AN EXPERIENCE OF COLD SEAL MIX APPLICATION AT CEBU AIRPORT, PHILIPPINES

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ABSTRACT

According to the World Bank, economic and social development is dependent upon the development of both transportation and communication routes, with particular and important needs in developing countries. This is the case for the Philippines particularly with regard to airfields due to the geographical spread of this country across many islands. There are many small and medium airports that require funding for maintenance, adding up to a big cost burden.

In this context, the Mactan-Cebu International Airport, MCIA, which is the second largest airport in the Philippines, was seeking to find an economically effective solution to provide a high level of safety, durable surface condition and pavement integrity. A trial was made using a cold seal mixture system, which was developed from the INSTAPAVE system. This system has been initially developed for upgrading gravel roads in the Philippines.

This paper describes the first trial using this technology for an airport in the Philippines. It presents the technical advantages and also discusses some improvements necessary to better meet the constraints of airport operations. Compared to other traditional alternatives, this can be seen as a responsible pavement solution to support longer-term sustainable development.

Keywords: Airport pavement, Cold seal mix, INSTAPAVE, sustainable development

1 INTRODUCTION

Airport asset management is driven by safety and reliability. This is particularly true for pavements, which have to insure the crucial phases of takeoffs and landings. Any degradation of the pavement, such as chipping loss, can lead to Foreign Object Damage, FOD, which can have disastrous consequences. Keeping the pavements at the right level of serviceability and reliability requires special attention. However Asset Managers also have to deal with budget constraints, and under these conditions, pavement maintenance has to provide cost effective solutions without any compromise of safety.

At the Mactan-Cebu International Airport in the Philippines, the taxiway pavement was subjected of severe ravelling without any structural weakness. The option for resurfacing existing pavement is commonly 50 mm (2 inches) asphalt concrete overlay. It gives back the right surface conditions in term of integrity and skid resistance; but the additional structural value of the 50mm is not always needed. Under these conditions, is it the most cost-effective option? The Mactan-Cebu Airport Authority, PhilAsia as contractor and Shell Bitumen as pavement solution provider have merged their efforts to find a cost-effective solution to restructure the surface conditions by using cold seal technology.

This paper presents the key outcomes of the initial trials conducted in March and May 2007 using cold seal mixture technology. After a general background, it reviews the different possible alternatives and more specifically the solution developed, INSTAPAVE+. Then the experiment is fully described including overviews and recommendations for further development.

2 BACKGROUND

2.1 The Philippines situation

The Philippines is characterised by its high number of islands and at the same time high population density. It is composed of 7100 islands, with a population of about 76.5 millions habitants. This specific configuration enhances the need for communication and airports become a key factor for communication and economic growth. This great need for transport infrastructure combined with the current economical level leads to the adoption of cost-effective solutions for pavement construction and maintenance. That has to ensure the right level of serviceability and safety for the cheapest cost.

The latitude at which the Philippines is located, results in specific conditions in terms of weather. The climate is tropical with relatively abundant rainfall; there are three pronounced seasons, the wet or rainy season from June to October, the cool season from November to February and the hot season from March to May. The consequences of

Figure 1. Philippines map

which are severe conditions for the pavement with regard to permanent deformation under high temperatures and adhesion under wet conditions.

2.2 The CEBU airport

The Mactan-Cebu International Airport (MCIA) is a major airport in the Visayas region of the Philippines, located in Lapu-Lapu City. It was opened in the mid-1960s to replace the smaller Lahug airport and then expanded to become the current MCIA. It is currently the second busiest airport in the country after Manila's Ninoy Aquino International Airport (NAIA) and serves as the country's primary alternative gateway.

Figure 2. View of the Mactan-Cebu International Airport, MCIA

Mactan-Cebu International Airport (MCIA) is a major trade centre in the south for both domestic and international traffic with wide-body aircraft A330 or B747. Its traffic is continually increasing and it now has 575 commercial flights weekly, transporting almost 10,000 passengers daily. Mactan-Cebu International Airport recently reported an average of 157 daily aircraft operations (landings and take-offs). About 52% of the flight operations at MCIA are commercial carriers while the remaining 48% are military aircraft and general aviation operations. The airport is made up of a large apron around the unique terminal, a single 3,300 meter runway, and a taxiway. The total area of the airport property is 11 km².

2.3 Pavement condition

Figure 3. Close view of the initial pavement surface

The runway was already overlaid a few years ago with 50mm (2 inches) of asphalt concrete. The current taxiways are 12-14 years old and suffer from ravelling and chipping loss. The surface is rough and in some places the surface layer has almost disappeared. The 20 mm coarse aggregates protrude from the surface leading to a high roughness level but poor embedment as it can be seen on figure 3. These conditions lead to a risk of Foreign Object Damage, FOD. On the other hand, the pavement does not show any sign of structural weakness of the lower pavement layers.

3 THE DIFFERENT ALTERNATIVES

The airport authority was looking for cost effective alternatives, which can take into account the following criteria:

- Restore the surface conditions to the required level with regards to surface integrity, FOD and skid resistance
- Traffic lights are present along the taxiways and must be kept in place after the works,
- Airport operation is 24 hours a day, 7 days a week and traffic restriction has to be limited as much as possible,
- Only taxiways have to be repaired but runway as well as apron levels have to be respected
- The total area to be paved is around 224,000 square meters.

3.1 Asphalt Overlay alternative

To rehabilitate the taxiway, the Airport Management was considering a hot mixture overlay. This solution was considered as the basic option. After some preparation works such as patching, cleaning and sweeping, a 50mm (2 inches) overlay of Hot Mix Asphalt (HMA) is laid on the taxiway, while a 25mm (1 inch) overlay is laid on the shoulders. This represents a total figure of about 24,000 tonnes of HMA. However it needs some additional works. The lights must be protected and then their level raised to keep leading to incremental cost and traffic disruption. The total cost of this alternative was evaluated to be of the order of US$3 million.

3.2 Cold seal mixture solution

Slurry seal technology was initially developed in the 1930's. The first application was made on the Berlin-Staarken Airport in 1936. However, the real extensive interest in slurry seal began in the early 1960's. [1]

It consists of a cold mixture made up with fine aggregates, filler, bitumen emulsion, water and additives, which is laid in thin layers for the wearing surface. It ensures a waterproof layer, a smooth surface and restores the surface conditions against chipping loss and skid resistance. However it does not add any structural value to the pavement nor correct important surface deformations. Under these conditions it is perfectly suited for preservative maintenance and the correction of minor defects.

This option is already widely used in Europe (Germany), South Africa and in the US for taxiways but also for runways. The Federal Administration Aviation in the US specifies the use of slurry seal. It is seen as a cost effective solution for maintenance when there is no special need for pavement strengthening. However, even though slurry seal is currently being used on airports successfully, the key challenge for this project was to use it under tropical conditions.

4 INSTAPAVE AS A SUSTAINABLE SOLUTION

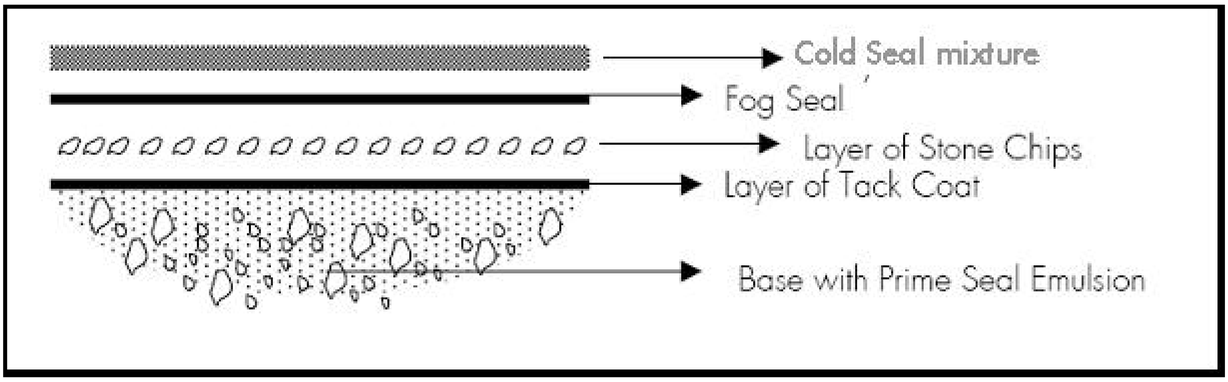
INSTAPAVE is a branded pavement solution developed by Shell Bitumen. The aim is to provide a cost-effective paving solution and was initially developed in the Philippines for surfacing gravel roads. It is now available in various options named INSTAPAVE+ and is currently being implemented across the world in different countries.

4.1 Road application

INSTAPAVE was initially developed for road applications, especially for gravel roads to be surfaced. It presents a less expensive solution than Hot Mix Asphalt. The system consists of four steps from bottom to top described below and in figure 4.

1. Priming - spraying of a low-viscosity asphalt-based primer
2. Chip Course - spraying a high-viscosity binder, followed by chip spreading, after which the surface is rolled
3. Fog Seal - a high stability bituminous coating diluted with water
4. Cold Seal Mixture - a high viscosity bituminous coating blended with aggregates, additives and water, mixed and spread by a controlled spreader box

Figure 4. The INSTAPAVE system for gravel road



INSTAPAVE is considerably more economic than the conventional alternatives of concrete or asphalt hot mix. It produces a surface, which is suitable for light to medium traffic making it ideal for rural areas and still more competitive than the costs of re-gravelling roads twice a year. The system enables local governments to afford projects, which replace gravel roads with bound pavements. For the same budget, more roads can be treated, meaning that more children have wider access to schools, more farmers can reach markets and more families have improved access to healthcare in hospitals. The local environment is improved since INSTAPAVE dramatically reduces the dust that is generated by gravel roads; dust is a major killer in the developing countries where it is the cause of the world’s 4th deadly disease - pulmonary lung disease. In this sense it contributes to sustainable development.

4.2 Airfield application

The INSTAPAVE system was further developed for airport application into INSTAPAVE+ as a preservative maintenance system. For airfields, INSTAPAVE+ system consists of, after support preparation, the application of a tack coat and a cold seal layer. The INSTAPAVE+ technical specification is based on the recommendation from the FAA for airfield application as described in item P626 of the Advisory Circulars AC150/5370-10B [2]. The grading and the Nominal Maximum Aggregate Size (NMAS) of the slurry mixture have to be adjusted to comply with airfield constraints. Coarser grading type III with a NMAS of 3/8' (9.5mm) can lead to problem with excessive tyre wear. The optimum grading is type II with a NMAS of 1/4" (4.75mm) providing sufficient friction with good resistance to excessive tyre wear.

5 THE TRIAL

As described in the background, the taxiway pavement surface showed severe ravelling degradation. The Mactan-Cebu International Airport (MCIA) Authority was seeking an innovative cost-effective solution as an alternative to asphalt overlay. Based on international references for slurry seal application on airfields, INSTAPAVE+ system was proposed for a trial.

The trial was performed on the central taxiway Delta, which is used for quick escape from the runway. A first trial application of 3m x 70m was made in March 2007. Based on that, the airport authorities gave the opportunity to complete the remaining 6m x 70 m trial site in May 2007. That has completed the width to take all the wheels of aircraft and to the full evaluation of the performance of INSTAPAVE+.

Figure 5. View of the 1st trial (black lane)

PhilAsia as applicator conducted this trial in coordination with Shell Bitumen in accordance with the guidelines and specifications of the International Slurry Seal Association, ISSA [3] and FAA P-626 Emulsified Asphalt Slurry Seal [2].

5.1 Mixture design

Prior to the work itself, a mixture design study was carried out with the components to be used for the trial in accordance with the ISSA A105 guidelines. This mixture design was conducted at the Shell Bitumen Technical Centre in the Philippines.

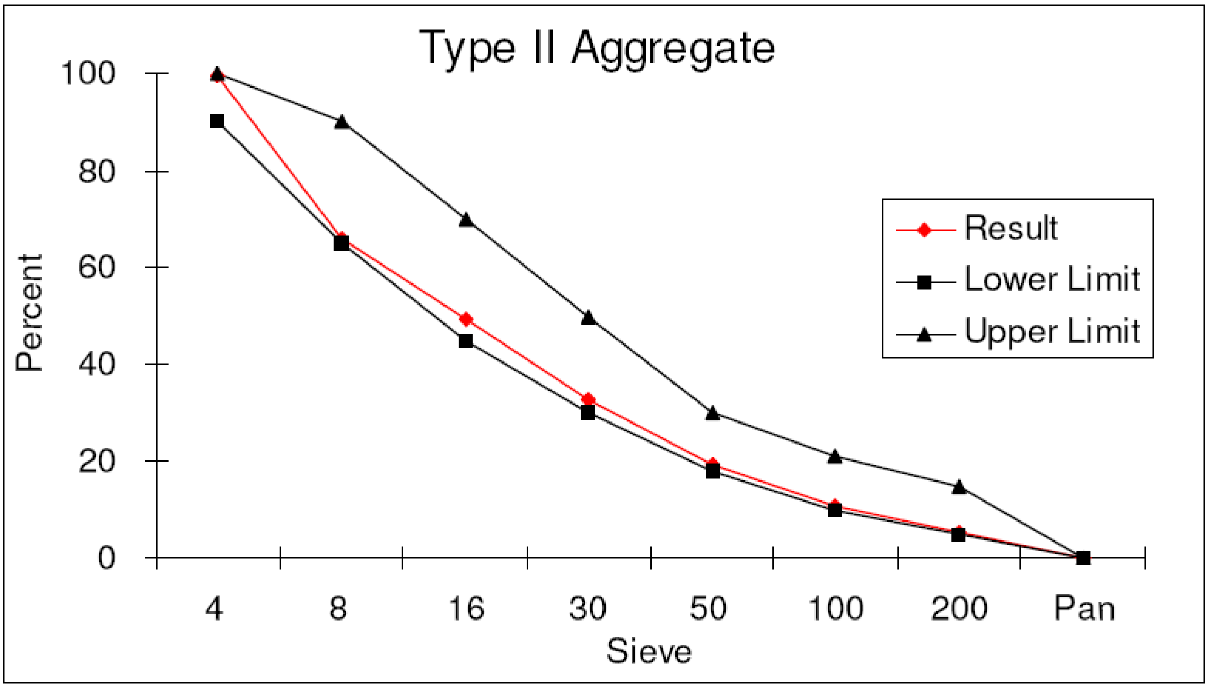
5.1.1 Bitumen emulsion

The bitumen emulsion used for the cold seal mixture was a quick set emulsion with specific emulsifier to control the setting. This type of emulsion was selected on the basis that quick set formula will provide the faster setting time required on airport applications. The bitumen ratio was 63% residual bitumen.

5.1.2 Aggregates

The aggregate was a type II grading according to ISSA A105 with a Maximum Nominal Aggregate Size of ¼ inches (#4, 4.75 mm)). It was crushed aggregate from a combination of coarse aggregates from a mountain quarry in Cebu and fines from Magdugo River. This combination improved the aggregate properties by reducing the aggressiveness as measured with Methylene blue and adjusts the grading curve. The final grading curve is presented in figure 6 with the upper and lower limits as specified by ISSA A105 guidelines for type II grading.

Figure 6. Grading curve of the mixture, Type II aggregate



5.1.3 Other components

The water used was tap water with temperature of not greater than 36°C. Portland cement was used to control the mixing time

5.1.4 Mixture formula

Once grading type II was selected, the mixture formulation was defined by adjusting the emulsion content to achieve a right mixing time, water content to provide the right consistency and the filler ratio to adjust the final result, if required. Based on experience, the formulation is initially set with a previous formulation and adjusted to meet the different steps of the mixture evaluation. The mixture evaluation consisted of six steps:

1. The cold seal mixture consistency in accordance with ISSA TB106, it assesses the ability of the mixture to spread naturally after mixing
2. Wet cohesion in accordance with ISSA TB139,
3. Excess of asphalt in accordance with ISSA TB109,
4. Wet stripping in accordance with ISSA TB114,
5. The Wet-Track Abrasion Test WTAT in accordance with ISSA TB100, it assesses the durability of the surface after water immersion,
6. The mixing time in accordance with ISSA TB113, it determines how long the material can be mixed before breaking.

The final mixture formulation was as follows in table 1:

Table 1. Mixture formulation

	Aggregates	Emulsion	Water	Filler (cement)
% in weight of aggregates	100%	13%	12%	3%

This mixture met the ISSA specifications presented in table 2.

Table 2. Mixture specifications (ISSA A105)

Test		Test method	Specification
Consistency		ISSA TB106	recorded
Wet cohesion	30minutes 60 minutes	ISSA TB139	12 kg cm min 20 kg cm min
Excess Asphalt		ISSA TB109	538 g/m² max
Wet stripping		ISSA TB114	90% min
WTAT after 1 hour soak		ISSA TB100	807 g/m² max
Mixing time		ISSA TB113	180 seconds min

5.2 Works

The application consisted of four steps described as below. Each trial was made into a window time of 12hours free of aircraft traffic.

Preparation (figure 7.1) - Paint marks were removed with an electric grinder. For sweeping a vacuum truck with a rotary broom was used to sweep off the excess stones and loose materials on the surface. The process was completed by manual sweeping to remove stones left on the surface after each pass.

Fog Sealing (Figure 7.2) – A hand spray tool with regulated pressure was used. It helps in the adhesion of the slurry layer to the surface and to penetrate the heavily scaled surface and keep the stones more intact.

Cold seal mixture Application (Figure 7.3) – The mixture was applied as soon as the fog seal turned black and tacky. The targeted thickness was set between 5 to 8 mm in accordance with the aggregate grading type II.

Rolling/Compaction (Figure 7.4) – Once the cold seal mixture became dry and not sticky, a 3T pneumatic tyre roller was used to compact and close the surface. It was equipped with a water spray system, to be used if the cold seal mixture was picking up on the tires during rolling. During the trial, the edges were rolled first to check if the mixture was ready for rolling

The curing time observed with the current mixture design was around 12 hours.

Figure 7. The four steps of INSTAPAVE+ application

7.1 – Preparation, surface sweeping

7.2 – Fog sealing

7.3 – Cold seal mixture application

7.4 – Rolling/Compaction

6 KEY LEARNING POINTS

6.1 Technical overview

Figure 8. Close view of the final pavement surface

After completion of the work and the full curing time, the surface has recovered its integrity. The cold seal mixture has filled the void left by the initial material loss and become embedded in the coarse aggregates, while the surface displays good micro-texture as it can be observed from figure 8 compared to initial state showed in figure 3. The general condition of the cold seal, checked after seven days of being opened to normal traffic, was good. In some cases, after weeks of operation big aggregates still remained on top of the surface. However no signs of tyre pick up and damage on the edges have been noted. The cold seal mixture has remained intact, adhered to the old surface and the bigger aggregates remain coated.

During the work the cold seal mixture application was particularly sensitive to weather conditions, especially wet ones. This phenomenon led to excessive curing time of the cold seal mixture prior to compaction. For the second trial, the emulsion formulation was refined to have a slightly quicker setting time. Also during the second trial in May 2007, the central lane was laid in a thicker layer resulting in a longer curing time. The keys to the success of the trial application are the following:

- The site was good for an INSTAPAVE+ application, no cracking was observed. Aircrafts are just passing over the paved surface and not turning in place.
- The materials used were of the right quality (aggregates & bitumen emulsion).
- The contractor’s crew was well trained and well informed about airport safety and standards.
- The project was closely monitored before opening to traffic

- Good coordination between airport authorities, the contractor and Shell Bitumen has ensured excellent and safe conditions for the completion of the trial

A “cold seal mixture for airport application” guide was prepared for full project implementation. This is based on special items on FAA P-626 Emulsified Asphalt Slurry application.

6.2 Applicator overview

PhilAsia as applicator of the INSTAPAVE+ system has found some strong advantages. The system is easy to apply and does not require any hot mix plant. Leading to less logistical constraints and more flexibility, as there is no coordination to make between the mixing plant and the job site. Transport of materials is less important. Also due to the thinner layer, the duration of the works is considerably reduced.

6.3 Airport authority overview

Overall the airport authorities were pleased with the trial application wherein a thin surfacing layer like INSTAPAVE+ can seal the voids and hold the bigger stones intact. They have seen this as a solution to prevent further material losses and extend the service life of the taxiway.

The target of this maintenance action was to restore the surface condition, especially the surface integrity and stop chipping loss. INSTAPAVE+ application perfectly fulfils this target by embedding the coarse aggregate of the initial pavement material, ravelling was stopped and FOD risk from the pavement was reduced.

The INSTAPAVE+ solution was also seen as a fast and secure solution. The thin layer thickness has avoided the need to upgrade the levels of the lights leading to cost savings and limitation of the traffic disruption due to taxiway closure.

The technical team from the Airport Authority has checked the stiffness of the surface after the first few days using steel bars and hammer. They have seen an improvement between the first trial in March and the second trial in May with an increase in material stiffness. The curing time was a key parameter and was improved from the first trial to the second one.

The engineers noted as well that the INSTAPAVE+ system provided a waterproof layer, stayed intact even after heavy rainfall and was able to coat the bigger aggregates with a slightly thicker application.

6.4 Recommendations

From this first trials of cold seal mixture application on an airport under tropical conditions, some improvements / recommendations have been identified.

1. Type 3 grading can be used to seal the bigger voids and to get better skid resistance. This is true when shear stresses are limited
2. When a thicker layer is required to fully recover initial coarse aggregates, two layers of grading type II can be used

3. Preparation of the support is key especially regarding the removal of paint marks
4. Modified bitumen emulsion has to be considered to provide higher performances of the final pavement
5. Define proper Quality Control to fit with airport constraints such as including the measurement of skid resistance

7 CONCLUSION

Although the use of slurry seal techniques is already widely used in several countries on airfields, there is much less application under tropical conditions. Slurry seal is mostly suitable for preservative maintenance to restore surface condition including minor defects.

The Mactan-Cebu International Airport taxiway was subject to severe ravelling after more than 10 years of use. Prior to the full rehabilitation of the taxiway pavement, a trial was made to see if cold seal mixtures can offer an alternative to standard 50mm (2 inches) asphalt overlay option used by the Airport authority. This trial was made in close partnership with the MCIA Authority, the contractor and Shell Bitumen as the solution provider.

The INSTAPAVE+ system derived from the system initially developed for roads was used. It is based on slurry seal technology. The bitumen emulsion formulation was refined to reduce the curing time. The mixture design was also refined to fit with local aggregates and surface texture requirement. With two trials, the final outcomes have shown positive and promising results. The expected targets have been achieved by stopping chipping loss and providing good skid resistance. At the same time this solution can save additional costs in association with light network upgrading. It is seen as a cost-effective and sustainable solution.

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