NIGHT PAVING IN TRINIDAD
ACHIEVING QUALITY

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INTRODUCTION

In 2003, the Airports Authority of Trinidad and Tobago (AATT) began construction of hot mix asphalt (HMA) overlay for Runway 10-28 at Piarco International Airport, Port of Spain, Trinidad. Due to problems with aggregate quality, overlay placement and pilot complaints on runway roughness, the paving works were suspended and the Trinidad and Tobago Civil Aviation Authority (CAA) requested that the U.S. Federal Aviation Administration (FAA) conduct a roughness survey using their airport pavement inertial profiler with their PROFAA analytical software to quantify the extent of the roughness. That survey confirmed that the pavement was rough as characterized by several commonly used roughness indexes, including simulated straight-edge, Boeing Bump Index (BBI), aircraft response, International Roughness Index (IRI), and simulated California Profilograph Index (PI). The FAA also identified several other issues associated with HMA production and placement and recommended that remedial actions be initiated to correct the problems.

In 2004, the AATT retained Roy D. McQueen & Associates, Ltd. (RDM) to design necessary improvements, prepare tender documents, and administer the construction program. The design utilized the FAA profiles obtained in 2004 with traditional topographic survey data to specify requirements for pavement milling, leveling course, and surface layers necessary to re-establish runway pavement smoothness and strength. Since Runway 10-28 is Piarco's sole runway, which is subject to heavy, high tire pressure aircraft channelized, braking and turning operations, the HMA needed to be designed to a high quality level to withstand these punishing loads in a hot, tropical environment. This necessitated modifications to FAA's then current standard P-401 specification [1] including incorporation of Trinidad Lake Asphalt (TLA) in the mix. Operational conditions also dictated night construction during a series of 8-hour runway closures. The contract documents were finalized and the project was tendered and awarded to Jusamco Pavers Limited of Trinidad in late 2005. Construction began in 2007, allowing time for importation of aggregates and construction equipment, and was substantially completed in 2008.

After completion of construction, an airport pavement inertial profiler was mobilized to Trinidad and the runway pavement was retested using the same procedures and analytical software as were used for the 2004 FAA survey. Comparison of the before and after profiles, smoothness indexes, and quality assurance results indicated a marked improvement in pavement quality and smoothness, with the runway pavement considered consistent with other major international airport runways in the U.S. This was the first construction project that demonstrated the utility of FAA's PROFAA program during design and construction.

Straight-edge testing in December 2009 (3 years after completion of construction) indicated that the HMA surface is still free from rutting, shoving, and plastic deformations. This has direct application to FAA's high tire pressure testing program of HMA pavement to support International Civil Aviation Organization's (ICAO)and aircraft manufacture's evaluation of revisions to Aircraft Classification Number (ACN) Pavement Classification Number (PCN) tire pressure limits and the performance of HMA pavements in general. The project also demonstrated that, with proper controls, it is possible to construct smooth, rut resistant HMA pavements during night construction projects.

BACKGROUND

Trinidad and Tobago is a unitary state of two islands and is the Caribbean region's most developed and industrialized country. In 2009, the country, which has a total area of 1,980 square miles, hosted the Fifth Summit of the Americas and the Commonwealth Heads of Government Meeting in Port of Spain. Together, Trinidad and Tobago have an estimated population of 1.3 million with an average annual growth rate of 4 percent. The major economic activities in Trinidad and Tobago include the production and export of crude and refined petroleum; manufacture based on natural gas – fertilizers, methanol, steel, urea – and tourism. Trinidad and Tobago's manufacturing industry is based on domestic requirements of essential goods in the area of food processing, textiles, clothing, furniture, and building materials as well as the assembly of some consumer durables. The Airports Authority of Trinidad and Tobago (AATT) was established in 1979 and is responsible for the management and operations of the two international airports.

Runway 10-28 at the Piarco International Airport (POS) is an asphaltic concrete flexible pavement 3,200 metres (10,500 feet) long and 45 metres (147 feet) wide with 3m (9.8 feet) shoulders, which was last strengthened in 1983. During the 14-year period ending in 1997, the runway recorded around 40,000 equivalent departures of the B747. At that time the longitudinal grade varied from 1.2 percent to 1.25 percent with transverse slopes of 1.5 percent each side of the centre line.

A study conducted in 1997 found the runway pavement required strengthening and surface rehabilitation. Tenders were initially invited in March 2001 and were re-invited in February 2003. The specifications on which the tender were developed was provided by a local consulting engineer, and consisted of selective repairs of runway cracks; installation of a reinforcing membrane over 500m of the keel at the Runway 10 end; and hot mix asphalt (HMA) overlay of 112.5mm on the existing pavement over the total length of the runway using Trinidad Lake Asphalt (TLA) blended binder. To limit operational disruptions, the work was confined to a five hour nightly closures between 12:00 a.m. and 05:00 a.m.

A construction contract was awarded to Jusamco Pavers Limited and construction of the overlay commenced in August 2003. However, in November 2003, construction was suspended due to the failure of the contractor to procure aggregate that met specified gradation requirements, as well as inconsistencies in meeting the acceptance criteria for air voids and mat density. Due to the unavailability of local aggregate of the requisite quality to meet the requirements of the specification, the contractor was given authorization to import aggregate for the project. Construction work resumed in March 2004, but was suspended at the end of June 2004 after the placement of the binder course and approximately 1800 metres (5,900 ft.) of the surface course mix. The works were suspended due to a shortage of aggregates for HMA production and the end of the off-peak period of Airport Operations.

Prior to the resumption of work, there arose a number of complaints from the users and the regulator of the Airport as to the roughness of the completed portions of the project. This prompted the Trinidad and Tobago Civil Aviation Authority (CAA) to commission the FAA to perform roughness testing and an analysis of the runway surface.

As discussed below, the FAA tests confirmed that the runway surface condition did not meet ICAO and FAA requirements for smoothness. The FAA also attributed the poor runway surface condition to poor workmanship, construction methods, and joint construction.

The AATT then developed a three point action plan consisting of the following:

- Conduct a comprehensive grade and elevation survey of the runway at POS;
- Engage an airport pavement expert to develop a detailed plan of action to upgrade the profile and cross-section of the existing runway to international standards; and
- Engage the relevant technical expertise, through the auspices of ICAO, to conduct an assessment of the works completed.

In September 2004, the Airports Authority commissioned a topographic survey of Runway 10-28 and retained Roy D. McQueen & Associates Ltd. (RDM) to inspect the runway and provide recommendations concerning the completion of the project. The topographic survey confirmed the uneven nature of the runway surface. RDM recommended short term repairs to critical areas of the runway surface and proposed the development of comprehensive plans and specifications for the restoration of the Runway surface to ICAO and FAA standards. RDM identified the following preconditions for the contractor to re-enter the site:

- Recalibration of the asphalt plant;
- Inspection of construction equipment for conformance to the specifications; and
- Engagement of a specialist consultant experienced in airport night paving.

The contractor, Jusamco Pavers Limited submitted recalibration certificates for their asphalt plant and paving equipment and in November 2004 retained A. Kay Berntson, P.E. as Senior Project Manager to manage the runway construction activities within the period of the defect notice. The contractor notified AATT of the sourcing of a milling machine and additional equipment to meet the Remedial Works specifications as prepared by RDM and indicated that suitable equipment will be available to meet our scheduled start.

The remedial works undertaken demonstrated an improvement of workmanship and quality. However, in order to have the project meet FAA and ICAO standards, the consultant (RDM) was asked to prepare design specifications and construction plans for the works required to restore the runway to ICAO and FAA standards, which were delivered in February 2005.

DESIGN REQUIRMENTS

The detailed design requirements for the pavement rehabilitation consisted of the following general actions that were necessary to bring the runway to FAA and ICAO standards:

- New runway profile;
- Uniform runway cross-slope;
- Removal and replacement of defective material at the Runway 10 end;
- Profile milling to correct roughness;
- HMA leveling courses to correct profile and cross-slope;
- Final uniform 60mm (2.4-in) surface layer
- Extended work hours from 10:00 p.m. to 06:00 a.m., six days per week.
- Adjustment of paving pattern to extend pull lengths;
- Recalibration and certification of plant and equipment;
- New HMA mix designs;
- Replacement of touchdown zone and runway edge lighting;
- Installation of electrical infrastructure to meet Runway Category II rating; and
- Improved construction quality control procedures.

Following the completion of the specifications and designs for the Runway 10-28 Improvement Works 2005, the AATT developed a comprehensive Project Management Plan to ensure a strong and experienced construction project management organization to ensure that the project was delivered on time, within budget, and that it met the quality standards in conformance with the regulatory standards. The project organization is shown in Figure 1.

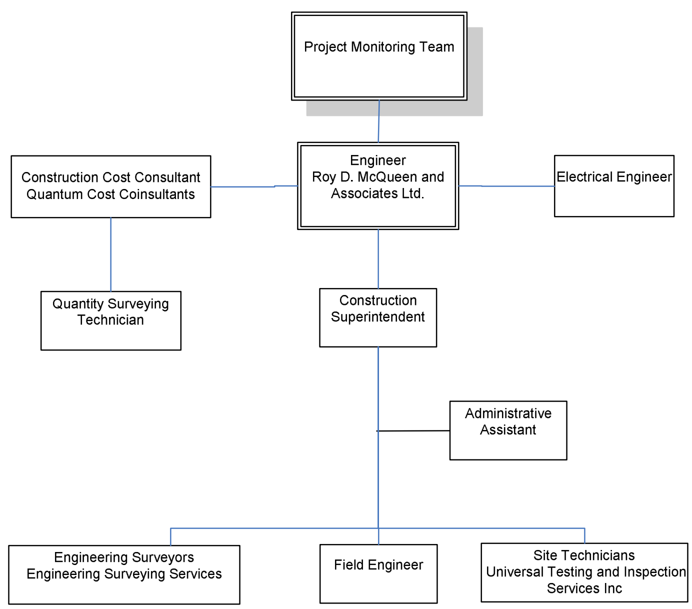

Figure 1. Project Organization

Pavement Condition. Typical workmanship issues on the runway pavement prior to the final rehabilitation are shown in Figures 2 through 4.

Figure 2. Transverse Joint Construction.

Figure 3. Bleeding/Fat Spot.

Figure 4. Longitudinal Joints.

Results of the 2004 FAA profile assessment with FAA's inertial profiler are shown in Figures 5 and 6 (courtesy of FAA) for straight-edge and Boeing Bump Index simulations from FAA's ProFAA program, respectively, with criteria limits superimposed.

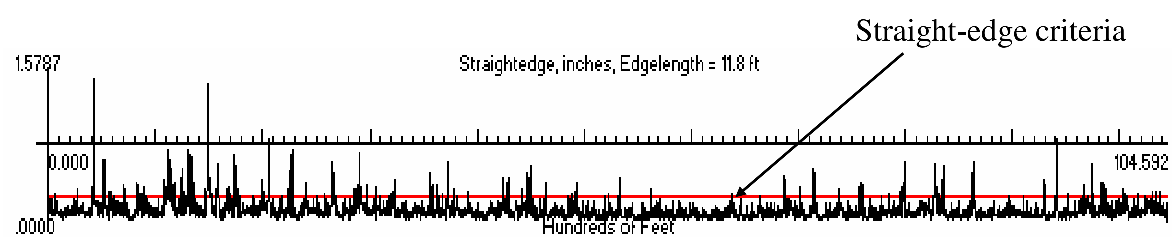

Figure 5. Straight-edge Simulation from ProFAA.

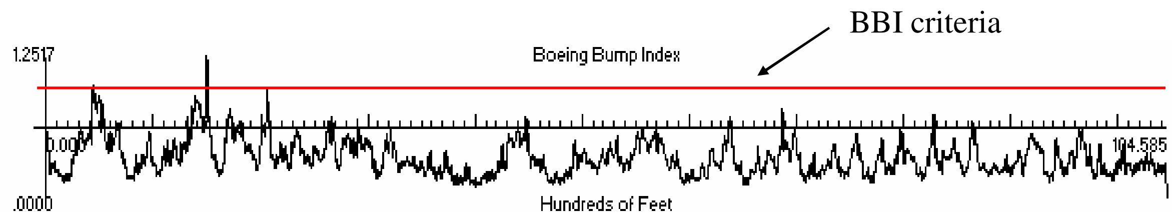

Figure 6. Boeing Bump Index Computation from ProFAA.

As shown, both the straight-edge and Boeing Bump Index (BBI) results significantly exceed suggested criteria limits, confirming pilot complaints of rough pavement. With the BBI approaching and exceeding 1.0 in several areas, according to Boeing manuals, operation on the surface could result in damage to the aircraft. A blow-up of one of these areas from the 2004 survey is shown in Figure 7, which clearly highlights the magnitude of the problem. Due to the severity of the roughness results, emergency work was undertaken in 2004 to repair the worst areas prior to the full scale rehabilitation project.

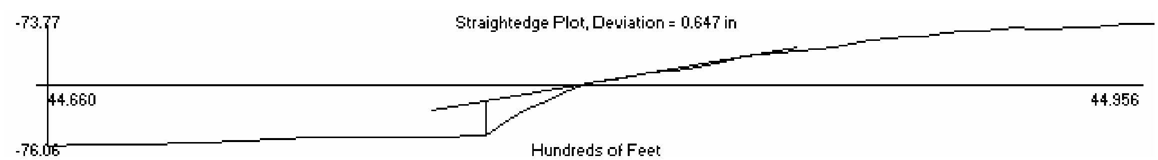

Figure 7. Zoomed Section of Profile Showing Straightedge.

Pavement Design. FAA's LEDFAA Version 1.3 design program [2], which was the design standard in 2004, was used to validate the pavement design for runway pavement strengthening for the traffic mix summarized in Table 1 and assumed subgrade CBR of 6.5 percent from prior Dynamic Cone Penetrometer Tests (DCP). Although the fleet mix may change over time, the weights and gear configurations of the design aircraft mix is believed to be conservative and representative of aircraft operations over the 20 year design period. This resulted in a 112.5mm HMA (4.5 inches) overlay on the existing pavement structure of 14-inch (356 mm) HMA on 13-inch (330 mm) aggregate base. As discussed below, post construction testing with a Heavy Falling Weight Deflectometer and structural analysis indicated that the pavement strengthening assumptions were exceeded.

Table 1.
Aircraft Forecast for Pavement Design.

Aircraft	Weight (lbs.)	Annual Departures	Annual Growth(%)
B-767-300ER	417,000	473	3.00
A320	167,000	220	3.00
B-727	198,000	459	3.00
A300-600	370,000	393	3.00
MD-83	161,000	2,794	3.00
B-747-200	750,000	369	3.00
DC-10-30	510,000	974	3.00
DC-10-30 Belly	510,000	974	3.00

Governing Standards. The following standards were followed for the design of the works:

- FAA Advisory Circular 150/5300-13, “Airport Design”
- FAA Advisory Circular 150/5320-6D, “Airport Pavement Design and Evaluation”
- FAA Advisory Circular 150/5370-10, “Standards for Specifying Construction of Airports”
- FAA Advisory Circular 150/5370-13, “Offpeak Construction of Airport Pavements Using Hot-Mix Asphalt”
- ICAO Annex 14, Volume 1, “Aerodrome Design and Operations”

Construction Requirements. The specifications for construction, particularly the requirements for P-401 HMA, were extensively reworked to provide necessary clarifications and guidance for accomplishing the work to FAA and ICAO standards. These included the following:

- Mix design requirements were clarified to include use of tensile strength ratio, in lieu of immersion-compression testing, for evaluating stripping potential; and criteria for asphalt film thickness and dust to asphalt ratio added.
- 1-inch (25mm) maximum size aggregate (MSA) gradations were specified for the surface course with ½-inch (12.5mm) MSA specified for leveling courses.
- The use of Trinidad Lake Asphalt (TLA) blend was specified to increase the rut resistance of the HMA.

- Acceptance criteria for voids in mineral aggregate (VMA) was added.
- Due to Contractor workmanship problems with the initial construction, test section requirements were amplified to have the Contractor satisfactorily demonstrate ability to meet the specifications for longitudinal and transverse cold joint construction before beginning work on the runway.
- Requirements for temporary transition ramp pavement were clarified, and since construction sequencing was changed to minimize transverse joints, requirements for longitudinal ramps were added.
- Requirements for truck scales were clarified.
- Requirements for storage bins were added and minimum daily tonnage requirements were added to optimize pull lengths during HMA placement.
- Use of automatic grade controls on pavers was added.
- Minimum and maximum lift thicknesses were added.
- Due to problems with initial construction, requirements for submittal of a Contractor Paving Plan were added.
- The use of a thin lift nuclear density device for Contractor Quality Control was made mandatory.
- Due to problems with smoothness during the initial construction, a revised Acceptance Plan for smoothness was added based on the use of FAA's inertial profiler and PROFAA, along with Contractor Quality Control requirements for smoothness based on straight-edge testing.

CONSTRUCTION METHODS TO ACHIEVE DESIGN REQUIREMENTS

Jusamco Pavers Limited was awarded the contract after tendering in January 2007. Before tendering, local aggregate suppliers were contacted and material sampled. However, since production quality control necessary for a project of this magnitude was lacking, high quality limestone aggregates that met the specification requirements were located in the Dominican Republic. Both 1-inch (25mm) and ½-inch (12.5mm) maximum size aggregates for the leveling and surface courses, respectively, were imported and stockpiled at a designated site on the airport. During the transportation of aggregates, samples were taken and gradation tests performed for every 300 tons of material that was brought on site, resulting in approximately 200 initial gradation checks. This information was used to determine the maximum and minimum limits for use in developing the mix design.

Washed concrete sand from Nova Scotia was used in the mix designs coupled with fine aggregate from the Dominican Republic. Additional construction equipment required to comply with the requirements of the specifications was sourced. This equipment consisted of milling machines, pavers, distributor trucks, rollers, brooms, lighting towers, and etc.

Both leveling and surface course mixes were designed using the Marshall method, in accordance with the MS-2 Handbook from the Asphalt Institute [2], as required by the specifications. Material properties for the mix are summarized in Tables 2 and 3 and a plot of the combined gradations for the surface mix is shown in Figure 8.

Table 2.
Material Properties.

	MATERIAL PROPERTIES						
Sieve Size	Applicable Standards ASTM C 136, C 117, &D 75	1" Caba Roho Limestone	3/8" Caba Roho Limestone	Conc. Sand Martin Marietta	Crushed Limestone Screening Caba Roho	Trinidad Lake Asphalt 60-75 Pen	Requirements
1 in. (24.0 mm)		100	100	100	100		100
3/4 in. (19.0 mm)		89	100	100	100		76-98
1/2 in. (12.5 mm)		41	100	100	100		66-86
3/8 in. (9.5 mm)		11	95	100	100		57-77
o. 4 (4.75 mm)		2	30	99	97		40-60
No. 8 (2.36 mm)		1	9	81	73		26-46
No. 16 (1.18 mm)		1	6	50	49		17-37
No. 30 (0.600 mm)		1	5	30	35		11-27
No. 50 (0.300 mm)		1	5	15	25		7-19
No. 100 (0.150 mm)		1	4	5	20		6-16
No. 200 (0.075 mm)		1.0	3.8	2.5	16.0		3-6
Asphalt Percentage:							4.5-7.0
Los Angles Abrasion	C 131	22	22				Maximum 40%
Specific Gravity	C127 C 128, D 70	2.579	2.582	2.575	2.574	1.120	
Sand Equivalent				81	85		Minimum 40%
Liquid Limit				N/A	N/A		
Plasticity Index				NP	NP		
Soundness	C 88	2.6	2.6				Maximum 13%
Angularity				48%			Minimum 45%
Trinidad Lake Asphalt 60-75 Pen	D 5710					69	60-75
Tensile Strength Ratio	D 4867			93%			Minimum 75%

Table 3.
Material Properties.

Percent of asphalt cement.	5.60%	
Asphalt penetration grade.	60-75	
Number of blows of hammer compaction per side of molded specimen.	75	
Mixing temperature.	340°	+/- 10°
Compaction temperature. (Marshall)	305°	+/- 5°
Temperature of mix when discharged from the mixer.	325°	+/- 10°
Percent natural sand.	0%	
Percent fractured faces.	100%	
Percent elongated particles.	1%	
Tensile Strength Ratio (TSR).	93%	
Anti-strip agent (if required).	NR	
Asphalt film thickness (microns)	12	
Dust to asphalt ratio.	0.98	

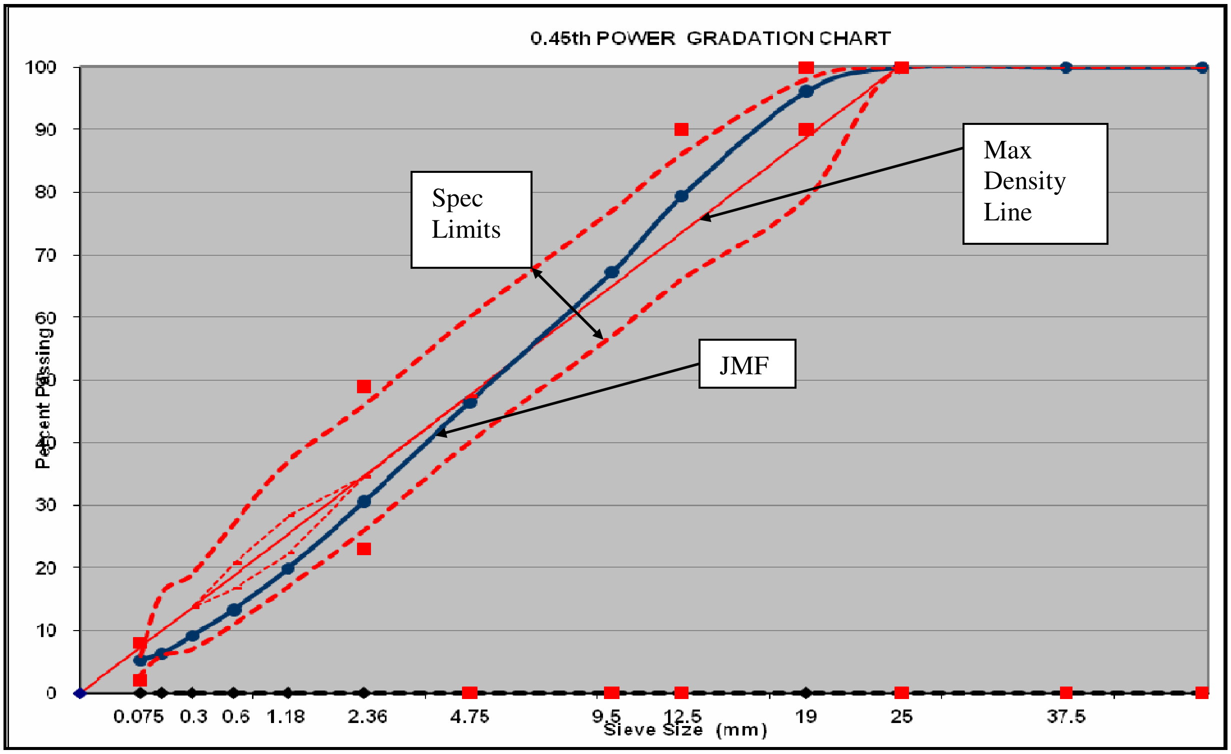

Figure 8. Mix Design Gradations and 0.45th Power Plot.

The asphalt cement base stock used for the TLA blend was 120-150 Penetration Grade asphalt produced in Trinidad. The base asphalt was blended with 30-35% TLA at Lake Asphalt's facility in La Brea. The blended product was shipped to the job site in 7000 gallon trailers. The material was kept heated and agitated to prevent settlement of fines.

Hot Mix Asphalt Production. A new 400 ton per hour HMA plant was acquired with a four bin cold feed, 50,000 gallons of on-site liquid asphalt storage, a positive displacement metering system for the asphalt, and a 100 ton portable silo equipped with a loss in weigh system for loading trucks. To support the asphalt production a state-of-the-art asphalt testing laboratory was assembled at the asphalt plant site for rapid acceptance and quality control testing (asphalt contents could be checked and results reported in about five minutes and combined mix gradation results could be reported in approximately one hour). Since the plant site did not provide a large area for material storage, aggregate stockpiles were replenished daily from the material stored at various sites around the airport, with aggregate gradations and moistures checked several times per day to control mix production. Quality control was maintained through constant monitoring and comparison of daily quality control (asphalt content, gradations) and acceptance (Marshall properties) test results during the production of the 67,500 tons of hot mix that was used on the project. During paving operations, density was continuously monitored with nuclear densitometers to achieve uniform pavement density and to meet rigid specification requirements.

Construction Operations. The project was divided into three phases. For the first two phases the threshold was displaced approximately 700m (2,300 ft.) on each runway end, leaving only the center 1800m (5,900 ft.) to be constructed during each nightly shift. To correct the profile, it was necessary to mill the entire length and width of the runway. The initial cuts by the milling machines were performed with dual stringline control. A single stringline with joint matcher was used on subsequent milling cuts to achieve the uniform cross slope required by the construction plans. A variable thickness leveling course then allowed placement of a uniform 60mm (2.4-inch) surface course.

For surface course pavement placement, a dual stringline was set to the finish grade elevations for the initial ("pilot") lane, with subsequent lanes placed using either a 30 foot (9.1m) ski or a joint matcher with a single stringline set to grade on the opposite side of the paving machine. The entire placement of the pavement on both Phase 1 and Phase 2 was completed in this manner. In preparation for the Phase 3 paving where the mill and fill operation had to take place during 8-hour nightly closures, all milling and leveling courses were completed prior to placement of the surface course to meet both the grade and strengthening requirements of the project.

In order to minimize the number of transverse joints in the surface course, the project specifications required first paving the two center lanes in the runway keel, one on each side of the runway centerline. Each center lane was placed at a minimum width of 18.5 feet (5.6 m) for a total width of 37 feet (11.25 m). A minimum pull length of 925 feet (300 m) was specified for the center 37 feet (11.25 m) keel during each nightly shift. Longitudinal ramps were placed on each side of each night's paving, along with transverse ramps at the end limits, in accordance with the details shown on the Plans. For the initial pass of the paving equipment in the keel section, dual stringlines were set at the finish grade on centerline and 5.25m right or left of centerline. After sufficient placement by the first paver, a second paver was utilized to place longitudinal ramps to the termination point for each nights paving. The procedure was repeated nightly until the two lanes on either side of centerline work were completed. This method of placement drastically reduced the number of transverse joints in the keel section, thereby improving rideability. For subsequent paving lane placement, the ramp was removed on one side of the keel section and two pavers were run in echelon placing a total of 15.75m wide in the side sections with the appropriate ramps installed at the taxiway intersections. Photos of the plant site and nightly paving operations are shown in Figures 9 and 10, respectively.

Figure 9. Asphalt Plant.

Figure 10. Dual Stringline Paving.

RESULTS

At the completion of the overlay works in 2007, the runway pavement was re-tested for smoothness with an inertial airport pavement profiler (APP) and PROFAA analysis, and for strength using a Heavy Falling Weight Deflectometer (HWD) and LEDFAA analysis. Straightedge tests were also performed to ascertain whether the TLA mix production and HMA placement met AATT's requirements for rut resistance. As discussed below, the construction met or exceeded all design requirements.

Pavement Performance. As is typical in the Caribbean, most (approximately 95 percent) of aircraft operations at POS occur in the easterly direction. Therefore, the pavement at the Runway 10 end is subject to a large number of take-off operations of heavy, high tire pressure aircraft, in addition to damaging turning and braking movements. The high concentration of channelized aircraft traffic in Trinidad's hot tropical environment was a real concern and challenge. It is often postulated that HMA will not perform satisfactorily in hot climates with heavy, high tire pressure aircraft operations. Therefore, the performance of the overlay is of particular interest to the FAA, ICAO, and the international airport community.

To evaluate the in-situ performance of the HMA materials, a series of straight-edge tests were performed at 5m intervals in both longitudinal and transverse directions on the Runway 10 end (the end receiving > 95 percent of traffic) in December 2009 (approximately three years after completion of construction of the Runway 10 end, and 115,500 departures) to identify the presence of any rutting or plastic deformation. Photos depicting the representative condition of the pavement surface are shown in Figures 11 and 12. As shown, no measurable rutting was observed. The reasons for this are attributable to:

- TLA asphalt blend;
- Dense, optimized aggregate gradation structure;
- Superior QA/QC program implementation; and
- Full compliance with compaction requirements of the specification.

It should be stressed that, although it is believed that the use of a superior asphalt binder, i.e., the TLA blend, appreciably added to the rut resistance of the pavement, the binder alone could not solely account for the excellent performance of the overlay. Rather, the use of aggregates and sands of superior quality, blended to produce a dense, optimally graded mixture, also significantly contributed to pavement performance, i.e., the aggregate and binder needed to work in concert.

Figure 11. Runway Condition.

Figure 12. No Observed Rutting.

Smoothness Results. As discussed, the rough condition of the runway prompted the resurfacing project. To achieve international standards, RDM redesigned the runway grades; formulated a program of milling and overlay; and developed a set of technical specifications that included tight tolerances for material quality and surface smoothness. At the completion of the construction works, SRA, Inc. was retained to perform a new set of smoothness measurements on the completed runway pavement surface using an APP and PROFAA analysis. The results of these tests are summarized in Figures 13 and 15, which depict the straight-edge and BBI profiles, respectively <u>after</u> the overlay was completed. Figures 14 and 16 depict the straight-edge and BBI profiles, respectively <u>before</u> the overlay was completed. Note the vertical axis scale differences when reviewing Figures 15 and 16. As shown, the runway smoothness has significantly improved from measurements taken in 2004 and is now consistent with international standards for runway smoothness.

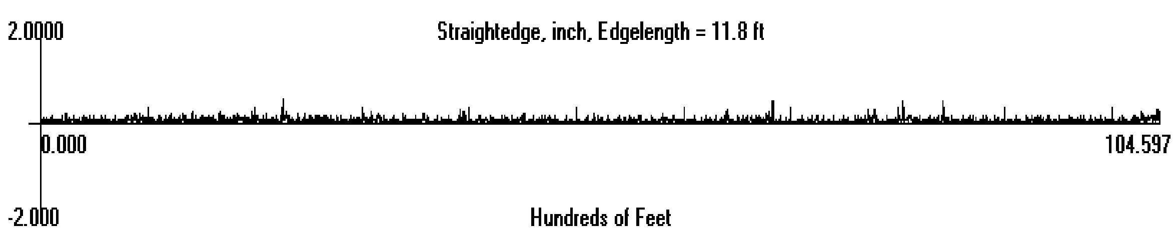

Figure 13. Centerline Straight-edge Profile – <u>After</u> Overlay.

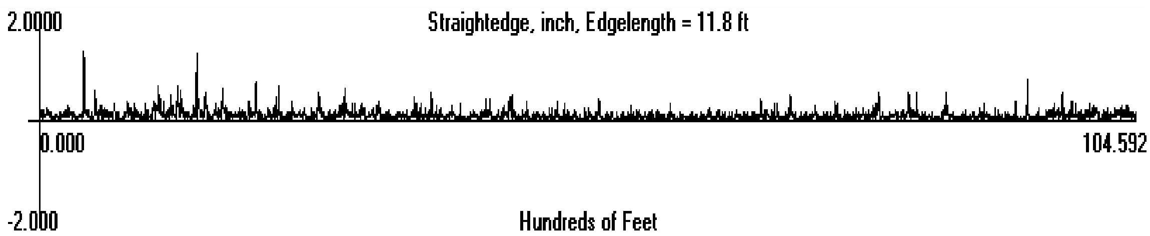

Figure 14. Centerline Straight-edge Profile – Before Overlay.

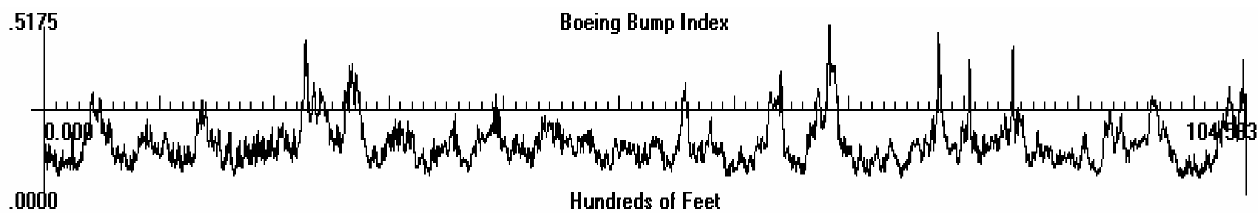

Figure 15. Centerline BBI Profile – After Overlay.

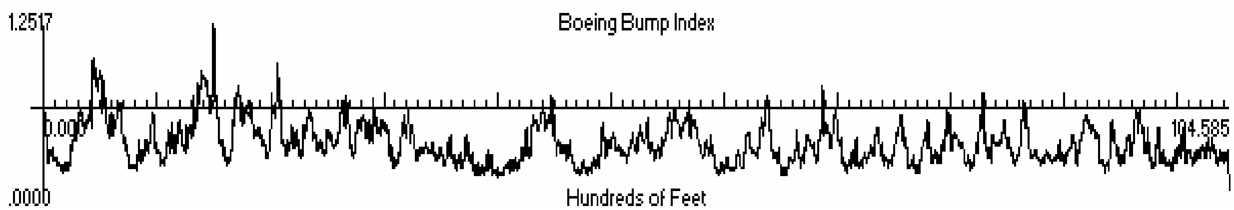

Figure 16. Centerline BBI Profile – Before Overlay.

Strengthening Results. After placement of the nominal 112.5 mm (4.4 inches) hot mix asphalt (HMA) overlay with profile milling and leveling courses in 2007, the runway was tested with a Heavy Falling Weight Deflectometer (HWD). The HWD results indicated that the in-situ elastic modulus and correlated California Bearing Ratio (CBR) of the subgrade was 12.5 percent, correlated from the back-calculated modulus using FAA's BAKFAA program of 19,000 psi, in lieu of the 6.5 percent suggested by the prior DCP tests. The increased subgrade modulus was due to a layer of fill that was not identified during the prior evaluation. The in-situ subgrade modulus, coupled with the high quality of the construction works, resulted in a pavement strength that exceeded design expectations. For reporting purposes, the runway Pavement Classification Number (PCN) was reported as 75FBWT. This will allow operation of all aircraft in the current and foreseeable commercial fleet, including the B777-300ER, B747-400ER, A380-800, and B787-9 aircraft.

CONCLUSIONS

The runway overlay project at POS provided several valuable insights that have application for airport paving projects at other international airports, including:

- FAA's inertial airport pavement profiler (APP) and PROFAA program can be used for pavement evaluation and design. The profiles and corresponding indexes can be used to clearly identify areas of concern that require remediation. Evaluation of the profile and application of PROFAA can be used to establish requirements and options for restoring pavement smoothness, e.g., profile milling, leveling course, stringline milling and paving.

- When coupled with an effective Contractor Quality Control Program, the APP and PROFAA can be used to evaluate the effectiveness of the construction program and can be used in paving specifications for acceptance purposes. It was also noted on this project that, for HMA pavements at least, the Profilograph Index (PI) with current FAA P-401 limits is not necessarily a good indicator of smoothness. Although the PI exceeded P-401 limits in some areas, other indexes, e.g., simulated straightedge, aircraft response, and Boeing Bump Index all indicated that a smooth operational surface was constructed.

- The use of TLA blended asphalt, superior quality aggregates and sand, and optimized mix design gradations will provide good performance in high stress areas in a hot weather environment. This underscores the need for proper binder selection, and aggregate selection and grading to meet the unique site specific requirements of the project. This has particular application for recent FAA initiatives to evaluate the performance of HMA for airport pavements servicing heavy, high tire pressure aircraft in hot weather environments. Although a TLA blend was used for the binder for this project, it is possible that similar results could be achieved with a polymer modified asphalt binder meeting requirements for elastic recovery and selection of a performance graded (PG) asphalt binder appropriate for the site specific temperature regime.

- The use of nondestructive testing (NDT) after construction provided data to objectively evaluate the effect of the construction in achieving the design assumptions for strengthening, enabling a more accurate assessment of load carrying capability and PCN computation.

- With proper planning and execution, coupled with rigorously enforced quality assurance and quality control programs, night construction in accordance with FAA P-401 specification and FAA Advisory Circular 150/5370-13 [3], will result in quality levels necessary for HMA at major international airports, even in remote locations.

REFERENCES

1. FAA Advisory Circular 150/5370-10C, "Standards for Specifying Construction of Airports, April 2005
2. FAA Advisory Circular 150/5320-6D, "Airport pavement Design and Evaluation", June 2006
3. Asphalt Institute MS-2, "Mix Design Methods", 1997
4. FAA Advisory Circular 150/5370-13, "Offpeak Construction of Airport Pavements Using Hot Mix Asphalt" September 2006