EARTHWORKS, DRAINAGE AND SUBGRADE

19 September 2007 (am)

TECHNICAL COMMITTEE C4.5

INTRODUCTORY REPORT

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EXECUTIVE SUMMARY

PIARC Committee “Earthworks, Drainage and Subgrade” (TC4.5) has pursued the following topics during the 2004-2007 work period:

- Promoting optimal use of local materials:
    a) Identifying progress in terms of soil and rocky materials treatment for road applications.
    b) Identifying progress in the use of wastes and industrial by-products as earthwork materials.
- Having indicators representative of the condition of geotechnical structures for road asset management.
- Anticipating the impacts of climate changes.

The Committee’s activities follow with PIARC Strategic Theme 4 “Quality of Road Infrastructure”. The goal is to ensure effective management of road assets by implementing management systems that are able to integrate all infrastructure components, based on indicators that reflect functionalities and taking into account the expectations of users.

In 2004 the Committee held meetings in Paris and in Thessaloniki, in 2005 in Tsukuba (Japan) and in Paris, in 2006 in Mexico City in Quebec City and in Lausanne. The next and last meeting will be held in Warsaw. A PIARC seminar is also planned for June 2007 in Rumania.

Concerning the first topic, on one hand, it was observed that the use of wastes and industrial by-products as earthwork materials has both economical and environmental benefits, but national policies for acceptance as fill materials are widely variable from one country to another, and especially the environmental criteria. A survey revealed a large, significant development in soils treatment with lime and hydraulic binders due to savings, to environmental constraints enhancement and to national, suitable specifications. However, the lack of know-how, of specialized equipments, of suitable binders… are always limiting factors to its development in some countries.

The scope of the second topic is to give an up-to-date guidance and practice with some recommendations for future improvement to the specialists and professionals in the field of road infrastructure management.

The third topic addresses the consequences of climate changes and the possibility to anticipate their effects on road infrastructures. This topic will be presented and discussed in a parallel session at the next World Road Congress.

In addition to these technical reports presented in this document, Technical Committee 4-5 organized and contributed to several events which promoted the development of international exchanges of high value on themes related to earthworks, drainage and capping layers. So, it is possible to quote:

- The committee meeting held in Tsukuba (Japan) on May the 25th, 2005 included an exchanging workshop between present committee members and Japanese professionals involved with the “use of industrial by-products and local materials in earthworks”. Eleven papers were presented during these exchanges by different countries including Japan.
- The committee meeting held in Mexico City (Mexico) on March the 30th, 2006 planned an exchange day between Mexican Association of Ground Ways members and those of TC 4-5 Committee. One hundred and twenty attendees participated in this exchange day where different papers were presented by TC 4-5 members and Mexican professionals. A CD-Rom gathering these presentations was distributed the day after to the participants.
- The TREMTI Symposium (dealing with soil treatment with lime and hydraulic binders) was held in Paris with support from PIARC. Several papers from TC 4-5 members were presented, while several members were included in the Scientific Committee of this event. The meeting committee of October 2005 had been organized in Paris during the same week to enhance the participation.
- The seminar “Earthworks in Europe” organized too in Paris and in the same week and also with the PIARC support was strongly held up by committee members for the interest of the event. Moreover, it is foreseen to hold a second edition of such a seminar in London on March 2008 to facilitate exchanges between European professionals.

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TOPIC 4.5.1 - PROMOTING OPTIMAL USE OF LOCAL MATERIALS

This topic is divided in two main themes:

- identifying progress in terms of soil and rocky materials treatment for road applications ;
- identifying progress in the use of wastes and industrial by-products as earthworks materials

Initially planned, a third theme “How to ensure a good integration of road infrastructures in landscape” was eventually addressed only in a paper entitled “Road earthworks integration in landscape: retrospective of some cases in France”, to be published in the “Routes/Roads” journal, this theme being beyond the geotechnical scope and the skills of the technical comity 4.5.

The first theme was essentially analysed on the basis of:

- the results of a PIARC survey launched in 2005 during the TREMTI conference. This survey was particularly highlighting the favouring and penalizing elements for soil treatment during the last years in about twenty countries;
- technical communications presented during two international conferences on soil and road materials treatment, respectively held in 2001 in Salamanque (Spain) and in 2005 in Paris (France).

It comes out from these elements that the economical benefits (transport, granular material savings), environmental positive aspects (limitations of borrow granular materials removal, restrictions to no compliant materials dumping) and the development of technical guidelines led to a large development in soil treatment techniques in numerous developed countries. Nevertheless, the lack of know-how, of adapted equipments, of local production for binders and even in some cases, negative experiences or penalizing climatic conditions have been detrimental to the development of this technique in some countries over the last decades.

The main identified progress is dealing with equipment as well as treatment products, methods or technical guidelines. For example, the following points can be quoted:

- the development of powerful in-situ mixers, enabling mixing very coarse materials and reaching large efficient mixing depth (at least 50 cm), spreaders more and more accurate in terms of binders proportion and with variable spreading width, blocks pulverisers able to crush siliceous elements of very coarse materials such as flints clays, sprinklers burying water which enable a better moisture content control, screening and mixing buckets for small works sites as well as mobile treatment platforms;
- the introduction of low dust emission binders, enabling soil treatment in urban areas or sensitive rural areas, of specific road hydraulic binders, of fast setting binders, blast furnace slags fines, etc …

- the treatment of dry and very dry soils treatment with lime milk, the introduction of the staged treatment method for soils containing sulfates, the application of recycled materials treatment (naturals or not), the transfer of treatment techniques from earthworks to road layers ;
- the development of guidelines in the last decade, in France, Germany, Belgium, United-Kingdom, Japan, … as well as the publication of national and European standards.

The second theme was treated essentially on the basis of the answers to the survey carried out by the TC 4.5. in 2005 through its members. This questionnaire was intended to identify the wastes and by-products used in the different countries as well as the conditions for use in order to characterize these materials from both geotechnicals and environmental aspects. In some cases, other documents (SESAR, ALTMAT and SAMARIS European programs reports) provided complementary information.

Thirteen countries answered to the survey: France, Croatia, Italy, Spain, Belgium, Portugal, Poland, Switzerland, Austria, Japan, Panama, Chile, Mexico.

First, it can be observed that few or even no elements are given by Asian, African or Northern America countries. Available data come mainly from Europe and, in a lower part, Central America and Southern America. Consequently, this survey can not claim it gives an accurate picture of the whole state of practice.

It appears that the answers are more or less exhaustive, depending on the countries (for example, some wastes or industrial by-products used in some countries were the object of only partial information).

Switzerland is noticeable for its application of a voluntary policy limiting the use of such materials. Similarly, Portugal doesn’t show a significant will to promote the use of such products.

In a general way, all countries have specific standards, more or less prescriptive, governing the use of wastes and industrial by-products in road infrastructures. However, some countries such as Chile, Japan or Portugal, for example, don’t have specific classification for such materials. On the other hand, all European countries have a common legislation, complemented in some cases by national standards.

Most wastes and industrial by-products are demolition concrete (buildings and roads), old pavements bituminous materials, blast furnace slag, fly ashes, municipal solid wastes and also tyres, rubber materials or, more rarely, dredging slurries and cellulose wastes.

Some countries such as Chile or Croatia are low or not concerned by environmental issues.

The destination of these materials is variable, depending on their nature and on the country. However, the most frequent uses are in embankments, capping layers or as substitution materials. They are mainly used alone, rarely in mixing and very rarely treated.

Except for Croatia, Switzerland and Portugal, a large development in the use of such materials was observed in road construction over the last decade. The main reasons are the lack of available good quality materials, the limitations material disposal and, more generally, increasing sustainable development policies and the low price of these materials.

TOPIC 4.5.2 - INDICATORS REPRESENTATIVE OF THE CONDITION OF GEOTECHNICAL STRUCTURES FOR ROAD ASSET MANAGEMENT

1. INTRODUCTION

While Road Asset Management is not a new concept, the primary focus has been on structures and pavement assets, and to date there is relatively little guidance published on the management of the geotechnical asset that underlies and supports these other highway assets. The purpose of this study has been to bridge this gap by reviewing current guidance and practice worldwide then setting out recommendations for future improvement in support of a joined up approach for road infrastructure management.

The highway geotechnical asset principally comprises: embankments and cuttings, reinforced and stabilised slopes, subgrade and capping beneath carriageway, structural foundations, environmental / landscape earthworks, ground drainage and landscaping.

The challenge of the geotechnical asset is that there is more inherent variability in the engineering performance of such assets than is exhibited by most other elements of the highway network. This variability and the difficulty in predicting long-term performance poses a significant challenge to asset managers who are seeking to plan and budget the maintenance of their assets.

To optimise maintenance requires:

- condition information,
- an understanding of long term engineering behaviour of the materials and water,
- a proactive approach to maintenance activities,
- a holistic approach to any defects that might be identified.

At the core of such a managed approach is effective operational data management from which the condition can be assessed, performance monitored and analyses undertaken. Performance indicators are a key component in an asset management system and condition indicators are a specific type of asset performance indicator.

2. CONCLUSIONS AND RECOMMENDATIONS

Pro-active Asset Management

Performance indicators are a vital component in an asset management system. They are both part of the management system and a key way of articulating good stewardship of the asset to other non-technical parties within the highway organisation and to customers.

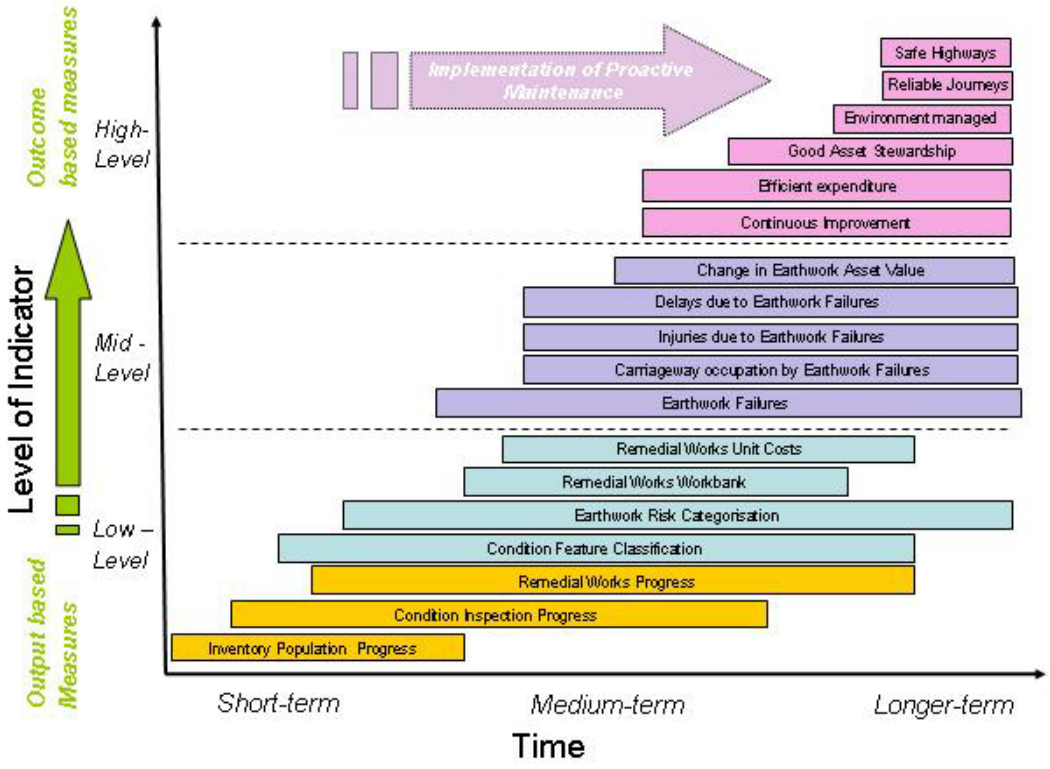
Performance Indicators

Our work suggests that:

- a mix of 'output' and 'outcome' based performance indicators should be adopted for geotechnical asset management and
- that a mix of low-level indicators used to manage a particular asset type, mid-level level indicators used to report performance to the overseeing organisation with high-level indicators to report to customers should be adopted with
- a distinction made between performance indicators related to the asset themselves and indicators related to the performance of the people running the network.

An outline 'roadmap' for the development of geotechnical performance indicators in a pro-active maintenance system is shown below as Figure 5.1.

FIGURE 5.1 RoadMap for Development of Performance Indicators



TOPIC 4.5.3 – ANTICIPATING THE IMPACTS OF CLIMATE CHANGES

The climate evolution and its consequences are one of the main preoccupations of the beginning of the 21th century. The initial target of this topic was to make a document for being able to anticipate the impact of the climate changes.

At first and as the subject was a wide one, the committee decided to make an article for the Routes/Roads magazine.

At the beginning the climate evolution had to be established and a scenario fixed. But all the climatologists don't agree on what will be the evolution for the world. So it was impossible to choose one scenario for the all world. It was decided to choose main evolutions.

On this basis, the consequences and the damage that can occur on earth structures were listed. With these elements, advice and practical solutions were written.

The last part of the article should have to present some damage that can occur because of the climate evolution.

During the meeting of November 2006 in Lausanne, the committee decided that it wouldn't be an article but a report.

The existent document would have to be completed with climate elements and a new part with good practical recommendations with a qualification of the risk according to parts of the structure.

The first part of the report presents the assumption of the climate evolution. To date no validated world scenario exists. The increase of the world temperature is recognized and some phenomena which were exceptional until now will happen more often. Evolution scenarios planned by Québec and Switzerland are presented in this report.

The second part is based on water lack or excess of water and its effect.

This part recaps the consequences of meteorological phenomena by a table and proposes ways for solutions. The cases of embankment structures and of natural slopes are separated because the difficulties are different in each case. The problem of the elevation of the sea, the permafrost modifications and the increase of the wind force, will be treated separately.

The preventive measures affect not only the new structures, by taking the climate evolution into account since the project stage, but also the existent structures by improvement and reinforcement works, advice for upkeep and running and finally repairing propositions when damages occur.

Some examples are presented in the third part. They show, more particularly, some damaged embankments and slope failures, due to the presence of water in excess. If they are not the fact of climate changes, theses damages could become it and their frequency could increase.

A submitted process is presented in the fourth part. It remains that the present can't tell any more what will be the future without taking the last scenario of climate evolution for the region.

General recommendations and steps to follow including the worse case of scenario are presented. On the base of a climate evolution scenario, the report presents preventive arrangements and steps to follow to avoid later damages.

DRAFT CONCLUSIONS

Topic 4.5.1 – Theme 1

Large development in soil treatment techniques in developed countries over the two last decades. Nevertheless, too many developing countries don’t have access to these techniques (cost, lack of binders, lack of adapted equipment…)

Important progress in the design and availability of specialized equipment for soil treatment.

Technical guidelines elaboration in the developed countries, for soil treatment, accepted by owners, contract managers, contractors, binders producers, …

Need to integrate soil treatment in a sustainable development approach, by taking into account positive aspects (granular materials saving, increasing the use of available materials in the project, limitations of natural materials dumping,…) but also limiting aspects such as energy expenditure and greenhouse gases emission.

Develop the understanding of physical, chemical reactions during settings of binders in soil treatment, in order to optimize its effect and durability.

Develop specific road binders or specific methods in order to limit or eliminate the negative effect of disturbing elements (chemical or mineralogical) contained by some soils.

Improve the adaptation of soil treatment to marginal materials or materials no compliant with specifications, in order to increase their use in earthworks.

Elaborate and develop reliable techniques for soil treatment in developing countries. These techniques must be based on a high use of local manpower and simple equipment, instead of heavy imported equipment for punctual use.

Topic 4.5.1 – Theme 2

High variability of waste and industrial by-products used as road materials. If the use of such materials is common in developed countries, it remains marginal in numerous other countries.

Two opposite policies are observed: promoting the use of such materials (in France for example) in spite of potential environmental risks and, on the other hand, a rigorous application of the precautionary principle and, thus, systematic dumping (Switzerland for example).

Well-adapted general legislation (national, European) for countries involved in the development of the use of such materials, even if a need for a technical guidelines appears clearly in order to define more precisely the conditions of use.

The nature of industrial by-products used as road materials is governed by local industrial conditions. Except particular cases, there are no or very few importation or exportation of these materials.

The destination of these materials is quite similar in the different countries: very often in embankments and sometimes in capping layers or as substitution materials.

If the impact on environment is a widely recognized concern, it must be addressed more thoroughly.

For the proper use of these materials both geotechnical and environmental aspects need to be taken into account.

Great interest to adapt and develop specific tests in order to characterize these materials from both geotechnical and environmental points of view. It appears that the conventional tests used for natural soils are not always adapted to the specificity of wastes and by-products.

Topic 4.5.2

- Consideration should be given by PIARC to extending the current study to look more widely at performance indicators adopted Worldwide by operators of other infrastructure systems such as flood defences, dams, railways.

- A particular focus should be on obtaining good cost, safety and reliability data for asset management regimes operating a ‘reactive’ approach and those operating a ‘pro-active’ approach. This would inform the decision to adopt a particular asset management strategy.

- The effective and consistent valuation of geotechnical assets should be explored.

- The specific evaluation of the particular merits of the different indicators was outside the scope of the current work but is an area for future potential activity.

- A pro-active asset management approach requires good quality, interoperable data. International work in this area is currently being undertaken and should be supported by PIARC to aid the implementation of geotechnical asset management systems.

- The work highlighted that a coherent framework is needed for the evaluation of different types of asset. In particular areas of whole life costing, risk management and value management should be integrated. This would enable assets with a low frequency of failure but a high impact on the network (such as geotechnical or structures assets), to be compared in terms of risk and value with assets such as pavements that have a high frequency of failure but a relatively low consequence.

TOPIC 4.5.3

This topic will be addressed in a special session about climatic changes during the World Road Congress. General conclusions will be issued from this session.