIEWS WITH STAKEHOLDERS

Annex 3: Discussions and Interviews with Stakeholders

Date	Location	Person (Name, Position, Organisation)	Key points discussed
17.03.14	MoI at Vaololoa – Laboratory	Lawrie Carlson – TSCP Project Manager Kasipa Paea – Lab Technician	Introduction to Laboratory and MoI Project Supervision Staff including Tevita Lavemai, Project Manager for Year 1 Contracts. Overview of TSCP.
17.03.14	Australian High Commission	Scott McLennan, First Secretary, Louise Scott, Second Secretary, DFAT	DFAT expectations from the Audit, Auditors intended activities for coming days.
17.03.14	MoI – O.G. Sanft Building	TSCP team: Lawrie Carlson, and Bruce Jackson, TSCP Roads Adviser.	Processes on supervision of contracts. Review of Contract Files, and Progress Reports from PECG.
17.03.14	Tonga Development Bank building	Balwyn Faotusia, Head Aid Management Division, DFAT, Scott McLennan, Louise Scott, DFAT	Brief outline of the Audit and its objectives.
18.03.14	MoI – O.G. Sanft Building	Local Contractors. Details in Finding 3.4.1	Key issues raised in Finding 3.4.1
18.03.14	Nissi Quarry	Luke Berrell, Quarry Manager, Bruce Jackson, TSCP	Iterative process undertaken to get the required aggregate grading for Otta seals.
18.03.14 (PM), and 19.03.14 (AM)	MoI at Vaololoa	Tevita Lavemai, Project Manager for Year 1 Contracts Peni Vea, Project Manager's Representative, Year 1 Periodic Hapi Oko, Project Manager's Representative, Year 1 Routine	Detailed review of contract records and questions arising out of that.
19.03.14 (PM)	Site Visit	Bruce Jackson, TSCP	Detailed inspection of all Otta seals from Year 1 Contracts
20.03.14	Local cafe	Sione Taumoepeau, Director PECG (Supervision consultant)	Brief outline of the audit. Issues related to project supervision.
20.03.14	MoI at Vaololoa – Laboratory	Kasipa Paea – Lab Technician	Detailed inspection of routine maintenance under C7.1.4 (Hihifo), C7.1.5 (Nuku'alofa), and some roads in Hahake District.
20.03.14	Site Visit	Hapi Oko, Project Manager's Representative, Year 1 Routine	Detailed inspection of routine maintenance under C7.1.4 (Hihifo), C7.1.5 (Nuku'alofa), and some roads in Hahake District.
21.03.14	Site Visit	Tevita Lavemai, Project Manager for Year 1 Contracts Sekitofa Malupo, Petani Quarry (Contractor)	Detailed inspection of routine maintenance under C7.1.1 ('Eua Island), and a visit to Petani Quarry.
22.03.14	Site Visit	Tevita Lavemai (MoI), Lawrie Carlson, Bruce Jackson (TSCP), Mark	Inspection of Otta seal work, pothole patching under routine maintenance, and some roads requiring rehabilitation / resealing.

Date	Location	Person (Name, Position, Organisation)	Key points discussed
		Barrett (DFAT), Chris Bennett, Megan Schlotjes, Will Costin (World Bank)	
24.03.14	Australian High Commission	Scott McLennan, Louise Scott, DFAT	Debrief of the documented Preliminary Observations and Findings (document).
24.03.14	MoI at Vaololoa	Ringo Fa'oliu, CEO, MoI; Louise Scott, DFAT	Debrief of the documented Preliminary Observations and Findings (document). MoI's vision for future improvements in contract management and materials testing.
25.03.14	MoI – O.G. Sanft Building	Balwyn Faotusia (Ministry of Finance) Lawrie Carlson, Bruce Jackson (TSCP), Scott McLennan, Louise Scott, Mark Barrett (DFAT), Chris Bennett, Megan Schlotjes, Will Costin (World Bank)	Debrief of the documented Preliminary Observations and Findings (document). Close out of the audit fieldwork.

ANNEX 4: COMMENTS AND RESPONSE MATRIX

Annex 4: Comments and Response Matrix

#	Draft Audit Report Section	Comment	Audit Response
Department of Foreign Affairs and Trade (DFAT) Comments dated 17 April 2014			
1	Section 1.1	Highlight that the quality (strength) of the aggregate used in the Otta Seal is less than required for a spray seal.	Section 1.1 amended to incorporate this comment.
2	Section 1.4.2	Check whether the MoI found additional concrete strength test results	The Contractor for C7.1.4, C7.1.5 (Five Star Construction) stated that concrete samples were not taken by the Lab. (Section 3.4, Finding 3.4.1). Also, the TSCP Road Adviser agreed with that statement. Therefore comment not incorporated in the Report.
3	Section 1.5	Include a point on the long term monitoring and evaluation of the performance of works, as detailed in the WB Guidelines for Performance Monitoring Otta seal resurfacings in the Pacific Island Countries (September 2011) copy attached.	Section 3.1, Finding 3.1.1. A new Recommendation (6) added to incorporate this comment. Section 1.5 also amended accordingly.
Tonga Transport Sector Consolidation Project (TSCP). Comments by Bruce Jackson, Technical Adviser dated 16th April 2014			
1	Section 1.4.2 First Paragraph	Reason behind accelerating the contract duration period from 12 to 9 month was taken as the Road Maintenance Fund had just been agreed to start and it was decided concentrate the routine maintenance done under the TSCP component of overall MoI/LTD road maintenance funding.	Section 1.4.2 Paragraph 1 amended to incorporate the intent of this comment.
2	Section 1.4.2 Second Paragraph	Work Orders for entire contract period based on monthly interval.	Section 1.4.2 Paragraph 2 amended to incorporate this comment.
3	Section 3.1 Finding 3.1.1 Recommendation 2	Year 2 Periodic Contracts have a Specification that prevents the use of a bitumen spray lance unless specific approval has been gained prior from the Engineer.	Section 3.1 Finding 3.1.1 Recommendation 2 amended to incorporate this comment.
4	Section 3.1 Finding 3.1.1 Recommendation 3	Year 2 Periodic Contracts have a Specification that details current accepted best practise of moving starts for bitumen spray operation to prevent excess thickness of bitumen application.	Section 3.1 Finding 3.1.1 Recommendation 3 amended to incorporate this comment.
5	Section 3.1 Finding 3.1.2, 5. b) Bitumen Sprayer Calibration	Year 2 Periodic Contracts have additional to Provisional Sum item within BOQ have a Specification that details specifically the bitumen sprayer calibration requirements as being mandatory.	Section 3.1, Finding 3.1.2, 5 b) amended to incorporate this comment.
6	Section 3.1 Finding 3.1.2, 6. a) Bitumen Storage and Spray Temperatures	It is agreed and noted for the ease of using Otta Seal Specification to have the Temperature Range detailed within the Otta Seal Section. With regards to Year 1 contracts reference is drawn to section 15.4.2 Binder Selection of Contract Specification for C612 that details that the average spray temperature is 150 degrees Centigrade and to refer to Section 5 Bitumen Surfacing of the General Specification. It is noted in table 15.4 MC3000 grade of bitumen is equivalent to AMC 5/6. Spray temperature for AMC 5/6 s covered in Section 5.3.7 a) i)	Comment accepted, but not incorporated in the Report, as both the Year 1 and Year 2 Specifications lack clarity with regards to bitumen spray temperatures.

#	Draft Audit Report Section	Comment	Audit Response
World Bank (WB) Comments dated 17th April 2014			
1		The report does not mention that no maintenance works had actually been carried out in the previous 3-4 years and whatever little force account capacity there was in the Ministry had been disbanded. This should be mentioned as it provides further context to the challenges faced on the project.	Section 1.1 Paragraph 2 amended to incorporate this comment.
2		There seems to be a common theme coming through the audit with regards to lack of information coming in or perhaps even tests that should have been done and were not. There were definitely failures by the TSCP team in managing the project, but this result is understandable with contractors lacking some experience and who would have been solely focused on getting the actual construction work completed. This problem is also not unique to this part of the world with contractors not necessarily being strong on the paperwork. Except if you connect payments to the information. In New Zealand we had a problem with as-build data not coming in until we have changed the payment terms where a contractor only get payment for the work completed on the day when the data is entered. That certainly steered the behaviour in the right direction.	Section 3.1, Finding 3.1.2. A new Recommendation (9) added to incorporate the intent of this comment.
3		The routine maintenance contracts were intended to be annual contracts, with work orders prepared either on monthly or quarterly basis. The quantities set at the start of the contract were really there for bidding purposes and represented the minimum amount of work that the contractor would be guaranteed payments for. In such contracts, the quantities are always notional, especially for pothole patching and operations that are influenced by weather, such as erosion and sedimentation and the quantities of debris to be removed. The contractor was expected to remain mobilised over the entire year and to have a site presence. This is an area that needs to be reviewed and the contracts adjusted accordingly. While multiyear contracts would be ideal, an alternative is an annual contract with provision for two extensions subject to satisfactory performance. The main requirement is that these are annual routine maintenance contracts with monthly or quarterly work orders, and not contracts with fixed quantities. We think after 2–3 annual rounds of these routine maintenance contracts, there should be a transition to performance based contracts.	Section 3.2, Finding 3.2.1, Recommendation 4 amended to incorporate the intent of this comment.
4		It may have been a case where the maintenance contractors were so pleased to get work that they used far more resources than planned, with the result that they completed 12 months of work in 6 months. This gives them a better cash flow, and a lower overhead cost. That is why the renewal process was caught unawares. It is recommended that careful control be kept over production rates to ensure that the maintenance team is always on site, as it is unacceptable that no maintenance is carried out for 6 months. The contracts should also include a clause of continuing, subject to good performance, until the new contracts have been awarded.	Comment accepted. Section 3.2, Finding 3.2.1, Recommendation 3 addresses the intent of this comment. Therefore no further amendments made to the Report.

#	Draft Audit Report Section	Comment	Audit Response
5		Based on the photographic evidence, it does not appear that the potholes are being filled after squaring the holes and filling and compacting the pothole repair mix to a specified depth. The report should confirm the method of pothole repair. This may be one reason why new potholes are forming adjacent to filled ones: the full extent of the damaged pavement area is not being repaired.	The pothole repair procedure stipulated in Contract is similar to current accepted practice, i.e. require trimming sides vertical and bottom horizontal, however does not require squaring the pothole (as was the previous accepted practice). By inspecting the repaired potholes it was difficult to determine whether the procedure was compiled or not.
6		The report does not provide an assessment of other routine maintenance activities: clearing drains, vegetation control, shoulder repair etc.	Due to the time lapse (6 months) since the last routine maintenance contract activity it was difficult to comment on how effective these activities were undertaken. Also, routine maintenance undertaken by MoI during this 6 month period to keep roads safe has assisted in the general upkeep of the road environment.
7		Regarding drain hole covers, and given the quantities involved, the use of 25 MPa concrete for thin elements such as drain covers in a marine environment is questionable. Should it not be 30 MPa at least? Also, just as important is the curing method and time of curing used. There should be appropriate specifications for pre-cast covers (were these available during the audit and attached to the C7 contracts?).	Comment accepted. The drain cover design seems adequate for pedestrian loading; however it is prudent to check for marine environment as well as possible occasional vehicle loading due to proximity to traffic. A new Recommendation (5) included in Section 3.2, Finding 3.2.1 to address this requirement.
8		The performance of Otta seals is very different from Chip seals and we should not judge Otta seals as we do conventional seals. This becomes evident from the observed bleeding of bitumen, yet function optimally when they appear fatty, unlike conventional seals. The local team is aware of the need to keep adding aggregate until no more material is accepted (initially this was not fully appreciated). This is particularly the case at intersections.	Comment accepted. The Report does not compare Otta seals with spray seals, rather assess Otta seal performance on its own merit. Therefore no amendments required to the Report.
9		Monitoring the aggregate spread rate as the auditor recommends is probably of no benefit as the final product is the test, not the quantities.	The Report does not recommend monitoring aggregate spread rates, only describes the method followed.
10		Bubbles as volatiles escape is normal, and if practical and warranted further aggregate should be added.	Comment accepted. Section 3.1, Finding 3.11, 4 a) amended to incorporate the comment.
11		International reports of poor performance are contained in Prof. Alex Visser's TRB 2013 Otta seals paper. Oversize material being plucked out leading to potholes, and inadequate rolling and replacement of aggregate leading to a smooth surface are the main problems, and occur in the short term (months). These have been carefully addressed in the Tonga procedure, hence there is no evidence of serious deterioration.	Comment accepted. No amendments required to the Report as a result.
12		It would be helpful to investigate how best to cut the bitumen with lighter grade hydrocarbons, is cutting with kerosene appropriate for the local climatic conditions?	The question raised in the comment is not within the purview of the Audit, and best answered by an expert on bitumen / Otta seals.
13		Can the bleeding not be rectified by blinding the surface with sand?	Blinding the surface with sand or fine aggregate, after using an appropriate softener such as Gilsabind ® is a standard treatment for bleeding, and this was discussed with the TSCP Team in addition to other options.
14		There is a need to develop a maintenance manual for Otta seals based on local experience and the experience from other tropical countries.	Comment accepted. Section 3.1, Finding 3.1.1, Recommendation 5 and the new Recommendation 6 address this need.

#	Draft Audit Report Section	Comment	Audit Response
15		Also is the asphalt bleeding a safety hazard?	Asphalt bleeding generally causes a safety hazard by lowering skid resistance. Section 3.1, Finding 3.1.1, Recommendation 4 was raised to asses this.
16		It is a good idea to get simple (and low-cost) data on the skid resistance of the Otta seals. Although there is little traffic, given this is an experiment case of new technology in Tonga, it would be good to have this sort of information. The auditor picked up that the although the surface appeared smooth given the amount of bleeding, on closer inspection there was an aggregate matrix flush with the surface, and it would be nice to note what impact this has on the performance of the road (such as skid resistance) and monitored in the future. It may not be necessary to use a pendulum tester to do so. The sand patch test is an easy method to measure texture, as mentioned in the report.	Comment agreed, however the pendulum test for skid resistance is not very complicated and the equipment is not overly expensive. No amendments made to the Report as a result of this comment.
17		Is it still not too early for the Otta seals to have fully 'cured' and set?	Comment accepted. Section 3.1, Finding 3.11, 4 a) amended to incorporate the comment.