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MANAGING ROAD ASSETS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE ADAPTATION

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ABSTRACT

It is obvious, also for the Hungarian decision makers, that high level management is badly needed for securing good road quality and favourable traffic conditions while satisfying road user needs. That is why the main objectives of road asset management are the preservation of the nation’s valuable road assets as well as the continuous meeting of road user’s expectations. In this field, various researches, and drafting of new specifications were carried out in Hungary during recent years. The most important ones are summarized below.

1. QUALITY OF ROADS AND SUSTAINABLE DEVELOPMENT

The responsibility of the Hungarian national road network authorities is to ensure that the road infrastructure is in such a condition that it provides safe, comfortable and economic transport of persons and goods; this has often been constrained by budget restrictions. In view of the expectation of national and regional, social and economic advantages, the road administration has recently decided to accelerate the construction of the missing elements of the motorway network. As a consequence, public funding allocated to the maintenance and rehabilitation of the existing road infrastructure (excepting motorways and expressways), have been kept far below the appropriate level.

Acknowledging this very fact, a National Road and Bridge Rehabilitation Programme (NUP) was elaborated and published in 2008, providing a base for planning the measures needed to improve road conditions for the period 2009-2020. It relied on the data available in the Hungarian OKA2000 road data bank. The main objectives of NUP were: preparation of decisions of high national economic significance for maintaining and improving the conditions of the national road network; compilation of a comprehensive plan for gradually eliminate road maintenance backlogs accumulated over decades taking into consideration technical, economic and environmental issues. Road management analysises were made using the HDM-4 model, while the PONTIS program was used for bridge management investigations.

Prior to the strategic road network analyses, data connections between HDM-4 and the National Road Data Bank OKA2000 were created by means of dedicated preparatory data input software. For 38 nearly homogeneous network links, the road sections with various condition levels were linked to typical rehabilitation techniques, favouring environmental-friendly variants with high recyclability content considering also their mean unit costs. (The deterioration models in HDM-4 were scrutinized, and replaced by pavement performance models based on 20-year performance data related to trial sections monitored by KTI Non-profit Ltd, Budapest). A special methodology was developed allowing to include into the Programme the roads with less than 1000 PCU/day AADT values, otherwise – based on efficiency - the model would not have recommended any condition improving measure for such roads.

First, strategic analyses were performed for the period 2009-2020, followed by a program level investigation for a 4-years period. Main steps of the strategic network analysis were as follows:

- determination of the economically most effective technologies related to the 38 network links up to 2020, assuming unconstrained budget,
- forecast of the performance of the road network without any rehabilitation works carried out in coming years,
- in the third strategic variant, road performance was forecast assuming the present (2008) yearly rehabilitation budget remain unchanged,
- the objective in the fourth scenario was to achieve by the end of the period under consideration, the present average road conditions prevailing in the European Union, according to optimal funding,
- finally, the yearly road rehabilitation budget needed to maintain the present average conditions was identified carrying out a series of calculations with HUF 10 billion (EUR 33 million, USD 50 million) steps.

As a result of the strategic analysis the yearly road rehabilitation budgets required for each scenario were determined, as well as the total length of road sections to be rehabilitated and the average IRI-values (the yearly change of average IRI-values in the case of the 5 scenarios is presented in Figure 1). Concerning the bridges, the required maintenance and rehabilitation costs were investigated separately. As additional national economic advantages, the savings in vehicle operation costs and costs of travel time, as well as the reduction of air pollution and fuel consumption were also taken into consideration. According to the results of the analysis HUF 70 billion (EUR 250 million or USD 320 million) road rehabilitation costs and HUF 18.1 billion (EUR 65 million or USD 85 million) bridge rehabilitation costs should be financed in Hungary yearly, to achieve by 2020 the average level of road conditions prevailing in the European Union currently..

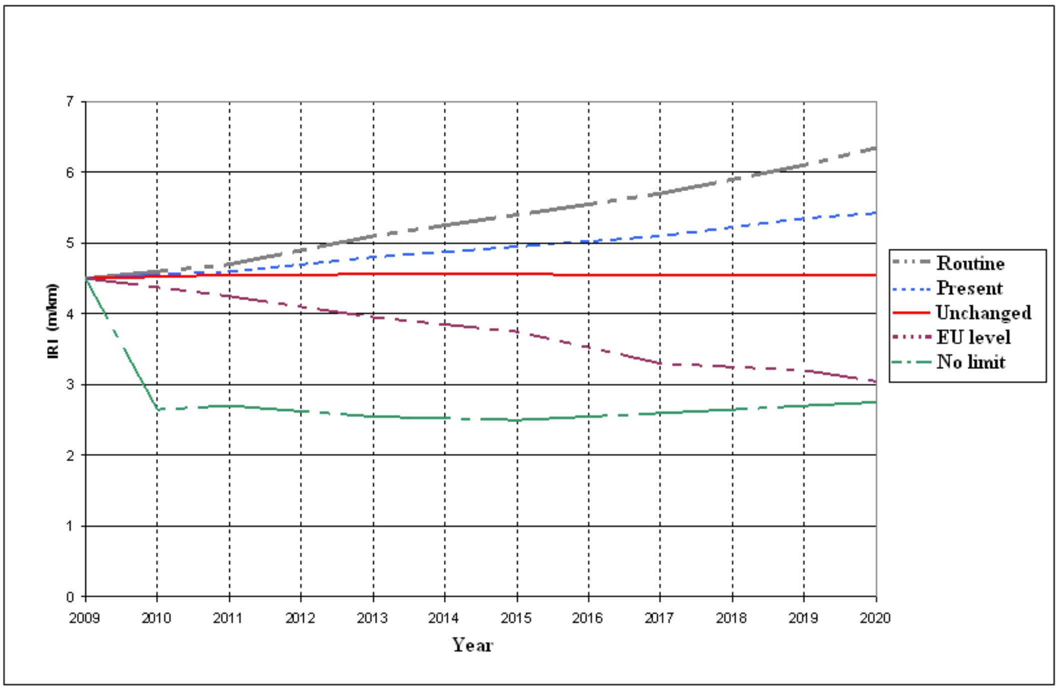

Figure 1- Yearly change of average IRI-values according to the 5 strategic scenarios

After completion of the strategic analysis, a programme level investigation was performed for the 2009-2012 period in order to put together appropriate lists of projects to be implemented. First, a list of main road projects was developed. When establishing the list of secondary road projects, only roads with AADT values exceeding 1000 PCU/day were dealt with. The lists of county road projects were only tentative, because other local aspects would have to be taken into consideration when finalizing the actual road rehabilitation programme. The length of a road rehabilitation project had to reach 3 km unless the total length of the road was shorter.

For the investigation of roads with low-traffic volumes, a normative-type methodology was applied. Data taken from the road data bank, (like the IRI-values characterizing unevenness,, the ratio between actual and allowed deflection values, as well as the degree and extent of cracking) were averaged for approximately 1.0 km long project-elements as a base for normative classification. As a result a qualification score has been determined, which then was linked to a well defined rehabilitation technology (e. g. one or two asphalt overlays, or pavement replacement) and its unit cost (HUF/m^2) which comprises also the costs of drainage and traffic engineering measures on the top of the actual costs of pavement rehabilitation). The efficiency of a given project element was defined as the traffic performance/total cost rate. As a result, according to the strategic programme variant aiming to achieve by 2020 the average road conditions prevailing in the EU today yearly HUF 28.7 billion (EUR 100 million or USD 130 million) is needed yearly during the first 4 years of the period under consideration.

KTI Institute for Transport Sciences Non-profit Ltd. carried out a multi-year research to evaluate the relationship between road pavement conditions and road accidents. All traffic accidents with personal injuries, occurred on the 31 000 km-long national road network over a 10-year period were taken into account, investigating whether there are any relationship between the number and/or severity of road accidents and the quality of pavements (condition parameters, and type of road rehabilitation technologies applied previously on the road section under scrutiny).

The results were obtained by linking the relevant information stored in the National Road Data Bank OKA2000 and that of the Road Accident Data Base. Traffic safety consequences of road rehabilitation technologies were assessed by comparing the characteristics of all road accidents occurred over a 3-year long period before and after carrying out the rehabilitation works.. The main results of the comprehensive investigation based on processing of several million data are the following:

- there was no significant relationship between some parameters related to the condition of a road pavement, like bearing capacity, longitudinal unevenness and surface deficiencies and the number and severity of accidents, occurred on the road section under scrutiny (dealing with light, serious personal injury accidents, and fatalities separately).,
- rut depth made the accident situation slightly worse if the road traffic was relatively high, this relationship is significant, however, within certain limits,
- macro and micro texture scores characterizing skid resistance of the road pavement surface, can be related unequivocally to the number and severity of road accidents; so improvement of this parameter resulting from road rehabilitation may lead to a significant reduction of accident costs,
- asphalt overlay usually leads to more road accidents and increased traffic safety costs, due to the generally increased speed following the intervention,
- surface dressing improves traffic safety, since the skid resistance of the pavement surface will be significantly increased after this intervention,
- the rehabilitation works carried out on motorways generally improve traffic safety, because resurfacing does not increase traffic speed, since the design speed achievable safely by the vehicles before and after rehabilitation remains usually the

same; hence a more even and more rough pavement surface yields positive consequences from the point of view of traffic safety,

- a reduction of road accident costs was detected following resurfacing of an excessively uneven road pavement,
- extension of accident investigations onto the whole length of the roads (instead of focussing onto their sections where accidents occurred) has not given definite answers to the question whether the rehabilitation of the pavements may improve further the overall tendencies concerning traffic safety observed countrywide. (The increase of both the number and severity of accidents could also be attributed to the growth of traffic volumes over the 4-years elapsed).

2. MANAGING ASSETS AND SUSTAINABLE DEVELOPMENT

The 31,000 km long national road network is under the management of the Ministry dealing with the transport sector (currently the Ministry of National Development).., Aiming to increase the efficiency of the management of road assets, several organisational measures were taken recently. The tasks of KKK (Centre for Co-ordination of Transport Development) are to manage and co-ordinate the activities related to the national road network following directives of the Ministry, as well as to harmonise the main decisions taken related to the railway network. NIF Zrt. (National Company for Infrastructure Development) deals with the development of transport infrastructure. AAK Zrt. (State Motorway Managing Company) operates, maintains and rehabilitates the majority of Hungarian motorways and expressways network, which has currently a total length of approximately 1.050 km. (Two motorways are managed and operated by private concessionaires).

MK Zrt. (Hungarian Public Roads Company) with its 19 county directorates manages the national public roads (except motorways and expressways). Compared to the former decentralized management system, the new organisation ensures the harmonization of the best road management practices all over the country, and the distribution of emerging new technologies in every county. Unlike routine maintenance and operation, new construction, rehabilitation and major maintenance are carried out by private firms selected and engaged through competitive public procurement. It is planned to launch experimental tenders for road maintenance and operation in the near future, allowing the participation of private firms too. MK Zrt. carries out the systematic condition assessment (monitoring) of the national road network, as well as the independent quality control of road construction and maintenance.

An eventual reduction of the present length of around 31,000 km of the national road network down to 6,000-6,500 km is being investigated. This latter length is considered to fit more realistically with the size of the country (93,000 km^2).

3. IMPACT OF CLIMATE CHANGE ON THE PERFORMANCE OF THE ROAD ASSETS

In Hungary – as in most other countries – climate change represents a serious challenge to every sector of the national economy including road engineering. Intensive research has started recently to explore ways how to eliminate or at least mitigate the detrimental effects of extreme meteorological events. At the same time, concentrated measures have been taken to reduce CO2-emissions which are directly related to the phenomenon of climate change. The nationwide economic significance of these activities can be emphasized by the fact that global warming in Hungary, according to the regional climate change model, exceeds the world average by 20%. During spring and summer in 2010 extreme meteorological events (hurricanes, deluge type precipitation) occurred 3 to 4 times more frequently than the same periods in preceding year. As a consequence, flooding caused road damages at an unprecedented extent.

The problems related to climate change can induce two types of measures. First, the so-called mitigation actions are meant to reduce the expected negative effects by decreasing greenhouse gas emissions which are considered to be the main cause of climate change. The other group of measures is that of adaptation, envisaging countermeasures aiming to eliminate or at least to reduce the negative consequences of climate change.

The Hungarian road administration relies on the results of research carried out by experts in the field, who proposed the following mitigation strategies and measures:

- carbon taxation (fuel tax),
- CO2-emission trading,
- evaluation of CO2-reduction,
- harmonization of policies related to energy, climate change, and sustainability,
- improving the safety of energy supply by motor fuel diversification,
- improving the energy efficiency of vehicles by 20% up to 2020,
- reduction of greenhouse gas emission by 20% up to 2020,
- increasing the share of renewable energy (bio-fuels) by 20% up to 2020.

The following specific instruments are planned for the transport sector: motor vehicle taxation as a function of CO2-emission; motor vehicle taxation as a function of CO2-emission; infrastructure user changes with differentiation or mark-ups for CO2; further development of the relevant regulations and standards taking into consideration climate change effects. In addition, indirect effects can be expected from an appropriate development of transport infrastructure, efficient planning of land-use influencing transport demand and the development of new vehicle technologies.

When adapting the road sector to, and minimize harmful effects of expected climate change, several measures were taken already, or are planned:

- strategic, risk based approaches for investment decisions when redesigning and retrofitting transport infrastructure,
- inventory of critical infrastructure (mainly roads) vulnerable to the effects of climate change that provides a complex condition evaluation for supporting future measures,
- integration of extreme weather information into available public information systems,
- development of sophisticated programmes for short and medium-term adaptation strategies for vehicle fleets and road infrastructures,
- integration of emergency planning into operation,
- impact of wider use of air conditioning in vehicles,
- the present economic crisis makes it possible to replace (renew) aged road vehicle fleets and to introduce new, more efficient technologies. (The financial support of the European Union expected in this respect).

The following climate change elements can be taken as serious threats for road infrastructure:

a) extremely high air temperature,

b) extremely low air temperature,
c) extreme precipitation,
d) extreme hydrological features,
e) excessively strong wind-storms.

ad a.) An important climate change element is global warming. Of the global climate models, PRUDENCE project forecast more intensive warming for Hungary than the global average. For the period 2070-2099, the minimum yearly mean temperature is expected to increase by 1.4^{o}C, compared to the period of 1961- 1990. This increase is expected to be the highest (1.7^{o}C) in summer, and the lowest (1.1^{o}C) in spring.

According to these forecasts, taking into consideration global warming cement concrete pavements are preferred against asphalt variants. (The resistance of asphalt pavements to permanent deformation decreases in those less favourable environmental conditions). The condition of concrete pavements with hydraulic binders is not influenced by increases of mean summer temperature. If the asphalt variant is selected, the use of a harder type bituminous binder with higher softening point, and the design of a binder content lower by some 0.1 mass per cent comes into consideration.

ad b.) The road sector has to be prepared to manage the more frequent occurrence of air temperatures below -15^{o}C, which are considered to be extremely low for our region. Here also cement concrete pavements come into the foreground. Good performance can be expected even in these climatic conditions, due to the insensitivity of this pavement type to extreme temperatures.

In very cold periods, the danger for frost increases. Slightly cohesive soils, especially calciferous loess, can be considered frost sensitive. The frost depth of dry soils exceeds that of wet, cohesive soils. When selecting pavement type, it should be taken into account that asphalt pavements are more heat-insulating than other pavement types resulting in an elevated frost line because of reduced frost penetration. This fact can be significant particularly for pavement structures on low-volume roads.

As a consequence of the Hungarian hydro-meteorological conditions, anti-frost layers have not been incorporated into new pavement structures when the total thickness of the pavement structure exceeds 500 to 600 mm, independently from sub-grade soil type.

One of the “positive” consequences of climate change in Hungary is an expected reduction in the frequency of freeze-thaw cycles, thus having a lesser impact on pavement structures than before.

ad c.) Two forms of extreme precipitation can be considered: a significant increase in yearly precipitation (higher probability of intensive rain or snow) or significantly less precipitation than before.

More length and/or locally very intensive rains can damage the road pavement structure immediately or at a later stage. Intensive rain makes road construction or maintenance difficult or, eventually, impossible. The highest resistance to this phenomenon can be expected from hydraulically bound layers.

Effective road drainage systems will become even more important than before, such as longitudinal or transversal slopes, and superelevation of pavement surfaces; shoulders with higher transversal slopes and even surfaces, ditches and public utility networks with adequate capacity; operational culverts, chutes, collecting (belt) ditches etc.

The traffic safety can be influenced – as it is well-known – by the following pavement defect types: insufficient skid resistance of pavement surface, deep ruts, potholes or local deficiencies of pavement surface; the first two increase the risk of serious accidents on wet pavement surfaces.

Typically, intensive periods of snowing can be expected in Hungary from the second half of December requiring some anti-skid measures to be taken. Thick snow layers are removed by snow ploughing. A particular problem can occur when strong crosswinds disperse some of the roadside snow onto the road pavement in a cut. Snow fences which are typically 1.0-1.5 m high, positioned along the road section to be protected against snowdrifts, and thus used as a protection technique can become more important than before due to the consequences of climate change; roadside hedges and wood belts can also provide an effective solution.

One of the consequences of climate change can also be a decrease in total precipitation, while, although rather rarely, the rain can be very intensive. Consequently, more frequent and longer hot and dry periods can be expected with the following consequences for road engineering:

- the construction season for cement concrete pavements is shortened,
- newly laid asphalt pavements layers cool down more slowly due to the high ambient temperature, and may delay the opening of the road to traffic,
- on the surface of asphalt pavements, the asphalt mortar is pushed out to the surface of asphalt pavements more frequently after the passing by of heavy vehicles which could cause serious traffic hazard in terms of skidding,
- unprotected slope surfaces dries out, and may crack due to the hot air temperature, jeopardising their water impermeability and stability.

ad d.) Global climate change also influences the hydrological conditions since sustained, high intensity precipitation can increase the discharge in water-courses, endangering the nearby road infrastructure. As a consequence, sub-grades can become saturated resulting in a significant loss in bearing capacity which can lead to the quick deterioration of pavement structures. If the level of flooding is above the pavement surface, the whole pavement structure may fail requiring total reconstruction.

Changes in the hydrological conditions can decrease the efficiency of the road drainage system. The high quantity of precipitation can also lift the groundwater level which can considerably increase the water content in sub-grade and/or unbound base layers causing the bearing capacity of the pavement structure to decrease.

ad e.) Another frequent extreme meteorological event can be severe wind-storms, such as hurricanes (such high-velocity winds have occurred recently where the wind speeds approximated those of a hurricane resulting in fatalities). Strong wind can be a major obstacle to road construction, rehabilitation and/or maintenance. It is recommended that the contractor monitor the relevant meteorological forecasts in order to prepare himself for such events.

Road traffic can be dangerous during very windy periods since dust coming from the shoulder, and nearby agricultural fields can significantly reduce visibility. Also, the stability of two-wheeled vehicles is directly endangered by strong side-wind. Hurricane-like winds can break roadside trees or columns which, when they fall on the pavement surface, can lead to fatal accidents.

In 2009, the KTI Institute for Transport Sciences Ltd. reviewed road-related Hungarian standards and technical specifications to assess whether further developments were needed to account for more frequent, extreme meteorological events resulting from climate change. The critical issues were identified, and the direction of changes of requirements and criteria was proposed in broad terms. In the near future, Hungarian standard committees will be set up to carry out the required changes.

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