Optimization of winter maintenance on heavily travelled freeways

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1 Introduction

Efficient freeways form the backbone of traffic and thus of our economy, as the latter is becoming more and more dependent on a - at all times - functioning infrastructure element: the road. Restraints imposed on driving in the wintertime are therefore becoming less and less acceptable. As a consequence, the standards of winter maintenance for heavily travelled or problematic road sections of federal freeways have become very high. Successful winter maintenance in these areas considerably contributes to avoiding or at least reducing winter-related restrictions and thus, the costs these entail for the road-user. In connection with an early and quick winter maintenance, road safety is also improved and micro-economic and economic costs of freight and public transport are reduced through less accidents, loss of time, etc.

Therefore, the Institute of Highway and Railroad Engineering (Head: Prof. Dr. Ralf Roos) of the University of Karlsruhe was commissioned in the summer of 2001 to carry out the research project „Optimization of Winter Maintenance on Heavily Travelled Freeways". The project primarily pursues two aims: Firstly, checking the capacity of highway cross-sections under wintry road conditions through a traffic investigation of winter-related congestions. Secondly, several pilot projects with individual highway surveillance centres shall be investigated with regard to optimizing the winter maintenance. These centres shall further receive scientific support throughout practical tests. In spite of the high standards of winter maintenance observed in Germany, individual measures for dealing with problematic road sections are gaining in importance, especially when considering the loss of capacity under wintry road conditions. It are these measures that shall be further developed within the stated research project.

2 Investigating the capacity under wintry road conditions

In the HANDBUCH FÜR DIE BEMESSUNG VON STRASSENVERKEHRSANLAGEN (2001), (Engl. Handbook for Design of Road Traffic Facilities), „capacity“ is defined as „the highest traffic density that a traffic stream can reach at its cross-section under the given road and traffic conditions.“

The capacity of freeway cross sections depends on several ancillary conditions and is thus subject to wild, time-related fluctuations. The factors of influence can be divided into four different groups:

- road conditions,
- traffic conditions,
- traffic control conditions and
- environment.

Road conditions mainly involve the geometrical and structural design of the roads. Examples are road bendiness, longitudinal gradient and cross section, i.e. the number and width of lanes. Due to its straight run of the road, bendiness hardly plays a role when looking at highways and can thus be neglected. The same is true of the lane width.

Unlike the road conditions, traffic conditions include time-variable factors. Traffic conditions mainly mean the composition of the traffic flow (traffic column) and lane distribution. The decisive parameter for traffic composition is the heavy vehicle traffic proportion, fluctuating throughout the day, week and year.

Traffic control and check conditions are ancillary conditions imposed in order to influence the traffic flow. For freeways, especially the speed limits and restrictions on passing and driving for heavy goods vehicles are important.

Environment factors are light, weather and road conditions. Wintry road conditions play a major role in influencing the traffic flow.

For determining the capacity under wintry road conditions, basically the following data was used:

- winter maintenance reports by the investigated highway surveillance centres,
- additional reports evolved by the Institute of Highway and Railroad Engineering for congestion registration carried out by the highway surveillance centres´ personnel

- details about the investigated road sections (longitudinal gradients, number of lanes, etc.),
- data with differentiated density- and velocity-values obtained from long-term stationed census points and
- accident reports.

The road sections investigated were the A 8 under the jurisdiction of the highway surveillance centre Ulm-Dornstadt (Baden-Württemberg) and the A 5 belonging to the area of responsibility of Alsfeld (Hesse). For traffic investigation, the highway surveillance centres carried out congestion registration half-yearly, in the winter periods of 2001/02 and 2002/03.

For evaluating larger amounts of data and obtaining the capacity, the winter-related congestions due to wintry road conditions were filtered. As only when congestions are due to high traffic volume does the traffic state indicate the capacity. In case of an accident for instance, as a rule, at least one lane is blocked for a certain time, creating a congestion long before the actual capacity of the cross section is reached.

After creating of a velocity/time variation curve that represents the exact time window of congestions, the data of the decisive time was analyzed. Then using the density-velocity-diagrams (d-v-diagrams) the maximum traffic volume that corresponds to the capacity is determined for winter-related congestion (see Fig. 1).

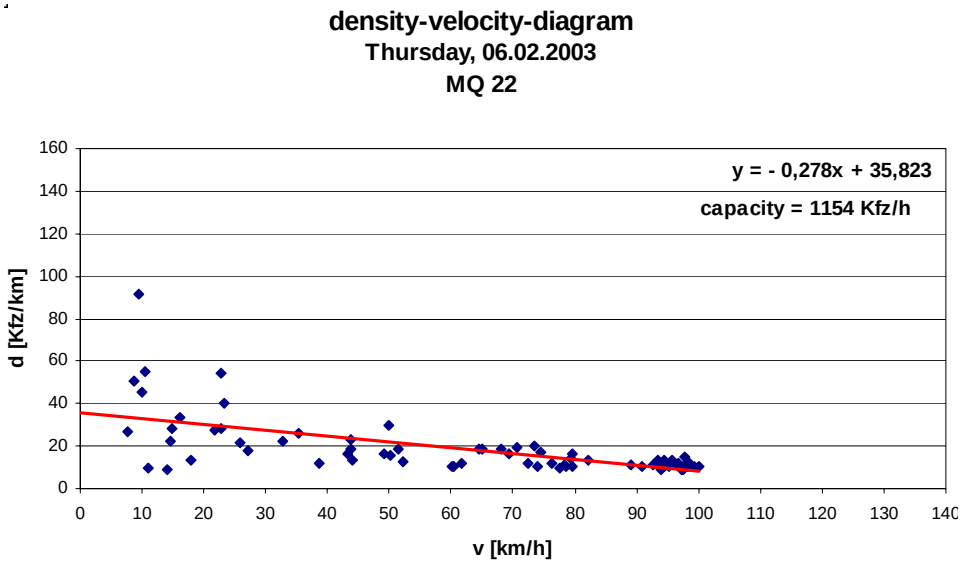

Figure 1 **Example of a d-v-diagram of a winter-related congestion – q_{max} capacity determined**

With this data, 14 winter-related traffic congestions could be analyzed and the capacity determined. The evaluation of the traffic congestions produced under wintry road conditions showed a decrease in capacity between 10 and 65 % at the measurement cross sections in Baden-Württemberg. At the census points in Hesse, capacity decreases of between 35 and 40 % were found. Due to the still very limited amount of collected data at present, these results can only serve as an initial clue. In further investigations in the winter period 2003/04, the method developed for evaluating the various influences on the capacity of wintry roads shall be extendedly applied and to back up the results

3 Selected optimization measures for winter maintenance on heavily travelled freeways

Parallel to looking at the capacity behavior, a group of selected optimization measures was examined. Examples of these measures will be presented in this contribution, namely the findings of the operation of a high performance vehicle equipped with a sweeper/airblast unit, as well as the possibility of imposing temporary driving bans on heavy goods vehicles during heavy snowfalls.

3.1 Use of a high performance vehicle equipped with a sweeper/air blast unit for winter maintenance

The special vehicle tested within the scope of this pilot measure is a winter maintenance vehicle, originally meant for airport operations and equipped with an additional sweeper/air blast unit. Two high performance vehicles were operated on a freeway for the first time in the winter period 2002/03 in jurisdiction of the Hessian highway surveillance centre Alsfeld. The results presented here basically refer to the introductory phase of the new winter maintenance vehicle. So what may be expected is that the potential for snow clearing speed and quality is actually greater. We are thus on the safe side using this data.

For winter maintenance purposes, the vehicle is equipped with a snow plough (see Figure 2) of which the clearance width is adapted to the entire system. It normally has a swivel share element and the clearance width is > 4 m. It further has a sweeper/air blast unit placed between both axles and blow jets for right or left-side clearance at the rear. The sweeper/air blast unit is a combination of rotating brushes and blow jets. A high performance turbine provides the blow jets of the sweeper and those at the rear of the vehicle with a controllable air stream.

For spreading pre-wetted salt, a 4 m³ superstructure, consisting of a standard-grit spreader and the pre-wetting salt machine is mounted on top of the high performance vehicle.

Figure 2: High performance sweeper/air blast unit being used in a winter maintenance vehicle

Sweeper/air blast operation thus means that after snow clearance through the snow plough, another combined mechanical-pneumatic clearance of the rest of the snow, slush or water is performed. The brush rotates parallel to the diagonally positioned plough, in the traffic opposite direction. Depending on the prevailing consistency of the snow, it can be equipped with a corrugated steel wire or bunch of strips of plastic. The contact pressure control of the brushes is continuously variable. The brush is automatically adapted to the pavement structure and is meant to work at high clearance speeds. The rest of the snow is swept in front of the vehicle by the brush and blown to the road side by the swivel blow jets on the sweeper. This allows a high clearance quality with only slightly tilted brushes. The last bits of snow are then moved to the rear of the vehicle where they are removed from the clearance cross section with the aid of the blow jets..

For analysis and evaluation of the high performance sweeper/air blast units, the Institute of Highway and Railroad Engineering had photos taken and the freeways filmed before and after the winter maintenance operations. Further, the provided winter maintenance reports and tachographs were evaluated and interviews carried out with the concerned highway surveillance centres´ personnel. The aim was to examine the clearance quality at high clearance speed, the actual clearance speeds, as well as the high performance sweeper/air blast units - focussing on exceptional cases that might arise during operation.

When determining the average clearance speed, most courses of speed provided by the tachographs could be clearly reassigned to the corresponding road sections with the aid of the winter maintenance reports. In order to determine the average clearance speeds, only the average speeds were counted that were easily reached on continuously travelled roads. The average clearance speed in the introductory phase was already found to be 45 km/h. Unlike standard winter maintenance vehicles, the high performance sweeper/air blast unit was only little influenced by longitudinal gradients.

Clearance quality was judged visually. For this purpose, the clearance procedure was videotaped and photos were taken while driving behind the special vehicle equipped with the high performance sweeper/air blast unit. Further, photographing and filming were also carried from higher spots, as for instance from bridges. This allowed a direct visual comparison of the road conditions before and after clearance at the computer screen.

When comparing the photographs showing the results obtained with standard winter maintenance vehicles (that only use a single snow plough for clearance) and high performance vehicles (with a snow plough and sweeper/air blast unit), the results of the additional mechanical-pneumatic clearance are clearly visible. After having evaluated the first clearance operations, an improved clearance can be seen and even snow removals are possible at high clearance speeds, as depicted in Figure 3. In order to back up these results, further investigations shall be carried out in the winter period 2003/04. They will then include the sweeper/air blast units the highway surveillance centre Freudenberg in North Rhine-Westphalia have been using since spring 2003.

Figure 3: **Clearance comparison of standard winter maintenance vehicle (left) and vehicle with high performance sweeper/air blast unit (right)**

3.2 Further measures

In order to avoid long traffic breakdowns, partly producing catastrophic conditions, further winter maintenance measures have to be systematically analyzed for heavily travelled road sections and periods of longer snowfall. In extreme situations, for instance imposing a temporary driving ban on heavy goods vehicles has to be considered. This allows the clearance vehicles to move forward easily and not possibly get stuck in a traffic jam themselves. After clearance, the freeway can be opened for heavy goods vehicles again. The Institute of Highway and Railroad Engineering will investigate these kind of measures as well in the winter period 2003/04 and work out recommendations when to best use them.

4 Prospects

The first results of loss of capacity due to wintry road conditions have clearly proved the great importance of winter maintenance, especially for heavily travelled freeways. For this reason, traffic investigation should be continued following the method developed in order to cover the various influences of wintry road conditions on the capacity. With the aid of a differentiated knowledge of capacity under wintry road conditions, winter maintenance could be made more efficient, especially on problematic road sections.

Evaluation of the research results has shown that special measures in winter maintenance, as for instance the use of a high performance vehicle equipped with a sweeper/air blast unit, present the possibility of specific support for winter maintenance, especially with regard to problematic road sections. Here, too, further investigations of individual measures are recommended. In extreme situations, measures such as imposing a temporary driving ban on heavy goods vehicles should also considered.

It has therefore been planned to carry on with capacity investigations and examine selected measures in the winter period 2003/04 in order to back up the results that have so far been obtained.

Sources:

Handbuch für die Bemessung von Straßenverkehrsanlagen (HBS) (engl. Handbook for Design of Road Traffic Facilities)
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