Optimal alignment of high speed railways

Key areas of traffic safety work
Danish Road Directorate (DRD)
The Road Directorate, which is a part of The Ministry of Transport, Denmark, is responsible for development and management of the national highways and for servicing and facilitating traffic on the network. As part of this responsibility, the Directorate conducts R&D, the aim of which is to contribute to efficient road management and to the safe use of the network. The materials research component is carried out by the Danish Road Institute while other R&D activities – primarily safety and environmental research – are carried out by the Directorate’s operational departments.

Technical Research Centre of Finland (VTT), Communities and Infrastructure
Communities and Infrastructure, employing a staff of 135, is one of the nine Operating Units of the Technical Research Centre of Finland (VTT), which has a total staff of 2,720. Research at this Operating Unit covers all aspects of transport, road engineering, geotechnology and urban planning. The unit has active international relations and a prominent role in these research areas on the national level.

Public Roads Administration (PRA), Iceland
The duty of PRA is to provide society with a road system according to its needs and to offer service aiming at safe, unobstructed traffic. The number of employees is about 340. Applied research concerning road construction, maintenance and traffic and safety is to some extent performed or directed by the PRA. The authority with its Research and Development division is responsible for road research in Iceland.

Norwegian Directorate of Public Roads
The Norwegian Directorate of Public Roads is one of the administrative agencies under the Ministry of Transport and Communications in Norway. The Directorate is responsible for the development and management of public roads and road traffic, as well as the Vehicle Department. This responsibility includes research and development of all areas related to road transport, and the application of R&D products.

Institute of Transport Economics (TØI)
The Institute of Transport Economics is the national institution for transport research and development in Norway. The main objectives of the Institute are to carry out applied research and promote the application and use of results through consultative assistance to public authorities, the transport industry and others. The Institute is an independent research foundation employing about one hundred persons.

The Swedish National Road and Transport Research Institute (VTI)
is responsible for research and development in road construction, maintenance, road traffic and transport, railroads, rail transport, vehicles, road user behaviour, traffic safety and the environment. The Institute is state-owned and has a total of 215 employees.
## CONTENTS

- **High speed railways: Alignment optimisation with vehicle reactions taken into consideration** ................................................................. 4  
  Swedish National Road and Transport Research Institute (VTI)

- **Research activities at the Danish Road Institute** ................................................................. 7  
  Danish Road Directorate (DRD)

- **The International Pavement Subgrade Performance Study** .................................................. 9  
  Danish Road Directorate (DRD)

- **Floating bridge in Norway - “no rebar corrosion” after five years of service?** ................................................................. 11  
  Norwegian Directorate of Public Roads

- **New cars crash most** ........................................................................................................... 14  
  Institute of Transport Economics (TØI), Norway

- **New edition of the Traffic Safety Handbook** ...................................................................... 16  
  Institute of Transport Economics (TØI), Norway

- **Intermodal transport research - is there any added value?** ............................................... 17  
  Technical Research Centre of Finland (VTT), Communities and Infrastructure

- **Key areas of traffic safety work according to European experts** .................. 20  
  Technical Research Centre of Finland (VTT), Communities and Infrastructure

## ANNOTATED REPORTS

- **Danish Road Directorate (DRD)** .................................................................................. 23
- **Technical Research Centre of Finland (VTT), Communities and Infrastructure** ........ 25
- **Institute of Transport Economics (TØI)** ......................................................................... 26
- **Norwegian Directorate of Public Roads** ................................................................. 28
- **Swedish National Road and Transport Research Institute (VTI)** ......................... 29
High speed railways: Alignment optimisation with vehicle reactions taken into consideration

The Swedish railways have mainly relatively poor alignment. Therefore, the Swedish concept of high speed railway traffic is based on the use of tilting trains. With this concept, train speeds may be increased without large investments in improvements of the alignment. However, in order to increase the capacity of the railway system, new railways are now being built. The question then arises: What is the optimal alignment of a new railway for use by conventional and/or tilting trains?

The horizontal alignment is often a binding constraint for permissible train speeds, even though modern trains (tilting trains) may compensate for certain shortcomings in this respect. The alignment has a high degree of permanence, since changes will affect various technical subsystems such as substructure, superstructure, catenary systems, etc. Hence, improvements in existing alignments are usually associated with high costs. Alignments are also associated with additional costs when building new lines. An unnecessarily high standard may make a project too expensive and cause an undesirable impact on the environment. These facts lead to the conclusion that the alignment should be optimised with great care when building new lines.

**Alignment variables – terrain corridor – construction cost**

In curve design, the major independent variables are the radii of the circular curves, the cant (also called superelevation; the difference in height between the two rails) and the lengths of the transition curves (and the corresponding superelevation ramps). For high speed traffic, the curve radii should be large and the transition curves long.

Cost differences between different alignment alternatives are mainly related to removal of obstacles. All alignment alternatives passing the same set of obstacles may be assumed to be equally costly to build. This approach may also be used when improving existing lines: The difference between new and existing railways is the number of obstacles to take into consideration, since improving existing lines involves the original obstacles plus the railway-specific installations.

In a curve between two predefined...
straight lines, larger radius as well as longer transition curves entail an inward shift of the track. Hence, when considering the available terrain corridor, defined by obstacles such as existing structures, there are conflicts between the desire for large radii and long transition curves.

**Principles of evaluation of alignments**

In this study, it was decided to evaluate alternative alignments through the dynamic vehicle reactions generated by certain standard vehicles passing the curves at a high speed. The procedure for evaluation of different alignments was chosen to match the evaluations of new vehicles as closely as possible.

Two international working groups (within CEN and UIC) are working on standardisation of evaluation procedures and have issued draft standards. The same variables, filtering, statistical analysis and limits as in these drafts were used in this study whenever possible and relevant. These variables included 99.85-percentiles of low pass filtered vertical and lateral wheel/rail forces, track shift forces and wheel/rail climbing ratios.

Passenger (dis)comfort was expressed in $P_{CT}$ (passenger comfort on curve transitions), a quantity which takes into consideration lateral acceleration, lateral jerk and roll velocity of the vehicle body. The $P_{CT}$ functions – there is one function for seated and another for standing passengers – show the percentage of passengers who regard the lateral ride uncomfortable. The functions were originally derived by British Rail Research from extensive passenger tests with tilting as well as non-tilting coaches. $P_{CT}$ has also been incorporated in a draft CEN standard.

**Dynamic computer simulations**

Full-scale tests with vehicles would be very impractical and very expensive, when evaluating alignments. Hence, it was decided to use the multibody computer code GENSYS, to simulate dynamic vehicle reactions.

Vehicle bodies bogies and wheelsets were modelled as rigid bodies and have six degrees of freedom each (see Figure 1). The track was modelled as a rigid body connected to each wheelset and there was one degree of freedom for each track body.

Hence, these models contained 46 degrees of freedom for each vehicle.

Springs and dampers in the GENSYS models were non-linear. Hence, the simulations were conducted in the time domain.

Three types of vehicles were used in the simulations: The Eurofima coach (a conventional passenger coach used by several railway companies in Europe), an SJ X2000 tilting coach and an SJ X2000 power car (representing a high-speed locomotive, suitable for both conventional and tilting coaches).
Analysis of horizontal curves

In the analysis of horizontal curves, the lateral positions of the adjacent straight lines were fixed in the same positions for all curve combinations, and the lengths of the transition curves were the same at both ends. The alignment can thereby be defined with two variables, and in this case it is reasonable to use the radius (R) and the length of a transition curve (Lt). These element combinations correspond to the most frequent case in a design process.

It has been found that obstacles at the middle and end of the curve constitute the extremes, requiring the smallest and the largest compensations of radius, when lengthening the transition curves. It has also been found that a smaller angle between the adjacent straight lines requires a larger compensation of radius than a larger angle between the straight lines.

In order to clarify the basic relations, only one binding obstacle was used in each terrain corridor, and was placed either at the middle or end of the curve. In the diagrams (Figures 2 and 3), the curve radius (R) at transition length Lt=180 m is 1888 m and these values correspond respectively to the smallest radius and shortest transition for conventional trains running at 200 km/h.

The resulting P_C T values for the X2000 tilting coach passing the different curves in 250 km/h are shown in Figure 3. Each alignment has been provided with its optimal cant, resulting in the lowest possible P_C T, but an upper limit of 150 mm has been applied. On short transition curves, passenger discomfort is caused mainly by high lateral jerk and high roll velocity, while on very long transition curves, the discomfort is caused by high lateral accelerations (since the radius is reduced). Compared to conventional vehicles, body tilt systems result in lower P_C T values, but also in longer optimal transition curves, since the negative effects of small curve radii are reduced. For the same reason, a higher limit than 150 mm for cant will result in longer optimum transition curves.

In the calculations, the limits for forces and climbing ratios were not exceeded unless the transition curves were far longer than optimum and the cant deficiencies were larger than 415 mm. However, no track irregularities were used in the simulations. Hence, further investigations, including different levels of track irregularities, are necessary.

Conclusions

It has been found that large angles between the adjacent straight lines and obstacles in the middle of the curves (rather than near the ends) favour longer transition curves, even though the radii must be reduced.

Vehicle characteristics also affect the lengths of the optimal transition curves. In particular, tilting trains favour longer transitions since the comfort in these trains is less affected by reductions of radii.

Figure 2. Possible R/Lt combinations in four different terrain corridors.

Figure 3. P_C T for a tilting coach passing curves in four different terrain corridors.

Article specially written for Nordic Road & Transport Research by Björn Kufver, Senior Researcher at VTI. It is based on results from a research project on Track/Vehicle Interaction, reported mainly in VTI rapport 424A.

ACKNOWLEDGEMENTS

The work has been carried out in cooperation with Professor Evert Andersson at the Royal Institute of Technology (KTH). It was financed by Adtranz Sweden, the Swedish National Rail Administration (Banverket), the Swedish Transport and Communications Research Board (KFB), the Swedish State Railways (SJ), and the Swedish National Road and Transport Research Institute (VTI).
Research activities at the Danish Road Institute

The Research and Development Department at the Danish Road Institute has 25 employees, mainly engineers. Below is a description of the matrix organisation for the research projects and a list of the projects included in the Institute’s Action Plan for 1998.

The activities of the Road Directorate presuppose that important new knowledge and techniques are procured, distributed and used within the entire organisation.

Research is defined as a systematic search for new knowledge with the purpose of direct application in the road sector. The research activities of the Danish Road Institute are concentrated on the areas of construction, operation and maintenance of roads. They also represent an important part of Denmark’s research on an international level within the road sector, since new knowledge is increasingly being procured through international co-operation.

The structure of the research activities of the Danish Road Institute can be divided into a number of research cells, each of which is included in one of four material areas and one of four subject items. The structure thus forms a 4 x 4 matrix of research cells.

The material areas are the following:
- **asphalt** for road paving,
- **concrete** for structures, bridges and roads, including composite materials,
- **unbound and stabilised basecourses and subbases**, including raw materials and recycled materials, i.e. crushed building materials, slag and fly ash, and
- **insulating and water proofing materials**, pre-fabricated membranes and sprayed materials for bridges.

The four items are the following:
1. **Environment**, i.e. the environmental influence deriving from the road and its materials, as well as technical activities in connection with the construction, operation and maintenance of roads. This includes subjects such as raw materials, recycling, storage, air pollution, noise, and run-off.
2. **Measuring technology and methods**, i.e. principles, techniques (incl. development of measuring equipment) and methods, which are used for measurement and testing within the four material areas.

<table>
<thead>
<tr>
<th>Subject Item</th>
<th>Environment</th>
<th>Measuring technology and methods</th>
<th>Bearing capacity</th>
<th>Surface characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unbound and stabilised basecourses and subbases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulated and protective materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### RESEARCH PROJECTS - 1998

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Responsible Engineer</th>
<th>Email Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deterioration of the asphalt E-moduli</td>
<td>Susanne Baltzer</td>
<td><a href="mailto:sub@vd.dk">sub@vd.dk</a></td>
</tr>
<tr>
<td>Water sensitivity of asphalt</td>
<td>Jørn Raabjerg</td>
<td><a href="mailto:jra@vd.dk">jra@vd.dk</a></td>
</tr>
<tr>
<td>Micro-properties of asphalt pavements</td>
<td>Jørn Raabjerg</td>
<td><a href="mailto:jra@vd.dk">jra@vd.dk</a></td>
</tr>
<tr>
<td>New test methods for measuring asphalt stability and durability</td>
<td>Carsten B. Nielsen</td>
<td><a href="mailto:can@vd.dk">can@vd.dk</a></td>
</tr>
<tr>
<td>Cataloguing the polymer structure of new and existing asphalt pavements</td>
<td>Vibeke Wøgen</td>
<td><a href="mailto:viw@vd.dk">viw@vd.dk</a></td>
</tr>
<tr>
<td>Damage and deterioration mechanisms of new and existing concrete bridges</td>
<td>Finn Thøgersen</td>
<td><a href="mailto:fit@vd.dk">fit@vd.dk</a></td>
</tr>
<tr>
<td>Blistering associated with bridge waterproofing membranes</td>
<td>Finn Thøgersen</td>
<td><a href="mailto:fit@vd.dk">fit@vd.dk</a></td>
</tr>
<tr>
<td>Testing methods and specifications for thin pavement with synthetic binder for bridges</td>
<td>Jeanne Rosenberg</td>
<td><a href="mailto:ros@vd.dk">ros@vd.dk</a></td>
</tr>
<tr>
<td>Durability and applications of bituminous waterproofing and existing thin pavements with synthetic binder for bridges</td>
<td>Jeanne Rosenberg</td>
<td><a href="mailto:ros@vd.dk">ros@vd.dk</a></td>
</tr>
<tr>
<td>Testing methods for adhesion of waterproofing membranes for bridges</td>
<td>Vibeke Wøgen</td>
<td><a href="mailto:viw@vd.dk">viw@vd.dk</a></td>
</tr>
<tr>
<td>Improvement of flexible stone mastic joints for bridges</td>
<td>Vibeke Wøgen</td>
<td><a href="mailto:viw@vd.dk">viw@vd.dk</a></td>
</tr>
<tr>
<td>Pavement condition measurements of road sections with subbases composed of incinerator wastes</td>
<td>Knud A. Pihl</td>
<td><a href="mailto:kap@vd.dk">kap@vd.dk</a></td>
</tr>
<tr>
<td>Environmental considerations of road structures</td>
<td>Knud A. Pihl</td>
<td><a href="mailto:kap@vd.dk">kap@vd.dk</a></td>
</tr>
<tr>
<td>Fundamental properties of bitumens determined with Rheometer testing</td>
<td>Jeanne Rosenberg</td>
<td><a href="mailto:ros@vd.dk">ros@vd.dk</a></td>
</tr>
<tr>
<td>Functional properties of Danish asphalt by the Nottingham Asphalt Tester (NAT)</td>
<td>Jeanne Rosenberg</td>
<td><a href="mailto:ros@vd.dk">ros@vd.dk</a></td>
</tr>
<tr>
<td>Accelerated loading of a rutting resistant wearing course asphalt</td>
<td>Carsten Nielsen</td>
<td><a href="mailto:can@vd.dk">can@vd.dk</a></td>
</tr>
<tr>
<td>Verification and improvement of pavement deterioration models from the SHRP2 - testing programme</td>
<td>H.J. Ertman</td>
<td><a href="mailto:hje@vd.dk">hje@vd.dk</a></td>
</tr>
<tr>
<td>COST 336, Falling weight Deflectometer</td>
<td>Ole Fog</td>
<td><a href="mailto:fog@vd.dk">fog@vd.dk</a></td>
</tr>
<tr>
<td>Comparison of modern non-destructive Testing (NDT) methods and analytical procedures for determining road structural properties</td>
<td>Gregers Hildebrand</td>
<td><a href="mailto:ghb@vd.dk">ghb@vd.dk</a></td>
</tr>
<tr>
<td>Asphalt temperature measurement during FWD testing</td>
<td>Ole Fog</td>
<td><a href="mailto:fog@vd.dk">fog@vd.dk</a></td>
</tr>
<tr>
<td>Road Testing Machine (RTM): Deterioration models for unbound granular materials</td>
<td>Robin Macdonald</td>
<td><a href="mailto:rmd@vd.dk">rmd@vd.dk</a></td>
</tr>
<tr>
<td>COST 337, Unbound Granular Materials for Road Pavements</td>
<td>Robin Macdonald</td>
<td><a href="mailto:rmd@vd.dk">rmd@vd.dk</a></td>
</tr>
<tr>
<td>Dynamic triaxial testing of unbound granular materials for road pavements</td>
<td>Susanne Baltzer</td>
<td><a href="mailto:sub@vd.dk">sub@vd.dk</a></td>
</tr>
</tbody>
</table>

3. **Bearing capacity**, including structural condition, which means that widely varying research subjects such as traffic load, deterioration models (structural) and permeability are covered by this item. The item has no relevance for insulation and materials.

4. **Surface characteristics**, which include functional condition, such as evenness, friction, surface structure, rutting, noise and deterioration models (functional). The item has no relevance for unbound and stabilised basecourses and sub-bases.

Above are shown the titles of the research projects being carried out in the Research and Development Department during 1998. Also mentioned are the names of the engineers responsible for the projects and their e-mail addresses.

Further information on the project may be obtained from the responsible engineers via their e-mail addresses or by fax or mail to:

Danish Road Institute  
P.O. Box 235  
DK-4000 Roskilde  
Denmark  
Fax: + 45 46 30 01 00

In addition to the projects mentioned above, the Research Department is engaged in a number of international projects with external partners.

*Article specially written for Nordic Road & Transport Research by H.J. Ertman Larsen, Deputy Director, Danish Road Institute, Head of Research Department.*
The International Pavement Subgrade Performance Study

An international project sponsored by the Federal Highway Administration (FHWA), USA, entitled the International Pavement Subgrade Performance Study, commenced in 1994. The primary objectives of the study are to investigate the failure mechanisms of a range of subgrade soils under the influence of loading and climatic factors, and to develop new and improved subgrade failure criteria and performance models.

The project, centred principally at the accelerated loading facility of the US Army Corps of Engineers at the Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire, USA, will continue until the year 2000. During the study, full-scale instrumented sections of flexible pavement on four different types of subgrade soils will be constructed at three different moisture contents. In the CRREL facility, the pavement sections are dynamically loaded by a Heavy Vehicle Simulator (HVS) built in South Africa. An important part of this research study has been conducted in the Danish Road Testing Machine (RTM) at the Danish Road Institute (DRI) and the Institute for Planning of the Technical University of Denmark (DTU/IFP).

As part of this international study, and to initiate the empirical study, the Danish research team undertook the task of constructing and load testing a preliminary test pavement in the Road Testing Machine (RTM) during 1995/96. The objective was to evaluate various instruments, instrumentation and testing procedures of interest for the full-scale test sections, and to provide a preliminary pavement deterioration model.

The first test pavement (RTM1) was constructed and load tested in 1995/96. Loading was stopped after 100,000 load repetitions due to a soil reinforcing effect caused by one of the groups of strain measuring instruments, when the permanent deformation (depth of rutting) at the surface had developed to an average value of approximately 13 mm (0.5 in.). On the basis of the experience gained from the first test pavement, the Danish research team constructed and load tested a second test pavement (RTM2) during 1996/97 with similar pavement materials and structure.

A dual tyre loading trailer applied accelerated loading to the two RTM test pavements, which were enclosed within a climate chamber maintained at a surface temperature of approximately +25°C (+77°F). During the RTM1 test series in 1996, two load levels were applied: 20 kN (4,496 lbf) and 40 kN (8,992 lbf) for 50,000 load repetitions each. During the RTM2 test series in 1997, three load levels were applied: 40 kN (8,992 lbf), 50 kN (11,240 lbf) and 60 kN (13,488 lbf) for 50,000 load repetitions each.

Response instrumentation in the RTM1 measured the stresses and strains of the unbound materials in three orthogonal axes to the same degree of duplication. The instruments included: strain measuring sensors (Strain Deformation Transducers, SDTs, and Emu strain sensing induction coils developed by researchers at Nottingham University, UK); Soil Pressure Cells (SPCs); Asphalt Strain Gauges (ASGs); Soil Moisture Probes and Pore Pressure Sensors (PPSs). RTM2 test instrumentation concentrated on measuring the vertical responses of the unbound materials using SDTs and SPCs; ASGs measured asphalt strains, while PPSs and thermometers recorded pore pressures and temperatures. Routine monitoring during both testing programmes included surface profile measurements with a Profilometer and FWD testing.

The 60 kN loading series was completed at the end of 1997, by which time the pavement had developed a permanent deformation (average depth of rutting) of 10 mm (0.394 in.). During the first half of 1998, the test pavement was frozen for a period...
of two months at a constant surface temperature of \(-10^\circ\text{C.} (+14^\circ\text{F.})\). After thawing the pavement during the second half of April 1998, the test pavement has been exposed to approximately eight hundred load repetitions up to mid-May 1998. The permanent deformation during this simulated spring thaw period accelerated to a level approaching double that developed during the previous 150,000 load repetitions under normal (stable climatic) loading conditions.

Details of the materials used and the construction and instrumentation of the two test pavements have been reported in a paper presented at the TRB 1997 Annual Meeting (RTM1) and in a recent publication from the Danish Road Institute entitled: Subgrade Performance Study, Part 1: Materials, Construction and Instrumentation (RTM2). The data collected during the two test series will be analysed and reported in an analysis report entitled: Pavement Subgrade Performance Study, Part II: Modelling Pavement Response and Predicting Pavement Performance.

Following the freeze/thaw accelerated loading research commenced in 1998, comprising accelerated loading of the weakened test pavement up to a state of failure, it is intended to continue to use the existing pavement and instrumentation to investigate the effect of a partial reconstruction or maintenance action on the extended life of the pavement.

Rehabilitation of the pavement by rellevelling and renewal of the asphalt surfacing may be carried out in stages by:

- Milling the deformed surface (rutted and possibly cracked) and filling with a suitable asphalt mix to relevel the test surface, followed possibly by a surface treatment.
- After a period of accelerated loading at load levels and repetitions to be decided, the deformed surface may be further overlaid with an asphaltic levelling layer and a thin wearing course layer. Further repetitions and varying load levels may then be applied until failure is again reached.

Following rehabilitation of the pavement surfacing, the effect of partial water saturation of the test pavement will possibly be one avenue of research investigated. This may be studied either by simulating rainfall on the surface and/or raising the water table within the body of the subgrade from below.

Other future possible topics of research for the RTM are:

- Incorporation of conclusions and new research directions from the OECD DIVINE project, which held three international concluding conferences during 1997. Two DIVINE research topics of relevance to RTM research are the effects of dynamic loading on the design and maintenance of pavements, and mechanistic models simulating the dynamics of pavements and trucks.
- Development of constitutive performance relationships for thin asphalt concrete surfacings based on varying test temperatures and multiple levels of applied pressures, since flexible surfacings are sensitive to operating temperatures and the intensity and frequencies of applied loading.
- Research has also indicated that the dynamics of the pavements as well as of vehicles play an important role in pavement response to dynamic traffic loads. A pavement analysis programme which combines the bimodal behaviour of asphalt concrete with the dynamics of unbound granular pavement layers and vehicles might be an outcome of such research.

Article specially written for Nordic Road and Transport Research by Robin Macdonald, Danish Road Institute, Research Department.

REFERENCES:
Floating bridge in Norway - “no rebar corrosion” after five years of service?

“No rebar corrosion” after five years in service is the status of the Bergsøysundet floating bridge. This “No corrosion” conclusion is based on an extensive measurement programme covering both instrumented corrosion surveillance and tests on chloride ingress in the pontoons.

But what is the situation in reality?

Bergsøysundet bridge is one of two floating bridges constructed in the early nineties. The bridge is part of primary road E36 along the west coast of Norway, connecting the islands of Bergsøy and Aspøy in Møre & Romsdal County.

The floating bridge consists of an 830 metre long steel frame supported on seven pontoons constructed of high strength LWA concrete. The elliptical pontoons, measuring 34 x 20 metres and with slipformed walls 6.1–7.0 metres high, were constructed during the period from April 1991 to April 1992. The pontoons were launched into sea water seven days after completion of slipforming. Concrete cover is 60 mm on the outside of the bottom slab and the walls, and 50 mm on the outside of the top slab.

Before 1991, no floating bridges had been built in Norway and as such the Bergsøysundet bridge represented a new type of bridge. Exposed to the severe coastal environment, it was considered essential to establish a relationship between the loads acting on the bridge and its static and dynamic response. In addition, a system for durability surveillance of the pontoons was installed by the company Oceanor. The bonded reinforcement is protected by a sacrificial anode cathodic protection system.

Durability surveillance

Corrosion surveillance of concrete structures is part of an Instrumentation, Documentation and Verification (IDV) project in progress at the Road Technology Department.

The IDV methodology states that instrumentation should ideally be selected on the basis of the parameters to be verified. But which are these parameters and do we want to verify whether corrosion is taking place or not? In this particular project, where the objective is to evaluate systems for durability surveillance, data obtained from the instrumented areas of the pontoons of Bergsøysundet bridge are compared with other independent observations relevant to the durability of the structure.

The system for monitoring the corrosion behaviour of the pontoons is based on three types of gauge: reference electrodes, ERE-10, for potential measurements; four-pin Wenner probes for recording resistivity; and electrical resistance (ER) gauges which indicate when corrosion starts. The gauges are arranged in a configuration forming an instrumented area.

On the two pontoons nearest the abutments, 14 instrumented areas were established, while five were established on each of the remaining five pontoons. In total, 53 instrumented areas were established, nine of them in submerged locations, nine at sea level, nine in the splash zone, 18 on the top slab and four on internal walls. Five of the 53 reference electrodes (approximately 10%), have since failed, all of which were located in the submerged or splash zone.

Electro-chemical readings

Extensive measurements of all the instrumented areas were performed by the consulting company Det Norske Veritas in December 1996, i.e. after five years’ service in sea water.

The potential readings at different locations around the pontoons are typically $-1200 \text{ mV}$ in the submerged locations and $-600 \text{ mV}$ on the top slab when recorded against the ERE-10 electrode, which gives a potential 90 mV more positive than a Cu/CuSO$_4$ electrode. The values are the average of recorded data from all seven pontoons. Generally, there are only small variations between data recorded at the same locations, e.g. the difference between all the values recorded in the submerged zone is less than 50 mV. These small variations indicate that the potential measurements are reliable.

The resistivity measurements vary between 400 and 1300 kohm cm, indicating low corrosion rates.

The ER gauges show no increase in electrical resistance. This indicates that there is unlikely to be any corrosion of non-cathodically protected reinforcement at the location of the ER gauges, which are at a depth of 40 mm from the concrete surface. Given the location of all the instrumented areas, it can thus be assumed, at least for the splash zone where there is an ample

Cross-section of pontoon showing average potential measured with ERE-10.
supply of oxygen and moisture, that the depth of chloride ingress is less than 40 mm.

**Chloride ingress and visual inspection**

Supplementary investigations of chloride ingress in the pontoons have been carried out by Selmer ASA as part of a national research programme on lightweight concrete, named “LettKon”. 20 chloride profiles were determined at 10 different locations on the pontoons. Nine of the investigated locations were in the splash zone at elevations 0.2, 0.7 and 1.2 metres above sea level, while one location was on the top slab, 3 metres from the edge.

The obtained chloride content, in percent of concrete weight, is highest at sea level and decreases gradually with increasing height above sea level. The chloride content in submerged locations was not measured. Using the upper limit for the recorded chloride profile at an elevation of +0.2 metre above sea level, the maximum chloride content at the depth of the ER gauge, placed 40 mm from the concrete surface, is 0.06 % by weight of concrete.

![Range of chloride content at various elevations above sea level.](image)

This is below the normally accepted threshold value of 0.07–0.09 % Cl⁻ required to initiate chloride corrosion (approximately 0.4 % of cement weight).

During the visual inspections, no signs that might indicate rebar corrosion were observed.

**“No corrosion” conclusion**

The evaluation of the recorded data from the different sensors gives a consistent conclusion of “No corrosion”. This conclusion is supported both by visual inspections and by supplementary tests on chloride ingress.

However, does this conclusion reflect the situation in reality? It is easier to prove that corrosion exists than it is to prove that there is no corrosion. After all, if corrosion exists, a corroded rebar will usually be produced as evidence, whereas a “No corrosion” conclusion is based only on indications. In addition, a “No corrosion” conclusion gives no indication of how long it will be before rebar corrosion starts.

The ER gauges placed in the concrete cover can provide a warning as to when the chloride front, defined as the Cl⁻ threshold value required to initiate corrosion, reaches the depth of the gauges and initiates corrosion.

Although the electro-chemical measurements have proved to be a valuable tool in the R&D work carried out, interpretation of the recorded data with regard to the presence of corrosion must be performed by specialists.
System for in service inspection

The objectives of this project have been to test the robustness and reliability of the sensors, to investigate systems for recording and documenting corrosion parameters and finally, to evaluate whether the obtained data, recorded within a limited area, are representative for the whole structure.

In addition, it is necessary to evaluate whether the surveillance system chosen for the Bergsøysundet bridge can form a cost-effective part of a management system and whether this can reduce the overall inspection costs of the structure in the long term.

In this particular case, where the instrumentation complemented the normal in service inspection programme, we are relatively firmly convinced that the “No corrosion” conclusion is correct.

However, if the evaluation has to be made on the basis of a limited number of electrochemical sensors, would it be possible to state that the recorded data are reliable and reflect the true condition of the structure?

What now?

The project is still in progress, but most of the above-mentioned objectives have already been partly attained. They will undoubtedly remain only partly attained since, as with any question concerning durability, the ultimate answer concerning the required 100 years’ protection cannot be given before that time has elapsed. Nevertheless, we feel that the project has taken a step in the right direction. In addition, a number of interesting topics have arisen in the course of the project and these are summarised below:

- What parameters should be monitored? How significant are they for durability and how reliable are the recorded data?
- How can we justify the use of equipment that is cast into the structure when its mean time to failure is less than the remaining service life of the actual structure?
- Are expensive specialists always necessary to interpret the results? Are stand-alone systems possible?
- Is durability surveillance only for special projects or will it become more widespread?
- Is it possible to perform an accurate cost/benefit analysis for a durability surveillance project?
- What are the criteria concerning the extent of automatic durability surveillance that will allow the principal inspection interval of a bridge to be increased by one year? Is durability surveillance cost-effective?
- Where should sensors be located? At the most exposed, most critical or the most expensively repaired sites?
- Does durability surveillance aim at detecting the presence of corrosion, the absence of corrosion or simply understanding corrosion?

Acknowledgements

Acknowledgements are given to two Norwegian national research projects: Durable Concrete Structures (bestandige betongkonstruksjoner) and Lightweight Concrete Structures (LettKon), and to the Research Council of Norway for their financial contribution to the project.

• What are the criteria concerning the extent of automatic durability surveillance that will allow the principal inspection interval of a bridge to be increased by one year? Is durability surveillance cost-effective?
• Where should sensors be located? At the most exposed, most critical or the most expensively repaired sites?
• Does durability surveillance aim at detecting the presence of corrosion, the absence of corrosion or simply understanding corrosion?
The newer the car you drive, the more you are exposed to accidents in which you yourself or another person is injured. New cars are more often involved in accidents than older cars. This is the main conclusion in a comprehensive research project which Institute of Transport Economics (TØI) has carried out in co-operation with Gjensidige Forsikring at the request of Directorate of Public Roads. The most probable reason is that a high level of comfort and a large amount of safety equipment in new cars contributes to higher speeds and a more defensive driving style, as well as less defensive driving behaviour.

The background to the study, in which data from more than 200,000 cars has been studied, is the general view that Norway has an old and thereby dangerous fleet of cars. It is often claimed that levies on new cars should be reduced so that the ageing vehicle fleet can be replaced by newer and safer cars.

The results of this research project raise doubts as to the validity of this argument.

Although newer cars have higher built-in safety which contributes to fewer injuries when accidents happen, the study shows that they are involved in more accidents in general. If you drive a newer car, the probability of both damage and injury is higher than if you drive an older car. No study has been made of whether the damage/injuries relate to persons in their own car, other cars, cyclists or pedestrians, has not been clarified and should be investigated in more detail. (Sten Fosser is now working as a safety adviser at NSB BA).

High average age

When the project began in 1995, the car fleet in Norway had an average age comparable with cars in the poorer countries of Europe. Although there appears to be a broad opinion that roads also have an excessively poor standard compared with other countries, it is strange that at the same time Norway is among the countries in Europe with the smallest number of fatalities in relation to the mileage driven.

Simple statistical relations show that the older a car is, the higher is the risk of an accident. On the other hand, all the statistics show that young and inexperienced drivers have a very much higher risk in traffic than experienced drivers. If we take into account the fact that the youngest drivers in general cannot afford to buy the newest cars, it is not self-evident that the car's age is the cause of older cars being involved in more accidents than newer cars.

It was on this basis that the investigation was started with the aim of isolating the effects of a car's age on the risk of accidents leading to damage and personal.

Method

The investigation has been carried out in co-operation with Gjensidige Forsikring,
and comprises about 211,000 private cars of less than 3.5 tons gross weight which are insured with Gjensidige Forsikring. Transportøkonomisk institutt obtained information in an anonymous form regarding the insurance situation and accidents involving each car.

The significance of a car’s age for the probability of an accident has been analysed with the aid of logistic regression. Calculations have been made of whether the probability of a car being involved in at least one accident in a three-year period is dependent on the car’s age and other factors. The other variables which have been used are car mileage during the past three years, the county in which the car is insured, and the age and sex of the owner/driver. It appears that the result cannot be attributed to older cars driven by younger drivers, or older cars driven shorter distances, or the county in which the car is registered.

Results

The analysis is limited to damage and injuries reported to Gjensidige Forsikring, since third party and injury insurance is obligatory for all cars. Material damage is not included since the proportion of cars insured against material damage decreases with the cars’ age. Thus, the investigation comprises accidents with other motorists and accidents leading to injuries.

The results show that, compared with the newest group of cars, the probability of an accident decreases as the age of the car increases. This applies both to damage (third party) and injuries. These results appear surprising, particularly the decrease in the risk of personal injury with increasing age of the car. Continuous improvements are being made to cars, which incorporate more and more safety equipment. Such equipment must first and foremost reduce injuries in a collision. Therefore, the trend in the risk of injury should be better than the trend in the risk of damage.

False sense of security

An immediate explanation for the results is that car drivers adapt their driving behaviour according to the characteristics of the car. Older cars are driven more carefully or are used in different conditions because the car is of an older model. Thus, the age of the car influences driver behaviour.

Several investigations have been made which show that drivers adapt their driving behaviour according to the car’s characteristics, in particular “active” safety equipment. For example, investigations have shown that drivers with ABS brakes drive faster as well as closer to the vehicle in front and that motorists with poor winter tyres drive more slowly than those with good tyres. Therefore, it is not improbable that a car’s age is also an influential factor for a driver, since the older the car, the more carefully it is driven. When using an older car which may not feel very safe, a driver probably drives slower and is more concentrated and cautious, possibly keeping a greater distance to the car in front. Older cars are less stable on curves, as well as making more noise and shaking and vibrating at high speed. All these factors may influence a driver to drive more carefully.

It is also possible that older cars are used less in particularly demanding driving conditions. In conditions where a person is uncertain as to whether he should make a journey or not, or is in doubt about which type of transport he should use, the age of the car, i.e. its characteristics and comfort, may be decisive for his choice. If the roads are especially slippery or if driving conditions are difficult for some other reason and the risk of an accident is particularly high, the age of the car may decide whether it is used or not.

Better protection

There is little doubt that new cars provide better protection than older cars in the event of an accident. Since this does not contribute to a higher accident risk for older cars, the explanation is probably that older cars are driven in a different way and more carefully than newer cars, so that there are fewer accidents per driven kilometre. Another consequence may be a lower speed at the time of an accident compared with newer cars, so that it also offsets part of the advantages of passive safety equipment.

The Traffic Safety Handbook published in February this year shows that many driving aids introduced in cars in recent years have a considerable safety effect. At the same time, we know that the newer a car is, the more safety equipment it has. Since our results point in the opposite direction, this may indicate that other changes to cars, such as better comfort and trafficability, have a greater influence on safety in a negative direction than safety equipment has in a positive direction. Putting the focus on safety equipment when marketing new cars may give drivers a false sense of security.

Further investigations

In order to obtain a better understanding of the relations between safety and a car’s characteristics, it would be useful to carry out a series of investigations.

Until further research results are obtained, there are grounds for stating that older cars are probably safer than newer cars, and that the main explanation is that motorists adapt their driving behaviour to the car’s characteristics.

REFERENCE

A new edition of the Traffic Safety Handbook has now been produced. The book contains approximately 700 pages with information on the best ways of reducing traffic accidents or limiting injuries when accidents happen. The authors have analysed more than 1,600 national and international research reports and compiled the results in a general survey.

In addition to the accident reducing effects of 124 different traffic safety measures, the book contains an evaluation of the effects of the measures on trafficability and environmental conditions, and the extent to which they are used in Norway today. It also provides an evaluation of which accessories offer the greatest benefit in traffic safety in relation to the cost of implementing them.

Local associations and others who are involved in traffic safety on a local level will also derive considerable benefit from the information showing the public bodies responsible for implementing the various traffic safety improvements, and the procedures followed when an improvement is to be introduced.

Four main parts

The handbook is divided into four main parts. Part I describes the content and structure, and provides a general introduction to the field of traffic safety, the factors influencing accidents and risks, various approaches, theories and methods, and the way in which the handbook is intended to be used.

Part II describes 14 general means of influencing traffic safety. These means are general and are used in many areas of society. They are not always regarded as traffic safety measures. However, the general measures are important, since they can influence the traffic volume, traffic distribution between different transport modes or routes, and traffic distribution in the road network. Examples of such measures include land use planning, changes in transport mode distribution, general vehicle levies and road pricing.

The eight chapters in Part III describe a total of 100 specific traffic safety measures in the following areas:

1. Road design and road equipment (20 measures)
2. Road maintenance (9 measures)
3. Traffic control (21 measures)
4. Vehicle technology and personal safety equipment (28 measures)
5. Vehicle inspection and workshop approval (4 measures)
6. Safety regulation of driver training and occupational driving (13 measures)
7. Road user training and information (4 measures)
8. Police enforcement and sanctions (11 measures)

Part IV, subject word register and glossary, includes explanations of words, symbols and abbreviations used in the book.

The book has been produced at the request of Samferdselsdepartementet and the Norwegian Road Directorate.

Structure

Each chapter describing a traffic safety measure in Part II (14 chapters) and Part III (110 chapters) is written according to the same plan. This has been done to increase clarity and assist the comparison of different measures. The chapters concerning safety measures are divided into the following standard sections:

1. Problems and goals
2. Description of the measure
3. The effect on accidents
4. Effects on trafficability (mobility)
5. Effects on environmental conditions
6. Costs
7. Cost-benefit evaluations
8. Formal responsibility and procedure

The handbook can be ordered here or from the Transportøkonomisk institutt. Tel: +47 22 57 38 00. Fax: +47 22 57 02 90. Further details can be obtained from Rune Elvik, Transportøkonomisk institutt. Tel: +47 22 57 38 22. E-mail: rune.elvik@toi.no
Traditionally intermodal transport has been favoured by politicians, although its growth has remained below expectations. However, ongoing studies show that the potential for growth is real.

The European Union has a Common Transport Policy (CTP). One of its goals is to enhance the co-operation of transport modes in both passenger and freight transport. Within the Fourth RTD Framework Programme there is a research area of integrated transport chains (ITC). The main objective of the research programme for ITC is “to solve the problems that impede the growth of intermodal transport and realisation of optimum quality under the conditions of sustainable mobility including environmental considerations”. The Commission has approved about twenty intermodal projects to be funded within the 4th FP (further information about the projects is available at http://cordis.lu/transport/src/integrat.htm). These projects deal with both technological and functional matters. VTT is involved in the projects SCANDINET and TERMINET.

SCANDINET - Promoting integrated transport in peripheral areas of the Union

The amount and share of intermodal transport is modest in the peripheral countries of the EU such as Scandinavia. This offers good grounds for developing intermodal transport. The potential may lie both in domestic transport and in freight movements between Scandinavia and the European mainland. By concentrating transport flows to a few chosen corridors and terminals, and providing better information about services than at present, better conditions for the intermodal transport can be created.

The research project for this purpose is SCANDINET, a joint venture of logistics services providers, researchers and transport administrations in the Scandinavian countries, Germany and Spain. SCANDINET is designed to meet the requirements of Task 3.1/1 of the Transport Research Programme of the European Union dealing with Integrated Transport Chains.

The overall goal of SCANDINET is to improve access to the infrastructure, information and market for intermodal transport services – in particular for SME’s (Small and Medium size Enterprises) and isolated flows. The project identifies the possibilities to combine domestic, international and transit flows by using intermodal transport in the chosen corridors and terminals and the possibilities to shorten the economic usage area of the intermodal transport from 700–800 km even to below 300 km. Furthermore there is an aim to define a concept for organisations which operate using telematic applications and information of intermodal transport. The results will be directed to support decision-making related to intermodal transport among users and the EU.

An interview based survey investigating the decisions that guide the choice of transport mode has been conducted among 40 Nordic industrial actors, forwarding
agents, and transport companies. In quality assessment, intermodal transport scored generally lower than single modal transport, indicating that shippers are less satisfied with the overall quality standards supplied by intermodal rather than single modal operators. Nevertheless, shippers are not uniformly satisfied either with the overall quality supplied by single modal operators. However, the conclusion is that there is a gap between the quality required and that supplied.

The following corridors form the basic network in Scandinavia:

1. Trans European Network (TEN) with enlargement to Pan European Network (PEN). The Nordic Triangle is part of TEN, connecting the Nordic capitals Copenhagen, Oslo, Stockholm and Helsinki.
2. Scanlink proposals and development based on industrial needs in Scandinavia.
4. Barents Euro-Arctic area connecting Scandinavia with the Kola Peninsula in the North.

The development of these separate transport corridors will form the basis of the Scandinavian potential intermodal network.

The SCANDINET project also assesses the economic area of usage of intermodal transport. The word “economic” has been given a wider interpretation than merely comprising monetary aspects. The focus has been to assess the domain and conditions of viable intermodal transport. Special attention has been given to the road-rail-road version of intermodal transport, but the sea mode is also studied. Findings are structured according to the major groups of executive decision makers involved in promoting intermodal transport between the Nordic countries and the rest of Europe. These groups constitute:

1. the public system (Commission, national and regional governments),
2. the demand system (the demand for transport services defined by consignors’ supply of goods and consignees’ demand for goods), and the transport system (forwarders, carriers and operators), the latter being split into two subsystems, namely
3. the transport functional subsystem, and
4. the transport decision subsystem.

The project concentrates also on information flows and architecture. In SCANDINET no new telematics technologies are being developed, but a feasible concept for a commercial information service is being established. Furthermore the purpose is to improve access to intermodal transport information, at the same time that the information service is expected to improve the efficiency and quality of intermodal transport. The description of intermodal transport information system architecture is the knowledge base. The concept includes definitions of communication systems for acquiring information, information systems for refining the data, and communication systems for delivering information services to customers. The result includes concepts for new business opportunities using information technology. Selected ideas will be piloted during the piloting phase.

Information services are divided according to transport chain phases. This shows the fields for new business ideas based on information. The structure is based on the process model to highlight the areas in which new services and concepts are required:

- information systems relating to the procedures and operations before the physical movement of goods that is the overall planning of the logistics pipeline,
- information systems relating to operations during the physical movement of goods including unit identification (bar codes, transponders, tags etc.) and tracking and tracing services,
- information systems relating to operations after the physical movement of goods including reporting and analysis,
- and information systems managing the flow of information between all parties in the chain.

**TERMINET - Towards a new generation of networks and terminals of multimodal freight transport**

TERMINET is a strategic and tactic EU project researching new possibilities for intermodal freight transport in Europe. It investigates innovative bundling and terminal concepts and analyses their technical and economic feasibility for the European transport network. Innovative concepts can be found in new ways to combine transport units or loading units, in new technologies, and in the development of new networks.

A hypothesis for the research is that the cost-quality ratio of intermodal transport can be improved through automation and robotisation of processes. New concepts will be analysed for concrete regions, trans-
port corridors, freight markets and terminal and node locations. The research will result in designs, simulations, animations and business plans.

In the past many innovative plans and projects in bundling and transhipment existed, and although the ingredients seem to be there, these plans have barely resulted in a quality jump in intermodal transport. TERMINET will integrate innovative concepts and assess their cost-quality ratio. The criteria for assessment are utilisation rates, frequencies, costs, speed cycle times and reliability. The central objective is to indicate probable, promising, and missing directions of intermodal transport.

Work packages 1 and 2 have investigated innovative bundling concepts and new generation terminal and node concepts for integrated freight flows as proposed by European actors in the transport field. Over one hundred concepts have been earmarked as of possible interest for TERMINET. Of these 24 bundling and 31 terminal concepts have been described in the reports “Innovative bundling network concepts in Europe” and “New-generation terminal and terminal-node concepts in Europe”. They have also been categorised according to the related modes.

The sizes of transhipment terminals have been categorised by the European Commission. Small terminals are where the yearly number of loading units is below 20,000, medium size terminals handle 20,000–100,000 and large terminals handle over 100,000 loading units. The sizes of terminals correlate with development needs. For small terminals it is important to have low capital costs in order to have a dense network. Two Swedish concepts “Light Combi” and “CCT Plus” seem promising in that respect. The mid-size terminals seem to be able to cope with the traditional technique of portal cranes and reach stackers (figure 1), although CCT Plus (figures 2 and 3) would suit there as well. The vast hub-and-spoke networks in Continental Europe require mega-hubs that are able to handle up to ten loading units per minute, when the automation of the cranes creates added value.

Article specially written for NR&TR by Jari Gröhn

Figure 2. A simple unmanned low volume terminal equipped with one CCT Plus transfer vehicle. Source: http://home5.swipnet.se/~w-51441/

1. The train arrives at the terminal. The loading unit (box) is raised by the wagon’s hydraulic pistons, which fasten to the corner fittings of the box, to the transferring position. The transfer vehicle adjusts itself in longitudinal direction and in elevation for the transferring.

2. A telescopic transferring boom stretches out over the railway wagon and places itself on a steel plate in the middle of the wagon. The transferring sled moves to the railway wagon and stops under the box. Air bags on the sled are filled to even out the possible unevenness of the box bottom. The hydraulic pistons are lowered and the box settles on the sled. The sled is pulled by wires to the transferring unit.

3. The unloaded box is moved to the temporary stands, and another box is picked to be loaded. The operations can be automated.

Figure 3. Operating principle of the CCT Plus transfer vehicle. Source: http://home5.swipnet.se/~w-51441/
A number of experts were contacted to evaluate which areas should be given extra priority in the development of the Swedish National Traffic Safety Program (Sveriges Nationella Trafiksäkerhetsprogram 1995–2000) (NTP). The result of a survey with the fourteen experts who participated shows that their ranking differs to some extent from the current priorities listed in the program. It should also be noted that experts from countries who traditionally give high priority to bicycle and pedestrian issues seem to have different basic values than experts from other countries.

The Swedish National Traffic Safety Program (Sveriges Nationella Trafiksäkerhetsprogram 1995–2000) (NTP) lists eighteen problem areas and ranks them according to column 2 in Table 1 below. The purpose of our survey is to study whether there is a consensus among non-Swedish experts that the areas listed in NTP are the most important ones to focus on to reach the long-term safety goals as currently defined, and whether the proposed areas are ranked appropriately.

The choice of “experts” can obviously influence the results of such a survey. We decided that someone with an exceptional overview of European traffic safety work should decide who the most competent people are to make up such an expert panel. At the same time, that person should not have detailed knowledge of the content of NTP. We decided that Professor Frank Haight, University of California at Irvine, would be the ideal person and requested that he pick a minimum of ten experts working outside Sweden, with at least peripheral knowledge of Swedish conditions. Prof. Haight gave us a list with seventeen names.

**Complementing the list of problem areas**

We originally planned to contact these experts twice. First, to have them complement the listed areas in NTP; and second, to rank all areas proposed by NTP or any expert. To let the experts complement the list and rank the areas simultaneously would obviously not give fair ranks to
write-in areas, since many write-ins would not be included by all experts. On the other hand, to contact the same expert twice would probably reduce the rate of return significantly. We therefore decided to use Dr. Haight’s list for the rankings and decided to contact other experts for complementing the list.

We included Swedish researchers among the new group of experts whom we contacted to complete the list of problem areas. Hopefully, they have a good knowledge – or at least strong opinions – of which areas have been neglected. We contacted twenty-two experts for this and got replies from thirteen (59%) in time to have their suggestions incorporated in the main questionnaire. The eighteen problem areas thereby grew to a total of twenty-nine. We gave these areas English titles, and the whole questionnaire was written in English.

Results and conclusions

Fourteen of the seventeen experts (82%) responded. Each expert assigned rank 1 to the area he/she determined to be the most important one, rank 2 to the second most important one, and so on down to rank 10. Figure 1 shows the results. The graph also shows the contribution of different experts. The higher the bar, the more important the area is judged to be. Rank 1 was converted into 10 units in the graph, rank 2 into 9 units, etc., down to rank 10 giving a 1 unit contribution. The area with the highest total importance (speeding) received just over 100 units. The height of the other bars can therefore be read as their relative importance in percent of the most important area.

The results can be summarized by ranking them according to their total importance as presented in Figure 1. This is done in Table 1 which also shows the original NTP ranking.

The comparison, as presented in Table 1, shows that the international panel of experts share NTP’s opinion that the greatest problem is high velocities. However, they do not think that alcohol is the second most important area to concentrate on, assigning it rank 9. They consider that special problems associated with elderly drivers and young drivers clearly warrant more attention (shared rank 2). They also imply that observance of rules and regulations is a major problem (rank 6). It is noteworthy that this problem has not been addressed by NTP. Furthermore, the experts argue that the risks of bicyclists, pedestrians, and motorcyclists must be reduced (ranks 4, 5, and 8 respectively). NTP does not specify which of these ‘unprotected’ road user categories should be given the highest priority. Another area not addressed by NTP is “falling asleep while driving/fatigue” (rank 15 according to the experts). NTP states that “too low a geometric standard” is a significant problem (rank 8). The experts argue that this should be given minimal attention (lowest rank) whereas “too high a standard” (leading to high speeds) is a common problem (rank 12). This contradiction may result from high standards on motorways imparting a high degree of
safety – mainly because head-on collisions are eliminated and side areas are made safe – whereas a high standard in terms of alignment and road width on two-lane rural roads and in urban areas encourages high speeds resulting in serious injuries.

The opinion of an expert seems to differ depending on whether or not he/she comes from a pedestrian/bicycle friendly country – i.e. the Nordic Countries and the Netherlands. Differences in “culture” are reflected, for example, in the fact that “lack of consideration” is considered a negligible factor in pedestrian/bicycle friendly countries but a major factor elsewhere in Europe. On the other hand, low levels of safety for children and in urban areas are considered problematic only in pedestrian/bicycle friendly countries. However, experts from these countries give a much lower priority to alcohol and fatigue than do experts from the other countries. As drinking and driving is less of a problem in Sweden than in most countries, the answers may reflect that the experts have not fully been able to rank the Swedish problems, but have been influenced by how they see the issues in their own countries.

Article written by
Per Gårder (Orono, Maine, USA) and Lars Leden (VTT, Finland).

Acknowledgement
We would like to thank all the experts who answered our questionnaires and our colleagues in the evaluation team: Sven Faugert, Johan Dovelius, Christina Johannesson, Peter Kempinsky and Markku Salusjärvi for their fruitful cooperation.

<table>
<thead>
<tr>
<th>Rank by experts</th>
<th>Rank by NTP</th>
<th>Problem area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Speeding is too common a problem</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>Older road users have too high risks</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>Young drivers have too high risks</td>
</tr>
<tr>
<td>4 (5)</td>
<td></td>
<td>Bicyclists have too high risks</td>
</tr>
<tr>
<td>5 (5)</td>
<td></td>
<td>Pedestrians have too high risks</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Road users do not follow the rules of the road</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>Safety in urban areas is too low</td>
</tr>
<tr>
<td>8 (5)</td>
<td></td>
<td>Motorcyclists have too high risks</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>O UI (operating under the influence of alcohol or drugs) is...</td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>Lack of consideration for fellow road users</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>The safety of children is too low</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>The geometric standard of road sections is often too high (speeds...)</td>
</tr>
<tr>
<td>14</td>
<td>10</td>
<td>Too many urban trips are done by automobile</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Too many intercity trips by car - too many vehicle-km of travel</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Drivers fall asleep while driving – fatigue</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>Night-time (after dark) risks are too high</td>
</tr>
<tr>
<td>16 (10)</td>
<td></td>
<td>Too many roads are designed improperly for preventing injuries</td>
</tr>
<tr>
<td>18 (10)</td>
<td></td>
<td>Too many vehicles are designed improperly for preventing injuries</td>
</tr>
<tr>
<td>19</td>
<td>16</td>
<td>Heavy trucks are over-involved in serious accidents</td>
</tr>
<tr>
<td>19</td>
<td>15</td>
<td>Risks are too high in winter conditions</td>
</tr>
<tr>
<td>21</td>
<td>17</td>
<td>Intersections often have sub-standard layouts and excessive risks</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>Safety equipment is not used</td>
</tr>
<tr>
<td>23</td>
<td>12</td>
<td>Emergency care is not effective enough</td>
</tr>
<tr>
<td>23</td>
<td>11</td>
<td>Road users do not get adequate support and guidance...</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Advanced ITS equipment and cellular phones divert driver attention</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>Road users need more and better indication (destination) signs...</td>
</tr>
<tr>
<td>27</td>
<td></td>
<td>Professional drivers... - ... are often too aggressive</td>
</tr>
<tr>
<td>27</td>
<td>8</td>
<td>The geometric standard of road sections is often too low</td>
</tr>
<tr>
<td>27</td>
<td>18</td>
<td>Too many animal accidents (moose and deer) cause insecurity...</td>
</tr>
</tbody>
</table>

Table 1. Comparison of ranking between European experts and NTP
(Swedish National Traffic Safety Programme)

Reference
A flexible test pavement, instrumented to measure stresses and strains in three primary axes within the upper 420 mm (16.5 in.) of the subgrade, has been constructed and load tested in the Danish Road Testing Machine (RTM). This research is part of the international Pavement Subgrade Performance Study, which aims at developing an improved mechanistic subgrade failure criterion. The test pavement was constructed during 1995 and an accelerated loading test was undertaken during 1996.

A loading trailer applied simulated accelerated traffic loading to the RTM1 test pavement within a climate chamber maintained at approximately 25°C (77°F). Two dual tyre load levels were applied: 20 kN (4495 lbf) and 40 kN (8990 lbf) for 50,000 load repetitions each.

Instrumentation included: strain measuring sensors (Strain Deformation Transducers and Emu strain sensing induction coils), Soil Pressure Cells, Asphalt Strain Gauges, Soil Moisture Probes and Pore Pressure Sensors. Routine monitoring during the testing program included surface profile measurement with a Profilometer and FWD testing.

This paper describes the following: construction of the RTM1 test pavement; pavement materials; the types and positions of instrumentation in the test pavement; typical responses obtained from the instrumentation; surface profile monitoring and structural testing during the accelerated loading test program.
Air pollution on 21 through roads with environmental priorities

The aim of the project is to calculate the pollution produced by private cars and the consequences of reconstructing through roads in 21 small towns along the main road network.

This report describes the emission of polluting agents by cars and the energy consumption on the same test stretches. Also, an examination is made of whether there is a more general relation between speed, the volume of emissions and fuel consumption.

DUMAS - Safety for Pedestrians and Two-wheelers

This report contains the Danish contribution to the EU project DUMAS, Developing Urban Management and Safety, Work Package 6, Safety for Pedestrians and Two-wheelers, National Report.

The overall objective of DUMAS is to produce a framework for the design and evaluation of urban safety initiatives, where safety initiatives entail integration and co-ordination of road safety objectives and other objectives at a local level.

The National Report presents the Danish case for the safety of pedestrians and two-wheelers. Key issues are accident statistics, exposure, national travel survey, injury risk, accident models, road safety measures guidelines and technical rules, and integrated safety policies. Italy, Greece, Germany, Great Britain, the Netherlands and Austria are also producing a similar National Report.

A reference list can be found at the end of the report.

First announcement:

International Conference on Asphalt Pavements in Copenhagen 2002

The Danish Road Directorate will host the Ninth International Conference on Asphalt Pavements in Copenhagen on 17–22 August 2002. The conference is arranged by ISAP – International Society for Asphalt Pavements and ISAP Organising Committee invites delegates all over the world to participate.

Express for intention to participate, to give a presentation or to be put on the conference mailing list may be sent to:

Road Directorate
Danish Road Institute
Elisagaardsvej 5
Postboks 235
DK-4000 Roskilde
Denmark

For further details please contact:

ISAP 2002
c/o DIS Congress Service Copenhagen A/S
Herlev Ringvej 2C
DK 2730 Herlev
Copenhagen
Denmark
phone: +45 4492 4492
fax: +45 4492 5050
email: dis@inet.uni2.dk
The main focus in this literature review of the effects of speed-reducing measures in urban areas was to find out how different measures have affected driving speeds and traffic safety. The measures under study included speed limits, humps, road narrowings, roundabouts, reconstruction of residential streets and through roads in small villages, and traffic calming on single roads or wider areas.

Measures that at first sight appeared fairly similar varied in their effects on speeds. This was mostly explained by the differences in road and traffic environments as well as the details of the implementations. Furthermore, the impact on speeds depended on the level of speeds in the before situation.

The reduction of speed limit alone did not necessarily have a marked effect on speeds. The same holds for informative measures, for instance speed limit markings on the pavement. Most effective were treatments where lowered speed limits were supported by informative and physical speed-reducing measures which were evenly distributed along the treated area.

A common feature of several implementations was that they had no explicit target for the speed level nor for traffic safety. Consequently, the effects on speed and safety were often negligible. However, some results convincingly show that speed-reducing measures can be designed and implemented in such a way that the target speed level, for instance 40, 30 or 20 km/h, can be achieved. Successful implementations have resulted in injury accident reductions by as much as 50%. Additionally, such measures typically have the support of local residents and road users.

In the case of individual measures, such as speed humps, it is known quite accurately how they should be designed and installed to achieve a certain target speed. For instance, if the target is to reduce speeds close to 30 km/h, cylinder segment shaped humps that are 3.6 m long and 10 cm high are recommended and the distance between humps should not be more than 60–80 m. Suitable design options exist for buses and heavy vehicles.

Driving speeds on urban roads can be effectively lowered by replacing level junctions with conventional roundabouts or, what is often more practical, by mini-roundabouts. However, roundabouts are not necessarily a good solution for vulnerable road users unless pedestrians and cyclists are level-separated from motor vehicles.

In the case of other measures, such as chicanes, road narrowings or displacement of the carriageway, the studies of the effects were fewer and the resulting speed are somewhat more difficult to predict. In general, however, it seems that humps (and related measures such as raised junctions or platforms) and (mini-) roundabouts are the most effective measures, and it is difficult to achieve speed levels well below 40 km/h unless they are employed.

Overall, it was not possible to reliably estimate the safety effects of speed-reducing measures on the basis of accident statistics alone because the measures often concerned a small area and the number of accidents was small. Instead, the effect on traffic safety can be estimated on the basis of the change in driving speeds. As a rule of thumb, a 1 km/h reduction in the mean speed can be expected to cause a 2% to 4% reduction in the number of injury accidents, and a roughly two-fold reduction of both fatalities and accident costs.
Car sharing in Oslo. A study of a group of pioneers

The first car sharing organisation in Norway started in 1995. By late 1997, this organisation, known as “Bilkollektivet”, had 120 members and 12 cars. A typical member is a man over 30 years, with or without children, with a high level of education and an income above average. Although the members are more concerned with the environment compared to other citizens, they have joined the organisation because they do not need to use a car on a daily basis and because they do not want to spend money on buying cars of their own.

Most of the members drive more than they did before joining the organisation. However, some have reduced their car driving, and a few have reduced their driving substantially. Totally, there is no difference.

On average, the members drive 7,470 km less than the inhabitants of Oslo who have a driving licence and a car in the household, but not less than those not using their car to travel to work. However, the study indicates that the members would use their car for journeys to work, if they had one.

Marketing public transport:

Analyses of marketing campaigns within the Norwegian Trial Scheme for Public Transport

The Norwegian Trial Scheme for Public Transport was founded by the Ministry of Transport and Communications in 1991 and was extended throughout the period 1992–97. This report is part of the overall evaluation for 1994/95 and focuses on the analysis of major marketing projects. The analysis is based on 11,447 telephone interviews conducted in connection with 12 projects. The interviews comprised a randomly selected sample of the population in the respective districts.

The results show that less than half the population was aware of the campaigns. The variation between the regions is considerable and is essentially due to the structure and design of the campaigns. Information on specific measures had the best outreach. Comprehensive design is also important. External channels, advertisements and press reports were the means that proved most effective, but information brochures were also relatively successful. It is difficult to reach young people. A more direct form of marketing is required to access this particular group.

Rural tourism in Norway

The foreign market for rented cabins during the summer season amounts to about 2.0 million guest nights, of which German tourists account for 63 per cent. The report sheds light on the structure of the demand for Norwegian rural tourism products, booking patterns, tourists’ information acquisition, their eating and dining habits and evaluation of food service facilities, their interest in Norwegian food and activities and, finally, their expressed motives for visiting Norway.
Short trips in European countries

This report is written as part of the EU project WALCYNG. The topic compares behaviour in different countries in Europe. The limit on how far people are willing to walk, whenever walking is regarded as transport, is about 1–2 km. Walking and cycling are frequently used as transport modes when the trip itself is the purpose, and on trips for shopping and buying smaller goods. A car is much more a direct means of transport. Many short car trips are made for shopping or transporting other people. Women walk more than men, and car drivers are more often men than women. In most countries, men cycle as much as women or more. Young people walk or use a bike more than older people.

Attitudes to walking and cycling instead of using a car

This report is written as part of the EU project WALCYNG. The topic consists of attitudes to walking and cycling instead of using a car in different countries in Europe. The report is based on data from interview surveys in Norway, Finland, Austria, Italy and Spain. Health aspects are important benefits of walking as well as of cycling. Not all trips are suitable for walking and cycling, and in many areas the conditions for walking and cycling are unsatisfactory. Walkers as well as drivers consider the infrastructure as well as political measures to be the most important factors for improving walking and cycling conditions.

Risk of fatal injuries and personal injuries in transportation - preliminary results

In this pilot project, the risk of fatal injuries and personal injuries in different transport modes is calculated on the basis of existing data. These calculations are difficult since definitions of injuries and journeys vary between different transport modes. The possibilities of reducing transportation accidents by moving traffic from high-risk to low-risk modes are discussed. Literature searches on transportation disasters have been made in international databases. Since few publications were found, a suggestion is made to the effect that theories and methods of studying disasters in other sectors of society should also be applied in transportation. The working paper concludes with proposals for further work.

Accident risk among novice drivers: An evaluation of changes in car driver training and licensing in Norway

In 1994–95, changes were made in the rules for driver training and licensing in Norway. Possibilities of private driver training were extended, mandatory training in traffic schools was reduced, and the licensing test became more extensive. A postal questionnaire on accidents and exposure was administered to about 23,000 drivers aged 18–20, divided into two groups who had obtained their licenses before and after the changes respectively. The results showed a small increase in private training and a decrease in training at traffic schools, but no differences in accident risk. For both groups, the risk was halved during the first 9–10 months of driving. The evaluation does not address possible effects of the reduced age limit for driver training (from 17 to 16 years) or the removal of the phase 2 driver training.
Studded tyres and air pollution

The use of studded tyres has led to an air pollution problem in the largest cities of Norway. In 1995, a project was initiated to calculate the socio-economic consequences of changes in the use of studded tyres. The project was also to propose a new policy for the use of studded tyres and restrictions applying to them. The project found that there is a socio-economic benefit in reducing the number of vehicles with studded tyres from 80%, which was the level in 1996, to about 20%. The Government has agreed to the project’s proposal of reducing the use of studded tyres to 20% in the four largest cities in Norway by the year 2002. The aim will hopefully be reached voluntarily, but if not, a tax will be levied on driving with studded tyres in these four cities.

A short summary of the project has been published in English and French in two internal reports from the Road Technology Department (NRRL).

Author: Jon Krokeborg
Series: Internal Report No. 2021 (English)
Rapport interne No. 2022 (French)

Road and traffic technology

The publication describes present day road and traffic technology in Norway. The four introductory articles deal with the following subjects: “Clearing the way”, “Through the mountains and over the fjords”, “Keeping traffic clean and safe”, and “The Norwegian Public Roads Administration”.

The first of these describes the geographical conditions, construction challenges, winter traffic conditions, and winter maintenance. The second deals with innovations in tunnelling technology, both in hard rock and across the fjords. The fjords are crossed by combinations of tunnels and bridges, the latest method being floating bridges. The third article deals with traffic safety and pollution resulting from traffic. The last describes some of the levels of road construction and maintenance in which the NPRA is participating.

The remaining part of the publication describes the main Norwegian firms involved in road and traffic technology in Norway as well as abroad, sorted into the following main groups: Technology and equipment, Information and communications technology, and Consultancy and other services.

Publisher: Norwegian Trade Council
Language: English
Noise trailers of the world
 tools for tire/road noise measurements with the Close-Proximity method

The International Organization for Standardization (ISO) is currently working on a proposed standardized measuring method for tire/road noise called the Close-Proximity (CPX) method. The CPX method relies on special test vehicles in which the noise emitted from one test tire at a time is measured with two microphones close to the test tire, currently specified as 0.2–0.4 m from the tire. The most commonly used vehicle for this purpose is a trailer which is towed by a van or a car.

This report presents a survey of all test vehicles, known to the author, employed for such noise testing; the great majority of them being trailers. The test vehicles are systematically presented and compared with respect to major design features. More than 30 vehicles have been identified as available worldwide. Although the design differs, it should be possible to adapt almost all vehicles to meet the proposed standard.

It is anticipated that the survey will aid and give hints in the design of new test vehicles, a topic that will come up quite frequently in the next few years when ISO standardization reaches a final status.

Passenger air-bag status indication awareness study

With the growing concern about the potential danger with rear facing child seats placed in the front seat of passenger airbag equipped cars, various systems are being considered for deactivation of the airbag.

To increase the awareness of and confidence in these proposed systems, information displays were developed for the purpose of telling the status of the passenger airbag system and to warn when necessary. A study of the effectiveness, understanding and acceptance of a selection of such information displays was jointly undertaken by Volvo Car Corporation, Saab Automobile AB and the VTI.

Respondents of various age and demographic composition, parents and grandparents of small children, were exposed to six different sets of information displays conveying passenger air-bag status (on/off) and warnings of the potential danger of an air-bag in combination with a rear facing child seat. The respondents were asked to interpret each display message, and also to state which one of the information displays that conveyed the message most clearly.

Conclusions were drawn concerning information content, and the use of symbols and colours.

The study did also investigate the respondents’ preference regarding automatic or manual disconnection of airbag systems.

Road surface characteristics and traffic safety

The aim of this project was to further study the relationship between traffic safety and road surface condition as a follow-up to a previous Nordic project with the same purpose, reported in 1989. The present study is based on statistics on traffic accidents with personal injury as well as property damage, reported to the police, in Sweden during 1986 and 1987.

When sub-dividing the road network into two categories of surface condition, “good” and “less good”, the following results were obtained:

- Considering all roads, accident rate is about five percent higher on “good” roads than on “less good” roads.
- In the summer, the accident rate on “good” roads is 13 percent higher than on “less good” roads.
- In the summer accident rate decreases with increasing rut depth, but accident rate increases with increasing rut depth in the winter.
- Accident rates increase with increasing roughness (higher IRI-index). This increase is higher in winter than in summer.

A very rough conclusion is that appearance of ruts may have a tendency to increase safety while roughness seems to decrease safety. This is however not quite true for major roads. Further studies are necessary in order to draw more definite conclusions.
Validation of indirect tensile test for fatigue testing of bituminous mixes

The Indirect Tensile Test (ITT), introduced in Sweden more than 10 years ago, is often used to estimate functional properties of bituminous mixtures such as tensile strength, elastic stiffness and fatigue characteristics. These parameters are essential in proportioning of asphalt mixes and analytical design of road pavements.

The validation of the ITT used in Sweden and presented in this report, will be used as input to a working group for European harmonisation of test methods within the CEN standardisation, (Comité Européen de Normalisation). The report also includes a description of the VTI test procedure for determination of fatigue characteristics of bituminous mixes.

Tranquillisers and hypnotics

Simulated driving and laboratory test performance of users and healthy persons

Comparisons were made between outpatients using various benzodiazepines and an individually age and sex matched control group regarding simulated driving (lateral position variation, brake reaction time), simple reaction time, choice reaction time and short term memory. The patients exhibited greater intraindividual speed variation in simulated driving, and impaired performance on simple reaction time and memory. No other differences were found regarding behaviour. No effects were found of a small alcohol dose on behaviour. BAC was just below 40 mg% at the laboratory tests and about 25 mg% at the simulator runs.

Subjectively, a number of differences appeared between the two comparison groups. The patients reported higher levels of anxiety and depression, and lower wakefulness and well-being. Certain effects of alcohol appeared with regard to subjective measures: a higher degree of confusion, fatigue and depression and lower well-being. Regarding fatigue, the patients seemed to be somewhat more influenced by alcohol than the control group.

No relationship between dosage and performance was detected in an analysis. There was, however, a tendency for lateral position variation to increase with increased dosage. For brake reaction time, short term memory and choice reaction time, there were similar tendencies, but weaker. Reported feelings of depression and confusion increased with increasing dosage.

The results do not give any clear indication that persons who use prescribed medication with benzodiazepines would constitute a notable traffic safety problem.

Drunken drivers given supervision instead of prison sentences

There is a need to compile a national database on drunken driving, since experience from other countries is not necessarily applicable to Swedish conditions. Legislation, drinking habits, and public attitudes to drinking and driving differ markedly from country to country. Since 1990, the driving licence unit of the Magnus Huss Clinic, at the Karolinska Hospital in Stockholm, has been collaborating with a probation office unit of the National Prisons and Probation Administration and the Offender Aid Society on a non-institutional drunk driving program of at least one year's duration, often linked with several years' follow-up. This article outlines experience and results derived from this program. Among other things, blood alcohol content is questioned as an indicator of the severity of a drinking problem.
Visit our home site
www.vti.se/ nordic

- Browse contents of recent NR&TR issues
- Order publications and back copies
- Subscribe
- Ask questions
- Send comments

Nordic Road & Transport Research

A joint publication of six Nordic public road and transport research organisations, offers you a convenient way of keeping in touch with current Nordic research results.
Questions concerning the content of the articles, or orders for the publications referred to, should be directed to the publishing institution, see addresses below.

REQUESTS FOR BACK ISSUES, AND NOTIFICATION OF ADDRESS CHANGES:
Readers outside the Nordic countries: see Swedish address.
Readers in the Nordic countries: see addresses below.

Web site: www.vti.se/nordic