CONCRETE ROADS: THE SIGNIFICANCE OF INTERNATIONAL TECHNOLOGY TRANSFERS IN THE DEVELOPMENT OF A ROAD CONSTRUCTION TECHNIQUE IN THE 20TH CENTURY

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ABSTRACT

Although concrete roads use a technology that was established a century ago, this same technology has been in continuous development during the course of the 20th century with advances in the design of road structures and the materials used as well as a steady broadening of the range of application of the technology. To a large extent this development was spurred by international exchanges of experience and in particular between the US and various European countries. The purpose of this communication is to illustrate how these international exchanges worked, who the principal actors were, and what their impact on the development of a certain key road construction technique was.
Belgium, like certain other European countries, has sustained the success and development of this type of roads by maintaining numerous contacts, particularly within the Technical Committees of PIARC, the technical publications of PIARC and the technology transfers supported by numerous experts in various countries.

1. INTRODUCTION

Most of the world's roads, particularly in developing countries, are unpaved. Paved roads are for the most part provided with a bituminous pavement: surface dressings or a thin bituminous layer. On the other hand, quite a few countries both in the industrialized world and elsewhere have experience, sometimes very long-standing, and sometimes recent of building concrete roads.

Concrete roads use a technology established at least a hundred years ago but which has developed immensely during the course of the 20th century. Changes have come about in the design of road structures, the choice of materials and the fields in which the technology is applied. To a large extent this development has been spurred by exchanges of experience between various countries and in particular between the US and various European countries. Concrete roads are used for the construction of motorways and principal roads, as well as for secondary roads and for the roads of the so-called tertiary network such as farm roads. Concrete roads can be found in many European countries, including Belgium, France, Germany, Switzerland, the Netherlands, Spain, the United Kingdom, Austria, Italy, Sweden, Denmark, Norway, Russia, the Czech Republic, and in North and South America, in countries such as Canada, the U.S., Mexico, Argentina, Chile. Elsewhere in the world Asian countries such as China, Japan, Malaysia, Thailand, India, and South Korea have built concrete roads, as have South Africa and Australia.

The decision to build concrete roads is governed largely by factors such as:

- the overall costs of the construction and maintenance throughout the entire life of the road;

- the use of local materials, including cement, and their impact on the balance of payments;
- the development of an alternative construction technique which for certain applications can be made competitive with more conventional techniques based on bituminous binders.

In the following, we will try to briefly sketch the history of concrete roads throughout the 20th century as well as the accompanying advances in the design and construction of these pavements. The development of these kind of roads would not have been possible without the international exchanges that have taken place and which have grown immensely in recent decades, although the involvement of contracting authorities, contractors and the industries concerned has also contributed greatly to their development.

Belgium, like certain other European countries, has sustained the growth and development of its roads by maintaining numerous contacts, particularly within the Technical Committees of PIARC, the technical publications of PIARC and the technology transfers facilitated by numerous experts in various countries.

2. THE HISTORY OF CONCRETE ROADS

Prior to 1900, the roads of the industrialized countries consisted mainly of cobbled or macadam roads. The appearance of the horseless carriage towards the end of the 19th century and the steady growth of road transport led to the improvement and expansion of road networks and at the same brought about changes in construction techniques in response to the need to make travelling more comfortable.

Up to the First World War, engineers tended to concentrate on the improvement of pavements. Later on the stresses caused by automobile use (vertical and tangential pressures, aggregate stripping, dust production), led to new construction techniques being introduced which contained the seeds of the techniques used to this very day: stronger road bases, coating of the aggregate with tar, macadam mortar, dressed setts, small setts laid in fan patterns, and concrete [1].

The first concrete roads known to have been built date from the end of the19th century in the U.S. and Scotland. The oldest such road in the U.S. dates from 1891 and was built at Bellefontaine in the state of Ohio [2]. In the early 20th century it was the Americans who were the leading designers and developers of concrete roads. The first concrete roads to be built in Belgium date back to 1913-1914. Nonetheless, the widespread application of concrete pavements in Europe only really got going after the First World War in the 1920s, particularly in the UK, Germany, France, Italy, the Netherlands and Belgium. At that time these pavements were usually laid as a paving surface over an older macadam structure thought to be inadequate for motorized vehicle traffic [3,4].

The length of the slabs was usually somewhere between 10 and 15 m. The transverse joints were made in the fresh concrete over the entire thickness of the pavement, and the upper part of the joint was then sealed. Even though joint dowelling was being carried out in some countries at that time, it was not a common practice. On the other hand, the installation of anchor bars in the longitudinal joints to prevent differences in the level between the two lanes and the opening of the joints was becoming widespread. Generally speaking the slabs were not reinforced. Where soils lacked good bearing properties, or where subsidence of the underlying soil was feared, a mesh of 2.5 to 3 kg/m² steel was placed in the lower part of the slab [5].

In certain infrequent cases, the concrete road was constructed directly on the natural subgrade. An example is the Drève de Lorraine, which was built in 1925 in the Soignes Forest on the outskirts of Brussels. The standard transverse section of this road is shown in figure 1. The concrete was poured directly into the fixed formwork of every other slab: i.e. one slab in two in the first phase, while the intervening slabs were poured in a second phase. The concrete was compacted in two layers with a total thickness of 15 cm, although the sides were somewhat thicker. The pavement was not reinforced and despite the old-fashioned design, the road remained in use for 78 years without requiring any major repair works.

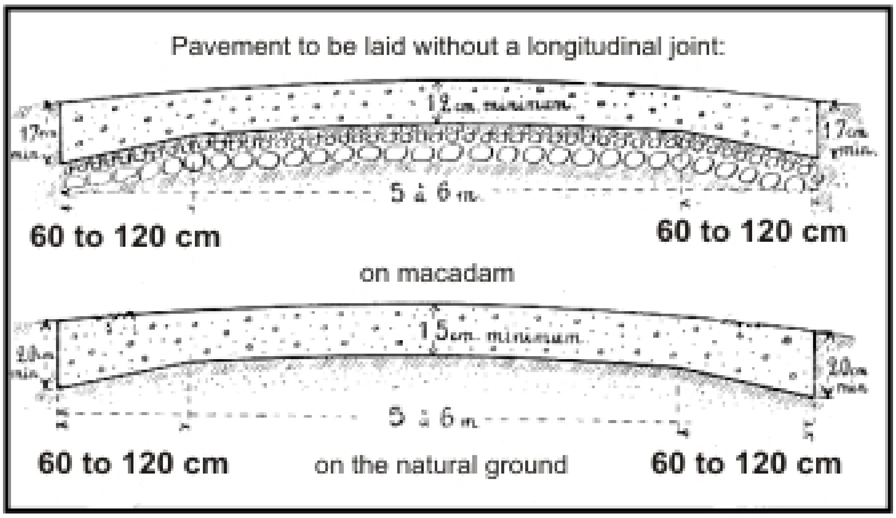

Figure 1 – Standard Transverse Section of the Drève de Lorraine

During the thirties and still following the lead set by the Americans, Europe saw the emergence of a system of new roads meant for fast automobile traffic: the motorways.
These included, to name but a few, the construction of a major concrete motorway network in Germany between 1934 and 1939 [6], as well as the first few sections of concrete motorways in the U.K. and Belgium [7].

However, all these innovative efforts were interrupted by the Second World War. During the war the roads suffered enormously, although it was the concrete roads that stood up best to the punishment. Up to 1950, in the immediate aftermath of the war, efforts were concentrated on repairing the damage that had been sustained during hostilities.

It was only after 1950 that major resources could be put into play for the improvement of existing roads and the construction of a new network of roads and motorways capable of coping with the ever increasing needs of road traffic and transport. In this respect the concrete road was regarded as a valid choice in certain countries, including Belgium, particularly because of the numerous technical and budgetary benefits offered by this type of structure [8].

A major effort to construct a full scale motorway system for Europe only really emerged after 1960. Two main techniques were used for the construction of concrete pavements:

- pavements made up of short unreinforced concrete slabs, separated by transverse contraction joints provided with a dowelled load transfer device,

- pavements in continuously reinforced concrete. This technique has been applied on a large scale since the early seventies, particularly in Belgium.

The latter technique was developed in the United States in the nineteen-thirties with the aim of eliminating transverse joints and controlling cracking by a continuous reinforcement. Typical of these pavements is their lack of transverse joints, with the exception of construction joints and expansion joints at the perimeters of certain engineering structures. Instead of being concentrated in the joints, the shrinkage of the concrete is spread over a network of fine transverse cracks which do not imperil the satisfactory performance of the pavement. The spacing and the opening of these cracks is controlled by continuous longitudinal reinforcement designed to obtain a network of cracks with an opening of less than 0.3 mm, and with an average spacing between 1 and 3 m.

As for Belgium, several missions made up of senior officials and Belgian captains of industry travelled to the US in the sixties in order to study and subsequently to adopt American continuously reinforced concrete techniques. After the construction of a number of experimental sections between 1965 and 1967, the technique was widely adopted for the construction of Belgium's motorways from 1970 on [9]. Nowadays continuously reinforced concrete represents about 40% of the total length of the Belgian motorway system.

Other techniques have been applied or experimented in some countries, such as reinforced concrete slabs, prestressed concrete and steel fibre reinforced concrete. These techniques have been either abandoned, or used for very special applications.

Since the beginning of the seventies new concerns have arisen, including the improvement of user comfort and safety and a growing preoccupation with the environment and durable development. These led first of all to the development of new surface treatments to improve the skid resistance of the pavement and reduce the noise nuisance caused by traffic, and secondly to the emergence of overlay and recycling techniques that could make the most of the materials already available in the road. These techniques will be discussed more in detail in §4 hereafter.

3. CURRENT STATE OF KNOWLEDGE OF CONCRETE ROADS – TECHNICAL, ECONOMIC AND ENVIRONMENTAL ASPECTS

Starting in the seventies, following the successive oil crises of that period, renewed interest in concrete roads emerged in numerous countries. It was this that spurred the PIARC Technical Committee on Concrete Roads, chaired by Professor C. Kraemer (Spain), to publish in 1987, on the occasion of the XVIIIrd World Road Congress of PIARC, a document based on minimum levels of consensus and aimed at summarizing the current state of knowledge of concrete roads in the countries using the technology [10], in order to help other countries, whether industrialized or developing, to consider the application of the technology.

The document comprises the following parts:

- a part intended for the contracting authorities who make the decisions: description of the essentials of the technology to help identify the most relevant areas of application in a particular national context, an overview of the main technological choices with reference to data from the economic context, etc.

- a part intended for the project designers and project supervisors responsible for the adaptation of the technology to a particular context: structural and thickness design, choice of the techniques to be used, and the sensitive aspects of the technique,
- a part intended for contractors and the persons responsible for the construction of the project: characteristics of the materials to be used, choice of construction procedures, recommendations for satisfactory completion.
- a part about monitoring methods and maintenance techniques.

From the purely technical point of view, the main quality of a concrete road is without a doubt its considerable rigidity, which ensures the even distribution of loads to the underlying courses and good fatigue performance. It is these properties that often make the overall cost of a rigid pavement competitive when the road is subject to heavy and dense traffic (motorways and primary roads, industrial roads, and pavements for dockside or airport use), as well as for lightly trafficked roads where the soil lacks bearing capacity.

The whole-life costing of concrete roads, which takes account of the various parameters that can be taken into consideration for the determination of the cost (cost of construction and maintenance, user costs, accidents, environment, etc.), is the subject of a recent publication of the PIARC Technical Committee on Concrete Roads [11]. Various examples of costing models are mentioned, in particular those employed in Sweden, the United Kingdom, the United States, Chile (the HDM-4 model), Australia and Austria.

In Belgium a study has been carried out that aims at comparing the whole-life costs of various motorway carriageway structures for continuously reinforced concrete and bituminous pavements [12]. The study shows that in a Belgian context the cost of building a structure with a continuously reinforced concrete pavement is generally speaking greater than that of a structure built from bituminous materials. Nonetheless when maintenance costs are added to the equation, structures using continuously reinforced concrete offer substantial savings in all cases, and that these savings start to kick in after seven to fourteen years, depending on the particular circumstances. In view of the low cost of maintaining such structures, these conclusions thus fully justify the Administration’s decision to construct a major part of the motorway system in continuously reinforced concrete.

Concrete roads are perfectly compatible with the idea of sustainable development. Indeed, it is well known that the long life of concrete roads has a beneficial impact on the various comparative models from the economic and environmental point of view. The relative infrequency of the need to provide a new pavement or carry out renewal works, combined with an almost non-existent maintenance requirement during the lifetime of the road, means that less material has to be used and that the energy inputs are lower. To this must be added that, overall, less inconvenience is caused to users as well.

With respect to the environment, we may point out that apart from other significant advantages:

- concrete roads can be 100% recycled. The recycling of concrete waste in the road base has long been widespread road-building practice.
- modern techniques involving aggregate exposure make it possible to build concrete pavements that have acoustic characteristics comparable to those of conventional bituminous pavements. These are therefore roads which retain excellent skid resistance while also offering comfort and safety to their users.

4. DESIGN AND CONSTRUCTION OF CONCRETE ROADS

In the following paragraphs, we will try to trace the development of design and construction practice as applicable to concrete roads, and which have resulted in the following current practices:

4.1. Choice of the type of road

Prior to the fifties, concrete pavements generally consisted of relatively long slabs (of the order of 10 to 15 m), with undowelled transverse expansion or contraction joints. This outmoded design combined with heavy traffic, an unbound base and the presence of water in the interface between slab and base, would sooner or later result in the phenomenon of "pumping" at the joints and the creation of steps in the pavement.

Experience with concrete roads acquired in various countries and the exchange of same at international encounters allowed concrete road design to start developing in the early sixties towards the following current practices:

- pavements made from unreinforced short slabs with transverse contraction joints. The length of the slabs is limited to 5 m. On heavily trafficked roads, it is usual to dowel the joints. Other measures for reducing the risk of pumping and the stresses in the concrete are the application of an appropriate drainage system outside the road and an extra width of the concrete pavement [13];

- continuously reinforced concrete pavements, which are generally reserved for motorway construction and heavily trafficked roads. The rate of longitudinal reinforcement rate lies usually between 0.6 and 0.7%. A document was prepared by the PIARC Technical Committee on Concrete Roads summarizing the various aspects of this type of pavement, which was based on a survey conducted in the various user countries [14].

4.2. Choice of base materials

The experience acquired over the course of many years shows that the materials used in the base play an important role in the performance of concrete roads. The concrete roads of yesteryear were often built on a base of sand or untreated gravel or even on the natural subgrade. When subjected to heavy traffic and with the presence of water at the interface of base and the pavement, the material of the base would slowly erode because of the pumping action referred to above.

So it was that in the sixties a start was made with using bound bases that were less subject to erosion, namely cement-bound granular material (with a cement content of 2.5 to 4%), bitumen-bound granular material or lean concrete.

With respect to continuously reinforced concrete, a design innovation was introduced in Belgium during the seventies, which was subsequently adopted in numerous other countries such as the Netherlands, Poland, etc. This was the provision of a thin bituminous layer between the lean concrete base and the continuously reinforced concrete pavement (see figure 2). The role of this course subsequently proved to be of decisive importance to the satisfactory performance of these pavements, as it made it possible to provide good adhesion between the pavement and the base, and thus eliminating the presence of water under the slab.

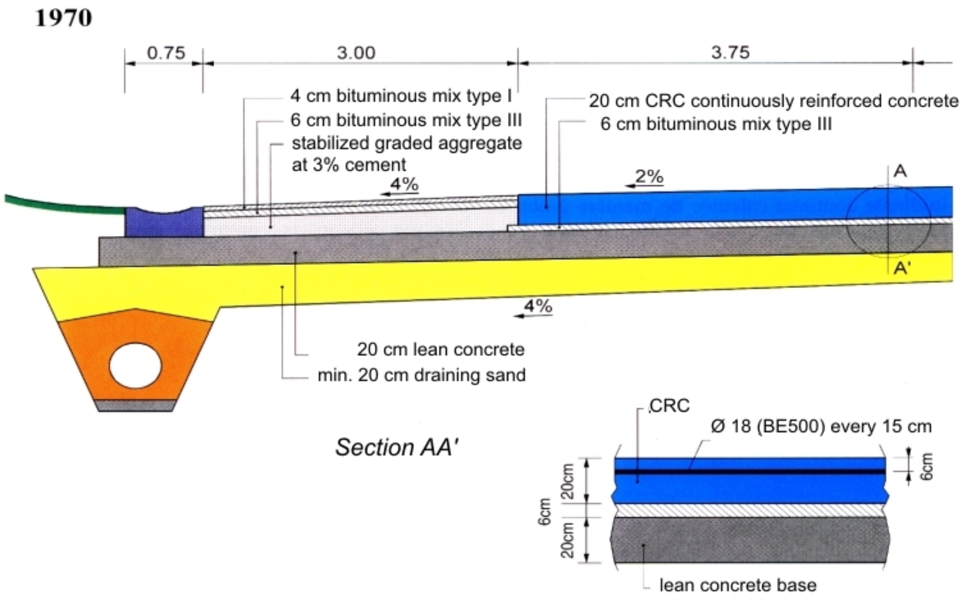

Figure 2 – Structure of a motorway in continuously reinforced concrete in Belgium (1970)

For low-volume roads, for example farm, vineyard and forest roads, the pavement may be constructed directly on the natural subgrade on condition that the soil had sufficient bearing capacity (e.g. a CBR > 2). If this is not the case, a base in untreated gravel is usually provided.

4.3. Equipment used for laying concrete

Concrete roads are built using machines that spread the concrete out, vibrate and smooth it. A surface treatment is then applied to give the concrete sufficient roughness.

When the first concrete roads were built and up into the thirties, the concrete was usually tamped or rammed by machine [5]. Thereafter and up to the sixties, the concrete was laid almost entirely using vibrating finishing machines running on fixed formwork rails [8]. Depending on the size of the site, the train of concreting machinery could include a number of machines for spreading the concrete, compacting it, creating joints in the fresh concrete, profiling it, treating the surface and applying a curing product.

As of the sixties, these machines were progressively replaced by “slipform pavers”, initially first on the large sites necessary for motorway construction. These machines, which were invented in 1946 in the US, made it possible to attain performances that were markedly better than those offered by the fixed form pavers. They have been introduced progressively in several European countries since the middle of the sixties [15,16], and were subsequently the object of numerous modifications, including for example the addition of special equipment that made it possible to vibrate the dowels into the fresh concrete. Around the mid-seventies they started to make their appearance on all type of roads, and are nowadays almost exclusively used in all countries.

4.4. Surface treatments

The purpose of a surface treatment is to give the pavement lasting increased roughness. The commonest form of surface treatment is the transverse or longitudinal brushing of the fresh concrete surface. Since the sixties, research into the improvement of skid resistance qualities of concrete roads has been carried out in various European countries, including

Belgium. One technique, which was widely applied to motorways in the early seventies, is deep transverse grooving. From the point of view of skid resistance the results were excellent, although the treatment gives rise to high levels of rolling noise both within and outside the vehicles. Other techniques that were tried during the seventies include chip-sprinkling and aggregate exposure [17](figure 3).

Figure 3 – Appearance of a surface after aggregate exposure

Chip-sprinkling consists of spreading hard aggregate with high polishing resistance over the surface of the fresh concrete and then partly pressing them down into the concrete in order to obtain the desired roughness. The advantage of this technique is that it makes it possible to use easily polishing aggregate in the concrete mix without affecting skid resistance. The technique was developed in Belgium in the seventies and was also tried on various motorway sites in France and Canada. The technique has fallen into disuse.

A different surface treatment has been used in several countries for the last twenty years. This aims at providing a surface texture by exposing the aggregate. Called aggregate exposure (figure 3), the technique has been in use in Belgium since the eighties. Treatment involves the spraying of the surface of the fresh concrete with setting retardant and then removing the surface mortar after the concrete has hardened, with the result that the aggregate is exposed. The resulting surface offers excellent qualities both with respect to skid resistance and rolling noise, as well as good durability, on condition that hard stone with high polishing resistance is used in the concrete mix. This technique subsequently migrated to other countries including France, Austria, the United Kingdom, the Netherlands and more recently, Germany.

4.5. Concrete overlays and inlays

Providing an overlay involves providing an existing road with a new concrete pavement regardless of the nature of the old road. The existing structure is therefore recovered and serves as a base. Inserting an “inlay” consists of removing all or part of the thickness of the existing pavement and replacing it with a new concrete pavement. The two techniques may make use of either concrete slabs or continuously reinforced concrete. Both have been used in various states of the United States since the sixties, as well as in numerous European countries [18,19].

Concrete overlays (figure 4) are particularly suited to road renovation works, particularly when the level of the thresholds of frontager buildings and the headroom offered by bridges does not constitute an obstacle to raising the level of the road surface. When the old pavement is made of concrete, it is worth stabilizing the existing pavement by cracking and seating the slabs in situ. It is also warmly recommended that a profiling bituminous course is provided between the old structure and the concrete overlay. When the old structure is a bituminous pavement, the existing surface is usually planed so that the overlay will have a uniform thickness.

« Figure 4 – Overlay constructed in 2003 in the Drève de Lorraine, originally built in 1925 »

The inlay technique is applied when the existing level of the road cannot be raised, or if only part of the road has to be rebuilt. It is particularly suitable for the right hand or slow lanes of roads and motorways subject to heavy traffic, and thus more exposed to deformation than the passing lanes, which are used more by light vehicles and which have considerably less impact on the structure.

A recent application of this technique are the ultra-thin overlays, which were developed in the United States in the early nineties under the name UTW or “ultra-thin white topping”. Since then they have been tried in several other countries. The technique consists of planing off a 5 to 10 cm thick upper layer of a rutted bituminous pavement and replacing it with a thin layer of concrete with good adhesion, for example at the approaches of junctions. Various trials have been conducted in Belgium since 2000 but these experiments are too recent for any conclusions to be drawn from them.

5. INNOVATIVE APPLICATIONS

The nineties also saw the emergence of a series of innovative applications of concrete pavements, and these are described briefly below. Information exchanges primarily within PIARC’s technical committees and at other international gatherings have made it possible for these new technologies to be quickly transferred to other interested countries. These applications have been the subject of detailed reports published in the reports of the world congresses of PIARC.

5.1. Roundabouts in continuously reinforced concrete (figure 5)

In Belgium as in many other European countries, traffic at major road junctions is increasingly managed by priority roundabouts, which are more reliable and ensure improved traffic flow. The pavements of these roundabouts are subject to particularly high levels of stress as a result of the tangential forces due to centrifugal force and the torsion effects these induce in the surface as well as the overload caused by the offside wheels as a result of the lateral shift of the vehicles. For these reasons several countries have been providing roundabouts with concrete slab pavement.

Figure 5 – Roundabout in continuously reinforced concrete

The first roundabout in continuously reinforced concrete to be built in Belgium dates from the mid-nineties. Since then the practice has become widespread. The design and behaviour of such a pavement is identical to that of a rectilinear continuously reinforced concrete pavement. Depending on the dimensions and radius of the roundabout, the pavement is constructed either with a slip-form paver or by using a vibrating beam between fixed formwork. Similarly the surface treatment and the possible use of surface pigmentation can be adapted to the requirements of the site concerned.

This application opens new prospects, particularly in countries where widespread use is made of continuously reinforced concrete.

5.2. Low-noise concrete pavements

Several studies have been carried out in various countries, including Belgium, the Netherlands, Austria and Germany with the aim of reducing the rolling noise arising from the tyre-pavement interface.

Low-noise concrete pavements can be created by providing an even surface with a fine and dense texture. This can be achieved by giving the surface an aggregate exposure treatment combined with the selected grading of the aggregate, for example by limiting aggregate size to 20 or 14 mm.

Tests have also been carried out using twin layer concrete pavements in which the aggregate size in the upper layer is no more than 7 mm, and where the upper layer is made from fine concrete subjected to an aggregate exposure treatment. The Austrians now use this technique systematically for the construction of their motorways. Contrary to formerly widely held views, the results of these tests show that it is possible to achieve rolling noise levels on concrete pavements similar to those obtained on bituminous pavements.

5.3. Composite pavements

The main structure of these pavements are in cement concrete (continuously reinforced concrete, concrete slabs or roller compacted concrete) and a wearing course in bituminous concrete. The principle here is to achieve an optimal combination of the various paving materials used in the road structure, so that the concrete provides structural strength, while the surface course in bituminous concrete ensures good riding qualities.

This technique is used in several countries, either when building new roads, motorways in particular, and or in the context of the renovation or rehabilitation of existing pavements.

5.4. Urban road projects in coloured or imprinted concrete

In recent years many countries have made a major effort to renovate the roads of the urban environment. Here the appearance of the pavement plays an important role in the integration of the road into the urban fabric.

A technique which is often used in combination with concrete or natural stone block paving entails the use of disactivated coloured concrete. Here coloured aggregate perhaps combined with a pigment is used in the concrete mix. The concrete may be laid either in one or two layers. The surface is then given an aggregate exposure treatment in order to reveal the colour of the aggregate. This technique has been widely adopted, particularly in France and Belgium.

Figure 6 – coloured disactivated concrete (Dinant – Belgium)

The imprinted concrete technique, developed mainly in the United States, gives the surface of the pavement the appearance of natural stone or concrete block paving. It consists of spreading a coloured powder over the surface of the fresh concrete, and then imprinting the surface of the concrete with suitable patterns to achieve the desired result. The technique is used mainly in urban environments and is reserved for special applications such as pedestrian crossings, roundabouts, humps, bus stops and similar.

6. THE CEMBUREAU CONCRETE ROAD SYMPOSIUMS

6.1. History of the Symposium

In the early sixties, the administrative services of CEMBUREAU, the European Cement Association (first established at Malmö, Sweden in 1947) located in Paris. Mr Henry Collis, Director responsible for the promotion of concrete, set up a work group called the "Promotion of the Concrete Road". Fully aware that this group met a very real need at a time when the European motorway system was being developed, he contacted PIARC, whose administrative services were also based in Paris. PIARC was more than happy to share in the work of CEMBUREAU, and this led to the establishment of a Joint CEMBUREAU/PIARC Committee, which was chaired by Mr Raymond Pelletier, and was made responsible for the promotion of concrete roads.

In 1967, a first "Congress" was organized with the technical and scientific support of the French Road Administration, while CEMBUREAU took charge of all the logistical and material aspects. Part of the programme included a visit to the Autoroute du Sud site at Dijon.

In 1969 the First International Symposium on Concrete Roads was officially held in Paris in association with the SFIC (the French Cement Industry Association) and with the patronage of PIARC. Representatives nominated by CEMBUREAU and others nominated by PIARC were asked to develop a technical programme. This group has become the ITPC (International Technical Programme Committee) that we know nowadays.

Since 1969, the Symposium has been organized by CEMBUREAU about every 4 years in a series of countries with the local assistance of the Member Association of CEMBUREAU and on all occasions with the patronage of PIARC.

1973	Berne	1994	Vienna
1978	Besançon	1998	Lisbon
1982	London	2004	Istanbul
1986	Aachen	and	
1990	Madrid	2006	Brussels

Belgium had the honour of organizing the 10th anniversary of the symposium. Between 18 and 22 September 2006 over 600 participants from 49 countries all over the world flocked to the event. This success is proof of how much interest there is in concrete construction techniques, which moreover represents a good response to current concerns about environmental care, and the more so now that we are facing a new challenge, namely the renewal and improvement of the roads of Eastern Europe.

6.2. Standards and practices for concrete roads

At the occasion of the 1st International Symposium on Concrete Roads, a synoptic table of European concrete road standards and practices has been drawn in cooperation with the PIARC Technical Committee on concrete roads. This table includes the principal design and construction standards and practices in the different countries, in particular the basic thickness and horizontal design requirements, joint design, materials and concrete characteristics, manufacturing and laying of the concrete [20].

As would be expected, there are considerable similarities in practices in the various countries, but there are also some large differences. These are not unexpected, as experience has shown that good concrete roads can be designed and constructed by a variety of methods. This table has been revised several times, the last one at the occasion of the Vienna Symposium in 1994 [21].

As for the activities of the PIARC Technical Committees, it should be noted that since the end of the eighties the symposiums organized by Cembureau have been widened to experts from other continents outside of Europe, thus facilitating international technology transfers for concrete roads throughout the world.

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