XXIInd WORLD ROAD CONGRESS
DURBAN 2003

ROMANIA - NATIONAL REPORT

STRATEGIC DIRECTION SESSION ST1
Road quality service levels and innovations to meet user expectations

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EXECUTIVE SUMMARY

The target of this report of the PIARC strategic topic TS 1 « Road Technology » is to identify innovative techniques to improve the provision and maintenance of road infrastructure in accordance with international best practice.

To meet this aim the report include :

1.A. Road Quality Service Levels

A road network has different types of highways, which can provide a serie of distinct trips, from main movements for heavy and speedy flows or for smaller movements of local access. Because of great diversity characteristics of road networks, Highway Administrations have to establish a hierarcy, a classification of the roads from the point of view of the functional services roads can provide – mobility or access – a functional « classification or level service » in consequences of that, reflecting the pavement and maintenance « service quality level ».

2.B. User Demands

In the last few years the highway network is considered a very important « industry » which use maintenance programmes as PM.S.

User groups – « clients » - consulted, identified as important the following parameters, which reflect engineering best practice for roads quality :

- Financial issues such as road taxes ;
- Services issues such as quality of roads ;
- Environmental issues such as pollution protection ;
- Safety issues such as best signing, traffic management.

3.C1. Surface Characteristics

The surface characteristics of measurement equipment is now automatic processed applied to surveys of road distress. As a remedial of road distresses we have a very high returns of costs.

The actual trand in Romania is that one which is aiming to reconsider the road network in its entire functional integrity and in its intimate connection with the road users and environment.

In these regards Pavement Preventive Maintenance (P.P.M.) is defined as a planned strategy of applying a cost-benefit surface treatments to a structurally sound pavement to preserve the system and retard future deterioration of pavement.

4.C7/8. Road Pavements

With the aim to bring the best service to road users and also to Road Administration during the last four years four significant new road technologies have been developed, experimented and implemented in Romania :

- Bituminous mixes stabilised with cellulose and glass fibres for the construction of wearing courses ;
- Bituminous mixes for wearing courses prepared with modified binders with reactive polymers (SBS, RBS etc.) ;
- The technology of mechanical distruction of existing deteriorated rigid pavement and use of the material resulted for construction of a strong base course for an elastic pavement ;
- Cold in situ recycling with addition of foamed bitumen in conjuction with cement lime and fly ash with very good results.

5.C12. Earthworks, Drainage and Subgrade

1. Risk Management of Existing Slopes

The primary causes of slope instability have been ascertained searching case histories of more then seventheen landslides to inherent of certain geologic formations, ground slope, vegetation, heavy rainfall and snows melt, water regime, clime, human activity for constructions.

Specific details of ground strength and potential driving forces can be ascertained only on site surveys and studies.

The primary causes of slope instability can be used as independent variable and using Regression Theory, other statistical Theory, especially Markovien Theory, can provide a more precise dependent variable the probability, the risk degree of hasard potential of an area.

5.C12. Earthworks, Drainage and Subgrade

2. Road Embankment Construction over Soft Soils

A stabilisation of soft soils as a subgrade layer increase strength and safety, bearing capacity and prevent shrinkage and swell, moisture and frost action.

Well known stabilising agents are cement, lime and fly ash or a combination of lime 3-5% with fly ash 5-25%, which mixed in place with soft soils has as result a flexible layer of 10-30 cm.

Since 1990 such cases we have been developed, experimented and implemented using the Geosynthetics in many embankment constructions.

Specifications and testing before, during and after the works cannot always ensure long term objectives attented, because these rules vary for the specific climate of site, especially for embankment on soft soils.

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1.A. Road Quality Service Levels

Road Administrations uses different classifications of roads, applied for specific purposes such as administrative classifications, route numbering, rural and urban, design types of roads based on geometric features, speed and traffic volumes etc.
A road networks has different types of highways which can provide a series of distinct trips from main movements for heavy and speedy flows or for smaller movements of local access.
Because of great diversity of the road networks, Highway Administrations have to establish a hierarchy, a classification of the road network from the point of view of functional services. They can provide - mobility and access - a "functional" classification or "level of service". This classification have to harmonize the routes with the environment and with traffic security as a comprehensive transportation planning, an integral part of total economic and social development.
Functional classification groups highways is done following the character of services. They can provide: motorway for main movements, distribution (national highways), road collectors and access or termination, in consequences of that, reflecting the pavement and maintenance "service quality level".
It is necessary to establish distinct characteristics of the traffic flow, geometric features of roads, the other functionally classes, the operational speed, the interchanges types etc.
The two major considerations in classifying highway network functionally are mobility and access.
The conflict between serving through trips and providing access to a dispersed pattern of trip origin and destinations, necessitate the differences and graduations of the various functional road trips. Limitation of access is needed on arterials to enhance their primary function of mobility and conversely the local roads provide access as primary function which causes a limitation of mobility for trips.
Concern on the methods to balance the main service quality indicators for the level of user demand are in progress.
We are making a start of the activities for Functional System Characteristics: concepts, criteria and procedure and hope to finish the research by the end of 2003.
The results of road functionally classification established in a large specialists group, show some consistence in relative existents (l990-2001) trips: 60-75% on distribution roads, 20-25% on collector road system, 2-10% on arterial system and 5-12% on terminal road system.

ST 1 – 1 Service Quality Indicators to Evaluate the Level of Response to Users Demand

2.B. Users Demands

In the last few years, the highway network is considered a very important "industry" which use maintenance programmes, a P.M.S. (Pavement Management System). Highway Administrations should use economic and technical criteria to establish maintenance projects to ensure efficient advantages for theirs "clients" and to assist decision making to obtain the minimum whole life cost.
User groups – "clients" – consulted, identified as important the following parameters, which reflect engineering best practice:

- Financial issues of road construction and maintenance programmes, road and vehicle taxes, road and bridge toll rates etc.;
- Services issues including standard of the network and the quality of road works, congestion, delays and travel time and cost, ride quality, accesibility and mobility provision of roadside facilities, overloaded vehicles, the visibility, maintenance for better surface characteristics, bypasses etc.;
- Environmental issues such as landscape and a wildlife protection, noise, visual intrusion, water and air pollution, vibrations etc.;
- Safety issues such as the maintenance of the road network during adverse weather conditions, road lighting and the best signing of flow directions to other functional road services, traffic management and telematics applications.

There is only a weak linkage between the identified needs of road users and the decisions taken by road authorities.
The roads must be considered as just another element in the "industry" production chain and in the same time as a result of this.
The road satisfaction users index has shown in 1998 on a small samples – 1600 people – taking as references the four groups of parameters mentioned the needs of road that users expressed as a score one of 100 are: 8% for financial issues, 37% for servicies issues, 33% for safety issues and 22% for environmental issues.
At national level, road plans are influenced by user groups which demand for speedy and long distance routes, road network development, improved safety, public services and use of telematic informations on roads, environmental mitigation and socio-economic programmes development. At local level the issues are similar but on a different scale and a large particular attention paid to local priorities.
Certainly we have to improve the parameters index to describe road characteristics, risk evaluation, freight transport for rural areas, decision process between Road Administrations and users, better use of existing network, monitoring and level quality assurance, international harmonization of performance indicators etc., and to make much more and larger census to define as global or total the functional and quality demands users expect to encounter.

ST 1 – 1 Road Quality Service Level and Innovations to Meet User Expectations

3 – C1 Surface Characteristics

The major objectives of C1 are to increase the seminal knowledge of the phenomena generated by the interaction of vehicles and pavement and to harmonize and modelize the pavement surface characteristics, which essentialy can provide general pavement behaviour.
The surface characteristics measurement equipment is now automatic processed applied to surveys of road distress.

Remedial measures and improvements surface characteristics to more than 2000 km of national roads rehabilitated in the last 8 years suggest very high returns costs due to improvement of surface of pavement. We have elaborated another inventory of road surface degradations.
The actual trend in Romania is that one which is aiming to reconsider the road network in its entire functional integrity and in its intimate connection with the road users and environment.
This new approach, which is viewed as a continuous management process, led our specialists to the idea of an integrated cyclic approach which includes:

- development of appropriate corrective actions to be intertaken by the Road Agency;
- the quantitative evaluations of the existing road network condition through an integrated approach PMS / BMS under an European Development Program for Romania (ANTRANS);
- development of specific road quality service levels;
- development of specific investigation methods and indicators to evaluate among road users their objective perception and opinions and of how road services are meeting users objective of the public – clients – expectations.

In these regards Pavement Preventive Maintenance (P.P.M.) is defined as a planned strategy of applying a cost-benefit surface treatments to a structurally sound pavement to preserve the system and retard future deterioration pavement.
In Romania P.P.M. is the primarily maintenance works applied early by 1980 and involves the timely application of carefully selected treatments to maintain pavement service life. These treatments may include various types of surface seals, thin lift overlays, crack sealing for asphalt pavements and crack and joint sealing for concrete pavements etc.
The key is to apply the treatments when the pavement is still in good condition, with no structural damage, especially when weather conditions are high-priorities needs.
Preventive maintenance must be applied with a right treatment, to the right road and the right time to improve safety, ride ability, fewer or less frequent repairs to add more additional years to pavement life.
Romania has to increase workers and engineers training and to develop additional research into new and improved techniques.

ST 1 – 2 Road Quality Service Level and Innovations to Meet User Expectations

4 – C7/8 Road Pavements

New road technologies and the management of repairing, maintenance and rehabilitation works are applied in order to provide the best service to road users
With the aim to bring the best service to road users, during the last four years three significant new road technologies have been developed, experimented and implemented in Romania, as follows:
The development of technical specification for a specific Bituminous Mixes Stabilised with Cellulose Fibres, type SMA: MASF 16 & MASF 8, and their implementation for the construction of the wearing courses for all road rehabilitation projects in this country. This type of mix have proved to be the first one which could accommodate the specific climatic and traffic conditions of the Romanian road network (e.g. very severe winters, very hot summers and exponential growth of heavy traffic).
It was developed and experimented road pavement mixtures prepared with various binders modified with reactive polymers, more suitable and much more efficient than the binders modified with the common inert polymers type SBS, RBS, IRS etc. A series of significant experimental road sectors have been performed during the last four years on the public road network and also on the circular Accelerated Road Testing Facility existing at the Technical University “Gheorghe Asachi” of Iasi, with positive results, which are justifying the extension of this valuable technology to the existing road works, especially on principal and European Roads, subject to heavy traffic.

It was applied the technology involving the mechanical destruction, by using appropriate equipment, of the existing deteriorated rigid pavements by the so called “slabs’ de-tension”, followed by appropriate, in situ, compaction and the use of the material, resulted in this process, for the construction of a strong base course, in the process of the rehabilitation of the existing rigid road pavements.
Assesment of slurry-seal and comparisons of differents methods of the anti-reflective cracking on both asphalt and concrete pavements are by now not concludent after six years.
Cold in situ recycling with addition of bitumen binders and sometimes using foamed bitumen in conjuction with cement, lime or fly ash are very good results.
User demands include safety surface pavement and performance, travel time and cost, work cost and duration.

ST 1 Service Quality Indicators to Evaluate the Level of Response Users Demand

5 – C 12 Earthworks, Drainage and Subgrade

1. Risk Management of Existing Slopes

The basic causes of slope instability have been ascertained by studying case histories of landslides. The primary causes are related to inherent properties of certain geologic formations, ground slope inclination, vegetations, heavy rainfall and snow smelt, water flow and water table regime, the clime, the humidity areas with specific vegetations, human activity for constructions and some types of catastrophes.
Terrain reconnaissance techniques are used as the first level for identification of landslides after the research on topographic maps which contain detailed ground contour data, on geological maps, color photography or infrared film etc.
Specific details of ground strength and potential driving forces can be ascertained only from site surveys and studies. Typical procedures employed in this phase must include drilling, sampling, coring, in situ testing and others devices for rate of ground movement, level of water in ground and pressure etc.
In Romania we have developped since 1975 a regional inventory of topographic and geological maps which shows an approximative approach of hasard potential landslide of an area.
Now a National Group is in progress and has established on the basis of case histories over 70 landslide produced since 1975, that the main causes of landslides, geologic formations, ground slope inclination, vegetation, clima and hydraulic regime can be used as independent variables which used them in a mathematical-statistical model studies as Multiple criterial methods, Regression theory, theory Markovien, Expectance theory, Value Engineering theory approach etc., can provide a more precise dependent variable from over 70 landslides, the probability, the risk degree of hasard potential landslide of an area to prevent it.
The contrameasures of landslides already designed and constructed for both pre-failure conditions and post-failure conditions, as surface and subsurface drainage, retaining walls, vegetation, increase resistances to landslide and decrease of active forces etc.

ST 1 Service Quality Indicators to Evaluate the Level of Response Users Demand

5 – C 12 Earthworks, Drainage and Subgrade

2. Road Embankment Construction over Soft Soils

The stabilisation deals a large area of activity but in road technology is that dealing with soil stabilisation, a physico-chemical treatment of unsuitable of soft solis, especially five grains humide soils, combinations of clay, lean clay, lean sandy clay or silty lean. The target of soil stabilisation is to improve such solis which by their nature are unsatisfactory for the pavement but became suitable after stabilization as a subgrade layer. A stabilisation soil as subgrade, means also more increased strength and stability of the subgrade under the climat variations, moisture, absorbtion and frost action.
Subgrade stabilized layers increase strength, prevent shrinkage and swell and increase bearing capacity.
Stabilizing agents well known are cement, lime and fly ash and the subgrade is considered a flexible layer.
The soft soils, very humide and high plasticity can not be succesfully used because of difficulty to obtain a well mixed stabilised cement soils.
Lichid limit must be under 40% and the content of fine particles under 5 mm over 55% and very fine particles less than 0,5 mm between 5-35%.
Fly ash and unhydrated lime are supplimentary cementations agents which can or not be used in combination with cement. Good results we have obtained using 3-4% of unhydrated lime and 5-25% fly ash in layers of 10-30 cm thickness.
The table shows the characteristics of poor soils – clay, lean sandy, silty lean etc., which are used in subgrade layers.

Materials	**Humidity**	**Frost susceptibility**	**Quality**	**Thickness higher (m)**	**CBR %**	**E daN/cm^2**
Sand Gravel Stone etc.	-	-	Very good to Excelent	-	15-80	50-800
Poor soils	W_{opt} + 5-15%	Medium to High	Unacceptable	1-10	2-10	< 30

The choice of proper admistive which should used depends by some number of laboratory tests which simulated field conditions and to obtain a minimum of 5% CBR.
The performance required of embankments is defined in terms on long term capacity, slope stability and limited settlements. Specifications and testing during and after the works cannot always ensure long term objectives attended because these rules vary for the specific climate.
If the conditions shown above in the table of the thickness of soft soils are higher and the CBR are less than 2% we have used classic methods for road embankment construction such as granulary, in or not addition with lime or cement columns.
Also in some particulary conditions can be used a high degree of compaction or sandwich method – succesivilly by layers of soft soil and dry granular materials.
Since 1990 in such casses we have been developed, experimented and implementated a new approach in Romania, the Geosynthetics technology.
The geogrids, geocomposites and geosynthetics were usually placed within a large layer of granular materials to support the embankment weigth on soft soils.

Physico-mechanical and chemical characteristics of geosynthetics are determined before and during use and technical issues as water pore pressure, stability, vertical and horizonthal deformations and settlements are continuously provided for embankments.
We use also geosynthetic technology for embankment such as: filtration within the drainage ditches, erossing control and biosintheticks geocomposite, rock falls, retaining walls with a three dimensional poliamide matting, placed behind the geocomposite and closing the square geogrid structure, retaining walls of soil reinforcement using three dimensional poliamide geocomposite etc.

CONCLUSIONS

1. Economic development is more and more linked to road transport and calls for an increase in capacity of road network, for parameters which need further studies of the functional level of service, structural or global condition for the level of services that the road networks can offer to the users, mobility and access, in consequences of that, reflecting the pavement and maintenance "service quality level".
2. The highway network is considered a very important "industry" and the "clients" consulted found as important parameters four issues: Financial, Services, Environmental and Safety, which need more logistic support.
3. New methods for pavement survey and assesment of the condition of highway network are considered regarding the new techniques, materials and methods for strengthening and maintenance of roads. The Pavement Preventive Maintenance (P.P.M.) is defined as a planed strategy of applying a cost-benefit surface treatments to a structural sound pavement to preserve the system and retard future deterioration of pavement. We have to improve P.P.M.
   The result are a reduced cost at minimum 30% of maintenance, an increase of the life duration of pavement the number of performanced surveys of network works.
   The use of multifunction vehicles carrying out measurements, use of nondestructive road techniques and use of models for preventive degradations, are in progress.
   It is necessary to promote international cooperation for recognition of same methodology.
4. With the aim to bring the best service toward user and also Road Administration, during the last four years we have been applied new technologies with very good results: Bitumen concrete using cellulose and glass fibres, bituminous mixes using polymers, reused of deteriorated concrete pavement, cold in situ recycling are current used.
   Technology transfer must be improved.
5. The National Group for Risk Management since 1990 took into considerations the primary causes of slope instability and use them as independent variables. Using statistical theories, especially Markovien theory. We hope to obtain a more precise dependent variable, the probability, the risk degree of hasard potential slide slope of an area to prevent it.
6. We use classic and modern methods for Road Embankments over soft soils.
   High degree of compaction, sandwich method, granulary in or not additions with lime or cement in columns since 1990, successfully in expansion Geosynthetics in all kind of embankments: filtration, biosintheticks geocomposite, retaining walls support of embankment weigth on soft soils etc.