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DISTRESS IN THE TARMAC

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Because the airport site is located in the floodway of Bangkok's eastern suburbs, it requires both effective flood protection and drainage systems to avoid problems caused by water seepage into the sand blanket under the airport's taxiways and runways, writes PROF WORSAK KANOK-NUKULCHAI

Last October, when the first sign of rutting was spotted in five of the six taxilanes and in one taxiway at the Suvarnabhumi International Airport, the Engineering Institute of Thailand (EIT) assigned a team of experts to join the preliminary investigation. The investigation revealed that the damage was caused by the premature failure of asphalt base course due to the separation of asphalt binder from aggregate surface in the presence of moisture, commonly known as "stripping". It was quite evident from the milled damage area that water seeped from the sand blanket underneath the cement-treated base (CTB) through expansion joints.

The key question is: How, and also how long, has the water been trapped in the sand blanket?

This article intends to provide technical facts to the readers who want to understand what really happened to the airfield pavement of this brand new airport.

WORRYING OBSERVATIONS

On 27 October 2006, about 2-3 weeks after the official opening of the airport, the first signs of distress were spotted at several locations in the taxiways and taxilanes, in the form of rutting, rutting with shattering and split, and rutting with hairline cracks (figure1). Since then, a similar pattern of failure has developed heavily in five of the six taxilanes and along the east parallel taxiway. Although both runways are still in good structural condition, plastic deformation of the asphalt wearing course was observed near the takeoff position. The extent of the damage is summarised in the table below.

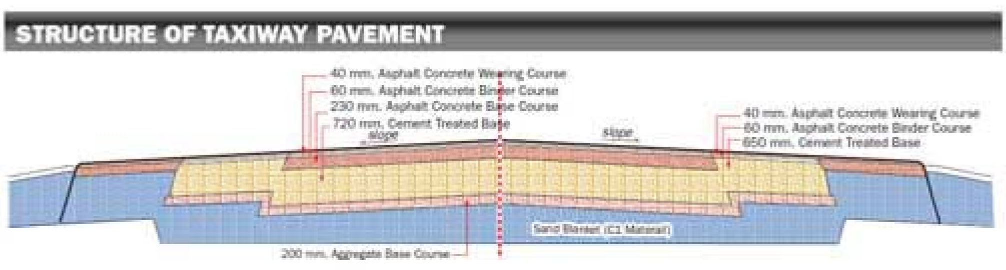
Summary of Pavement Damage as of 25 January 2007

Airfield Pavement	Area (sq m)	Distressed Area (sq m)	Locations	Typical Damage
1 West Runway	295,500	15	Taxiway Curved	Wearing course plastic deformation
2 East Runway	318,000	78	Junction	Wearing course plastic deformation
Total Areas	**613,500**	**93**		**Damage area = 0.00015%**
3 West Taxiway	724,868	800	E13, E21	Rutting, cracks or shattering
4 East Taxiway	572,956	18,081	B, B2, B5	Rutting, cracks or shattering
5 Cross Taxiway	217,706	23,673	G	Rutting, cracks or shattering
6 Taxilane	303,086	54,046	T4,T5,T8, T11-T15,T17	Rutting, cracks or shattering
Total Areas	**1,818,616**	**96,693**		**Damage area = 5.31%**

Illustration of taxiways and taxilanes.

Overview of east runway, taxiways and the drainage system.

Suvarnabhumi airport covers an area of 20,000 rai (3,200 hectares). In its first phase, the airfield serves its hourly 112 flights with two runways, six taxiways and six taxilanes. The tarmac consists of three layers of asphalt concrete, namely the base course (23 cm thick), the binder course (6 cm thick), and the wearing course (4 cm thick). Underneath are four layers of the cement-treated base (CTB), 18 cm. thick each, sitting on top of the sand blanket (approximately 80 cm thick) left over from the ground improvement process.



Plastic deformation was observed on the wearing course at the turn-around segment of the taxiway leading to the takeoff position of the runway (Figure 2). This location is normally under maximum load when the plane takes off with a full load of fuel. The high shearing stress that causes plastic deformation was imposed by braking, accelerating or turning traffic. Plastic deformation is greatest at high temperatures, especially for the AC 60/70 binder grade used in this case. The occurrence of the plastic deformation at this location is therefore a common phenomenon and only routine maintenance is required to repair this type of distress. Aside from this surface distortion, both runways are in good structural condition.

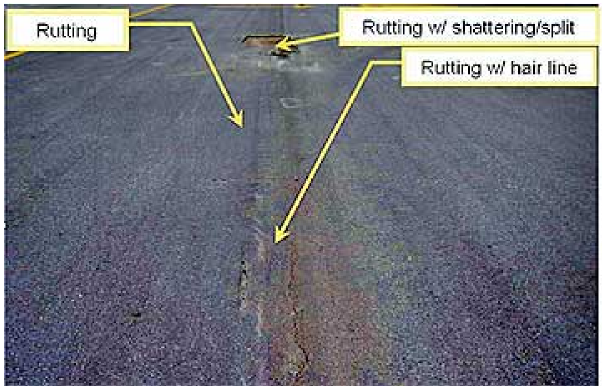


Figure 1: Typical distress in the taxiways and taxilanes.

Figure 2: Surface deformation of the runway.

Initial investigation was made by coring the asphalt concrete pavement at a diameter 100 mm throughout its 33 cm thickness from the damaged areas (Fig. 3). The following observations can be made:

- All core samples from damaged area show evidence of asphalt stripping at the base course, a typical effect of soaking water, while core samples from undamaged areas show good condition.

- The water had infiltrated into and confined in the asphalt concrete base course for a long period. Thus, the base course has been immersed in and impaired by the water.

- As a result of asphalt stripping, asphalt binder was separated from aggregate surface, leading to premature loss of strength and stability of the base course.

- The load of the aircraft had then impaired the failed asphalt concrete pavement, causing rutting on the surface.

Based on the core samples, laboratory tests have indicated the correct job mix and aggregate gradation of the asphalt concrete material. This was also confirmed by a separate test at the Highway Department.

To expose the cement-tested base (CTB) for visual inspection, an area of asphalt concrete pavement was milled at the damaged area of the taxilane. It was evident that there was no sign of damage or subsidence in the CTB. However, traces of water seepage were clearly observed (Fig 3) along the rim of the expansion joints in the CTB. This evidence of seepage further hinted that a large quantity of water might still be trapped in the sand blanket.

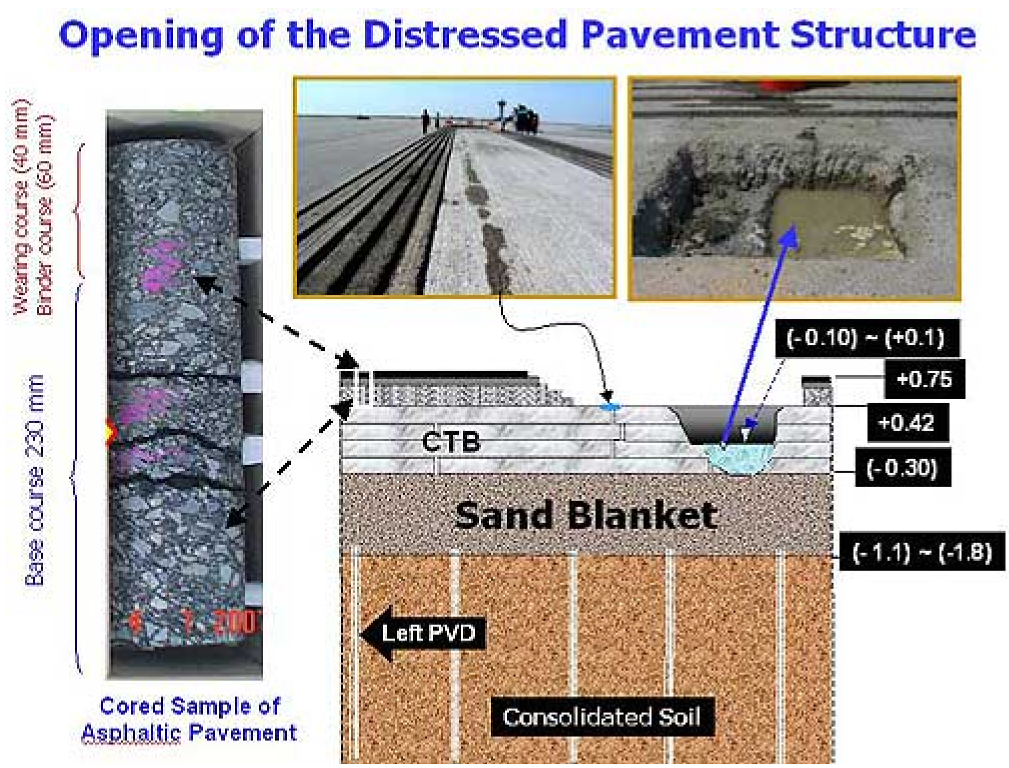


Figure 3: Illustration of milled pavement in the taxilane T11, a core sample of asphalt concrete, trace of the water seepage at CTB joint and the test pit.

On January 31, a test pit (Fig 3) was dug on Taxiway T11, where damage was found to be extensive. After the excavation went through CTB and exposed the top surface of the sand blanket, water seeped through the sand immediately until the water level reached about 20 cm above the sand blanket (or roughly at +0.0 MSL). The water stayed at that level even when attempt were made to clear the water.

Interestingly, to prove that water in the sand blanket is fully confined with no connection outside, a deep excavation was made nearby, but outside the pavement area. After the excavation, the dug hole was completely dry. No sign of water from the sand blanket had receded into this empty hole.

Meanwhile, Highway Department experts have tested the samples of sand and CTB from this test pit and reported that all materials tested have met the standards.

Excavation to test the connectivity of the trapped water.

HOW WAS THE WATER TRAPPED?

Based on the official report of the investigation committee appointed by Airports of Thailand Public Company (AOT), the following reasons had been given for the trapped water:

1. Runoff of rainfall water was collected and retained within the airport compound in the pockets of sand used to fill fishponds, swamps and waterways prior to the airport construction. Water from this source might find its way into the sand blanket.

2. Surface water spilled from the drain age canals, during the flooding period, over the top soil around the unpaved neighbourhood into the sand blanket.

3. Surface water once trapped underground was not able to escape due to the lack of a subsurface drainage system. This was aggravated by the blockage of culverts and other underground structures.

4. Based on soil boring records, thin sand layers may exist originally within the soft clay layer at a level about 10 metres deep. Some of these sand layers may cross path with the leftover PVD, thus allowing running shallow ground water to seep upward into the sand blanket.

On the last point, some geotechnical experts argued against this possibility. At the end of the PVD preloading, the extra surcharge consisting of crushed rocks was removed. Thus, it is no longer possible for water to move up to the surface through the PVDs against the hydraulic gradient and against gravity at the end of consolidation process.

In addition, there is hydraulic back-pressure from the trapped water in the sand blanket making it impossible for such hydraulic upward flow to occur.

Because the airport site is located in the floodway of Bangkok's eastern suburbs, it requires both effective flood protection and drainage systems. The aim is to prevent flooding from flash floods, as well as to drain away rainwater in the catchments of the airport compound. The design of the polder system includes the perimeter polder dike, internal drainage system, two pumping stations and a perimeter road (Fig 4).

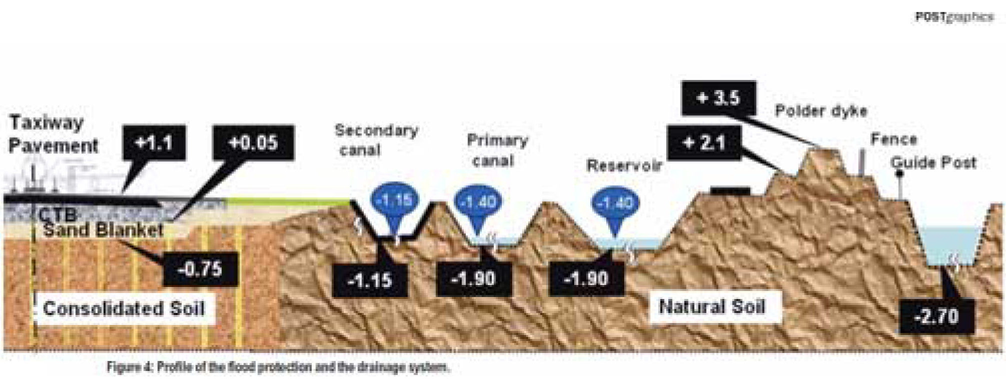


Figure 4: Profile of the flood protection and the drainage system.

Basically, the internal drainage system for runoff water consists of:

1. The unlined primary canals and reservoirs both with the bed at -1.90 m MSL. Based on the design criteria, water level in the primary canals and reservoirs must be maintained not higher than -1.40 m MSL.

2. The secondary canals with concrete linings. The canal bed of the secondary canal is -1.15 m MSL. It is designed to be dry except during the raining.

The primary and secondary canals are interconnected by ditches to ensure that the runoff water from the pavement area will flow under gravity towards the two pumping stations located at the south corners of the site. In the operating manual, water in the primary canals and reservoirs must always be controlled at the pumping stations to ensure that the water level is maintained at -1.40 m MSL or lower.

With the design assumption that no rain water runoff can leak into the sand blanket, no subsurface drainage system exists to systematically drain trapped water from the sand blanket. This might be a weakness in the design criteria of the airfield pavement.

WHAT'S NEXT?

In its press release issued on 15 February 2007, the Engineering Institute of Thailand (EIT) strongly recommended that, similar to a first-aid treatment, trapped water should be drained out urgently to minimise the potential spread of cracks on taxi lanes, taxiways, and even on runway. This immediate action should be carried out with the consent and cooperation of all concerned parties including the project management consultants, the designers and the contractors.

Alternatively, the AOT should seek temporary protection from the court to implement the required first-aid treatment without damaging its rights under the contract. Meanwhile, it was reported that the AOT plans to commission a team of international experts to carry out an in-depth technical investigation in order to recommend long-term remedies.

GROUND IMPROVEMENTS

Suvarnabhumi Airport compound is situated on formerly agricultural land, fish farms, swamps and waterways. A thick deposit of soft clay is found over 10 metres deep, with 100-120% water content, on top of medium stiff clay and stiff clay with water content of 50-90% and less than 50% respectively.

Soil is a multiphase system, comprising a solid phase (soil particles) and a fluid phase (air and water) called the pore fluid. For soft clay, the higher the volume of the fluid phase, the weaker and more compressible the soil mass. Therefore, any reduction of water in the pores of the soil, which decreases the volume of the soil mass (Figure A1) and subsequently increases the particle-to-particle contact, increases the strength of the soil and reduces its compressibility at service stage.

To be suitable for airfield pavement, pore water in the soft soil must be squeezed out to result in water content around 80%. Thus, the soft clay is transformed into medium stiff clay. This consolidation process can be accelerated by a modern technique using Prefabricated Vertical Drains (PVD).

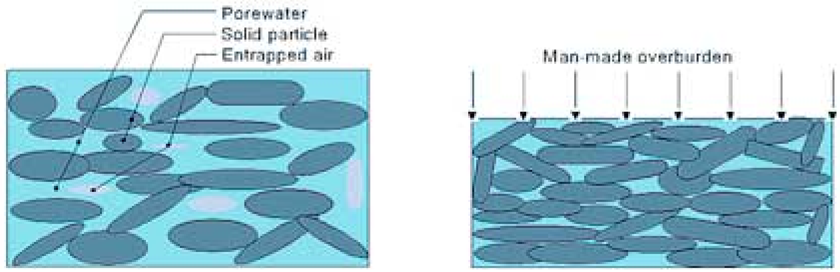


Figure A1: Natural and consolidated soft clay deposits.

PVD is a plastic tube core wrapped in a filter jacket, made of non-woven polyester or polypropylene geotextiles or synthetic paper. PVDs drain soil by squeezing out pore water, a process that can be accelerated by adjusting the spacing of PVDs. In this process, water flows a lot more quickly horizontally towards the drain and then vertically along the drains towards the permeable drainage layer at the top. The step-by-step procedure of consolidation using PVD is illustrated in Figure A2.

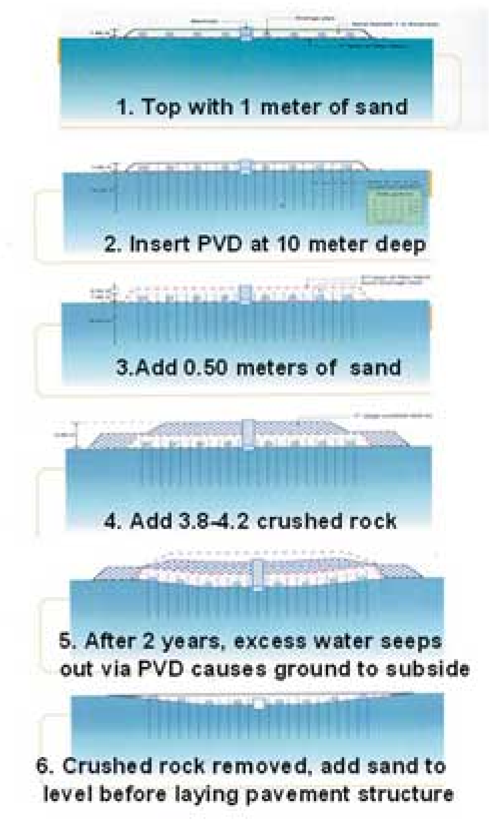


Figure A2: Consolidation process of soft clay under the airfield pavement.