

Impacts and Benefits from APT Programs for the Asphalt Industry

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ABSTRACT

In the last decades it can be observed that more knowledge and responsibility is moving from the road authority side to the road contractor side. Also the detailed descriptions of the products to be used in the specifications are moving into the direction of functional requirements.

By going into the direction of functional requirements the contractor needs to be able to produce a mix that will fulfil the functional requirements set by the road authority. That means the contractor needs to know how long a certain layer will perform well and how long it will last and how much risk he will have if it will be applied in a certain period of the year.

In large contracts where the contractor is responsible for the (entire) pavement for a long period and it can be observed the contractor in general will chose for a surface layer (or a pavement) that has proven to durable (in the past). So often a proven solution will be chosen instead of a new concept.

In the last 20 to 30 years several new asphalt products were development, like stone mastic asphalt (SMA), porous asphalt, double layer porous asphalt, high performance mixes, very thin layers of asphalt concrete and ultra thin layers of asphalt concrete.

At this moment different types of Warm Mix Asphalt are being developed by the asphalt producers.

For these products developments Accelerated Pavement Test (APT) facilities are hardly used.

This paper describes the possible reasons for that.

In some situations APT facilities were used by contractors. Some examples from various countries are described.

In the conclusions the (possible) benefits of using APT facilities are mentioned.

INTRODUCTION

In the last 50 years a lot of changes and improvements took place in the European asphalt industry:

- The road building companies became larger and they started to work at a national scale and some companies started to work European wide.
- In the past the road authorities had a lot of knowledge and experience and they told the contractor in detail what had to be done. Nowadays the knowledge level at the road authority side is decreasing and in several situations the in-depth knowledge available disappeared.
- The knowledge level at the contractors' side increased and is now (in many countries) at a high level; the contractor asphalt producer has in-depth knowledge of the asphalt material.
- In the past contracts described in detail what needed to be done.
- At this moment several countries are working in the direction of functional contracts, so it is not necessary to describe the material itself in detail but what the road and the road surfaces should behave like for the future.
- In short it means that more knowledge and responsibility is going from the road authority to the road contractor and we are moving from detailed descriptions in the specifications to functional requirements in the specifications.
- In the past the pavement design was totally based on (local) experience. Later on pavement modelling started. The first model was in fact the linear elastic model that can be used to design the thicknesses of the pavement layers.
- Quite recently the concept of long life pavements started. When a long life pavement is designed, the pavement is in fact designed in such a way that the pavement construction will stay there forever without any structural damage. The only thing that has to be done is to maintain the road surface. That surface layer might be replaced now and then to have good surface properties but there will be no need to reinforce the construction itself because it was built in such a way that it can last forever.
- In the future the asphalt mix design for different pavement layers will become part of the pavement design as well as risk assessment of the different pavement layers.
- By going into the direction of functional requirements the contractor needs to be able to produce a mix that will fulfil the functional requirements set by the road authority. That means the contractor needs to know how long a certain layer will perform well and how long it will last and how much risk he will have if it will be applied in a certain period of the year. That means that risk assessment will become important and the road building company should know the risks when a certain asphalt mixture is applied in certain circumstances.

In the last 20 to 30 years also a lot of progress was made in the asphalt product development. New products were developed like stone mastic asphalt (SMA), porous asphalt, double layer porous asphalt, high performance mixes, very thin layers of asphalt concrete and ultra thin layers of asphalt concrete for a good skid resistance and a low noise level.

New asphalt paving techniques were developed. The separation of the functions of the different pavement layers is investigated, that means that there is no need to have thick top layers; a thin top layer will be sufficient. The top layers are important because the surface characteristics need to fulfil the surface requirements. A good and even (smooth) surface with good skid resistance properties is required. In case of perpetual pavements in fact just a high quality, ultra thin top layers is needed that can be used as a kind of wallpaper on the existing substrate.

Environment, energy reduction and reduction of emissions are becoming more important. Several techniques have been developed to reduce the asphalt production and application temperature. This leads to energy savings and less emissions. The reduction of emissions is not only important for the environment, it is also important for the workers in the asphalt industry to be able to work in a clean environment.

Depending on the chosen technology, a reduction in the asphalt mixing temperature of up to 30° C can be achieved. This technique of producing and paving asphalt mixtures at lower temperature (called Warm Mix Asphalt) also has other advantages like less wear of the asphalt plant, less aging of the bitumen and earlier opening of the road for traffic.

At this moment several techniques for Warm Asphalt are available:

- Process engineering
- Foamed bitumen
- Aerogenous Agents
- Special Bitumen and Additives
- Warm Emulsion Technique

New techniques are still being developed.

APT PROGRAMS VERSUS LAB-TESTING AND TEST-SECTIONS

Accelerated Pavement Test (APT) facilities are often used for testing of new products and new pavement structures.

When a contractor is developing a new product, several stages can be regarded. It will start with the development of an idea / concept based on a need or an expected future need of the client (Road Authority).

The next step could be a literature review, to see what has already been done, and which information is available with regard to the subject. Based on this an asphalt mix design will follow and test will be chosen that can be used to characterise the relevant mixture properties. The test results might lead to a re-formulation of the mix design and new lab tests will be done to check the changes / improvements. The number of lab test depends on the innovative character of the mixture.

One should be able to produce the mix in an asphalt plant and to compact the mixture in the road. By producing slabs (or by using a specific test) in a lab one can check the compactability of the mixture. The proof of the pudding is in the eating. So when the asphalt mixture recipe has been defined, a test section will be built. This could be done on a non-critical area on e.g. on the area of an asphalt plant or on a (private) road leading to or in a quarry.

To be able to observe the influence of certain parameters different variations of a mixture could be produced.

When the contractor is convinced of his product, the next step could be to apply the product on a road of a road authority. So a test section will be built. This could be part of a certain project.

In this way, the product will be tested step by step, and each step is closer to the reality. When the contractor is convinced that his new product is perfect, he can offer it to his clients.

In some countries there is a procedure available [1.] to show that a product is ready to be used.

In the process of product development APTs could play a role and proprietary products can be tested in APTs. The advantages are:

- Well controlled pavement structure
- Instrumentation can be added
- An objective way to compare structures
- It could be the step between lab testing and real practice
- The loading is well known (and “close” to reality)
- ‘Fatigue testing’ is closer to the reality; real loading with rest-periods (healing)
- ‘Rutting resistance testing’: real loadings on a 1:1 scale (with lateral wander)

In the next chapter the use of APTs by some contractors is described.

EXAMPLES OF APT TESTS FOR THE ASPHALT INDUSTRY

Poland

Introduction

In the summer of 2002, the mobile Heavy Vehicle Simulator, HVS-Nordic (of the Swedish Road and Transport Research Institute (VTI) and the Technical Research Centre of Finland (VTT)) was used in Poland for tests on two road structures prior to the construction of 100 km of motorway between Warsaw and Berlin [2.].

VTI in Sweden received an enquiry from NCC in Poland whether it was possible to use HVS to test some road structures in situ in Poland.

The project coordinator for motorway construction in Poland was a company called A2 Bau Development GmbH. The actual construction was carried out by the companies Strabag and NCC Polska. They were each responsible for half the motorway each.

For the new sections of the A2 Toll Motorway near Poznan a design proposal by the responsible consortium A2 Bau Development GmbH has been made for a semi-rigid pavement consisting of an unbound drainage layer (frost protection layer), a cement-bound subbase course (lower layer), a cement-bound main base course (upper layer) and an asphalt pavement consisting of an asphalt base course and an asphalt surface layer [3.].

It was specified that the design life should amount to 7 mill. equivalent load cycles of a 115 kN standard axle load in the first stage, which is relevant for the basic pavement design. In the second stage (scheduled to start after 6 mill. equivalent passes of the 115 kN single axle load) an upgrading will be made to a total design life of 20 mill. single axles of 115 kN by strengthening of the asphalt layers.

A2 Bau Development proposed a type of road construction that was slightly thinner than what the tender documents specified. The authorities were uncertain about this alternative, but answered that if A2 Bau Development could demonstrate in some way that the thinner construction could carry to the



agreed traffic volume they were prepared to agree to this proposal.

For this reason two test sections were built in Poland, one complying with the tender documents, and a thinner version according to the A2 Bau Development design.

In order to verify the design assumptions used for the first stage of the A2 pavement with respect to the fatigue life respectively the residual pavement life it was decided to conduct a comprehensive field test. The test sections were built on the construction site in Markowice with two different thicknesses of the cement-bound layers.

The required 6 million vehicle passages would take quite a long time to simulate, and therefore it was decided at an early stage to simulate this traffic volume with a smaller number of vehicle passages but at a higher load.

The HVS loaded each test section with 600,000 passages of an axle load of 16 tonnes which was (according to calculations) considered to be equivalent to 6 million passages of an axle load of 11.5 tonnes.

The test sections [3.]

In Markowice two test sections near the construction site of the motorway were built, guaranteeing representative subgrade conditions. Each of the test fields had a length of at least 50 m and a width of more than 4,5m. Within the test sections two different pavement structures were constructed. Test section 2 was planned with a 5 cm asphalt surface layer, a 10 cm asphalt base layer, two cement stabilized layers of 20 cm each with different compressive strengths after 28 days (R28) and an unbound frost protection layer (Test Section 2). For Test Section 1 the Cement Bound Layer had reduced thicknesses of 15 cm and 10 cm. Due to insufficiencies during construction, real thicknesses varied significantly.

Since the objective of the test was mainly to verify the employed design criteria that are based on the primary response and the layer fatigue characteristics under loading conditions a comprehensive instrumentation of the test sections was decided.

The pavements at the test sites were instrumented with strain gauges, soil pressure cells and deflection gauges in order to assess the pavements' response under the load and to compare these response measurements with values calculated from theoretical pavement models. During the construction of the test pavements as well as during the load application deflection measurements with the Falling Weight Deflectometer FWD were performed periodically.

Data analyses [3.]

A method was developed to combine the analysis of the results of the response measurements and the results of the deflection measurements with the FWD. Consequently these most likely ranges for the E-modules were used for comparative pavement design calculations. These design calculations indicate that an alternative construction with a reduced thickness of the cement stabilised base layers can fulfil the given requirements specified for the first phase of the pavement life.

These findings are strongly supported by the results of the accelerated loading test, since at the end of the tests none of the loaded pavement structures showed any fatigue damage.

Results [3.]

The study from Technical University of Vienna as mentioned above showed that the thinner structure should comply with the specified requirements, but a study at IBDiM in Warsaw came to the conclusion that the thinner structure was too weak and could not be considered.

In the end the road authority accepted the alternative proposal and the road was constructed in that way.

France

Since 1985 the fatigue track of the LCPC in Nantes was used several times by contractors.



The contractors were private companies as Eurovia, Screg, Colas, Asfa (Association Society French Autoroute (motorway)), Shell and Total [11.].

The aim is mostly testing the new materials or new concepts under heavy traffic and to have equivalent of about 15 years in three or four months.

It is important for the contractors to have a full scale model of the new pavement to be tested and that the new materials that are used are produced in a normal mixing plant and that they are applied by using normal equipment (paver, compactors etc...) and that they are loaded/tested by real traffic [11.].

The new materials are always tested in the laboratory before they are tested in the APT. To confirm the behaviour of the pavement under heavy traffic it is better for the contractors to have a test with the fatigue track. Sometimes there is a difference between the test in laboratory and the test on full scale model. With the test in the fatigue track (carousel) it is possible to see all the difficulties of the different stages, production, paving, compacting, behaviour under traffic, etc. [11.].

In 1995 - 1996 the French company Jean Lefebvre (which is now part of Eurovia) tested a new material for road bases (Grave-Mousse®) at LCPC.

This Grave Mousse was tested in the framework of the Road Innovation Charter. The behaviour of this new material was tested at the fatigue track of the LCPC in Nantes [4.]. In the test track four structures were tested, one of them being the Grave Mousse section.

Grave Mousse is a 0/6 to 0/20 graded base course material made by coating unheated aggregate with foamed hot bitumen. Foamed bitumen is made by injecting a small quantity of water containing a foaming agent additive to a selected hot bitumen. The water vaporises instantly generating a foam which is immediately mixed with a blended or unblended aggregate in a bitumen content of 3.5 to 4 %.

Grave Mousse, used for reinforcement or new construction, is laid in a thickness of 70 to 150 mm. Smaller thicknesses are laid for reprofiling or reshaping purposes.

Its method of manufacture generates discontinuous individual inter-grain bonds which are quite different from those obtained with a conventional hot mix. This type of bond gives the product its very unusual properties [4.].

It is laid in the conventional manner with a grader or paver, and compacted with tyred rollers and vibrating machines, depending on the thickness applied.

A tack coat must be spread before laying Grave Mousse and a seal coat is applied to protect the product pending laying of the final wearing course.

All aggregates usually employed for base courses can be used in Grave Mousse. Also materials as crushed alluvial rock, reclaimed asphalt and recycled cement concrete can be used. It is a cold manufacturing and laying techniques.

The behaviour of this new material was successfully demonstrated at the fatigue track of the LCPC in Nantes [4.].

UK

The vast majority of the work carried out at the Pavement Test Facility (PTF) of TRL is for Government clients, particularly the HA. A couple of fairly recent examples were commissioned directly or indirectly by commercial companies. [5.]



One of them is "The performance of reinforced unpaved sub-bases subjected to trafficking" [6.]. This work was directly sponsored by Tensar, who has supported a number of trials of their product with the PTF of TRL.

Geosynthetics are used in pavement construction to reinforce the sub-base layer, when the underlying material is weak, or when the thickness of the pavement needs to be kept to a minimum. The effectiveness of this technique is difficult to quantify and is best investigated by undertaking full scale trials. Trafficking Trials have been carried out to assess the

ability of a range of different geosynthetic reinforcements to reduce the surface deformation of an unpaved road. Twelve different reinforcements were included in the Trials. The performance of the reinforcements was quantified in terms of pavement stiffness, and surface deformation of the sub-base. [6.]

Another example is the trials of EME material for a project jointly sponsored by the Highway Agency, Quarry Products Association and Refined Bitumen Association. This work has been reported in TRL Report TRL636 [7.]: “An investigation was carried out into the properties and performance of a high modulus asphalt material designed using the French design method with ingredients readily available in the UK. The asphalt material, known as Enrobé à Module Élevé (EME) Class 2, was evaluated under full-scale loading in the PTF at TRL.

Two test sections were constructed using full-scale plant to provide a direct comparison of the performance of an EME binder course with that of a heavy duty macadam (HDM) binder course. This direct comparison allowed the performance of the 'new' material to be calibrated against a material that experience has shown to perform well in service.

Two additional test sections were used to test a one meter wide (wheel-track) trench inlay to confirm that it could be included as a realistic and sustainable alternative maintenance treatment for surface rutting on heavily trafficked roads.

The EME Class 2 material deformed less than the HDM and no cracking was observed along the joints adjacent to the trench. Indirect Tensile Fatigue Testing (ITFT) and Indirect Stiffness Modulus (ITSM) stiffness testing before and after saturation with water, and permeability measurements indicated that EME would be durable and would act as an impermeable layer beneath a thin surface course. No reduction in stiffness was measured after 50 days of soaking, and the cracking resistance of the richer EME Class 2 was superior to that of HDM.

The very low air voids obtained in both the HDM and the EME binder courses using conventional plant, confirmed that the laying and compaction of EME Class 2 layers does not require special measures. As a consequence of this work an interim specification for EME Class 2 has been developed and specification trials under contractual conditions are planned for the near future. These will provide confirmation of the material's structural properties and mixing, laying and compaction characteristics” [7.].

The Netherlands

In the Netherlands the LINTRACK Accelerated Load Testing facility of the Technical University of Delft was used in the Dutch innovation programme called “Roads to the Future”.

The objective of this innovation programme, initiated by the Dutch Ministry of Transport in 1996, was to initiate innovations that will contribute to high quality mobility (e.g. faster maintenance, safer, quieter, more reliable, etc.).

The main goal of the Dutch Ministry was to assist the industry in making the first step in the innovation process. The goal was to start the development of the idea and to help to start the realisation of a prototype.

The pilot ‘Pavement of the Future’ (which is part of the program ‘Roads to the Future’) started in 2000 with a design contest. Construction companies were invited to submit ideas for a modular road. A special request for the design was that it should be a ‘silent’ road surface, with noise reduction better or equal to two-layered porous asphalt (at a traffic speed of a least of 100 km/hour). From the 20 submitted ideas, the 4 best ones were selected for design and construction of a test section at a service location along highway A-50 (in the eastern part of the Netherlands). The 4 best ideas were constructed in November-December 2001.

These four selected pavements were:

- The way of no rebound of the contractor Heijmans

- Rollpave of the contractor Vermeer
- Very Silent Module of the contractor KWS
- Modieslab of the company Modieslab v.o.f.

These four selected pavements got a budget for further development.

When the 4 selected pavements were built in a test section at a service location along highway A-50 these pavements had hardly been tested; only a limited amount of calculations had been done. So it was not sure whether they could carry the traffic of a highway. The traffic on the test sections at the service location was also limited.

In order to be able to look at real traffic loadings the Dutch Ministry of Transport decided to use LINTRACK. In this way they were able to test the bearing capacity of the pavements. This was done together with additional design calculations to be able to see what would happen if the construction would have been thicker or thinner [8].

The structure of the 'Rollpave' test section was [8.]:

- 30 mm asphalt wearing course (Rollpave),
- 120 mm ScorepaveM (50+70 mm),
- 30 mm STAC (50% PR),
- 90 mm STAC (50% PR),
- 250 mm AGRAC base,
- 5 m Eastern Scheldt sand
- natural clay subgrade



The 'Rollpave' layer is a 30 mm asphalt wearing course, pre-manufactured and it is 2,5 m wide. It is rolled on / unrolled from reel. On the road it is bonded to the substrate by new technique based on electromagnetic waves.

For "Pavement to the Future" the APT was able to show that 2 of the 4 selected structures were not good enough for a highway application and they failed quite soon in the test. The two others (Rollpave and Modieslab) past the test in the APT.

Conclusions from this study were[8.] :

1. The LINTRACK was very useful in determining which types of modular pavement structures are very promising.
2. The model used for Modieslab proved to be correct and was successfully used to optimise the product.

At the Technical University of Delft they are also working on the product development for a company. Based on lab testing and advanced modelling they could show that some of the proposed products under development are very interesting.

Real testing of these new product types, that have been investigated by lab research and advanced modelling, might be tested in the APT to show that they really have a potential.

An APT is not a simple tool to investigate a pavement. It is a combination of good lab research combined with good modelling and the proof of the pudding is in the eating / in the APT [9.].

CONCLUSIONS

The use of APTs by contractors until now is limited.

The main reason will be the costs involved. Using an APT is quite/very expensive.

Other disadvantages are:

- No representative traffic
- Difficult to measure the skid resistance.

In large contracts where the contractor is responsible for the (entire) pavement for a long period, it can be observed the contractor in general will choose for a surface layer (or a pavement) that has proven to be durable (in the past). So often a proven solution will be chosen instead of a new concept.

The following general conclusions can be drawn:

- ALT offers a potential for reducing the risks of using new materials / innovative pavements and/or working under new contractual relationships [10.].
- ALT should not be used as a stand-alone tool, but in coordination with laboratory work, field testing and computer modelling [10.].
- APTs are a good tool to verify new pavement designs before starting building it in a major construction of in a major road.
- Accelerated pavement test facilities provide significant data for analysing and predicting the effects of traffic loading on the performance of pavements.
- APTs are not always capable of predicting environmental effects and other long-term (ageing) effects.
- APTs provide a link between lab tests on one hand and the long-term pavement performance on the other hand.
- APT can be used to fill the gap between the uncertainty of the design model / techniques and the real, long-term pavement performance. So a tool for the validation of performance models.
- In an APT new materials or new concepts can be tested under heavy traffic and an equivalent of about 15 years of traffic can be simulated in three or four months.
- APT is a good tool to analyse an analytical design model / procedure in which the pavement material characteristics are used to predict the pavement performance
- APTs are a good tool for the determination of the effects of special vehicles with complex loading configurations like the Boeing 777.
- APTs give an opportunity to follow the crack growth and development (in the road surface) because it is easy and safe to find and mark the surface cracks.

When Accelerated Pavement Test facilities are going to be used by a contractor it is important to know in advance that the road authorities will accept the conclusion that are based on this APT results.

In the last decades also a lot of new asphalt products were developed and at this moment different types of Warm Mix Asphalt are being developed by the asphalt producers. For these product developments Accelerated Pavement Test (APT) facilities are not often used (may be except France). This means that the costs of using an APT are often higher than the benefits of using an APT.

In France they have a system called “Charte d’Innovation Routière” (Road Innovation Charter) which facilitates the implementation of innovations in the road building industry. When the performance of the innovation complies with expectations, the road authority delivers a certificate on the acceptable

performance of the product [1.]. This system encourages the road building industry to come up with innovations and this system might be the reason why more new systems are tested in France than other countries.

Although APTs are a good tool for analyzing and verifying design models, it is not (really) used by the contractors. In general it is not the first priority of a contractor / asphalt producer to produce a new design model. A (new) design model is only useful when it is accepted by the designer / road authority.

The impacts of APT can be observed in the understanding of the pavement behavior in general and the pavement performance in particular. In these areas APT have shown their benefits and their impact. For the asphalt industry in general the results obtained by the use of APTs by the (national) research institutes are very beneficial. It improved the understanding of the behavior of pavements and it brought pavement modeling and pavement design to a higher level.

For a road building company the targets are different. They need a return of their investments. For this reason research in their own lab facilities will be the first chose. If that is not sufficient or if they do not have the facilities, the next step is a research institute. Only for large scale projects, APT facilities might become an interesting solution.

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