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## **AAPA**

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## **ABSTRACT:**

### **DEVELOPMENT of DURABLE MICRO SURFACING for HIGH TRAFFIC in THAILAND**

Micro surfacing has been introduced in Thailand by TIPCO Asphalt Co in the early 2000's

This technique has been introduced as an efficient and economical technique of maintenance for waterproofing, for sealing superficial cracks and for re-storing the skid resistance of the existing asphalt pavement. The thin application presents undeniable advantages over hot techniques for elevated expressways in Bangkok where we are limited in height with curbs and lateral water drainage

Long laboratory investigations concerning the selection of premium quality raw materials such as the source and gradation of aggregates, the source of bitumen, choice of natural latex, adapted emulsifier and the use of Emulfix process (Colas patent) for producing smaller particle size emulsion combined with the knowhow of the group in the field of micro surfacing have led to a performing product that is highly recognized by the road authorities. The fast growing sales of the CSS-1hP emulsion by TIPCO assesses high level of performances and suitability with the market. More than 14,000T of emulsion corresponding to approximately 11 million sqm<sup>2</sup> of single layer have been delivered in 2013. High performances combined with long service life of micro surfacing may explain that the budget of micro surfacing has been double for 2013 thus confirming the non-stop growing of this surface technique

Beside cost efficiency, several parameters may explain this growth such as:

- Success of the first trials on urban expressways in 2000's
- Superficial roughness solving
- Control of the cohesion build up for night applications that are mandatory in BANGKOK for any road work
- Long lasting performances
- Perfect suitability with customers' expectations
- Flexibility of cold technique versus hot applications and low environmental impact in urban areas

Apart of technical aspects, the attempt has been converted thanks to a highly efficient marketing policy that consists to provide the full technical assistance to customers such as the selection of quarries, aggregate and job mix design, upgrading of machines, calibration, short seminar and field assistance at the starting of projects.

Two grades are proposed (type II and type III). The type II (according to the ISSA definition) is used on rural roads and tends to gain over slurry seal regularly while the type III is dedicated to high traffic such as elevated expressways in BANGKOK, normal expressways and highways. The service life under high traffic and tropical temperature is over 5 years minimum depending upon the profile of the section and the characteristics of traffic

The application of micro surfacing is now extended to cape seals and colored surfacing.

This paper deals with the technical matters, designing and in situ performances

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## **DEVELOPMENT of DURABLE MICRO SURFACING for HIGH TRAFFIC in THAILAND**

### **1. INTRODUCTION**

Cold mixes in Thailand in the past decades were essentially based on Slurry Seal Type II for road surface maintenance. This technique gave satisfaction until the years 1995-2000. Nevertheless its application was limited to the rural roads as it could not withstand constraints of higher traffic and ensure a quick re-opening to traffic. Tighter road budgets allocations for maintenance combined with an increasing demand of economical maintenance technique for high trafficked road network has pushed TIPCO Asphalt to propose the micro surfacing Type III which has revealed to be the best ratio performance / cost technique versus any other road solutions for restoring surface properties and improving drivers safety without excessive disturbance of traffic.

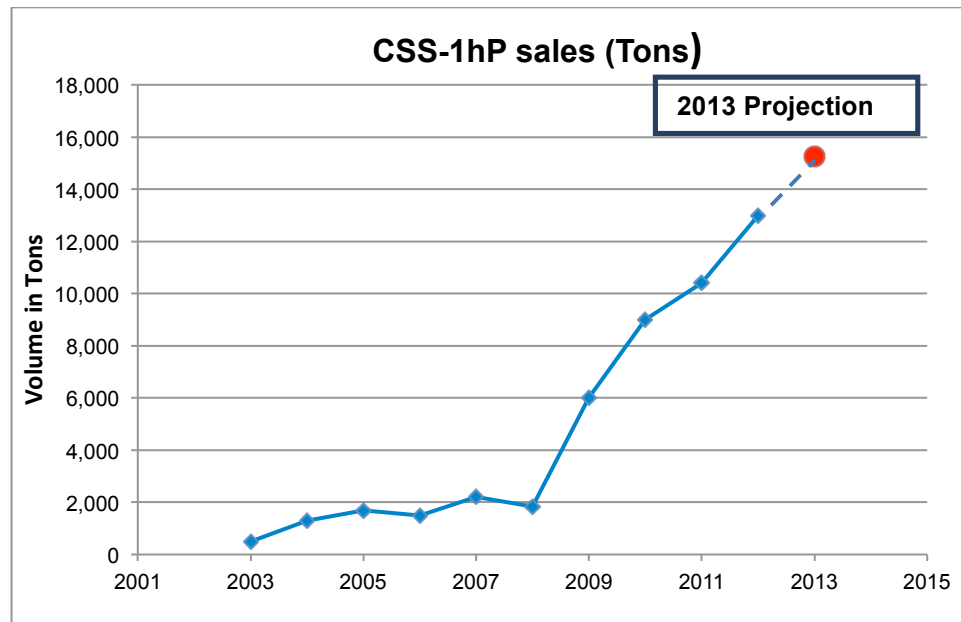
The first trials took place in the 2001's on urban expressways in Bangkok and they were crowned by success. Since that time performances have been regularly improved and micro surfacing development has grown up to become an "incontestable" technique for the maintenance on expressways. Its application extends now to national and rural roads where it is gaining market share over the conventional slurry seal

### **2. STRATEGY of DEVELOPMENT**

TIPCO ASPHALT is a THAI industrial company which produces, markets and sales bitumen and manufactured bituminous derivatives such as bituminous emulsions, cut back, polymer modified bitumen, joint sealers and cold premix throughout in ASIA. TIPCO is not a road construction company stricto sensu and then does not apply the finished products or pavements made with its own binders.

In this regards TIPCO sat a specific strategy to develop the market of micro surfacing in THAILAND through his customers based on 3 pillars

- A - Analysis of the demand:** Restricted budgets, cost efficiency, adequation of the technique with the demand for solving problems of skid resistance and aquaplaning on expressways and quick re-opening to service have been key factors that have played in favor of the micro surfacing. Since 2003 (date of real starting) the sales of emulsion for micro surfacing has grown up slowly until 2007 and has followed a regular development since 2008 as shown in the graph 1



Graph No1

**Specifications for Micro Surfacing:** Road techniques cannot develop as long as they are not covered by specifications. In this regards and in close relation with the road authorities (Department of Highways) specifications have be issued for micro surfacing including those for the quick set emulsion and aggregates.

Micro Surfacing follows the DH-S 415/2546 that is mainly based on the “Recommended Performance Guideline for Micro Surfacing – A143-2010 “issued by the ISSA. It includes the recommendations for aggregate that takes into consideration the singularity of aggregate resources in THAILAND that is composed mainly of Limestone. Limestone amount for about 80% and the balance between granite and a bit of Basalt in the East side

Asphalt emulsions are specified under the DH-S 405/2538 for micro surfacing. The specifications for asphalt emulsions refer to the ASTM D 2396 for the CQS-1h. Specifications for the polymer modified emulsion have been added and there are classified as CSS-1hP according to the DH standards

**B - Providing the Most Performing Product:** This has required a long approach and optimization in laboratory over few years, helped by the feedback from job site

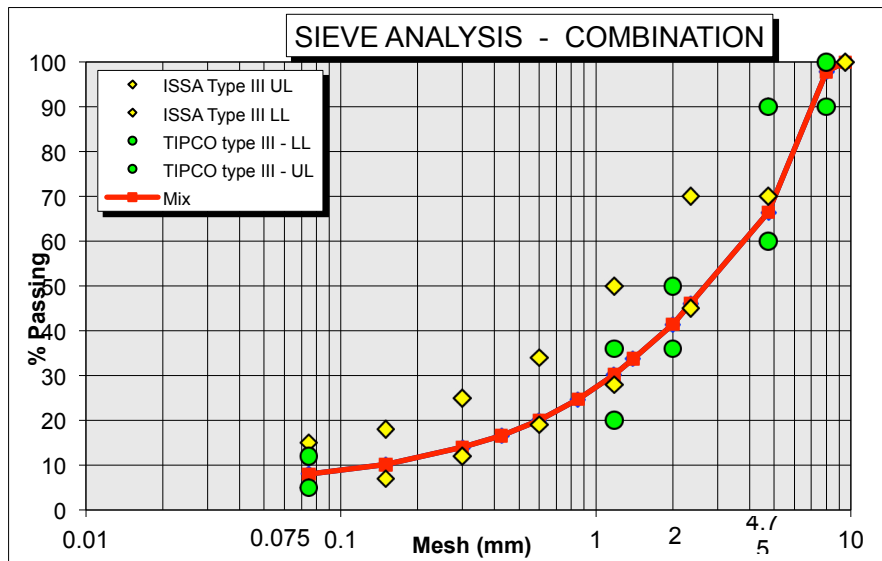
- **Aggregate Mix Design:** Specifications remains a frame for achieving a basic quality but they are not stringent enough to face constrains generated by the high traffic, high ambient temperature (of about 30oC over the year with some pic at 40oC during the hot season) and night application as all road works in BANGKOK.

This led us to work for gaining in performances by controlling each key parameter that interacts on the final performances as much as we can.

We propose 2 types of micro surfacing:

- **Type II** for rural and urban roads (0/4.75mm size) which is made of 100% crush sand
- **Type III** for expressways and national roads (0/9.5mm size) which is a combination of stone dust (0/4.75mm) and chipping (4.75/9.5mm). We rose the percentage of chipping a bit to range finally between a conventional Type III and 0/10 micro surfacing gradation. The

improvement is significant in term of skid resistance and reducing risks of bleeding on site. This contributes as well to increases the service life of the mix



Graph No2

- **Quality of Aggregate:** Limestone is our most common source of aggregate and we have no choice to deal with it. The quality of crushed stone is one of the two key parameters (with the characteristics of binder) which govern the breaking process. In this respect we pay a special attention to the cleanliness, presence of clay, shape, reactivity and percentage of filler. All aggregate which does not comply with our internal specifications based on the above parameters is rejected. Stone dust is often considered as a waste product and we have no power on quarry owners to modify the crushing process. Acceptance test is then a preliminary prior to start the formulation of the mix

In-fine, for all projects in BANGKOK we have selected for our customer only ONE source of aggregate. The chipping is previously screened to remove the oversize that might make drag marks on the surface and it is blended with the stone dust at the stock pile

- **Bitumen:** The standard bitumen grade in ASIA is the 60/70 penetration. The bitumen used at the origin of this project was a common paraffinic from THAI refineries modified with additives to fasten the setting and cohesion. The performances were not really satisfactory even in day time and outside temperature of 30-40oC and the surface pavement temperatures of 50-65oC. Road works on expressways in Bangkok are realized by night and setting and cohesion build up have been found much longer generating some loss of chipping at re-opening to traffic. This has been a source of complains from project owners and road users even if the level of loss was low (< 300g/cm2). This is a well known phenomenon for those who experienced night application with emulsion based cold mixes

This problem led us to investigate deeper for reducing the loss chipping at young age and switching from paraffinic to naphthenic bitumen

- **Polymer Modified Emulsion:**  
In regards to the tropical temperatures combined with high traffic on expressways, using pure 60/70 penetration grade bitumen would be a non-sense and a guarantee of failure. In this respect micro surfacing in THAILAND uses preferably highly polymer modified emulsion whatever the application (rural roads or expressways) and grade, Type II or III according to the hereafter specifications

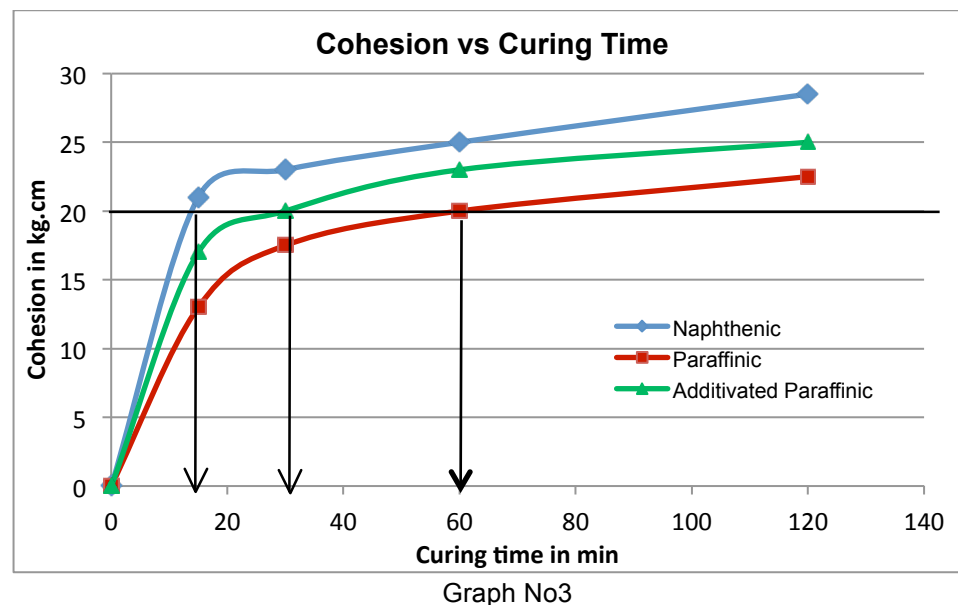
Specifications	DH-SP 405/2538
Sieve test	< 0.1
SAYBOLT Viscosity 25C	20-100
Storage Stability 24h (*)	< 1.5
Settlement 7 days (**)	< 15
Particle charge	Positive
Evaporation at 163C / 3hrs	
- Percent residue	> 60
- Solid Polymer Content	> 3.5
- Penetration	40-100
- Softening point	> 60
- Elastic Recovery 25C	> 30
- Ductility 25C	> 40
- Solubility in TCE	> 97.5

The softening point of the residue is particularly high and it is met by using high dosage of Natural Latex (use of local production is mandatory) whose the particle charge has been reversed in a previous operation which consists mixing the charge reversal with the latex solution under stirring

### Challenge: Improving the Cohesion Build up

**3 ways have been investigated with success.** These 3 parameters cumulate for offering outstanding performances so far. Nevertheless in a policy of excellence we are still working for improving the existing characteristics and give satisfaction to projects owners and customers. Other ways are under investigations and looks promising at the first evaluation

- **Using naphthenic bitumen** produced in our refinery of MALAYSIA since 2009. The naphthenic bitumen reduces the time for re-opening by about 50% (for 1hr to 30min). This has been checked on site with a shorter setting time and faster increase of cohesion (graph No3)  
For example: In France – UK and Germany NYNAS bitumen (naphthenic source from Venezuela) is privileged for micro surfacing and chip sealing thanks to its outstanding cohesion build up

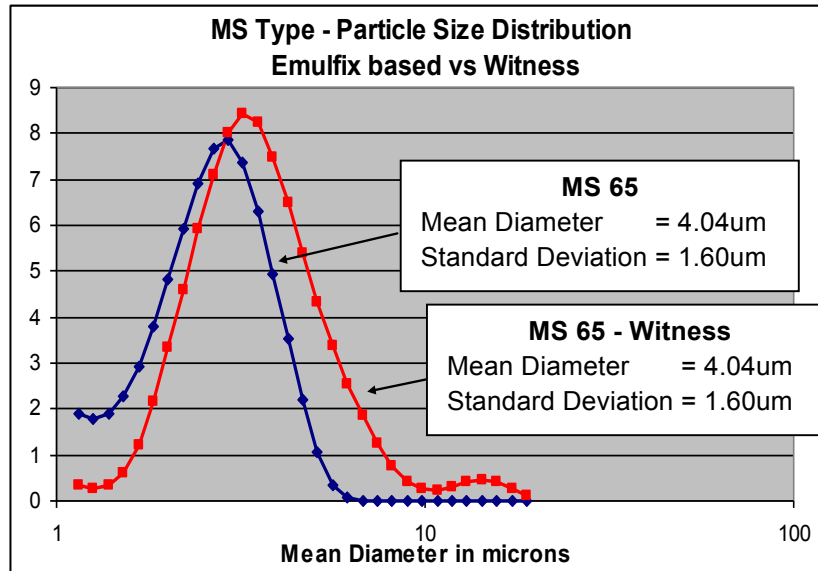


- **Using EMULFIX** process (COLAS patent) for manufacturing our emulsions. The principle is based on the reduction of the particle size and the dispersion

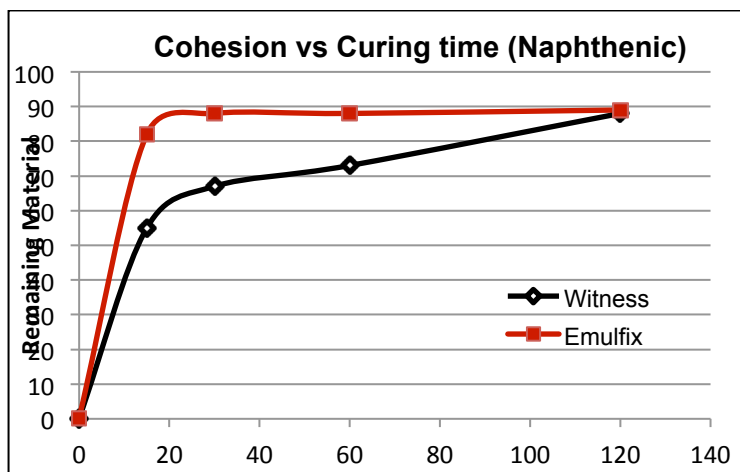
**It is achieved by mechanical process where additives are excluded**

For the low bitumen content emulsion the viscosity is not significantly modified but the mean diameter and the dispersion of the bitumen droplets. This results in an increase of the specific area and then for the same concentration of emulsifier in the faster breaking, shorter setting time and stronger cohesion build up

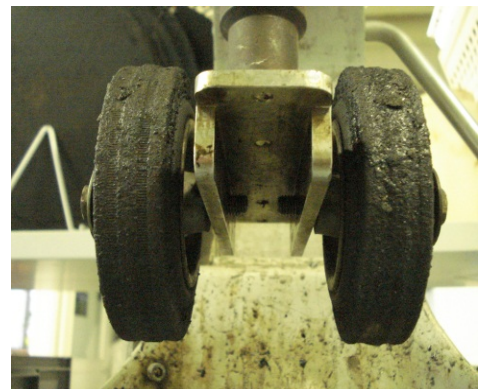
You can see below (Graph No4) the impact on the MS emulsion tested in our subsidiary in India on the particle size and in the Graph No5 the consequence on the cohesion build up



Graph No4

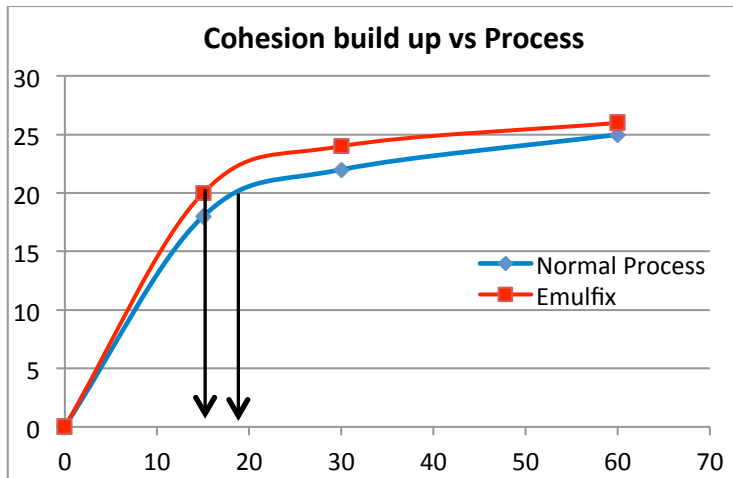


Graph No5



**Loss Chipping:** The percentage of loss chipping is measured by the TCSS test which is a variation of the WTAT using rubber wheels instead of rubber pad. This is particularly adapted for chip sealing and you can see the loss of chipping after different curing times. Results are largely in favor of EMULFIX with a sharp increase of cohesion after 20min compared to the witness

**Cohesion build up:** It has also been measured with the cohesion tester after different curing times at ambient temperature vs a witness according to the ASM standard. The formulation of the mix is strictly similar in both cases and you can see in the Graph No6 the increase due to EMULFIX. The time for re-opening or reaching 20kg.cm is 20% shorter with EMULFIX



Graph No6



**Mixing Time, Set time:** Mix design Agg 100 – Cement 1 – Water 6.5 – Additive 1 – Emulsion 10.8

	Mixing time (sec)	Set time (min)
<b>Witness</b>	<b>100</b>	<b>5</b>
<b>Emulfix</b>	<b>65 – 70</b>	<b>2</b>

- **Selection of the source of Latex:** We are not allowed to import synthetic or flipped Latex. We know from previous investigations that synthetic or flipped Latex are more performing and giving high cohesion values but we have no choice than using the local production of latex stabilized with ammonia. Depending on the supplier the quality may vary and this impact
  - **The breaking and setting time**
  - **The stability of the emulsion when the latex is introduced into the mill**

In consequence for us we recently import the polymer from the South for our for emulsion plants despite longer distance of transport for some of them

### C – Efficient Marketing Policy based on the “Customer Satisfaction”

TIPCO through his Marketing and R&D departments provides ALL technical supports to customers at any step of the process

- Selection of quarry – Acceptance test
- Job Mix design
- Training Customers staff for micro surfacing.  
This action is essential as they have usually a long experience of slow set system and not at all for the quick set system and control of the mixing time
- Modification or upgrading of the machine (dosage devices and spreader box) with the customer’s agreement as this operation may be costly in regards to the main age of slurry seal machine in THAILAND (> 20 years for most of them)
- Calibration of the machine prior to the application



- Adjustment of the job mix design on the machine
- Technical assistance at the starting of the job

This places the customer in confidence and contributes to develop this product efficiently as he knows that he can rely on TIPCO any when

Machinery upgrading is absolutely necessary in regards to the old age of equipments in THAILAND and their use for slow set system without any control of breaking / stabilizing agents. The national park of machine is composed of BREINING, BERGKAMP, ROAD SAVER and AKZONOBEL brands

Upgrading consists in setting pumps, flow meters, control system, sensor, synchronization and automatism as shown on hereafter pictures and upgrading spreader boxes as well





## MIX DESIGN and PERFORMANCES

The aggregate mix design is determined from the sieve analysis of the 2 fractions of aggregate that are re-combined in the proper ratio. The percentage of emulsion is calculated from the specific area of the re-combined aggregate, richness modulus and another factor linked to the specific gravity of the aggregate. The richness modulus is a coefficient proportional to the conventional thickness of a film of bitumen of density = 1 coating the aggregate.

This method is employed in FRANCE for any type of asphalt mixes (Hot or Cold) and it is stipulated in the NF EN standards.

$$\text{Residual AC\%} = \alpha \cdot K \sqrt[5]{\varepsilon}$$

With  $\alpha = 2.65 / \text{Sp Gr}$  where Sp Gr = SSD Sp Gr of the aggregate Mix

**K = Richness Modulus**

$\varepsilon = 0.25G + 2.3S + 12s + 135f$  where:

**G** = % Retained at 6.3mm

**S** = % between 6.3mm and 0.315mm

**s** = % between 0.315mm and 0.075mm

**f** = Passing at 0.075mm

By experience it ranges for micro surfacing from

4.0 – 4.2 for high and heavy traffic

4.3 – 4.5 for medium to low traffic and rural roads

In regards to the outside and ground high temperatures we must pay attention for not overdosing the binder to prevent bleeding at young age. The dosage of binder is finally governed by the risk of bleeding in one hand and the risk of excessive loss of chipping in another

### Typical Mix design and Performances

		Typical Values	
Stone Dust	%	Variable	
3/8 Chipping	%	Variable	
Cement	%	0.5 - 2	
Stabilizer	%	0.5 - 2	
Water	%	6 - 9	
Emulsion	%	10 - 12	DH-SP 405/
Mixing Time	sec	< 120	> 120
Set Time	min	< 5	< 30
Cohesion after			
- 15 min	kg.cm	18 - 20	
- 30 min	kg.cm	21 - 23	
- 60 min	kg.cm	24 - 27	
Re-opening	min	< 30	< 2 hrs
WTAT	g/m2	≤ 300	< 500

## APPLICATION on BANGKOK ELEVATED TOLL WAYS (internal Ring Road)

The work in BANGKOK is realized by THAWAWONGSEE (TIPCO Subsidiary) since 2005 using ROAD SAVER machines. It is equipped with a tank for the stabilizer and a cement bin for controlling the breaking of the mix

The application is done by night and the traffic is re-opened after 2 hrs (against 30-1h maximum in day time) to secure the setting and prevent from lose chipping as traffic speed is difficult to manage

The micro surfacing type III is placed in single layer at the rate of about 12-16 kg/m<sup>2</sup>. The existing structure is a minimum 10 years old asphalt pavement placed on concrete slab. The surface is smooth due to the polishing of the limestone aggregate. The cross deformation does not exceed 1.5 – 2cm in any point

The mix is not compacted as the mix is laid in 10 - 12mm thick but also to avoid to move the chipping on their flattest face and then reducing the skid resistance.

The level of traffic is estimated to about 120,000 to 150,000 vehicles / day / way of circulation in absence of accessible data

## SKID RESISTANCE

You can see below follow up carried out after one year of service. The result is expressed in BPN (British Pendulum Number)

After ONE year the average BPN is still over the requirement (around 60 against minimum 55) despite the very high traffic especially during the rush hours

The superficial roughness is maintained at an acceptable level during 4 – 5 years and this determines (from in situ experience) the service life for such a technique under severe traffic and weather conditions. So far the service life is minimum 5 years on the BANGKOK expressways

## SECTOR B

Place : Bangkok Expressway Co.,Ltd (BECL)

Testing : date 19-20 Nov 2010

Ref . Main line Outbound (One year service)

**Receipt Point : Rama 3 => to Rama 6**

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	-
Distance (m)	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	####	
km/No.	9+773	9+300	8+800	8+300	7+800	7+300	6+800	6+300	5+800	5+300	4+800	4+300	3+800	3+300	2+800	2+300	1+800	1+300	0+800	0+300	
Wet T																					
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Place : Bangkok Expressway Co.,Ltd (BECL)  
Testing : date 19-20 Nov 2010  
Ref . Main line Inbound (One year service)

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Distance (m)	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	9500	####	####
km/No.	0+263	0+700	1+200	1+700	2+200	2+700	3+200	3+700	4+200	4+700	5+200	5+700	6+200	6+700	7+200	7+700	8+200	8+700	9+200	9+700	10+174
Wet T																					
LL			72			68			66			60			65			50			65
LM			70			70			75			60			65			55			66
LR			65			74			70			65			65			55			68
ML		64			63			65			59			55			50			55	
MM		58			64			68			57			65			51			60	
MR		61			65			64			56			55			55			60	
RL	52			56			71			57			56			64			50		
RM	68			70			64			50			65			48			55		
RR	64			60			67			57			56			60			55		

- **Bangkok Elevated Toll Way by night**



## A photograph showing a road construction or maintenance project. In the center, a large orange machine is applying a dark, liquid material (likely a sealant or primer) to a road surface. Several workers in orange safety vests and hard hats are visible around the machine and on the road. One worker in the foreground is using a long-handled tool to spread the material. The road is bordered by a concrete barrier on the right and a guardrail on the left. The sky is blue with scattered white clouds.







### Close up on the Aspect of Type III



## CONCLUSIONS

Since 2005 more than 3.5 million sqm of micro surfacing Type III have been placed on the elevated Toll Ways of Bangkok. The skid resistance is maintained at high level (> 55 measured with the BRITISH Pendulum after ONE year) and give satisfaction to the authorities. This demonstrates that Micro Surfacing provided that it is properly designed can be used successfully on expressways and withstand any type of traffic and constrains

Outside Bangkok, more than 30 million sqm have been laid since 2003 with a constant development year after year

TIPCO claims about 90% of the market share thanks to his policy of excellence which combines full technical assistance to customers / contractors, and a permanent improvement of his product.

Some axes of improvement are now under investigations and the first results are promising. This should help us to keep the leadership and to propose cold solutions adapted to the extreme constrains of traffic with higher and durable performances

M.LENFANT