

**ICAO/ALACPA/FAA/ACI-LAC
Seminar on Airfield Pavement Design,
New FAA Design Software for Airport
Pavement Thickness Workshop,
and
Short Course on Annex 14 and Related
Documents for the NAM/CAR/SAM
Regions (Americas),**

Bogota, Columbia, 11 to 16 September 2005

**Pavement Design -
Non Conventional Materials**

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1-INTRODUCTION

1.1-For over fifty years researches have attempted to devise new technics to design pavements, the motive was not cost reduction, generally this approach was tied to circumstances such as:

lack or shortage of one or several key pavement components (flexible and rigid), availability of materials presenting characteristics likely to replace a conventional pavement materials, research for and development of more efficient and less costly pavement materials, and the use of local materials.

1.2-Our study will concentrate on two well known materials used in the design and construction of pavements during the past few years.

They are: Fly ash and Trinidad Lake Asphalt. As researches continue, there may be new discoveries which will probably lead to new technics of pavements conception.

1.3-In approaching this topic we thought it appropriate to give a short historical background on Fly Ash and Trinidad Lake Asphalt provide an update on the technology of their utilization, give some words on the old standby uses for these materials. We also will attempt to stimulate mutually beneficial discussions of ideas, problems, and techniques.

FLY ASH

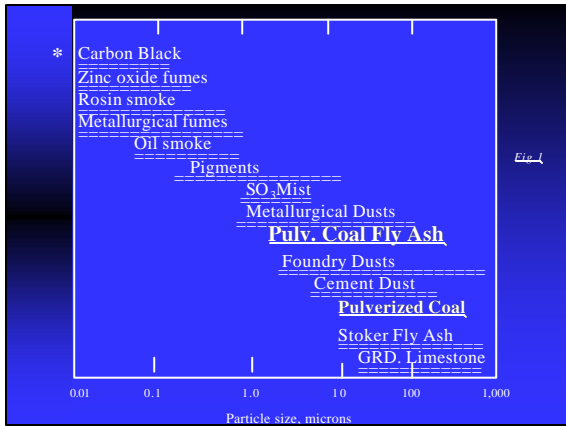
Fly Ash what it is?

- a) Product of combustion, primarily the product of burning pulverized coal
- b)The burning of residual oils in large industrial or power boilers
- In (a) as pulverized coal is burned, fly ash is formed from the incombustible components in the coal and those particles of coal that not burned, due to incomplete combustion within the furnace proper.

•Chemically, more than 85 percent of most fly ashes consist of alumina, silica, iron oxyde, lime and magnesia. As the ash particles leave the furnace, they are suspended in the flue gas and, as such, form what can be considered as an industrial aerosol. *Fig.1* below illustrates how the particle size of fly ash compares with other familiar industrial aerosols.

Fig.1

*Aerosol System consisting of colloidal particles dispersed in a gas, a smoke or fog



After the fly ash has been separated from the flue gases, it is found that in the bulk state the ash can and will vary greatly, having a wide range of particle sizes and a considerable variation in chemical content.

As seen in the above definition, fly ash is widely diverse in its physical and chemical properties.

This diversity in make up has consequences

lead to
many of the misunderstanding
which
placed severe limitation on its current commercial use

As this presentation proceeds you will need to reach the

Conclusion Face up with the fact that we are sadly lacking in basic knowledge relating to a product that we are dealing with every day.

Reality? Face a tiger by the its tail in that we have a product that is readily available in many places of the world and has a great potential.

A question remains

Fly ash has been used for over 63 years now and we are still not capable to explain why one ash performs satisfactorily in a particular application while another ash, apparently similar, performs differently or on extreme occasions is actually detrimental to the product or process in which its is being used?

Fly Ash- Production and Utilization

Production		
1967	US Electrical Utility Industry by itself	21 to 22 millions ton of fly ash
1980	" " " " " "	39 to 40 " " "
2000	" " " " " "	78 to 80 " " "

Table 1

Table 1- gives an indication of fly ash provided by US Electric Utilities compared to the coal consumed in the U.S. Data available show that the electric utility industry consumed (data for 1965) 60 percent of the coal burned in the U.S. with only 25 percent giving to all other industrial installations which might be able to produce relatively small quantity of fly ash. The remaining 15 percent of the coal consumed went into the production of coke and minor use which had little or no commercial value as far as the production of fly ash is concerned.

Table 2. World utilization of fly ash

Country	Production of fly ash in 1965, million tons	Estimated utilization of fly ash in 1965, million tons	Percentage of production
France	9	3.5	40
Germany, West	4	2.0	50
United Kingdom	10	2.7	27
United States	20	5.5	3
U.S.S.R. (Russia)	20	1.3	6

* Estimate

Utilization- *Table 2* gives an overview of world utilization of fly ash in 1965. It appears from the listed data that the problem to be solved then was that of disposal of the ash left over. This situation has significantly changed as years went by. By the 2000 it seems that except for the U.S. the quantity of fly ash left over has significantly been reduced.

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Fly Ash – Quality

- Controversial areas surrounding the topic
 - Particle size and shape, density, color and chemical properties do vary over wide spectrum of values.
 - Quality of fly ash collected at any one source can and does change from time to time.
 - Inability to accurately predict its performance (affect marketing possibilities even may never be overcome)
- Major uses for fly ash are specially in the U.S.
- Constituent, in concrete. Inasmuch as fly ash is a pozzolan. It can not only replace cement in the mix, but as an add-mix to help or aid in the workability of the concrete mixtures-concrete blocks and types of grouting operations.

- Ingredient, not only in the stabilization of the soil used as the base for roads, highways or runways, but in the strengthening of the base immediately under the paving through the use of mixes.
 - Production of lightweight aggregate
 - Filler in asphalt paving
- Some small-scale uses of fly ash are worth mentioning as being successful specially at developing countries
- a) Additive for core sand used in foundries
 - b) Additive in masonry mortar
 - c) Blasting compound particularly when it is used to clean metal surfaces
 - d) Manufacture of acoustical blocks
 - e) Constituent in heat-insulating cement

- f) Soil amender to act as a soil conditioner
- g) Filler for for such products as: roofing, fertilizer, soap, paper, rubber, asphalt tile etc
- h) Building bricks of fly ash (West Virginia University's School of Mines) consisting of approximately 75 percent fly ash
- i) In England large quantities of fly ash are being used in structural fills on highways, embankments, airport runways and other mass applications where a stable base is required.

2-FLY ASH: SPECIFICATIONS, LIMITATIONS AND RESTRICTIONS

- 2.1-There are specifications, limitations and restrictions on most thing we buy and sell, fly ash is no exception.
- Specifications: a compromise between the desire of the purchaser to insure that a product meets his needs and the desire of the producer to sell everything he produces.
- Both parties have the common desire to the specifications in terms that will enable either of them to determine whether the product meets specifications before it is used.

Fly ash: used for bituminous pavement, concrete, lightweight aggregate.

Fly ash: calls for a performance-type specifications expressed in terms of the characteristic of the final products that results when the fly ash is used.

It should be noted that different specifying bodies do not agree on specifications. Examples:

- Specifications for fly ash to be used as an ingredient in concrete have been established by ASTM, the Bureau of Reclamation, the Groups of Engineers, some State Highway Departments, several Municipalities, and:

-Characteristics measured, methods of measuring the characteristics and the specified limits to these characteristics vary (*Table 3*) ▶

Table 3 - Typical specifications for fly ash for use in concrete

Item specified	ASTM	Bureau of Reclamation	British standards	New York City	City of Chicago
Chemical Specifications					
SiO ₂ , pct, minimum	70.0	75.0	--	35.0	42.0
Al ₂ O ₃ , pct, minim.	70.0	75.0	--	15.0	15.0
Fe ₂ O ₃ , pct, minim.	70.0	75.0	--	--	--
MgO, pct, maxim.	5.0	5.0	--	3.0	3.0
SO ₃ , pct, maxim.	3.0	4.0	2.5	3.0	6.0
Alkalies (Na ₂ O), pct, maximum	1.5	2.0	--	--	--
Moisture, pct, maxim.	3.0	3.0	1.5	--	1.0
Loss on ignition, pct, maximum	12.0	5.0	7.0	12.0	6.0

Specifications differ in significant ways in:

- what is specified
- the limits placed on the specified values
- the methods used to measure the specified characteristics

Purchaser viewpoint: unknown degree of risk that a fly ash which meets specs may not prove to be satisfactory in service.

Producer viewpoint: specifications may well be more restrictive than is warranted leadings to the rejection of fly ash that would perform satisfactorily in service.

From both viewpoints the testing required to determine whether a given lot of fly ash meets specs is time consuming and undesirably costly. Results of recent research seem to suggest new characterization methods more meaningful as a basis for specifying fly ash. These results show that fly ash has several distinct function in concrete: It is (1) a pozzolan, (2) a workability modifier, (3) a fine aggregate and (4) an absorbent of air-entraining agents.

*As a pozzolan fly ash reacts and thereby decreases the amount of free-calcium hydroxide in hydrated portland cement.

*As a workability modifier fly ash reduces the amount of water required for a given degree of workability.

*As a fine aggregate, through its intrinsic strength, fly ash contributes to the net strength of hardened cement paste, mortar and concrete. The greater the intrinsic strength of an ash, the higher will be the strength of mortar or concrete containing it.

*As an absorbent of air-entraining agent most fly ash require greater quantities of-air-entraining agent to achieve a given air content than is required for a corresponding fly-ash-fire concrete.

LIMITATION AND RESTRICTION

One of the major limitations on the use of fly ash is the inadequacy of present specifications and methods for testing fly ash symptomatic of a much broader limitation. Lack of knowledge about fly ash is relative in the sense that the knowledge is not complete or that it is available to only a few people.

Where fly ash is available technical assistance is necessary not only to promote its greater use, but equally important to prevent misuse of fly ash. International cooperation and sharing of knowledges on fly ash seem to appropriate and promoted.

Remember the Detroit Edison Co. and the N.Y. Con Edison were among the first to install dust removal equipment to collect fly ash, rather than discharge it to the urban atmosphere. Thanks to the then active campaign to minimize air pollution, companies burning coal were required to limit the dust content of the combustion products discharged from the stack. It was dumped as a waste at a cost until Nai C. Yang and its team of researchers at the Port Authority of N.Y. and N.J. intervened and after a year of researches, including some stambles, found some useful uses for the fly ash. The results today are a runway at Newark Int'l Airport and Kennedy J.F.K. Int'l Airport.

For Mr. Dedman, Fly Ash has been developed into a valuable by product of the electric generating industry through intensive research, application, and marketing programs, leading to widespread use as a building and construction material. In Britain, fly ash-clay bricks, lightweight aggregates, concrete products, and road construction uses absorb over 40 percent of the total output. The degree of progress is attributed to the organization of a system of marketing and timely, convincing publicity.

France: For Mr. Adolphe Jarrige, Consultant Engineer, Retired, Paris, in France there are two types of utilization of fly ash: commercial cements and roadbuilding operations. In the mid 1960, both these utilizations reached a level in France not observed in other countries. These results were attributable to special circumstances and to certain initiatives, which differ for each of the two groups, but also to an overall situation with regard to the coordination of work.

Germany: According to Mr. Hermann Erythropel Chief, Research and Development Department, Steinkohlen-Electrizitat, A.G, Essen Germany, in Germany the utilization of brown coal ash is practically impossible, so that these have to be dumped since the early 1960. In 1966, the production of hard coal ash was about 5.8 million tons (table 4). This quantity has not risen very much because the consumption of high-ash coals has declined of these ashes, about 63 percent is utilized. This percentage, however, is likely to rise owing to the promotion and instruction organize by private enterprises.

Table 4

Ash Production and Utilization in West Germany, 1966, million tons

Ash type	Brown coal	Bituminous coal	
		Amount	Percent used
Fly ash-----	3.92	0.84	31
Fused granulated ash-	.16	4.18	68
Clinkers-----	1.15	.77	73
Total-----	5.23	5.79	63

Table 4

Poland: Mr. Antoni Paprocki, Assistant Professor, Institute of Building Technics, Warsaw, Poland observed that although production and utilization of fly ash in Poland have increased yearly since the 1960, the latter lags behind the former and by 1975 almost 5 million tons have been discarded and this trend has continued.

Comparative tests between fly ash and several types of aggregates show that fly ash has binding properties and should not be treated as aggregate.

Russia: Dr. Vladimir V. Stolnikoo, Chief of the Concentrate Laboratory, All-Union Research Institute of Hydrotechnics, USSR, has conducted a systematic investigation into the effect of fly ash admixture on the principal properties of concrete. The investigations were aimed mainly to the problem of fly ash utilization in concrete for construction of hydrotechnical structures of various kinds. His studies look into the problem of accelerating the hardening and increasing of strength of concrete made with the fly ash admixture for prefabrication of elements of concrete units.

In summary its was found that:

- An remarkable property of fly ash is the posed particle surface and high context of rounded-off particles is negligible.

- The workability of concrete mix containing fly ash is often higher than that of a mix with cement only.

- The low water requirement of concrete mix with fly ash admixture speaks in favor of fly ash as compared with many other hydraulic admixtures.

Switzerland: Mr. Zygmunt Falecki, Economic Affair Officer in the Secretariat of the United Nations Economic Commission for Europe emphasized that all of us know the main activity of the UN is to strive unceasingly for peace, nevertheless, there are other undertakings directed towards progress in the economic, social, technical, scientific and cultural spheres. Utilization of ash in fact, increases the value of coal; it means production of cheaper energy, and energy is the very basis of industrial development.

U.S.A: Contributions by the United States with respect to fly ash are reflected in Proceedings: Edison Electric Institute-National Coal Association-Bureau of Mines Symposium, held in Pittsburg, Pennsylvania, March 14-16, 1967 compiled by John H. Faber, John P. Capp and John D. Spencer. This document is for sale by the Superintendent of Documents, U.S. Government Printing Office Washington, D.C.

The papers presented by the U.S Experts at the above Symposium cover all aspects on researches on fly ash from availability of fly ash, quality, present utilization, fly ash as raw-materials for manufacture of cement, fly ash specifications, fly ash marketing, fly ash in roadway construction, fly ash in concrete and concrete block, lime-fly ash-aggregate mixtures, bricks from fly ash, fly ash in agriculture, fly ash in the cementing of wells, nuclear measurement of Carbon in fly ash, ASTM specifications on fly ash for use in concrete, reactions of hydrated lime with pulverized coal fly ash.

CONCLUSION – FLY ASH

This short presentation on Fly Ash was not intended to address all of the problems faced by the fly ash industry, but rather to review basic data on the past and present availability, quality and use of fly ash, specially as pavement material. We have also attempted to acquaint you with some of the problems which not only face those engaged in the fly ash processing and distributing business, but also those in the electrical utility or fly ash as producing industry. Lastly we have tried to emphasize our own lack of some basic knowledge concerning fly ash and the absolute necessity of obtaining these much-needed data before we can continue the important and beneficial use for fly ash which, where needed, we cannot afford to waste.

Rational use of fly ash is somewhat pessimistic due primarily to the problem of disposing of it, discounting such solution as its conversion to nuclear power. The marketing of fly ash may get worse before it gets better. Before fly ash can be sold in large quantities, those factors that now limit and restrict its use must be overcome.

Fly ash should no longer be thought of as a waste but should be thought of as a useful by-product of coal that can be utilized if quality controlled.

The developing world in general and, in particular, the countries primarily associated with this meeting may not be engaged, for the moment, in fly ash research, nor developing high interest in its use. It seems that some trials of the use of fly ash as an additive or complement to cement have been carried out. No precision can be given at this time on the findings. Perhaps, we may gather some information from our discussions.

We do believe that cement manufacturers of our countries should, if not already done, examine fly ash in their laboratories and experiment on the activity of these ashes with their cements. Who knows by reason of the low price of the ash, the manufacturers may make great profit as a result of using ash. And lead to the acceptance of fly ash for commercial cement.

As seen above, the problem of fly ash rational utilization is not only a technical problem it is also an economical problem. As stated by Dr. Stolnikov, we have in the United States a saying "Time is money", in this case we can say "Fly ash is money" and we have the possibility of improving the properties of concrete of various kinds but also to "get money from fly ash".

TRINIDAD LAKE ASPHALT

1-INTRODUCTION

1.1-Islands of the Caribbean are famous to millions of tourists throughout of the world as attracting paradises. Among them is the Island of Trinidad which is more famous for more than a century for is "Pitch Lake": the largest deposit of "Natural Asphalt" in the world, located at Punta La Brea on the south east coast of the island.

Fig.1 



Fig. 1 - The Asphalt "Lake" at La Brea, Trinidad

1.2-It has been said that the "Pitch Lake" was discovered by Sir Walter Raleigh in March 1595. It was, moreover, completely covered and surrounded by jungle and tropical forest it was accessible only from the sea.

1.3-The main deposit of the lake, consisting of an inverted cone of massive volume and depth, is now agreed by both Petrologists and Petroleum Geologists to be of volcanic origin, which on the seaward side, had breached the crater at some remoter period and allowed the excess of asphalt to flow down to the sea, two thirds of a mile north of the lake itself, thus investing the shore line and the Point and seated with a massive revetment of bituminous material.

1.4-Early attempts were made to use the asphalt, not by digging in the lake itself, but by simply picking up the quantities of material on or near the sea-shore. Sir Raleigh used the asphalt for caulking his ships and found it to be "most excellent good".

1.5-Experts opinions diverged as to the origin of this unique deposit. The earlier theory of a mud volcano liberating an enormous volume of petroleum and mineral matter in a state of protracted agitation during which the volatile constituents were dissipated and the heavy bituminous residue became uniformly homogenized with the fine clay and silica minerals, water and gas, has been superseded by the conclusions of Dr Kugler and other experts as a result of later researches and more advanced environmental knowledge.

Fig.2 →



Fig.2- Lake digging equipment

1.6-Details on the findings of Dr Kugler and others concerning the origin of the deposit, the sediments, the depth of the lake (speculations,1925), the depth of the deposit, the various components of the material at different depths, temperature of the Lake, are available to participants.

Fig.3 →



Fig.3- Excavation of Trinidad Lake Asphalt from the "Lake" at La Brea, Trinidad. The raw material is scraped from the surface.

1.7-Today the Lake is situated about 3,600ft from the sea and occupies an area of about 90 acres in a depression immediately to the south of a 140ft high hill, from the summit of which the ground slopes gently northwards to the sea (Fig.4). In appearance the surface of the Lake is a uniform expanse of asphalt which is intersected by areas of water, the extent of which naturally varies according to the season. A not time does the surface become entirely dry and there is always water lying in the folds of the asphalt.

Fig.4 →

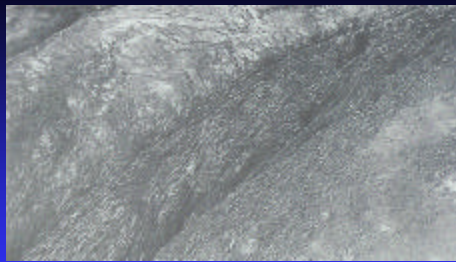


Fig.4- Close-up illustration of surface of the Trinidad Lake

1.8-Although quiescent, the asphalt still moves with a natural slow “stirring” action. The present maximum depth of the Lake is approximately 250ft. The asphalt itself is an emulsion of water, gas, bitumen, and mineral matter, the latter consisting largely of fine silica sand and a lesser amount of impalpably fine clay.

2-Dealing with T.L.A

2.1-Mining and Refining

The mining of the Lake asphalt was originally done by hand. This methods is still used by contractors employed by the Trinidad & Tobago Government to supply its own road construction operations. Over the years the excavation methods have been mechanized.It consists of a long process which is mainly one of dehydration and no high temperatures, which could modify the characteristics of the asphalt, are involved. The asphalt thus prepared constitutes the Refined Trinidad Asphalt, or Trinidad Epuré, of Commerce.

2.2-Composition

The crude asphalt as mined from the Lake shows that it is extremely uniform in composition:

Water and gas volatilized 100°C	29.0%
Bitumen soluble in cold carbon disulphide	39.0%
Bitumen absorbed by mineral matter	.3%
Mineral matter, on ignition with tricalcium-phosphate	27.2%
Water of hydration of clay	4.3%
	99.8%

After a simple refining process the Trinidad Lake Asphalt (Epuré) has the following composition:

Bitumen soluble in carbon disulphide	53.0 – 55.0%
Mineral matter	36.0 – 37.0%
Difference	9.0 – 10.0%

The bitumen of the Trinidad Asphalt can be separated from the mineral matter by solvent. When free from mineral matter, it has a specific gravity of about 1.032 at 25°C (77°F). It is ultimate composition is then:

Carbon	82.33%
Hydrogen	10.69%
Sulphur	6.16%
Nitrogen	0.81%
	99.99%

2.3-USES

The widest uses of Trinidad Lake Asphalt have been and fields of paving and building construction. Its use as paving material was first recorded in 1815. Its primarily role was to prevent the rapid growth of weeds in the street of Port of Spain. The use of the asphalt, however, only added to the fertility of the weeds.

The first Trinidad Asphalt pavement was laid by the Belgium Chemist. E.J. de Smedt in front of the City Hall in Newark, New Jersey, in 1870 and in 1873 a section of Fifth Avenue in New York was surfaced. The first Trinidad rolled asphalt work in London was laid on a portion of the King’s Road, Chelsea in 1891.

From this time on, TLA played an important part in the development of the road construction industry in the USA and in England. Development in Europe followed a rather different pattern.

Mastic Asphalt had been used for over 250 years (1820) but TLA due to its uniformity and thermal stability led to an increase in this form of paving. Later, for economic reasons a modified form of Mastic Asphalt or Gussasphalt was developed and in recent years, Germany, Switzerland and Austria used this Gussasphalt. More recently France, the USA have undertaken large-scale trials with Gussasphalt, including one of the now famous Pennsylvania Turnpike in 1971. It is to be noted that all these trials included TLA in the binder in accordance with German specifications.

TRINIDAD LAKE ASPHALT

3-AIRPORT PAVEMENT CONSTRUCTION AND MAINTENANCE

3.1-According to Lake Asphalt of TLA (1978) limited Brighton, La Brea, Trinidad West Indies, "For over 60 years Trinidad Lake Asphalt (TLA)" has been specified and used for airport runways, taxiways, aprons primarily because of its very high durability, its resistance to deformation and rutting and also its improved fatigue resistance over a wide temperature range, resulting in a material which is capable of providing long life, low maintenance airport surfacing.

3.2-The following is a short summary of wide application of TLA at some selected airports in the world and the lessons learned by the users of this "natural" asphalt.

3.3-La Guardia, Newark and JFK Airports,

With the advent, in 1970, of the wide-body aircraft at the above airports combined with an increase in air traffic during the same period, the additional load on the pavement surfaces and the anticipated accelerated deterioration, deformation and shoving of the asphalt concrete pavement, it was considered necessary to improve the pavement properties of the binder materials. The Port Authority of New York and New Jersey engineers in their quest for solutions to their problems, including that of developing a bridge deck paving system to replace the ones that were no longer available, learned that TLA, a natural asphalt, had been widely used as a durable asphalt pavement



Fig.6

Fig.6- The grooved asphalt surfacing on Runway 13L-31R, at J.F.K. Airport, photographed after a year of service.



Fig.6-a

They also noted that this natural asphalt provides a greater stability in heavily traffic areas. In addition, the PA engineers learned about the applications of TLA in Europe were Hot Rolled Asphalt mixes in England and Gussasphalt and Mastic mixes in Germany.

The Port Authority researchers conducted experimentation with blending natural asphalt with petroleum derived asphalt. The result was a more durable pavement with potential of high stability, improved skid resistance and a better resistance to wear and deformation.

From the good results achieved at La Guardia Airport (1981), application was extended at Newark Int'l Airport and JFK Airport in areas with heavy operational conditions. The PA experience at these facilities was positive specially the blending of the TLA with the conventional petroleum derived asphalt which demonstrated high stability and resistance to deformation.

The Port Authority performed a laboratory study to gain a better understanding of why pavements constructed using the natural asphalt blended binder performed better under hot weather conditions than pavements constructed using conventional asphalt binders.

Table 1- gives data on the composition and Properties of TLA. Details on the Port Authority Laboratory study are available to the interested participants.

Table 1 →

Table 1	Typical composition and Properties of TLA as determined by the Port-Authority of N.Y. and N.J. (1981)
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Table 1 - Typical composition and Properties of TLA as determined by the Port-Authority of N.Y. and N.J. (1981)

The conclusion reached was that "the results of the laboratory study demonstrate the significant improvement in durability of asphalt concretes made using the Trinidad Lake Asphalt blended binders is directly related to the improved physical properties of the asphalt concrete when it is compared to the asphalt concretes made using conventional, unblended binders".

3.4-Wearing Courses on Runways and Taxiways in Europe

Prof. Dr. Ing. Ernst-Ulrich Hiersche from Germany gained a rich experience using Trinidad Lake Asphalt to which he referred to as Trinidad Natural Asphalt (TNA). The list in Table 2- gives the Airport/Airfield concerned the year of the projects and a brief description.

Airport, Airfield	Year	Project Description
München	1968	Recovery, repaving course 2 in 8 cm. Bituminous base coat 0.35 m. 1.2 cm wearing course of 5 cm bituminous concrete U12 with 1.8 weight % TNA.
Bremen	1969	Recovery, new wearing course of bituminous concrete U12 with 1.8 weight % TNA.
	1980	Recovery, following installation of end-of-runway lighting was necessary rehabilitation work due to poor subgrade conditions, new wearing course of bituminous concrete U12 with binder of 889 and 1.8 weight % Trinidad Natural Asphalt.
Deelen/Aggen	1983	Recovery, reconstruction of a starting field in 1984, wearing course of bituminous concrete U12 with 3.0% TNA in the bitex.
Luxemburg	1984	Recovery of the runway for 1,870m up to 4,000m width 0.0m. Wearing course of bituminous concrete U12 with 1.2 weight % TNA.
Stuttgart	1984	Recovery, removal of the wearing course after failure of the wearing and binder course. Wearing course of 5 cm bituminous concrete U12 with 2.0 weight % TNA.
Hannover	1983	Recovery, new wearing course of bituminous concrete U12 with 0.4% binder of 8.30 and 2.0% TNA.

Table 2- Civil and military airports in Europe with runways in Trinidad Natural Asphalt (TNA)

The reasons for using TNA on airports according to Prof. Hiersche were:

- Stiffening of the motor (binder and filler)
- Increasing the stability of the pavement (in summer)
- Improving and facilitating the compactibility of the mixture (in the Marshall test and at the construction site)
- Denser composition of the bituminous mix
- Deceleration of the binder hardening

•Lengthening of the useful life

•Resistance against chemical de-icing agents such as urea and Frigantín

•Resistance against kerosene and other contaminants

Prof. Hiersche emphasized that structural requirements (weather-resistant, dense wearing courses, insensitive to chemical action with great resistance to deformation and skid resistance) are contradictory in part, as it is well known that dense asphalt concrete pavements tend to deformation.

CONCLUSION

The unique properties of Trinidad Lake Asphalt in road surfacing made by researchers over the world has been confirmed by the observation of pavements extending over many years. These properties are:

- The consistent uniformity and thermal stability of the product over many years;
- The exceptional adhesion when used as a binder;
- The high mechanical stability in paving mixtures;
- The non-skid surface texture developed by mixtures incorporating Trinidad Lake Asphalt;

- The characteristics matt-grey surface of the pavement due to the translucence of the inherent bitumen and the light colour of the colloidal particles of the fine mineral matter in the TLA, makes it well suited to night driving conditions.

As seen above, wide use of the TLA has been made in countries such as: Austria, Belgium, Canada, England, France, Germany, Hong Kong, Japan (Gussasphalt), Trinidad & Tobago, The United Kingdom, the USA all of which recognized the importance of Trinidad natural asphalt for asphalt pavement in Europe and in the USA.

TLA binders designs have been used successfully at many large airports worldwide such as: Kastrup in Copenhagen, Varkans Airfield, Finland, JFK in New York, Salt Lake City in the USA, Piarco International in Trinidad, Bremen, Pferdsfeld, Bremgarten Airports in Germany and most recently at the Kai-Tak Airport in Hong Kong etc.



Fig.7 - Kastrup Airport, Copenhagen, on which TLA based surfacings have been specified for runways, taxiways and aprons



Fig.8 - The 50mm TLA wearing course overlay being laid at Luxembourg runway extension.

The properties of the natural asphalt have remained unchanged since laboratory tests conducted over one hundred years ago to determine the unique characteristics of the lake asphalt.

It is well admitted today that when TLA is incorporated in an asphalt mix; it provides pavements with enhanced resistance to deformation especially at high temperatures. Other asset of TLA is bringing to the mix a higher structural value.

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