THE DEVELOPMENT AND PERFORMANCE OF A NEW ULTRA THIN FRICTION COURSE FOR OR TAMBO INTERNATIONAL AIRPORT IN SOUTH AFRICA

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Abstract

A critical aspect of any commercially operated airport in South Africa is to comply with internationally recognized safety standards for aircraft operations at the airport. Such standards have been developed by the International Civil Aviation Organization (ICAO) and amongst others, addresses the functional properties of the runway surface to mitigate potential safety risks during high speed operations. These properties include the surface profile of the runway (drainage properties), friction characteristics and the safety conditions surrounding the tarmac. It has in general been recognized by the international fraternity that the ICAO recommended standards for friction characteristics i.e. skid resistance and texture depth can only be achieved through the application of a special surface treatment.

A long term vision by Airports Company South Africa (ACSA) to develop a suitable and economically viable surface treatment for runways in South Africa resulted in the development of an Ultra Thin Friction Course (UTFC) for South African conditions, complying with the ICAO recommended properties for friction characteristics of newly constructed runways. Locally available aggregates and binders were used in the development of this asphalt mix. The mix was produced and constructed by local contractors and suppliers in 2006.

This paper presents the relevant mix design and performance characteristics that were considered during the development process. The grading of an UTFC used successfully on an Airport in Denmark was used as basis, and mix designs were done with 3 different geological rock types. These 3 mix designs were evaluated and the best candidate design selected for trial sections. This paper also reports on the contractor's experiences during the construction process and ACSA's assessment of the performance of the UTFC and maintenance requirements to date.

1 Introduction

1.1 Background

As part of the ongoing rehabilitation and upgrading program of airside facilities at OR Tambo International Airport (ORTIA) during the years 2002 – 2008, Runway 03R-21L had to be rehabilitated and upgraded during 2006/2007. This work included:

a) The repair of any fatigued asphalt portions of the runway structure,
b) The strengthening of the runway structure for the expected future medium term aircraft loading through the construction of additional asphalt layers,
c) The increase of the runway cross-fall from 1.0% to 1.5% to improve drainage of water off the runway surface,
d) The replacement of the runway lighting system and
e) The construction of an Ultra Thin Friction Course (UTFC) as surfacing layer to improve runway skid resistance.

1.2 The design brief

It was emphasized that this runway is the main arrivals runway at the airport (typical accommodating 90% of all landings at ORTIA) requiring special consideration with regard to the ICAO recommended requirements for safe landing under all weather conditions. The ICAO requirements (according to Annex 14 of the Aerodrome Design Manual) are as follows:

- Clause 3.1.22/23 – “having good fiction characteristics when the runway is wet” and if measured with the GRIPTESTER at 65 km/h the friction value (Grip number) after construction should preferably not be less than 0,74 at 1mm water film thickness.
- Clause 3.1.24 – The average surface texture after construction should preferably not be less than 1mm in order to disperse surface run-off water during breaking, achieving maximum friction between the pavement surface and the aircraft tyre. “Note 1 – This normally requires some form of special surface treatment.”

The other problem with the current runway surface layers is that although they meet the ICAO requirements after construction, the surface characteristics deteriorate to intervention levels over relatively short periods due to the very high frequency of tyre contact and wear. The runway therefore requires frequent maintenance interventions, such as, the removal of rubber tyre deposits that reduce the skid resistance and texture depth. The engineers were therefore requested to consider the application of alternative wearing course materials to reduce the cost and frequency of surface maintenance as much as possible.

1.3 The objective of developing a suitable UTFC for runways at ORTIA.

A UTFC is known to exhibit good initial surface characteristics (skid resistance and texture depth) and it is also expected to provide better long-term serviceability at the required levels. The first UTFC layer at Copenhagen Airport was constructed some 10 years ago and at the time of this project it was still performing very well.

Figure 1: Typical UTFC Surface Texture

Based on this experience it was believed that a UTFC could also be developed for the runways at ORTIA which would be able to fully comply with the ICAO recommended minimum requirements for surface texture and friction characteristics. The texture depth that was achieved at the Copenhagen Airport after construction exceeded 2mm while the friction values after 8 years of service still varied between 0,6 and 0,8.

In personnel communication with the airport management at Copenhagen Airport it was indicated their UTFC could even be self cleaning with regard to rubber deposits and no rubber removal has been undertaken to date on these surfaces. The reason for this phenomenon at the time could not be confirmed.

Considering the experience at Copenhagen Airport, the objectives of developing a UTFC for ORTIA was therefore to:

- Provide a runway surfacing layer that will exceed the ICAO requirements in terms of runway surface friction characteristics and texture depth.
- Retain these characteristics over an extended period.

1.4 Stakeholder consultation

One of the requirements for assessing the suitability of the new proposed friction course was to engage the stakeholder and particularly the airline operators, in the evaluation process. The airlines were asked to comment on the expected tyre wear for aircraft and the possibility of improved safety conditions considering the possible change in runway surface at ORTIA.

One of SAA's leading aircraft manufacturer's commented that it should be understood that in order to make a direct comparison between the UTFC and any previous surface textures, idealistically a trial period on new and the old surfaces should be run by a dedicated aircraft. The results would however be vastly contaminated with the following factors:

- Only 20% of tyre wear occurs during landing while 50% of tyre wear occurs during the take-off and landing rolls with the remainder during taxi.
- Considering that at most every second landing is at ORTIA, the exposure to the UTFC wear characteristics is reduced to only 10% of the tyre life.
- The runways visited by SAA especially in African countries have a severe impact on tyre life, as much as a 50% reduction due to runway, taxi and braking conditions.

Although it was doubtful that the UTFC surface will negatively impact on the tyre wear compared to that for the current runway surface, the factors above even more so indicate that a new UTFC surface at ORTIA is not expected to substantially influence the current rates of tyre wear.

When considering the wet weather properties of UTFC it is was expected that a coarse UTFC would indeed reduce aquaplaning. It was however also emphasized that aquaplaning forms less than 0.5% of the carrier's need for premature tyre removals. There was also the possibility of improvement in aquaplaning safety if grooved runways could be replaced with UTFC but only in the touch-down area.

2 MIX DEVELOPMENT

2.1 Assessing the status quo

UTFCs are specially developed asphalt mixes that are applied at very thin application rates by means of a paver to achieve the desired friction requirements with a smooth riding quality. In the past, these mixes have been primarily developed for road construction purposes, replacing surface treatment wearing courses. The development of these friction courses in South Africa is still in its early stages (Pretorius FJ, Wise JC and Henderson M, 2004). A number of these UTFCs have been imported into South Africa as proprietary products. Two of these products together with a locally developed product were assessed against the above ICAO recommended minimum requirements with the following results in Table 1:

Table 1: Functional properties of various friction course (UTFC) products in South Africa

Friction layer	Road number	Grip tester – GN (65km/h – wet)	Average texture depth (TD) mm
Gripphalt	P90-1	0,67	0,7
ULM	P66-1	0,67	1,2
NOVACHIP	N1-18	0,62	1,6

The above results were obtained from constructed surfaces in non-trafficked areas where the traffic is not expected to have influenced the performance characteristics since construction. None of these products comply with the ICAO recommended minimum performance parameters for new construction (GN> 0,74 and TD > 1mm). The locally produced Gripphalt, a SMA type product with modified bitumen, produced disappointing results while the imported proprietary products would also not be suitable to produce the required friction characteristics after new construction. For comparative purposes it should be noted that maintenance planning is only required to kick in at GN = 0,53.

2.2 Mix design and structural performance parameters

The Copenhagen example was considered a suitable model on which the new South African UTFC mix can be based. Both in Denmark and South Africa, 100% crushed and durable rock from igneous origin has been used, although experiments have also been done with quartzite aggregate obtained from mining activities in Johannesburg. As the Danish aggregate and durability properties do not apply in South Africa it was therefore decided to apply the same property specifications as for open graded (porous) asphalt. The main objective of this was to prevent premature fracturing of the aggregate, especially during compaction under the rollers. An important feature of the UTFC is the stone on stone contact, similarly to what would be experienced in a porous asphalt or SMA.

The shape of the aggregate and the grading curve were considered the most important aspects of the design to achieve the desired aggregate packing structure for a coarse surface texture. The grading curve shown in Figure 2 (copying the Copenhagen UTFC) does not fully resemble an open graded mix structure, because it allows a significant volume of mastic to fill the voids in the coarse aggregate skeleton. In order to prevent possible stripping of the mix, it was considered important to create an open structure while still maintaining sufficient adhesion (through the mastic) to prevent ravelling which was the problem with an early open graded trial section on the runway in 2000. Limiting the Flakiness Index to 20% ensured sufficient packing of the aggregate that would result in a dense and stable aggregate skeleton packing. Based on a 50 blow a side Marshall Compaction test, the minimum required Voids in Mineral Aggregate (VMA) was specified as 25% and the design Voids In the Mix (VIM) should not have been less than 15%. As a result of numerous additional trials at the start of construction, the VIM specification was relaxed to 13% while being able to maintain a constructed void content of more than 14,5%.

The mix was expected to behave very similarly to an Open Graded or SMA mix. Durability of the mix will always be a challenge as it allows the infiltration of water and air into the compacted mix, thereby increasing the risk of oxidation and premature ageing which eventually results in stripping. Preventative measures included the addition of 1,5% hydrated lime to the mix as an anti stripping measure and also 0,3 % cellulose fibre to prevent the bitumen film from draining down from the aggregate during transport.

In the final mix design phase, the integrity and durability of the mix was to be tested for the following performance parameters:

- 6% minimum void content after 300 gyrations - SHRP Gyratory test procedure
- maximum aggregate loss of 10% - Cantabro abrasion durability test
- maximum aggregate loss of 15% - Cantabro abrasion durability after applying the Modified Lottmann ageing treatment

2.3 Laboratory trials

The laboratory trials comprised a number of asphalt mixes which were tested for compliance with the above design parameters. Three types of coarse aggregate have been applied in the process, determining the optimum mix composition for the specified volumetric properties. The aggregates included Quartzite, Dolerite and Granite.

The Copenhagen example refers to granite as the source of aggregate and it was considered a possibility that this particular source of aggregate might be the reason for the self cleaning properties (rubber deposits) of the UTFC. It was however found that most granite in the vicinity of the airport is known to be soft, exhibiting high percentages of binder absorption. This aggregate type therefore had to be discontinued from the trials.

For both the Quartzite and Dolerite mixes, the optimum binder content was found to be approximately 5,1 % using a 40/50 penetration grade bitumen for maximum stability. The use of a modified binder would have been considered if the specified structural performance characteristics could not have been achieved. Both the choice of binder and the binder content compared very favourable with the mix composition that was applied in Copenhagen.

The most important difference between the two mix types is the percentage VMA in the mix and consequently the percentage Voids Filled with Binder (VFB) required to achieve the optimum mix composition as can be seen in Table 2 below. The grading curves for both mixes were identical. The difference can probably be attributed to the difference in the Flakiness Index (FI) between the two types of aggregate with the Dolerite effectively having a FI of less than 10%, producing a VMA of 25 %. The Quartzite FI was 15% producing a VMA of only 19 %.

Analyzing the suitability of these two aggregate types, it was important to consider foremost the expected durability of the mix through the amount of binder required to produce an optimum mix composition. The results of the initial laboratory tests are shown in Table 2. The minimum VMA for both mixes was achieved at approximately 5,1% binder content by mass but due to the substantial difference in the aggregate BRD, the Dolerite binder content by volume exceeded that for the Quartzite by 1%. The net effect of difference in binder content could best be observed in the difference in binder film thickness namely 21µm vs. 14 µm. The Dolerite was therefore selected as the preferred coarse aggregate for the UTFC and further plant trials were required to confirm that all other specifications could be met.

Table 2: Volumetric properties of optimum mix compositions for various aggregate types

Aggregate type	Aggregate BRD	Minimum VMA %	VFB %	Optimum binder content %	
				By mass	By volume
Quartzite	2,74	18.8	51.9	5,1	12,1
Dolerite	2,92	24.4	70,4	5,1	12,8

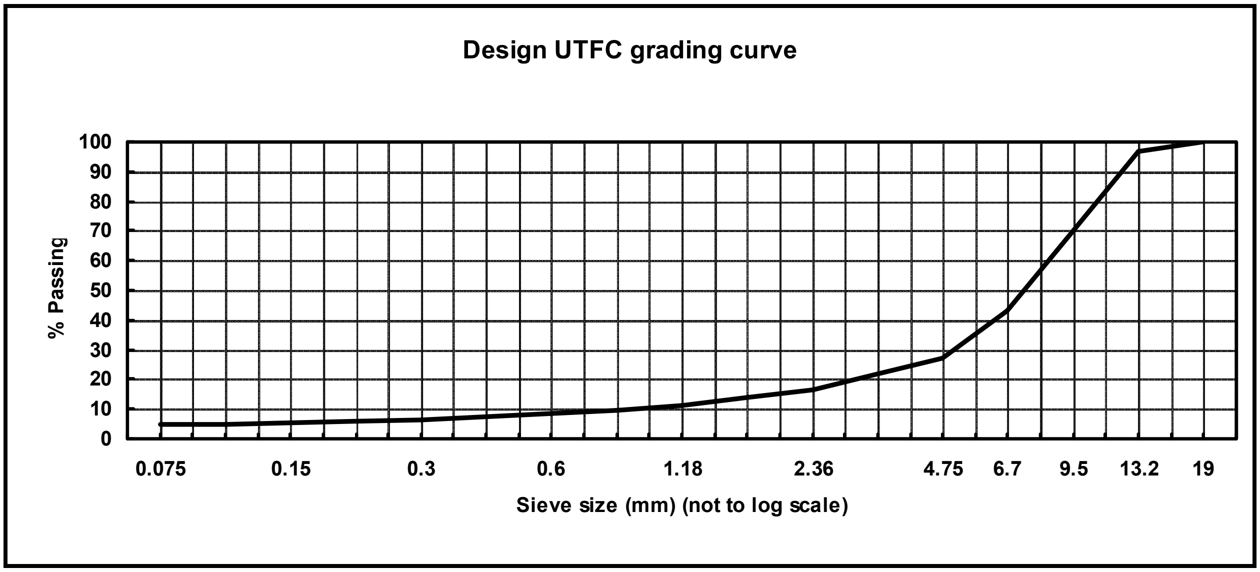

Figure 2: UTFC design grading curve

Further tests were performed on plant trials to verify that a plant mix can be produced that comply with the minimum specifications for structural integrity and durability and to determine the optimum binder content as shown in Table 3. The plant trials resulted in an increase in VMA and a reduction in the VFB but which still provided a suitable mix composition to achieve the main objectives of the design as shown in the following table:

Table 3: Plant trial test results for Dolerite aggregate

Binder content %	VMA %	VFB %	VIM %	Cantabro untreated %	Cantabro Lottman %	Voids @ 300 Gyrations %
4,7 – 4,9	22 - 28	39 - 45	13,5 – 17,4	11,4 – 13,3	11,9 – 23,0	9,5 – 19,0
5,0 – 5,2	23 - 26	42 - 47	13,5 – 15,0	8,0 -8,2	10,7 – 17,3	8,6 – 15,9
5,3 – 5,4	25 - 27	41 - 48	13,0 – 14,7	13,6 – 14,5	13,6 – 16,1	7,7 – 11,8

From the plant trials the following was concluded:

- The optimum binder content can vary between 5,0 and 5,2%
- The design void content is more than 13,5%
- The durability as expressed in terms of aggregate loss in the Cantabro test is good, both in dry conditions and when tested for moisture susceptibility.
- Excessive deformation under traffic would not be expected

3 UTFC PAVING TRIAL

3.1 Objective of the UTFC paving trial

Having reached an agreement on the mix composition, proof was still needed that the functional properties of the friction course could be achieved under aircraft loading. These properties should be achievable through the paving process and had to be confirmed before applying the UTFC overlay across the whole runway surface. The trial was to be performed in two stages to limit the risk of poor performance under operational conditions. The first trial was to be conducted on a non-operational surface where, in addition to the functional characteristics, also the structural performance of the friction course could be confirmed before proceeding with a second stage where the UTFC was to be tested on the runway.

It was recognized that functional parameters such as friction values and texture depth are intimately dependant on the quality of the paving and adhesive properties between the UFTC and the support layer. A number of important differences between the Copenhagen and ORTIA experience had to be considered for verification before the friction course could be declared suitable for operations.

One such deviation is the application of the tack coat. In Denmark as is the case with most other European countries, SBS modified bitumen emulsion is available for tack coats. These binders are known for their good adhesive properties in combination with high viscosity values. In South Africa the only suitable alternative tack coat material available on the market is a 70% SBR modified bitumen emulsion with 3,5% latex. This material is also known for its good adhesive properties but usually requires longer curing time with lower viscosity values. The cost of importing SBS into South Africa would have been excessive hence this option was not considered viable.

A further important difference with the Copenhagen example is the fact that at ORTIA, the UTFC will be applied on newly constructed asphalt wearing course surface while in Copenhagen the UTFC was paved on a rough textured milled surface. The latter is expected to usually result in better bonding between the old surface and the overlay plus the advantage that higher application rates of tack coat can be accommodated, decreasing the risk of flushing.

The question was also raised as to which thickness this mix can be paved with the emphasis on “Ultra thin”. It was argued that the Nominal Maximum Aggregate Size of the mix is 13,2mm and that a layer thickness of at least twice the NMAS is necessary to produce an even and smooth surface.

3.2 Non-operational paving trial

A paving trial was conducted on an abandoned runway surface applying various tack coat application rates and paving thicknesses of 20 and 25mm. The trial sections were 120m long to obtain reliable friction test results.

In short, the friction values ranged between 0,65 and 0,72, the texture depths exceeded 1,5mm and the 25mm paving thickness proved to be providing the most consistent smooth riding surface while the 20mm paving thickness occasionally resulted in aggregate streaking. The friction values did not comply with the ICAO recommended minimum value of 0,74 but this was attributed to a bitumen film on the aggregate surface which was expected to wear off with time.

The adhesion characteristics of the various tack coat application rates have been assessed using the TORQUE BOND TEST. The test has been performed by the Council for Science and Industrial Research (CSIR) at various time intervals after construction to determine the most suitable/required curing time that is needed before the first touch down can be allowed. Cores were cut from the UTFC/wearing course and tested under laboratory conditions at 20^{o} C. The results are shown in Figure 3.

3.3 Runway paving trial

The results of this trial section were sufficiently promising to allow the final stage of the paving trial on an operational runway pavement. A layer thickness of 25mm has been specified and a tack coat application rate of 1,0 l/m2 was regarded suitable to achieve a shear strength of at least 600 kPa . This value has also been considered suitable by the developers of the ultra thin surfacing ULM (ULtra Mince), a proprietary gap graded asphalt mix with a nominal 10mm size aggregate, developed in France and produced under Agrément certification in Europe (British Board of Agrèment).

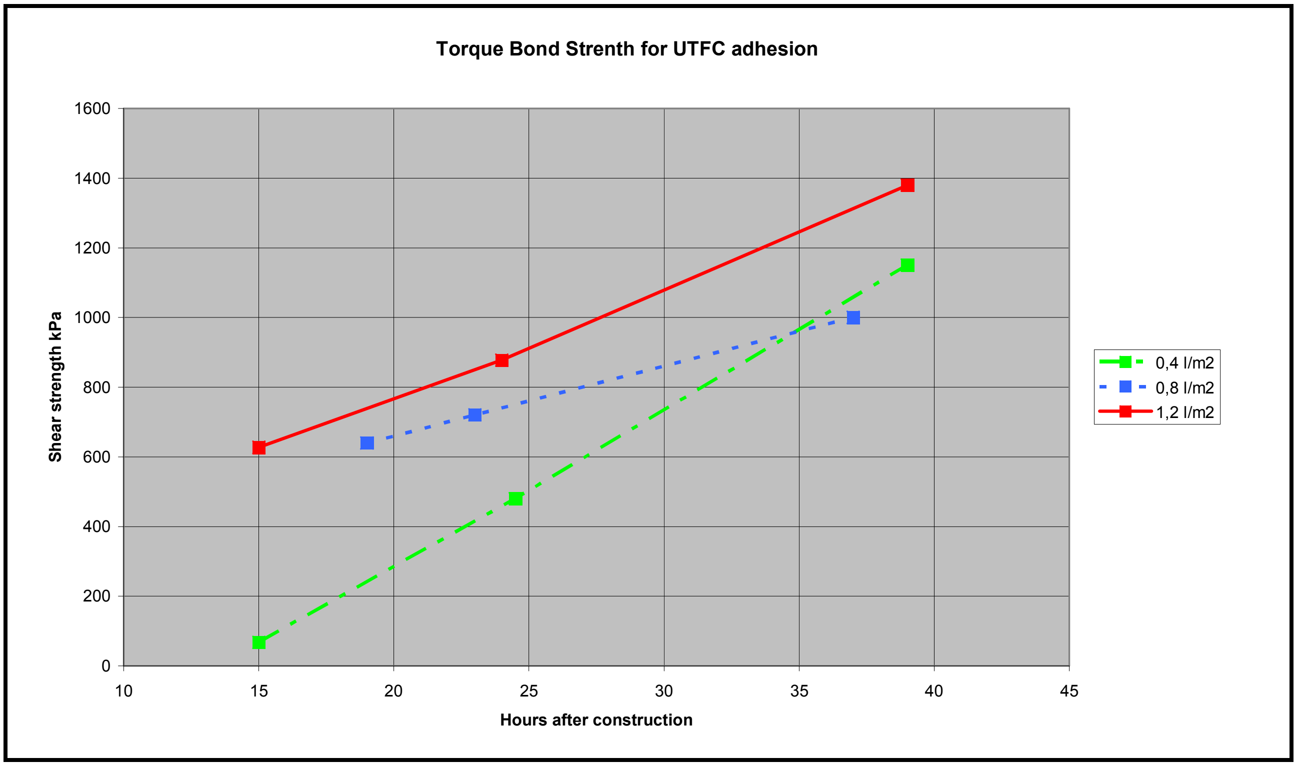

Figure 3: Torque Bond test results for various tack coat application rates

Two trial sections (5m wide strips of UTFC) were constructed on the main departure runway 03L-21R at ORTIA. This runway was chosen to reduce the risk of a non-performing trial seriously affecting the airport operations (landings) as this runway accommodates less than 25% of all landings at the airport. The two strips were constructed between 2m and 7m from the RWY centreline, each more than 100m long and 25mm thick, after having milled out the same thickness of the original asphalt surfacing. One section was constructed in the touchdown zone approximately 600m and the other approximately 1700m from the main approach end (03L) (maximum breaking conditions). Texture depth and friction values were tested immediately after construction and again 4 months after construction without rubber removal maintenance being applied in that period.

Table 4: Functional properties of Runway paving trials

	Trial section			
Performance parameter	Chainage 600		Chainage 1700	
	April 2006	August 2006	April 2006	August 2006
Friction value GN (65km/h)	0,65 – 0,73	0,64 – 0,82 (0,75)	0,67 – 0.70	0,66 – 0,84 (0,75)
Texture Depth mm	1,6	1,8	1,8	1,8
Adjacent friction values (not UTFC)		0,38 – 0,54		0,59 – 0,71

From the tests results shown in Table 4, it was obvious that a friction layer (UTFC) has been developed that can comply with the ICAO recommended requirements for new runway construction. The assumption that the friction values will improve with time as the binder film wears off has been confirmed and it was even found that rubber built-up in the touchdown zone did not affect the friction values or the texture depth.

4 UTFC CONSTRUCTION AND PERFORMANCE UNDER OPERATIONAL CONDITIONS

The construction of the UTFC on Runway 03R-21L was completed in December 2006. In accordance with the specification, the UTFC was applied using a spray-paver, paving a width of 5m at a time, completing 45m width sections of the runway at a time during off-peak construction hours under operational conditions. The paving equipment comprised a tracked version of the paver fitted with a tack coat SprayJet Module, suitable to pave thin asphalt layers on a tack coat than has been applied moments before the mix was deposited on the surface. One serious matter of concern during the construction period remained the even application of the tack coat underneath the spray-paver where visual contact with the sprayers was obscured. Right from the start, it was observed that the high viscosity polymer modified tack coat proved to be difficult to spray and regular blockages had to be cleared, resulting in numerous stop-start situations. Within a year of construction, a one hundred meter long paver lane was showing signs of ravelling and had to be replaced with new asphalt.

The general quality and appearance of the paved asphalt was good and the riding surface was acceptable, considering that the full length of the runway surface had to be constructed within three months under operational conditions, including various joints in the process. Ten to twelve ton steel wheel rollers were used to compact the asphalt mat, taking care not to damage the aggregate in the stone to stone contact situation. A three wheeled roller was used to break down the mix and tandem rollers were used to complete the compaction. A water sprinkler system on all the wheels was used sparingly to moisten the rollers to prevent the paved asphalt sticking to the rollers.

During the course of construction, friction tests were done to confirm the safety of the runway. In Figure 4 it can be seen how the UTFC improves the friction values of the runway surface when compared to that of the underlying dense graded asphalt wearing course While the friction values for the UTFC varied between 0,60 and 0,75 (with higher values in the touchdown area confirming the paving trial experience), the friction value for the dense graded mix reduced with time (below 0,60) for the earlier constructed dense graded wearing course between chainage 1000 and 1800.

The friction values for the UTFC after construction have also been tested for a period of two years during which rubber removal was postponed for nearly one year to verify the effect of rubber on the friction performance of the UFTC. The results are graphically shown in Figures 5 and 6.

Considering that the average friction values of the UTFC in November 2006 was approximately 0,65, it can be seen that this has increased to an average of 0,72 in May 2007 when the next friction test was performed. Both the 21L touchdown zone and the central part of the runway had a value of 0,71 but more interestingly is the increase in friction value of 0,79 for touchdown zone 03R (main arrivals).

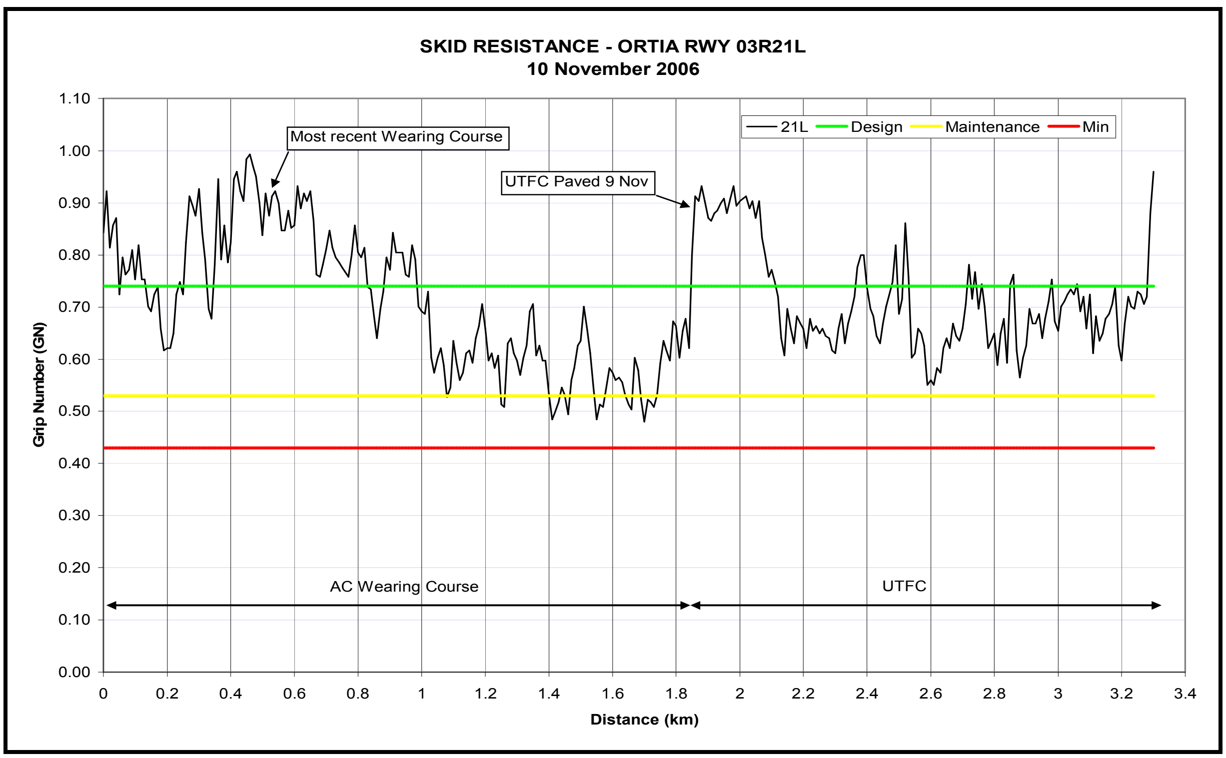

Figure 4: Friction values during construction

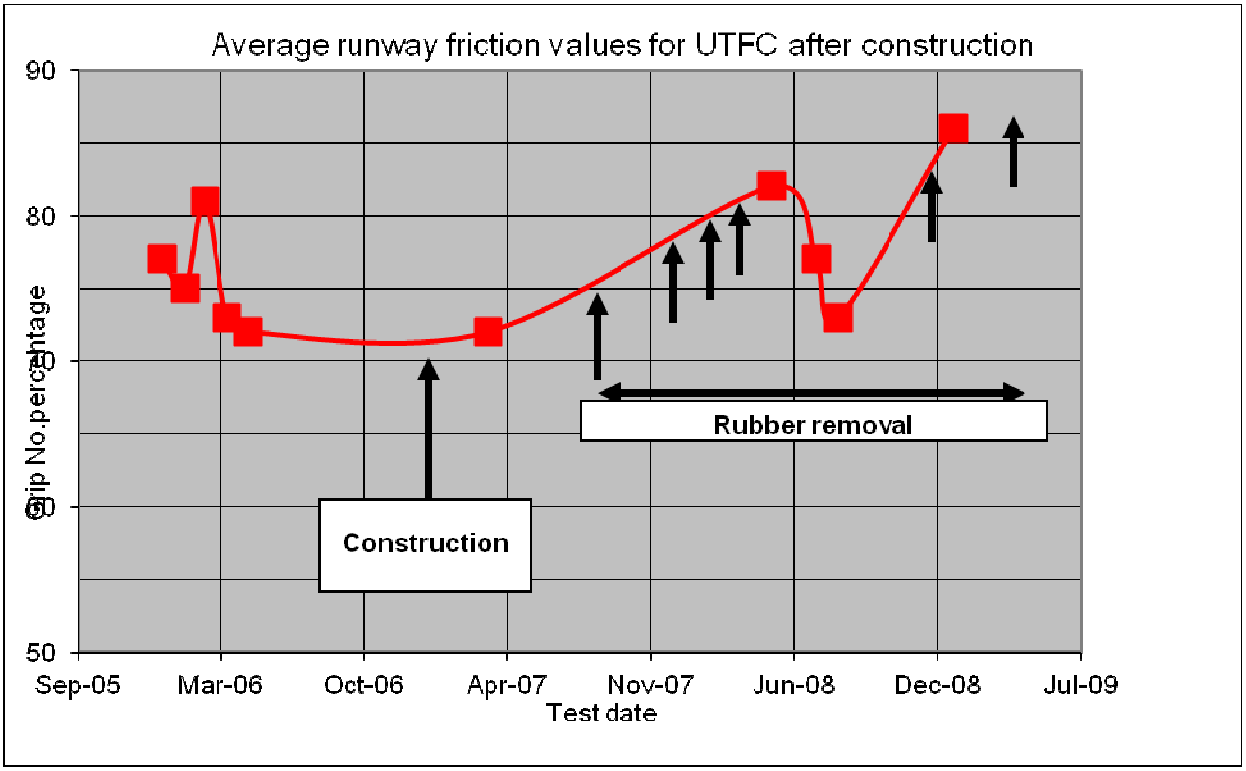

Figure 5: Average runway friction values for UTFC - Jan 2006 to August 2008 [for UTFC]

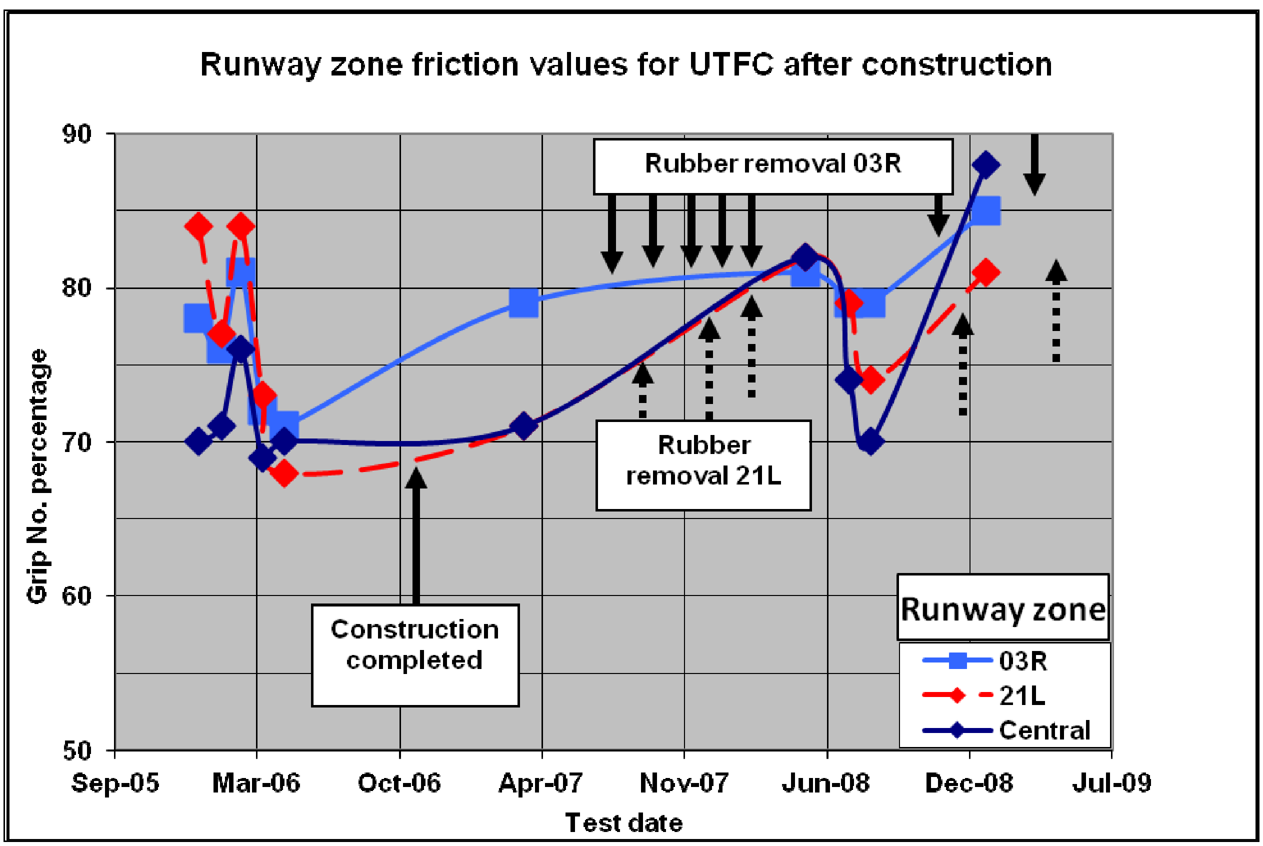

Figure 6: Average friction value for UTFC per Runway zone

In the winter of 2007, inspectors reported a substantial built-up of rubber at the main touchdown area of runway 03R. Repeated rubber removal maintenance took place between September 2007 and April 2008 after which maintenance was ceased again. The result was a substantial increase in average runway friction value to 0,82 followed by a steady decrease over a three months period to 0,73. During the whole period between the date of completion and the last measurement in August 2008, the friction value for the 03R touchdown area never dropped below 0,79. The same could not be said for Touchdown area 21L although the lowest friction value also did not drop below 0,70. The fact that friction values never dropped below 0,7 at any time after construction indicates that the UTFC has been performing above expectation.

It therefore appears as though the friction values are dependant on the number or rate of movement applications and especially on the number of landings in the touchdown area. Runway 03R receives up to 70% of all arriving aircraft at the airport and Runway 21L not more than 20% of all landings. Further analysis of this phenomenon is currently underway, as it is important to understand the dynamics of the UTFC performance in the light of maintenance planning. It is interesting to note that these results imitated similar findings at Copenhagen Airport.

5 CONCLUSIONS AND DISCUSSION

In 2005, ACSA expressed a need for the development and or application of an ICAO compliant friction layer on their main arrivals runway 03R-21L at ORTIA. Previous experimental applications of various types of asphalt mixes were less successful and proprietary friction course products were found to be very expensive, mainly due to the unfavourable exchange rates.

As part of the ongoing upgrading program of airside infrastructure at ORTIA, the consultants proposed to conduct an asphalt mix development program based on the experiences gained by Copenhagen Airport which was reported on at earlier conferences. Considering the fact that this mix comprises a semi open graded grading, design parameters have been compiled primarily to achieve sufficient structural integrity and durability in combination with ICAO compliant functional properties in terms of friction values and texture depth after construction.

Crushed Dolerite aggregate was found to be out performing two rival aggregates, Quartzite and Granites which are locally available in close proximity of the construction site. The optimum binder content was determined mainly based on the minimum VMA and maximum voids in the mix while still achieving suitable limits for aggregate loss in the Cantabro abrasion resistance test (also after curing in accordance with the Modified Lottman water susceptibility test) and for resistance to permanent deformation in terms of the SHARP Gyratory test procedures.

During the asphalt paving trials it has been confirmed that the ICAO recommended requirements for newly constructed asphalt surfaces, i.e. texture depth of more than 1mm and friction values exceeding 0,74 (65 km/h wet), can be achieved after a few months of traffic, allowing the bituminous film to wear off from the aggregate surface. A SBR polymer modified bitumen emulsion tack coat, applied at a rate of 1 l/m^2 was found suitable to sufficiently stick the UTFC to the underlying surface even though the surface has not been treated by means of milling to achieve a rough texture.

The UTFC has now been in service for close to five years. Friction tests indicate that friction values increased with time; especially in the touchdown areas. More frequent landings might even be beneficial for improved skid resistance. The built-up of rubber deposits in the touchdown areas is still being experienced. This may be a reason for concern, although it does not seem to adversely affect the skid resistance when tested with the grip tester. Heavy rubber contamination has not been experienced while friction values are still well above the minimum threshold for maintenance planning. According to the FAA advisory on Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces, texture depth (or decrease in texture depth) would normally not be considered an issue as long as the wet friction-value of the runway surface is still above the minimum specified limits.

6 UTFC IN PERSPECTIVE

When reflecting on the UTFC design grading after conclusion of the project, a big similarity was noticed between this UTFC grading and that of Bitumen Rubber Semi Open graded Asphalt (BRASO). BRASO was developed in South Africa in the mid 1980’s and after it proved to have exceptional fatigue properties has been used extensively not only in South Africa, but also in various countries around the globe.

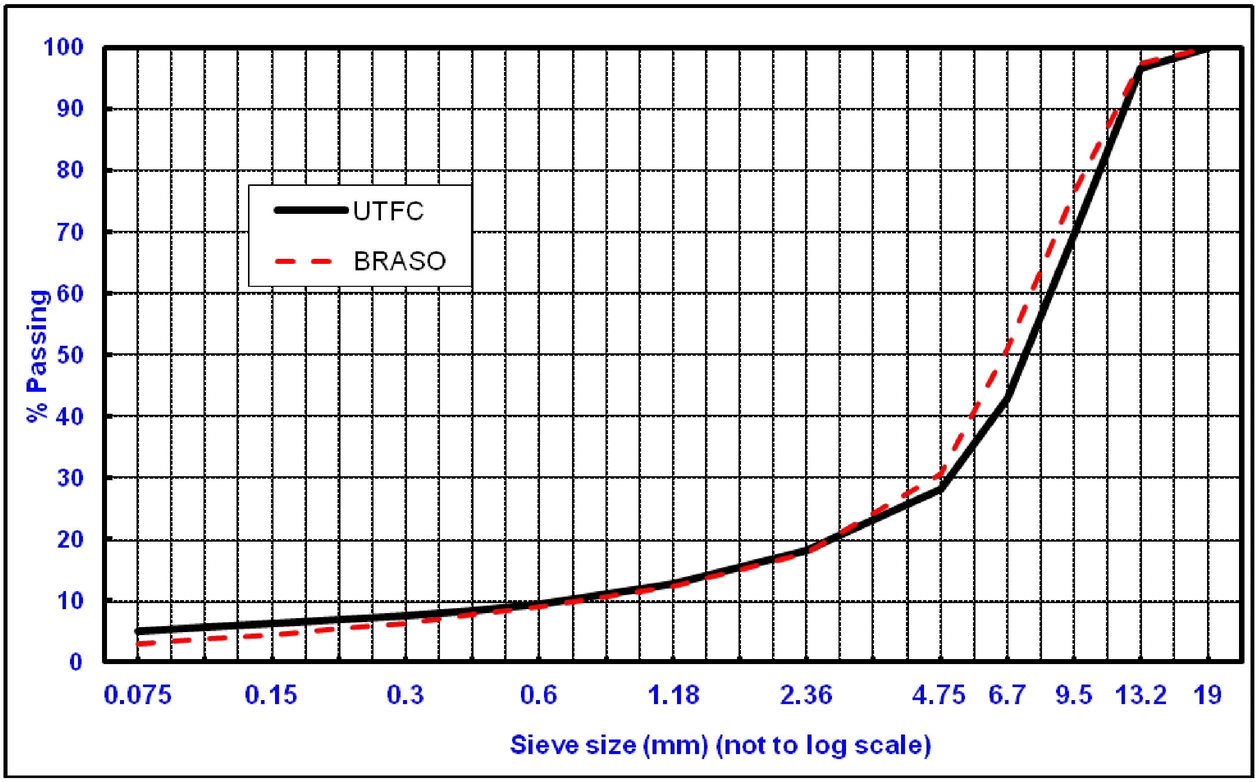

Figure 7: Comparing UTFC and BRASO grading curve

In the above comparative grading curve, the filler content of the BRASO is slightly lower at 3 % in comparison with 5% of the UTFC, which is common for Bitumen Rubber asphalt mixes in South Africa. The VMA values of BRASO is typically in the region of 20% – 22%, which is slightly lower than the UTFC, but the BRASO binder content is much higher at 7.2% – 8.0% resulting in VIM values ranging from 4% - 6%. Although the design approach of the two mixes are completely different, the common grading curve warrants further investigation into a "marriage" of the technologies. The main aim would be to develop a UTFC with all the advantages associated with the open graded mix with added durability provided by the bitumen rubber binder.

It is also interesting to note that the UTFC mix composition applied at OR Thambo International Airport resembles a similar mix that is currently being specified in various States of the US for improved skid resistance on roads and also mainly as a protective shield against ageing of the underlying surfacing (Colorado Department of Transport, 2006). In the US, this is being referred to as Bonded Wearing Course (BWC). The latter could be classified as a "gap graded, Ultra-Thin, Hot Mixed Asphalt (HMA) mixture applied over a thick polymer-modified asphalt emulsion membrane (tack coat)". The tack coat also comprises a modified bitumen emulsion tack coat with application rates in the order of 1,1 *l*/m2. The ORTIA UTFC grading curve resembles that of the Type C grading enveloped although somewhat coarser in the 0,5mm sieve size. Both mixes require a binder content varying between 5% – 6% and a minimum film thickness of 10 µm (US Department of Transport, Federal Highway Administration, 2007).

It is therefore proposed that consideration be given to the possible application of this Ultra Thin BWC mix as a suitable alternative for friction courses for other airport runways in South Africa although consideration could be given to further research in this regard, especially improving durability and resistance to rubber removal maintenance actions.

7 ACKNOWLEDGEMENT

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9 KEY WORDS

Runway, Asphalt, Ultra Thin Friction Course, UTFC, Skid resistance