Permit Vehicle Routing System in Hungary: Protecting Bridges from Highly Loaded Vehicles

Gyula Kolozsi
UTIBER Kft (Transport Consulting Management, Ltd.), Budakeszi, Hungary
Ákos Szilassy
ÁKMI Kht (State Highways Technical and Information, Ltd.), Budapest, Hungary
Gyula Agárdy
SZIF (Széchenyi István College), Györ, Hungary
László Gáspár
KTI Rt (Institute for Transport Sciences, Ltd.), Budapest, Hungary

ABSTRACT

Hungary—together with other Central European young democracies—has been more and more integrated into the "family" of developed Western European countries. The economic boom and the increasing transport needs cause high loading of roads and bridges.

From 1910 on, written Hungarian Bridge Codes have been available which include the design loads. During the past 88 years, the intensity of loads has been increased by three, while the total number of road vehicles has grown from some hundreds to the present 300 vehicles/1,000 inhabitants.

The continuous development has, of course, needed the repeated updating of these Specifications; the 8th version is presently valid. (The actual design loads can be presented.) We have already special vehicle loads for old bridges which are similar to the realistic loads of the actual road vehicles. The traffic size is monitored continuously by built-in measuring stations (WIM-stations).

For the permit vehicle routing system of overloaded vehicles, a computer programme used by the central highway administration has been available since 1987. Some 25,000 permits are issued for vehicle routing every year. The ratio of overloaded vehicles is 40%. Special attention is given to the vehicles which have a total weight of 2000–2500 kN.

In the computer selection of vehicle routing, the programme considers every route between the starting point and the destination and evaluates the possible obstacles (including bridges) of the routes available in the data base from the view-point of size and loadability. If the result of built-in routine checking is "sharp," the calculation should be checked by a specific method.

The method needs an updated database which is loaded by the managers of highway bridges and the data are updated every year or after major changes.

A computer-assisted routing of hazardous materials developed in Hungary is also outlined.

HUNGARIAN HIGHWAY BRIDGES AND THEIR SPECIFICATIONS

Hungary—together with other young democracics of Central Europe—has been recently more and more interested in the community of developed Western European countries. The resulting economic liveliness and the increasing transport needs cause an intensive load of roads and bridges. Figure 1 shows the Hungarian main road network together with the neighbouring countries.

In Hungary there are some 13,000 bridges (above 2.05 m span) on the public highway network. Excluding the bridges of local and private roads, about 6,000 bridges can be found on the systematically maintained and periodically inspected national public highways of this population. The number of bridges above 1500 m^2 amounts to slightly above 100. Considering all of the bridges in Hungary, the average bridge area slightly exceeds 155 m^2 (taking into account that already the structures above 2.05 m span are taken as bridges in Hungary). It can be consequently stated that the majority of the bridges in the Hungarian highway network are small-span structures.

From 1910 on there have been valid bridge codes in Hungary. During the past 88 years, the average load of the structures has increased by 3, and the number of vehicles on the roads has grown to 300 vehicles/1,000 inhabitants.

The continuous development required modifications to the bridge codes. Presently, the eighth generation is valid (*1*). (Figure 2 illustrates the Design Loads and various Load Classes in the Bridge Codes). For the control of roadbridges built before 1951, special vehicle loads similar to the presently used vehicles are applied. (This method seemed to be necessary due to the repeatedly changed specifications during the past 50 years.)

TRAFFIC CONTROL MEASUREMENTS

The axle load and the total load of heavy trucks—which can be considered primarily responsible for decreasing the durability of planned road pavements and bridges and for the growing deterioration—are significant parameters of highway traffic. It is well-known that the deterioration of transport facilities constitutes a hazard for safety, increases the transport costs, creates upkeep expenses because of the need for high maintenance and rehabilitation.

The axle load and the total load (as a function of the number of axles) for the vehicles frequenting the Hungarian public highway network without permission are specified in an appropriate specification. The present valid specification—thanks to the country's intention to join the European Community (EU)—differs only slightly from the specifications actually valid in the EU (*2*). Figure 3 informs about permitted axle loads, while Figure 4 about the permitted total loads as a function of the number of vehicle axles.

The task of road authorities is to ensure the suitability of the road network for safe traffic, including heavy highway vehicles, that is, equal chances should be provided for road carriers. At the same time, the authorities, as responsible managers of property, have to protect the roads from early damage and deterioration—the maximum legal vehicle and axle loads must be checked intensively and continuously.

This special service controls the highway traffic size and also checks the total weight and the axle load of passing vehicles using built-in (stable) and mobile weighing

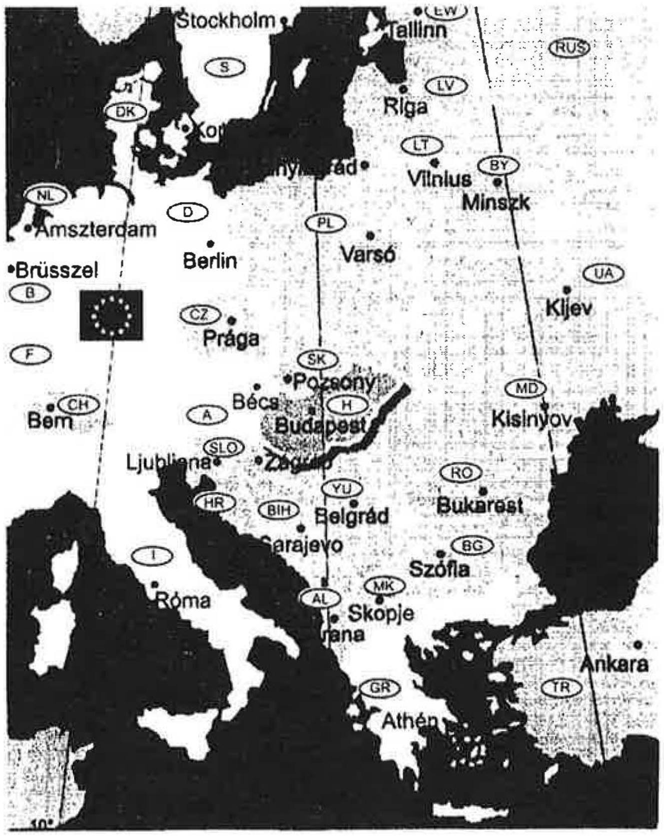


Figure 1(a): Hungary in Europe.

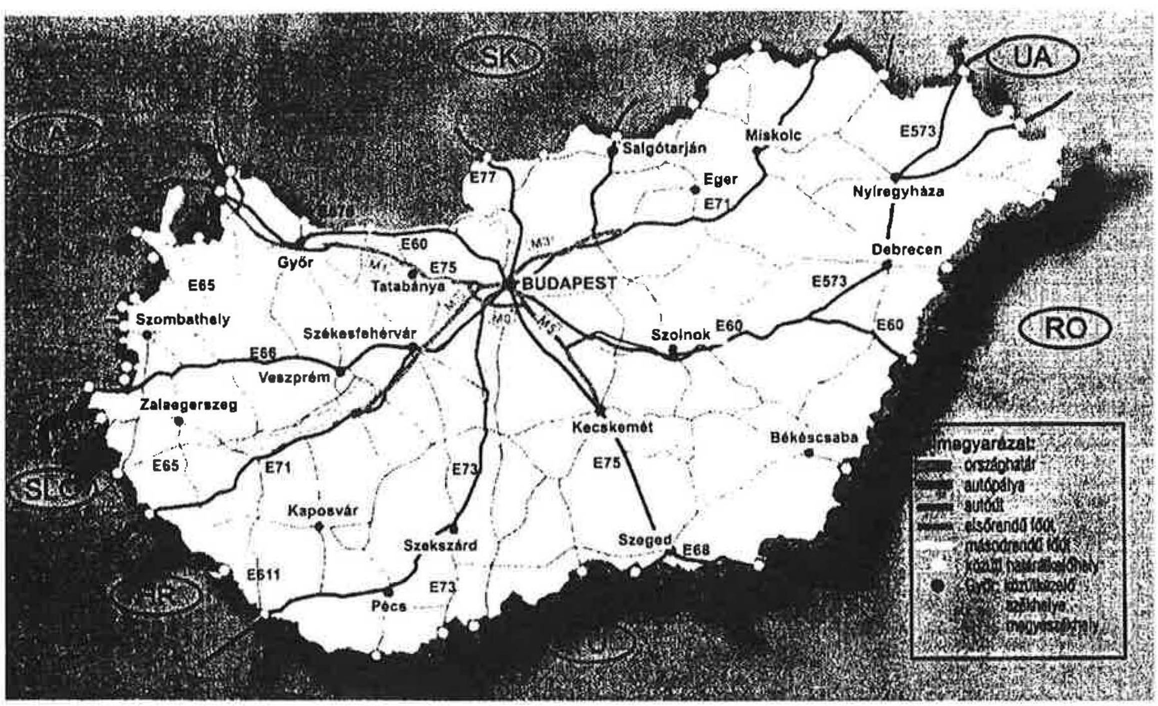
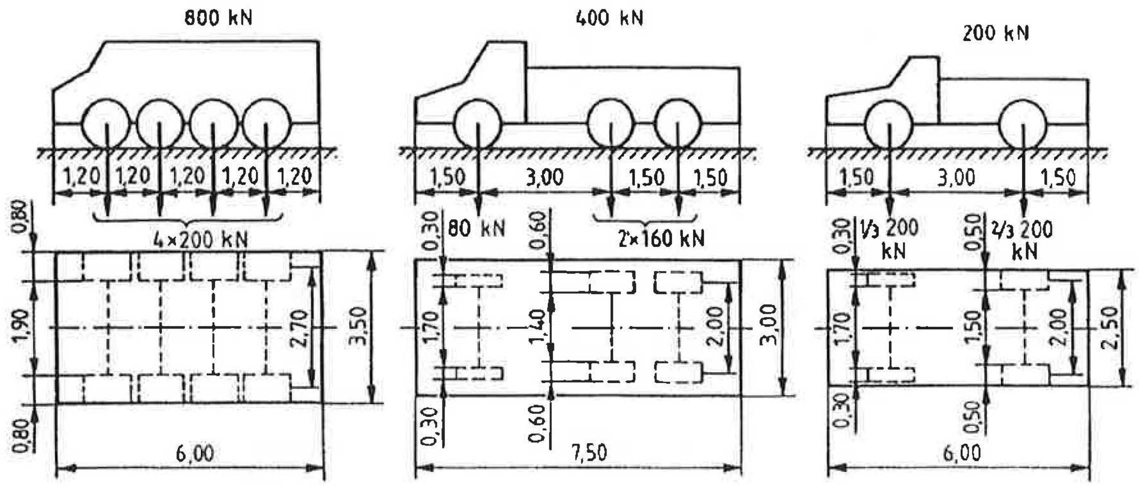


Figure 1(b): Hungarian trunk road network.



Vehicle Class A Vehicle Class B Vehicle Class C

Figure 2: Loads in highway bridge codes.

units. Of the 4,200 Hungarian weighing units, there are 40 of the WIM (Weigh-in-Motion) type. These have been used to control the axle loads of moving vehicles for 3 years. The WIM measuring units are usually applied along highly trafficked roads and close to major bridges. The duration of a measuring cycle lasts 15 days and it is planned in different periods for every season.

The evaluation of the more than 2 million measurements collected in 1996 and 1997 has produced surprising results, which are, however, totally congruent with international experience. More than 10% of the vehicles measured exceeded the permitted loading limits. In several cases, the measured actual single-axle loads were twice the legal limits, while the dual or tridem axles were sometimes 1.5 times higher than the relevant legal limits. It was an interesting experience that the difference between the static mass of heavy vehicles and the sum of the axle loads of moving vehicles was significantly higher than that considered in the dynamic factors of our design specifications till now. This very fact was also emphasized by some presentations of the Weigh-in-Motion Conference held in Lisbon in September 1998 (*3*).

As a result of the research on avoiding severe road and bridge damage, it was recommended to substitute the fourth-power deterioration factor applied for flexible pavement design so far by fifth-power law. As an unambigous consequence of these measuring results, it can be mentioned that the unit axle conversion factors—primarily for the articulated vehicles—must be changed.

Load configuration	Permitted axle load	
	t	kN
Vehicles without pneumatic tyres (excluding chain-type ones)	6	58.9
Single axle (excluding air spring suspension) {d<1.00m}	10	98.1
Air spring suspension single axles (d<1.00m)	11	107.9
Double axle "A" (1.00m≤d≤2.00m)	16	157.0
Tridem axle "A" (d≤1.30m,$d_{outermost}$≤2.60m)	22	215.8
Tridem axle "B" (d>1.30m,$d_{outermost}$≤2.60m)	24	235.4

Figure 3: Permitted axle loads.

Vehicle Type	Permitted vehicle total mass, t
Vehicle without pneumatic tyres (excluding chain-type ones)	12.0
Two-axle vehicles	20.0
Three-axle vehicles	24.0
Four or more axle vehicles	30.0
Three-axle vehicles train or articulated vehicles	28.0
Four-axle vehicle train or articulated vehicle	36.0
Five or more axle vehicle train or articulated vehicles	40.0
From the view-point of overloading fee	40.0

Figure 4: Permitted total loads as a function of the number of axles.

It was remarkable that the number of weight violations correlated in number to the number of speed limit violations. This kind of result could have occurred only by the use of automatic systems, since an "alarm chain" was usually active when applying "manual" mobile measuring station somewhere.

The irresponsible carriers breaking the laws can not be deterred even by the high fines for their detrimental activities. The carriers are usually not aware of the fact that not only the traffic safety and the life expectancy of the overloaded vehicles are reduced, but also the durations of roads and bridges decrease due to the too high traffic load. The "high fine" is not proportional at all to the damage caused. (Till the termination of the Hungarian Road Funds some months ago, the fines became part of the Road Funds.)

PERMITTING VEHICLE ROUTING

In the past years—because of the economic transition and liveliness of the country, as well as the NATO military movements in Hungary caused by the Balkan war—the number of overloaded vehicles asking for routing permission has considerably grown. These vehicles have sometimes 600–800 kN total loads. However, multiaxle huge vehicle trains with 2000–2500 kN total load and dimensions well beyond the standard also occurred on the roads.

In Hungary, the central road authority uses a computerized system for the permit routing of overloaded vehicles. Some 25,000 permit vehicle routings are issued yearly, 40% of which is the share of permissions given for overloaded vehicles.

The traditional manual registration using maps is being replaced by computerized permit vehicle routings, which allows the reduction of the chance of mistake. This computerized system based on the National Road Data Bank will be completed in the near future. The National Road Data Bank is being updated every year. It also provides the database for the Hungarian Pavement Management and Bridge Management Systems. (As a Hungarian BMS, the adaptation of the American Pontis bridge management system among local conditions was implemented in 1998.)

The computerized system mentioned has two main functions: it can be used either for permitting the passing (travelling through) a bridge or for permit vehicle routing.

When investigating passing a bridge, the program utilizes the design load class, the span, the width, the eventual vertical clearance limitations and the major structural features of the bridge. The calculations are carried out based on the actual bridge load carrying capacity. (If the local bridge engineer reveals severe condition deterioration during periodic inspection which can influence the load carrying capacity of the structure, he can modify the load carrying capacity. Then the reduced load carrying capacity in the registration is considered by the program.) The calculation is performed presuming an idealised static model—two-support beams—and without considering the realistic cross sections and structural features. All of the suppositions and the simplifications done during calculation increase safety and, in such a way, this estimated calculation can provide even 30–40% more safety.

These calculations can have four output types:

- Vehicle passing can be permitted (the calculated actual bending and shear loads do not exceed the design values).
- Vehicle passing can be permitted with special measures (the calculated actual bending and shear loads reach the design—limit—values, then the exclusion of other vehicles, reduced passing speed in order to decrease the dynamic factor or passing along the bridge axle, etc. can be fixed as preconditions).
- Detailed investigation is needed for the eventual permission of vehicle passing (the calculated actual bending and shear loads exceed limit values, but the detailed calculation using actual parameters can eventually have favourable results).
- Vehicle passing is prohibited on the bridge (the calculated actual bending and shear loads exceed the design value considerably, and no favourable results are forthcoming from the individual, detailed static calculation).

Although prohibiting vehicle passing on actual bridges, the program is appropriate for permit vehicle routing. This case, the procedure consists of the series of the individual calculations outlined before as well as of the analysis of the possible routes between the starting point and the destination. When comparing the possible routes, clearances, road profiles, layouts, traffic sizes and compositions, the by-passes of settlements, pavement widths, possible obstacles, distances and travelling times are analysed as available or calculated data.

The program needs—besides the yearly updated National Road Data Bank information—a special daily updated Road Information database which comprises the temporary road narrowings, closures, detours and other traffic limitations.

It is hoped that—after the implementation of this Hungarian program outlined earlier—the favourable national statistics will continue in accordance with which no Hungarian bridge has collapsed due to overloading yet. During the past 25 years, one bridge was removed by the river due to scour. However, a lot of bridge damages happened because of the illegal passing of oversized vehicles; 8 of these bridges collapsed during the past 25 years. Figure 5 shows a bridge damaged by an oversized vehicle travelling on the bridge without permission.

COMPUTER-ASSISTED ROUTING OF HAZARDOUS MATERIALS

The joining of Hungary in the ADR agreement (*4*) necessitated the development of a program system for the routing of hazardous materials. The first version was completed by 1989 (*5*).

Figure 5: The bridge over Hernád at Gesztely deteriorated by the crash of an oversized vehicle.

A lot of foreign programs are known for the solution of this task (e.g., *6*). The most global and most up-to-date system combines the graphical and the alphanumerical solutions. Such a GIS (Geographic Information System)-based variant is presented by Lepofsky and Ablowitz (*7*).

When developing the Hungarian program system, several former foreign research results in the topic were considered. The most important ones are listed below:

- The quantity of the dangerous materials to be transported is doubled in the USA every 10 years (*8*).
- The most important issues related to transporting hazardous materials are the reduction of the number of possible accidents and the minimization of the harmful consequences of the accidents occurring (*8*).
- 74% of hazardous material transportation is done on highways. Some half of the highway accidents occur when transporting petroleum and 20% with gasoline (*6*).

The first step of the Hungarian system is the identification of the possibly dangerous goods in the vehicles entering the country through any of the 26 state highway border stations. Since several of the neighbouring countries have not joined the ADR agreement (*4*) yet, first the meeting of ADR specifications has to be checked. In the case of transit goods, the eventual obstacles to leaving Hungary are to be also controlled.

An important part of the system is the list of especially dangerous materials as well as the major traffic flow diagrams for the highway network.

The routing of the vehicles with dangerous goods is carried out—as much as possible—on rural sections and on those with relatively low traffic. The tourism centres (e.g., the region of Lake Balaton) are possibly not included in the routes.

The necessity of routing comes up only over a given quantity of the hazardous materials transported. Routing also can be issued for repeated transport over a relatively long (e.g., 1 year) period.

The program system allows the automatization of the administration of the highway transport of hazardous materials at state border stations using IBM-PC/XT personal computers.

Its main functions are as follows (*9*).

- Background subsystem (dangerous material data registration, description of their treatments individually and in goods groups, description of transport routes, dictionary for the names of dangerous materials in Hungarian, English, German, French and in accordance with UNO-Code)
- Operational subsystem (entering and leaving the country for vehicles with dangerous goods, list of these vehicles, yearly traffic data)
- Analysis subsystem (input and listing of traffic data, traffic loading of routes).

The present system includes information about 120 materials and 36,000 terms for the identification (*10*).

A continuous further development of the system is being carried out.

As a farewell photo, Figure 6 illustrates the famous Széchenyi Chain-bridge in Budapest, one of the symbols of the capital.

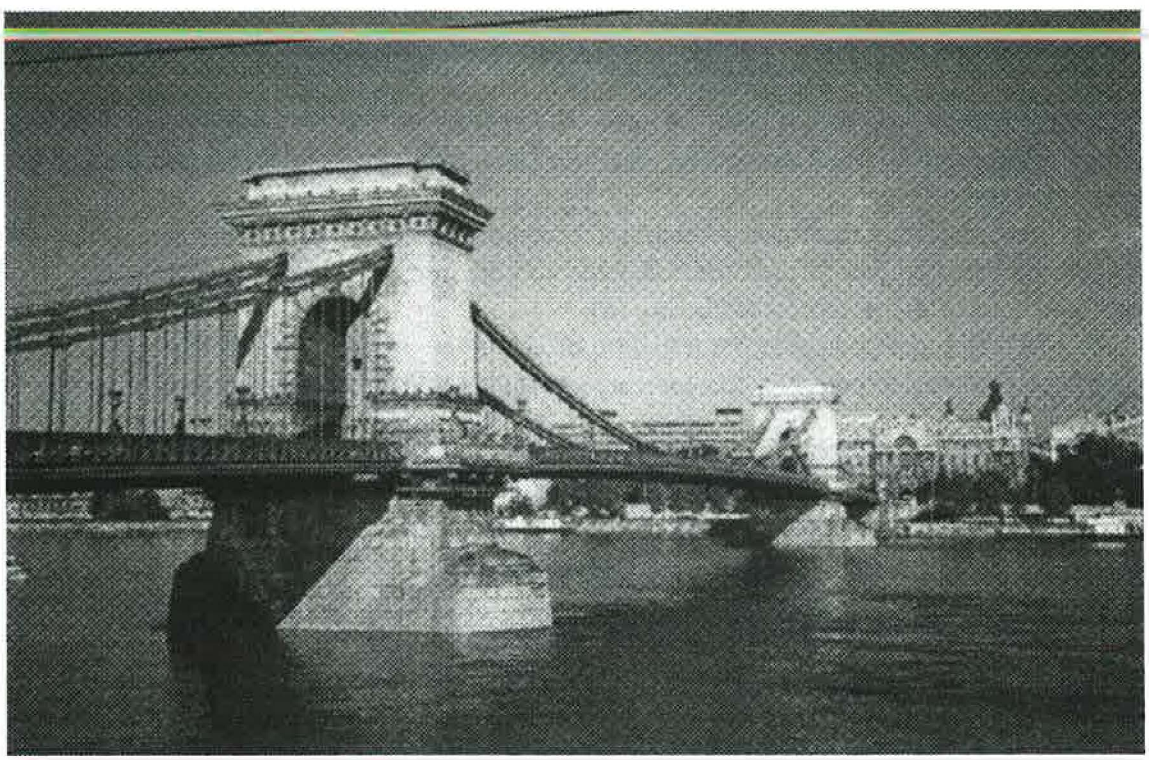


Figure 6: The 150-year-old Széchenyi Chain-bridge in Budapest.

REFERENCES

1. *Highway Bridge Code* (in Hungarian), ME 3700/1995.
2. "Maximal values of highway vehicle axle loads and total masses" (in Hungarian). 6/1990(IV.12) KÖHÉM and 10/1988(IX.24) KM Order.
3. Gulyás, A. *Experience of WIM in Hungary.* 2nd European Conference WIM. Lisbon (European Commission) 1998.
4. "Accord européen relatif en transport international de marchandises dangereuses par route (ADR) et protocole de signature en date," a Genéve, du 30 septembre 1957.
5. Bakó, A., T. Szántai, and I. Tary. "Solution of Transport Management of Hazardous Materials Using Microcomputer" (in Hungarian). *Közlekedési Közlöny* No. 51–52, 1989, pp. 888–893.
6. Russel, E.R. "Rating Countermeasures for Mitigation of Hazardous Material Incidence." *Journal of Transportation Engineering*, Vol. 119, 1993, pp. 211–225.
7. Lepofsky, M., and Ablowitz, M. "Transportation Hazard Analysis in Integrated GIS Environment." *Journal of Transportation Engineering*, Vol. 119, 1993, pp. 239–254.
8. Kalevala, S.A., and Radwan, A.E. "International Issues of Transporting Hazardous Materials." *Transportation Quarterly*, No. 42, 1988, pp. 125–139.
9. Tary, I., A. Bakó, and T. Szántai. *User Manual of the Program System for Hazardous Material Management* (in Hungarian). UTINFORM 1987.
10. Bakó, A., T. Szántai, and I. Tary. "Microcomputer-Assisted Routing of Hazardous Materials" (in Hungarian). *Veszélyes*, No. 2, 1994, pp. 36–41.