XXIIIrd WORLD ROAD CONGRESS
PARIS 2007

HUNGARY - NATIONAL REPORT

STRATEGIC DIRECTION SESSION ST4

ASSET MANAGEMENT: TECHNICAL INPUTS TO DECISION MAKING

Dr. L. GASPAR
KTI (Institute for Transport Sciences), Budapest, Hungary
gaspar@kti.hu

ABSTRACT

No complete Asset Management framework is used in Hungary yet, due to several administrative, budgetary and economic reasons. However, several activities can be mentioned that have moved the country towards an asset management approach during recent years. They are linked to owner's objectives and customers needs, institutional framework changes, business arrangements, and technical tools.

Using concentrated resources, the development of the Hungarian motorway network has been accelerated recently. As a consequence, the general condition of "ordinary" roads (others than expressways and motorways) has been deteriorated. A National Road Rehabilitation Programme was elaborated for 2007-2016. By implementing the projects identified in the Programme, it is expected to reach the present average road condition level of the European Union.

The users' needs were surveyed by an enquiry carried out in a Hungarian county where public transport bus drivers were questioned about the condition of the roads travelled regularly. Their opinion was taken into consideration for the local short-term road maintenance programme.

The estimation of gross and net values of national road and bridge assets started in Hungary in 1981, and the survey has been repeated regularly ever since. The time series of net/gross asset value ratios of national road and bridge assets are used for road management purposes. A "survey of compliance" (rating the condition of a given road by comparing its actual condition parameters to those required by the standards), has been launched on the whole Hungarian national road network in 1979, and the main condition parameters have been measured regularly ever since.

After a recent reorganisation, the maintenance and rehabilitation of the "ordinary" national roads is performed country-wide by a new non-profit company. Other special companies are responsible for motorway network development as well as for motorway maintenance and management.

Road and bridge works are traditionally contracted out through competitive procurement to private contractors. A major new motorway project is financed, and built within a public/private partnership scheme in 2004-2006. The motorway toll collected under a vignette system is actually used for financing of maintenance and management of the motorways managed by a State owned company.

The first network-level PMS had been elaborated by 1990 and developed further, based on the experience gained and on the Finnish HIPS-model relying also onto Markov transition probability matrices. Ranking type, project-level Motorway PMS and City PMS were also created. The HDM-4 model has been investigated and adapted to Hungarian conditions too. The American PONTIS bridge management system was adapted and developed further.

A 16-years long monitoring of 60 test sections has resulted pavement performance models and provided information about the actual condition improving impact of various rehabilitation techniques.

So, the technical tools in Hungary are available to assist asset management decision making, based on detailed and reliable information.

1. INTRODUCTION

No complete Asset Management framework is used in Hungary yet. The following obstacles hampering its development can be mentioned:

- competent authorities did not recognise yet the real importance of asset management,
- administrative measurements related to asset management are often driven by "political" decisions,
- permanent road budget deficit makes difficult to develop and implement risk sharing, life-cycle costing and other progressive techniques,
- actually the bulk of available resources is spent to finance an accelerated development of the expressway & motorway network, therefore the maintenance and rehabilitation of existing assets is deeply underfunded,
- the integration of various components of an Asset Management system (like PMS and BMS) is hindered by the lack of generalised economic parameters,
- it is difficult to quantify the benefit obtained by developing appropriate technical tools to decision making.

However, there are several major and useful activities, policy changes, researches which could be identified and qualified, proving that Hungary moved towards the elaboration and establishment of an asset management approach during the past years. These can be grouped in the four main topics of an Asset Management framework, as follows:

a) Owner's objectives and customers' needs
b) Institutional framework changes
c) Business arrangements
d) Technical tools.

2. OWNER'S OBJECTIVES AND CUSTOMERS' NEEDS

The main objective of the State and the municipalities, being the owners of the Hungarian national public road network is, of course, to provide a transport infrastructure in good conditions for use, allowing safe, comfortable and economic transport of persons and goods. Due to budgetary constraints, however, this complex target has been only partially respected. Aiming to obtain the expected social and economic benefits at national and regional level, the highest priority is actually given to the accelerated development of the missing links of the Hungarian expressway & motorway network. That is why, much more limited amount of resources was made available for the maintenance (rehabilitation) of the existing "ordinary" road network (other than expressways or motorways).

It is well-known that the objective of an asset management approach is to optimise the maintenance and operation of the road network. This can not be realistically aimed at in Hungary under the prevailing conditions. Nevertheless, the high level Hungarian road administration already recognised the dangers represented by the ever worsening conditions of the ordinary road network, and initiated the elaboration of a National Road Rehabilitation Programme for 2007-2016. It is intended to reach the present average road conditions of the European Union by implementing the projects listed in that Programme. Performance indicators' target values were identified, differentiated for main roads and secondary roads, which are to be reached by 2016, taking into consideration the pavement deterioration meanwhile. Minimum traffic lane widths were also included among the performance indicators' target values. Bearing capacity and lane width requirements were determined for bridges too, on main roads and secondary roads as well.

The users' (customers') needs were surveyed by an enquiry carried out in a Hungarian county where public transport bus drivers were questioned about the condition of the roads travelled regularly. Their opinion was taken into consideration for the short-term maintenance programme of the county's road network. User complaints collected by county road managing offices are also used for maintenance policy setting.

In order to ensure the planned assets will meet real user needs, the construction of new motorway sections is preceded by extensive public enquiries allowing all stakeholders to express their opinion, including the environmental lobby ("greens").

The proper management of the road assets presupposes an appropriate knowledge of the technical and economic parameters of the network. That is why, the estimation of the gross and net values of national public road (and bridge) assets started in 1981, and that survey has been repeated in every 5-6 years since, using practically unchanged methodology. The time series of the net/gross national public road & bridge asset value ratio (N/G, %) data provided a clear picture about the overall trend of pavement and bridge deterioration (N/G = 66.7 % for roads and 75.9 % for bridges in 1981; while 59.4 % for roads and 49.2 % for bridges in 2004). Some details can be seen on Table 1.

Table 1 – Evolution of net/gross asset value ratio (%) of Hungarian national public roads and bridges between 1981 and 2004

Net/gross asset value (%)	1981	1986	1990	1995	2000	2001	2004
Roads	66.7	61.7	58.8	60.1	62.5	62.1	59.4
Bridges	75.9	70.7	66.8	56.9*	55.8	54.6	49.2
Roads + bridges	67.4	62.5	59.4	59.8	62.1	61.8	59.4

* Slightly different evaluation technique from 1995 on.

Comparing the existing parameters to the standardised ones, a so called "survey of compliance" of the national road network started in 1979. A visual evaluation of pavement surface defects and measurement of main condition parameters (pavement bearing capacity, unevenness, rut depth, micro and macro texture) have been performed since, in every 3-5 years. An inventory of the public road assets was also prepared in 1981, and the yearly changes have been also registered since that time.

The National Road Data Bank –modernised in 2001 – stores the main data necessary for decision making related to the assets. More detailed information on their respective public road and bridge assets can be found in the data banks of 19 county road management offices, which they utilize for decisions at local level.

3. INSTITUTIONAL FRAMEWORK CHANGES

The national road network of 30 000 km is managed by the Road Transport Division of the Hungarian Ministry of Economy and Transport, including the allocation of available budgetary resources. A new distribution of tasks and consequently, a kind of reorganisation took place in 2005. Presently, UKIG (Directorate for Road Management and Co-ordination) has the responsibility for the management and co-ordination of national roads, while the main directives in this respect are set by the Ministry, the policy maker. NA ZRt. (National Motorway Company) is dealing with the development of the national road network. AAK ZRt. (State Motorway Management Company) carries out, administers and controls the maintenance and rehabilitation of expressways and motorways. Two motorways (M5 and M6) are managed by private concession companies. The maintenance and rehabilitation of the ”ordinary” road network has been fully centralised recently. Magyar Kozut Kht. (Hungarian Public Roads Non-profit Company) has actually a country-wide responsibility, operating local offices in all 19 counties. (Until 2005 the county road directorates, lately management companies had been only partially dependent upon the central road administration.) This new institutional framework is expected to allow the implementation of uniform road management practice around the whole country, furthermore to facilitate the distribution of new technologies and best practices.

Except for routine maintenance and operation, new construction, rehabilitation and major maintenance works are contracted out to private companies, through standardised public procurement.

Regular collection of data reflecting actual road conditions, as well as independent quality control of road construction and maintenance works is contracted out also by Magyar Kozut Kht.

4. BUSINESS ARRANGEMENTS

Works related to the national road network are traditionally financed by the State, contracting them out with a generally 3-year-warranty period. Adding to those completed in the nineties, a major motorway construction project (M6, 58 km) was funded and executed by the private sector, under a public/private partnership scheme in 2004-2006. After a 22 years long concession period, the facility will be transferred back to the public road administration. The concession company will receive regularly a so-called availability fee, which could be reduced if not all agreed performance indicator values (e.g. rut depth, IRI) are attained. (Other motorway projects using similar PPP financing structure are planned in the near future).

It is interesting to mention the dispute and the agreement reached between political decision makers and the concessionaire. In October 2004, the winning consortium signed a Concession Contract with the Hungarian Ministry of Economy and Transport for the financing, construction and operation of a 58.6 km long M6 motorway section to be completed by May 2006. The agreed pavement structure comprised asphalt layers with a total thickness of 20 cm above a lean concrete base course of 20 cm. The use of 750 000 m^3 blast furnace slag embedded into the motorway embankment was also agreed upon in the Concession Contract, as a brand new technique in Hungary. In May 2005, the concessionaire requested the modification of the original pavement structure, increasing the thickness up to 24 cm and using a 25 cm thick mixed-in-place cement stabilisation base course. The main objective was to accelerate the works in order to meet the tight deadline. Based on experts’ opinion, the minister requested a preliminary justification that specified strength and homogeneity levels could be reached by the proposed technology. Several test sections were constructed to prove that every requirement could be met. Since these attempts have not been fully successful, the minister declined definitely the request in September 2005. The main reason of refusal was that justification, whether this technology, never used in Hungary before, is appropriate or not, was apparently not convincing enough. Later on the concessionaire requested the eventual maintaining of 13 mixed-in-place stabilisation base course trial sections, built by using various recipes. The minister agreed to maintain them (they had not to be removed with the asphalt layers above), provided they should be monitored by an independent institution during a 5-year period, in order to prove their performance is not worse than that of the others built into the pavement of the motorway, using a different technology.

The users of the Hungarian motorways have to purchase a vignette which should be displayed on the windshield of the vehicle, and entitles the vehicle to ride on all Hungarian motorways within a given period. 1 day (only for HGVs above 12 tons), 4-day (only for cars), 10-day, monthly and yearly vignettes are available for 4 categories of vehicles. The motorway toll collected is used for financing the maintenance and rehabilitation of the expressways and motorways managed by AAK ZRt, totalling about 900 km.

5. TECHNICAL TOOLS

The Hungarian road administration has already fully acknowledged the importance of up-to-date and accurate data, needed for asset management practices and decision making. Information on the collection, recording, storage and utilisation of these data will follow.

5.1. Database

The main inventory (technical) data related to the public road network were recorded into a mainframe computer in the 1970's. The "survey of compliance" mentioned above, assessing the conditions of the Hungarian national road network started in 1979. Comparing actual and design standard parameters related to site plan, cross section, road pavement structure, junction and bridge elements, "compliance rate" of road network elements was calculated. These surveys were performed in every 5 years, while the visual evaluation of surface defects has been carried out yearly. Since 1991, the unevenness, rut depth, micro texture and macro texture data have been assessed using a laser RST (Road Surface Tester). Systematic dynamic pavement bearing capacity measurements using KUAB falling weight deflectometers started in 1993, replacing the former quasi-static measuring methods (Rosa, 2004).

Uniting several regional road data bases, the first version of OKA (National Road Data Bank) had become operational in the 1990's. It had already relied onto a junction (knot) type site reference system, although the traditional chainage system using road number + kilometrage has also been maintained ever since, allowing a smooth conversion between the two systems.

The computer system of the National Road Data Bank was developed further between 2000 and 2003, and from 2004 on, a more sophisticated data base, OKA2000 became operational. Its following features can facilitate, among others, to prepare appropriate technical tools for decision making (Forrai-Hernadi, 2004):

- it has three (country, county and small region) operational levels;
- it relies on maps, among others, thematic maps;
- the data base allows the storage of data time series;
- every data is stored together with its input date;
- it stores only major bridge data (there is a separate, detailed Bridge Data Bank),
- its major programs are: data display and updating program, user updating program, topology updating program, data relation program;
- it includes subsystems like: pavement structure subsystem, traffic subsystem, junction subsystem, Roadmaster (surface defects evaluation) subsystem;

- the data base has a hardware key type protection against unauthorized (illegal) use of data;
- it has a well organised methodology for data updating.

5.2. Pavement Management Systems

Pavement and bridge management systems have been implemented, and their continuous improvement is being carried out in order to provide more and more reliable technical tools for the decision makers in the road sector.

The first Hungarian network-level pavement management system (MPMS) was elaborated in the late 1980's. Its mathematical and engineering models were completed by 1990 (Bako, 1992; Gaspar, 1991). Due to the lack of pavement condition data time series at that time, Markov transition probability matrices were selected as a model for the PMS. 16 matrices were developed taking into account (i) two pavement types (asphalt concrete and asphalt macadam); (ii) three traffic categories (0-3000; 3001-8000 and min. 8001 PCU/day); and (iii) three intervention types (only routine maintenance, surface dressing, new asphalt layer). A combination of the following condition parameters were used for the characterisation of overall condition levels:

- pavement bearing capacity score,
- unevenness (roughness) score,
- pavement surface defect score.

The classification of various condition parameters into 5 classes seemed to be sufficiently detailed, considering the network-level nature of the PMS.

The 41 overall condition levels occurring relatively frequently on the Hungarian national road network were chosen for the matrices of 41x41 size.

The optimum criterion selected was the minimisation of the sum of agency and user costs.

The MPMS-model can be used for

- the determination of resources needed (to reach some future general condition state at the lowest expense),
- resources' allocation (optimum distribution of financial means available for various intervention types and regions),
- evaluation of technical and economic consequences of an eventual modification of the amount or distribution of available resources.

MPMS was improved further, considering operational experience gained in the meantime, and implementing some elements of the Finnish HIPS-model having similar basic principle. The new model (HUPMS) has the following main features:

- several (max. 10) time periods,
- 2 pavement types (asphalt concrete and asphalt macadam),
- 4 condition parameters (unevenness, bearing capacity, surface defects, rut depth),
- up to 8 intervention types improving pavement condition ,
- 3-3 traffic categories for each pavement type.

The optimum long-term solution sought by MPMS is, where and when the road network under scrutiny would reach the technically-economically most favourable, so-called steady state of equilibrium.

Markov-matrices of 135x135 size are used. Due to the number of pavement types, traffic categories and intervention types, 48 matrices are included into the model.

The multi-period models allow to reach the steady state using a several-year long successive approximation. Several limit values (constraints) can be set, e.g. for the total amount of available resources, or for the ratio between agency intervention costs and traffic operation costs.

The optimum criterion (objective function) is conceived by combining the minimum of the sum of intervention and traffic operation costs. Various multiplicative weighting factors can be chosen for these two cost types.

HUPMS has been used for the yearly network-level distribution of resources for the entire Hungarian national road network and in various strategic analyses (Gaspar, 2003).

Since HUPMS is unable to consider the special features of motorways, a separate Motorway Pavement Management System (APMS) were developed. It is a ranking type, project level model with the following features (Gaspar, 2003):

- 3 pavement types (cement concrete, modified hot rolled asphalt, stone mastic asphalt),
- 3 condition parameters for cement concrete pavements (unevenness, surface defects, skid resistance),
- 5 condition parameters for asphalt pavements (unevenness, surface defects, skid resistance, rut depth, bearing capacity),
- investigation period of 25 years,
- 5 intervention types for cement concrete pavements, 6 intervention types for asphalt pavements,
- 2 traffic categories (below and above 8000 PCU/day/traffic lane)
- both agency and user costs considered,
- possible strategies: only routine maintenance, use of optimum schedule of interventions.

The minimal construction length for each condition improving intervention type is given and it is defined, whether it can be implemented on a single traffic lane or only on all lanes simultaneously.

The engineering model includes matrices providing the “optimum” intervention and unit road user costs for each pavement type, traffic category, intervention strategy and initial condition combination.

The preliminary analysis is performed for 100 m subsections. Actual projects are created taking into consideration the minimum possible intervention lengths and number of traffic lanes to be rehabilitated at the same time.

The program calculates first the total costs in case of routine maintenance and that of optimum schedule of intervention for each project, within the period of 25 years, then the road user costs are determined.

The projects are ranked on the base of these financial data, and those to be implemented can be selected in function of the total amount of available resources (Gaspar, 2003).

Another model was developed for the project-level management of urban roads, later on. The City PMS applied similar ranking technique, and can be characterised by the following features:

- combined road condition index,
- one or more condition parameters (e.g. surface defects, rut depth),
- intervention costs,
- accident data,
- traffic volume,
- net value of each road section.

A rolling methodology of planning was used with a 10-year time horizon. The network is assumed to be consisting of homogeneous sections from the viewpoint of condition, pavement type and intervention type improving pavement condition.

The deterioration function is given for 3 condition parameters (pavement bearing capacity, surface defects and unevenness). Three condition levels are distinguished. The actual deterioration is determined (in a performance model) in function of the initial condition, traffic volume and pavement type. An optimum intervention type (e.g. strengthening, drainage system repair) is determined for each pavement type, traffic volume and condition level combination.

Total costs for the 10-year investigation period are determined for the routine maintenance and for the optimum intervention strategies, respectively. As benefits, the positive effect of the implementation of optimum intervention strategies on the road user costs is considered. The projects are ranked using decreasing cost/benefit ratios.

The HDM-4 model (Robertson, 2000) has been investigated and successfully adapted to Hungarian conditions, too.

5.3. Bridge Management System

The elaboration of a bridge management system in Hungary started in the early 1990's by the following main activities:

- development of a simple, ranking type bridge management system (Csorba, 1996),
- the regular estimation of net and gross values of bridge assets (Gáspár (a), 1996),
- bridge compliance rating using 5 main condition scores (Tóth, 1987),
- development of a compliance rating method for bridge rehabilitations and constructions (Gáspár (b), 1996),
- medium-term (10-year) bridge maintenance and rehabilitation programme for 1991-2000 (Agárdy, 1996).

In 1995, the high level road administration decided to adapt the American PONTIS bridge management system to Hungarian conditions. The following main activities were needed for that adaptation:

- conversion of 123 data files,
- definition of new structural elements,

- definition of “environmental factors”,
- development of a Hungarian cost module,
- control of American – “do nothing” an “do something” type – Markov transition probability matrices for the deterioration of bridge elements, their eventual modification.

The “bridge inspection” technique of PONTIS management system is more detailed than that of the Hungarian system applied earlier. The methodology needs a preliminary determination of the main elements of the bridge under scrutiny, following special guidelines (Agardy, 1997), condition rating of each element using scores from 1 to 5, definition of “environmental factors” for each bridge element. The new bridge inspection methodology was duly presented to bridge engineers of all 19 counties, then several trainings had been organised for them, before the new technique has been applied country-wide from 2000 on.

The Hungarian PONTIS adaptation was developed further later on, into a performance-based bridge management system, leading to the following main results (Agárdy, 2002):

- developing a model enabled to reach the optimum for each and every bridge element, neglecting the eventual inter-relationship of adjoining bridge elements,
- developing a model enabled to reach the holistic optimum taking into consideration the inter-relationship of adjoining bridge elements too (i. e. the influence of the rehabilitation of an element onto the condition of an adjoining element),
- developing a model allowing the selection of so-called standard bridge spans defining the optimum intervention strategies for them.

5.4. Road Management Model

The basic principles of a complex (integrated) road management model (Figure 1) were defined recently (Bakó, 2002):

- the optimisation at a higher level of resources available for both, road and bridge construction and maintenance became achievable, by combining PMS and BMS,
- long-term efficiency is provided,
- it provides a significant support for maintaining the entire road network at a predetermined condition level,
- it enhances to obtain a favourable level of traffic safety,
- it provides the specified capacity of the facilities concerned,
- it minimises the whole life (life cycle) costs of the road network.

The combination of the two Hungarian management systems is facilitated by the fact that both models are based on Markov transition probability matrices.

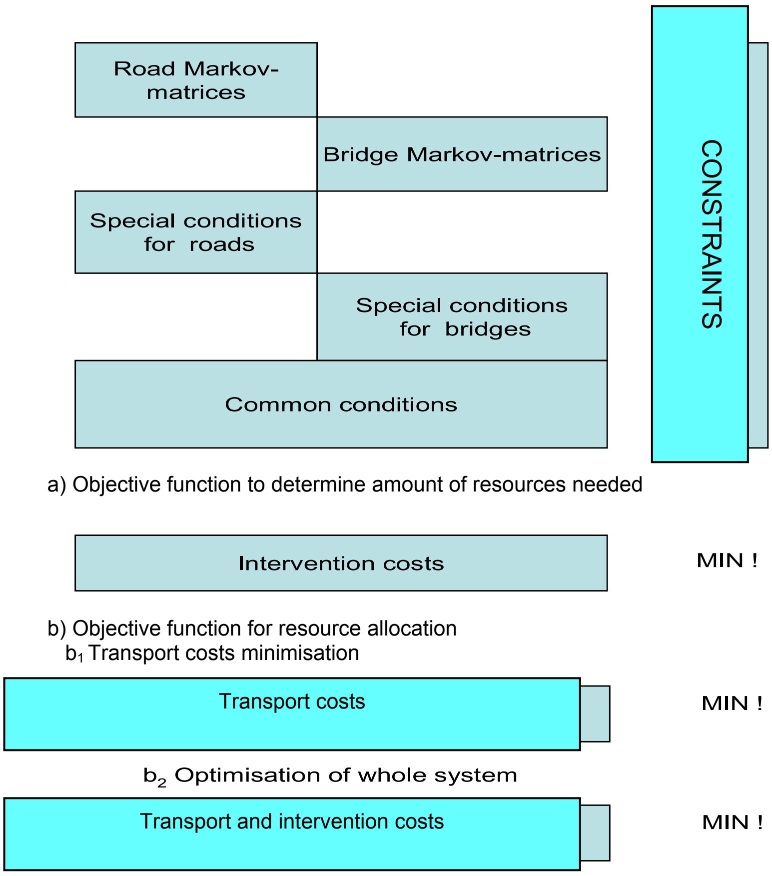

Figure 1 – Combined road- and bridge management model

Some recent Hungarian research results are summarised briefly in the following, which provided useful inputs for technical tools of asset management linked decision making.

5.5. Relevant research results

Some 60 sections characterising typical pavement type - traffic volume - sub-grade strength combinations, each of 500 m length were designated on the Hungarian national public road network in 1991 for regular yearly monitoring. These 60 trial sections represent 14 road section classes, and the already 16-year long time series of their various condition parameters (longitudinal unevenness, rut depth, bearing capacity, macro roughness, micro roughness, surface defects) have allowed to develop more and more reliable pavement performance models (Gaspar, 2003). These performance models can be utilised for regular updating of the elements of Markov matrices of the Hungarian network-level HUPMS.

The reliability of the monitoring process was studied, leading to the following results:

- the "improvement" of IRI and rut depth data observed although rarely on sections without intervention, can be explained by different measuring lines followed during yearly RST-measurements,
- time series of data characterising surface defects reflects generally "normal" distribution patterns,

➢ that almost 20 % of bearing capacity data reflecting improvement without any obvious "reason" can be attributed to basically different weather conditions

Since the majority of the test sections underwent some kind of intervention (overlaying, resurfacing, surface dressing) during the 16-year monitoring period, the actual condition improving effect of the interventions was investigated, leading to the following main results (see Figure 2):

➢ typically a the score of 1.4-1.5 could have been reached after intervention, independently of its actual type, in case of surface defects, (scores distributed between 1 and 5, where 1 is the best),
➢ IRI-values were improved on an average by 0.50 m/km after resurfacing and by 0.80 m/km after overlaying,
➢ rut depth values were reduced on the average by 2.26 mm after resurfacing, by 4.51 m/km after overlaying and by 0.34 mm after surface dressing,
➢ the improvement achieved was apparently higher when initial condition parameter were lower,
➢ the deterioration process after the intervention usually does not defer significantly from that of the previous one.

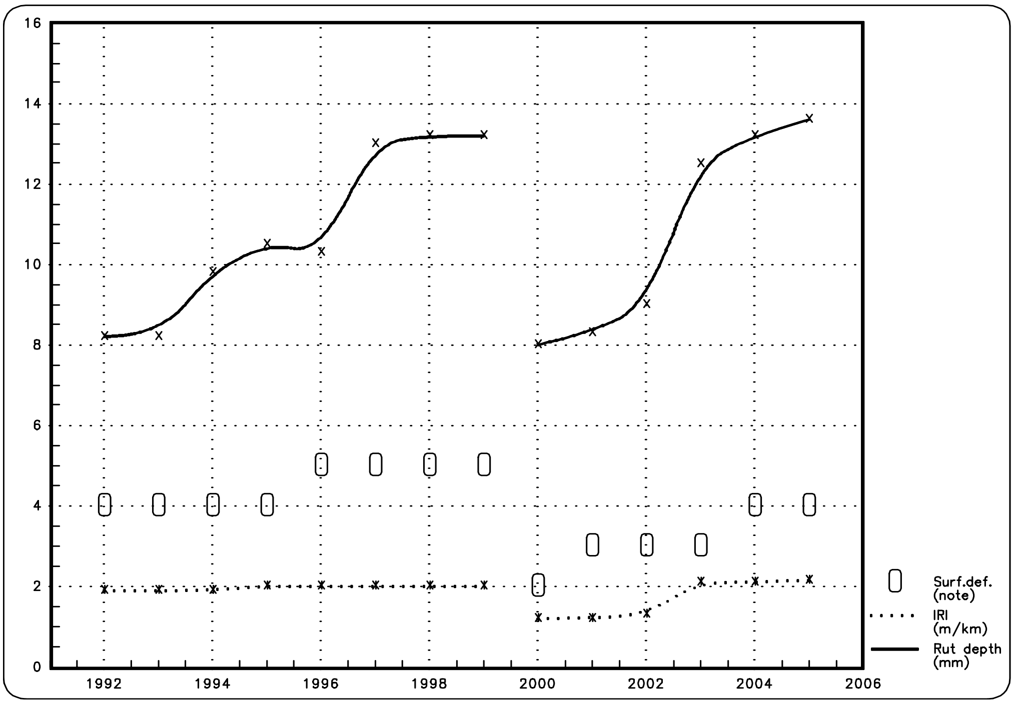

Figure 2 – The deterioration function of a test section before and after intervention (strengthening)

Finally it can be stated that technical tools for decision making are continuously improved and developed in Hungary, aiming to improve the quality of decision making by providing more and more detailed and reliable information.

REFERENCES

Agárdy, Gy. et al. (1996) Medium-term bridge maintenance and rehabilitation programme (1992-2000). Közúti Közlekedés- és Mélyépítéstudományi Szemle (Scientific Revue of Road Transport and Civil Engineering) № 2, pp. 78-87. (In Hungarian)

Agárdy, Gy. et al. (2002) Hungarian 5-year Bridge Maintenance and Rehabilitation Programme as a part of Asset Management. IABSE Symposium, Melbourne, Australia. Proceedings, Vol.1., pp. 616-623.

Bakó, A. (1992) The mathematical model of the first Hungarian network-level PMS. Közúti Közlekedés- és Mélyépítéstudományi Szemle (Scientific Revue of Road Transport and Civil Engineering), № 2, pp. 71-79. (In Hungarian)

Bakó, A. et al (2002) Towards the Transportation Asset Management System in Hungary. 3rd International Conference on Decision Making in Urban and Civil Engineering, London, CD-ROM Proceedings.

Csorba, A. (1996) Bridge Management System (HGR software). Közúti Közlekedés- és Mélyépítéstudományi Szemle (Scientific Revue of Road Transport and Civil Engineering), № 2, pp. 88-93. (In Hungarian)

Forrai-Hernádi, V. (2004) Introducing the National Road Data Bank (OKA2000) Közúti és Mélyépítési Szemle (Revue of Roads and Civil Engineering), № 7, pp. 6-10. (In Hungarian)

Gáspár, L. (1991) The creation of first Hungarian network-level PMS. Közúti Közlekedés- és Mélyépítéstudományi Szemle (Scientific Revue of Road Transport and Civil Engineering) № 4, pp. 132-141. (In Hungarian)

Gáspár, L. et. al. (a) (1996) Calculation of the gross and net value of bridges. Kozuti Kozlekedes- es Melyepitestudomanyi Szemle (Revue of Road Transport and Civil Engineering) № 2, pp 70-73. (In Hungarian)

Gáspár, L. et. al. (b) (1996) Efficiency calculation method for interventions on bridges. Kozuti Kozlekedes- es Melyepitestudomanyi Szemle (Revue for Road Transport and Civil Engineering) № 2, pp. 65-69. (In Hungarian)

Gaspar, L. (2003) Road Management. Academy Press, Budapest, 361 p. (In Hungarian)

Robertson, N. (2000) Introducing HDM-4. Software for investigating road investment choices. The World Road Association.

Rosa, D. (2004) Background of Hungarian PC-based highway data bank. Közúti és Mélyépítési Szemle (Revue of Roads and Civil Engineering), № 7, pp. 3-5. (In Hungarian)

Toth, E. (1987) Sufficiency rating of highway bridges. Mélyépítéstudományi Szemle (Scientific Revue of Civil Engineering), № 10, pp. 417-423. (In Hungarian)