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Polymer modified waterproofing and pavement system for the Höga Kusten bridge in Sweden

Ylva Edwards[1] and Pereric Westergren[2]

INTRODUCTION

The document describes a project for choosing the most suitable waterproofing and pavement system for the Höga Kusten bridge over the Ångerman river. The bridge will have a length of 1 800 metres and its towers, which measure 180 metres above water level, will be Sweden's tallest structure. The Höga Kusten bridge will be one of the world´s longest suspension bridges and will be completed in the autumn of 1997.

The waterproofing and pavement for this bridge must be chosen with care. A lowest average temperature of -20°C, a minimum temperature of -40°C and a maximum temperature of +30°C have been recorded. To be able to recommend the most suitable system for the bridge, a project was started by the Swedish National Road Administration as early as 1991. Different waterproofing and pavement products and systems were discussed and tested, separately and in different combinations for evaluation.

PRODUCTS AND LABORATORY STUDY

The materials studied were:

- Epoxy primer system and/or bituminous primer
- SBS-modified bituminous sheet, 3.5 mm and with a polyester reinforcement
- Mastic asphalt, with conventional bitumen and Trinidad Épuré
- Mastic asphalt, with SBS-modified bitumen
- Gussasphalt with conventional bitumen and Trinidad Épuré
- Gussasphalt with SBS-modified bitumen
- Split mastic asphalt with SBS-modified bitumen and fibres

Laboratory testing was performed at the Swedish National Road and Transport Research Institute (VTI), starting in 1992. Testing covered characteristics and performance of the different products and systems at low and high temperatures. Adhesion (to steel deck and between layers), shear and sliding resistance were important parameters studied for total built-up systems.

Systems with SBS-modified bituminous sheet (3.5 mm thick), SBS-modified mastic asphalt (4 mm) and conventional mastic asphalt (4 mm) were compared. The conventional mastic asphalt system corresponds to the system which was used in 1981 for another large Swedish steel bridge, the Tjörn bridge, as a reference to the "new" polymer-modified systems.

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TEST BRIDGE

In 1993, eight different systems were laid on a steel bridge at Pitsund (further north than the Höga Kusten bridge) for evaluation on site and laboratory testing at VTI. Sixteen test areas (2 m x 2 m) were prepared on the bridge.

<u>Laboratory testing and field testing</u>

All material used on the bridge was tested at VTI for characteristic and functional performance. Testing was performed according to BRO 94 test programs for primer and sheet products. Mastic asphalt and Gussasphalt products were tested for parameters such as indentation value, dimensional stability, softening point Wilhelmi, low temperature test Herrmann, dynamic creep test, three-point loading test and thermal stress restrained specimen test (TSRST). Recovered binder was also tested (traditional analysis, chemical analysis (Iatroscan, GPC), fluorescence microscopy and low temperature BBR analysis).

When laying the test areas in 1993, tensile bond testing was performed on the bridge. Temperature measurements were made during laying. Follow-up inspections on the bridge were made, twice in 1994 and once in October 1995. The test areas were visually inspected, mainly for cracks. Severe cracking was observed only for the reference system, on both test areas. At the last inspection in October 1995, tensile bond tests were also performed. The results were generally very good for all systems.

FATIGUE TESTS AT THE OTTO GRAF INSTITUT

Fatigue tests of the entire waterproofing and pavement system were performed for four possible systems and the reference system at the Otto Graf Institute (FMPA) in Stuttgart from 1994 to 1995. Testing was performed in accordance with the German ZTV-BEL ST-92 "Dauerschwellbiegeprüfung", from -30°C to +30°C, in some cases with the double loading applied.

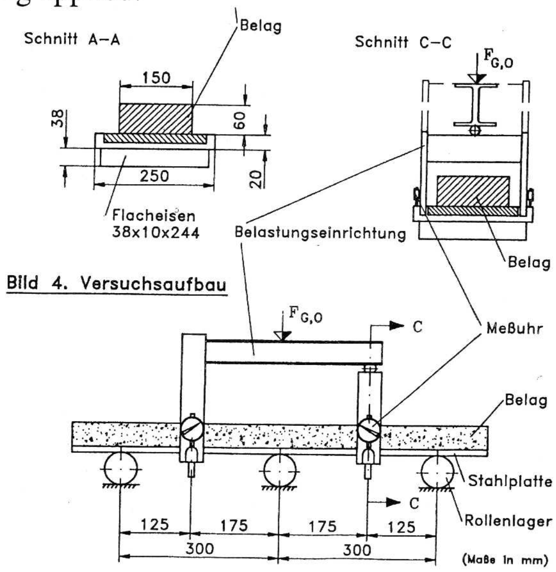
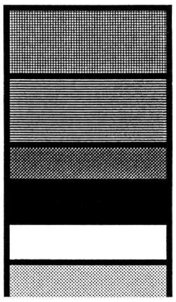


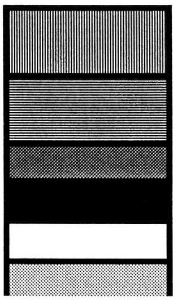
Figure 1: Fatigue test (Dauerschwellbiegeprüfung)

Fatigue test results were generally good for all four polymer modified systems and test temperatures. The reference system did not pass the test at +20°C and was therefore not tested further (at -20°C and -30°C). The polymer modified waterproofing and pavement systems tested are described below.

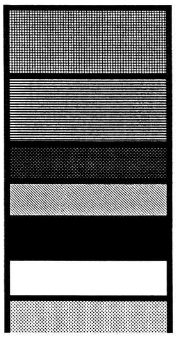
Testing was performed at VTI on original material (cubes and blocks) from the manufacturer and on material returned from the Otto Graf Institute after heating for test specimen preparation. Recovered binder from original products and heated products was compared to the original binder. This was done for quality and heat stability control of the products used.



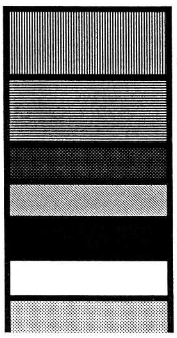
Split mastic asphalt	35 mm	
Gussasphalt "Polymer" PGJA 8	21 mm	**SYSTEM 1**
Sheet	3.5 mm	
Epoxy	500 µ (600 g/m²)	
Epoxy primer	100 µ (100 g/m²)	
Steel		



Gussasphalt "Polymer" PGJA 11	35 mm	
Gussasphalt "Polymer" PGJA 8	21 mm	**SYSTEM 2**
Sheet	3.5 mm	
Epoxy	500 µ (600 g/m²)	
Epoxy primer	100 µ (100 g/m²)	
Steel		



Split mastic asphalt	35 mm	
Gussasphalt "Polymer" PGJA 8	21 mm	**SYSTEM 3**
Mastic asphalt "Polymer"	4 mm	
Sadofoss	300 g/m²	
Epoxy	500 µ (600 g/m²)	
Epoxy primer	100 µ (100 g/m²)	
Steel		



Gussasphalt "Polymer" PGJA 11	35 mm	
Gussasphalt "Polymer" PGJA 8	21 mm	**SYSTEM 4**
Mastic asphalt "Polymer"	4 mm	
Sadofoss	300 g/m²	
Epoxy	500 µ (600 g/m²)	
Epoxy primer	100 µ (100 g/m²)	
Steel		

WATERPROOFING AND PAVEMENT SYSTEM FOR THE HÖGA KUSTEN BRIDGE

As a result of research and testing during the project period from 1991 to 1995, a suitable system for the bridge has been suggested by the Swedish Road Administration.

The public procurement was completed in July 1996. Contractor as well as waterproofing and pavement system for the Höga Kusten bridge are now official. Skanska is the contractor.

The waterproofing and pavement system will be in accordance with the SYSTEM 1, described in this document, and will be laid during late summer of 1997.

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Pavement wear from studded tyres – the Swedish solution

Kent Gustafson[1]

INTRODUCTION

Since the 60's and 70's when studded tyres were introduced and more commonly used, pavement wear has been a problem, especially on the road network with high traffic volumes. During the 80's, the problem was accentuated owing to an increasing traffic intensity and the increased use of studded tyres.

Research and development efforts concerning pavements have contributed to more durable pavements. There has also been a development of studded tyres and as a result, rutting has not increased but on the contrary been kept at an acceptable level.

The development of studs has resulted in studs that are more favourable to the pavement. The stud types that were very aggressive to the pavement such as tube studs, have been prohibited and weight regulations have become more stringent. Since a couple of years, only studs having a weight lower than 1.1 g are allowed on passenger cars. Wear caused by these lightweight studs is considerably less than that caused by conventional steel studs.

The regulations for use of studded tyres have become even more severe concerning, e.g. the allowed number of studs per tyre, stud protrusion and stud force. The period of use during the winter has been shortened.

The development of more durable pavements has contributed to the reduction of pavement wear. Today, it is known that the ideal pavement as refers to wear must contain the largest proportion of coarse and wear-resistant stone aggregate possible, united by strong plaster. The largest aggregate should however be limited to approximately 16 mm since rolling resistance and tyre noise will reach unacceptable values otherwise. The type of asphalt pavement that is closest to the ideal pavement is the Stone Mastic Asphalt or the asphalt concrete rich in stone (SMA). In recent years, the SMA has become more and more common on streets and roads with considerable traffic volumes.

PAVEMENT WEAR

The wear of studded tyres on the road surface can be measured as abraded quantity of asphalt mix per kilometre of road and passage of studded vehicles. An expression has been defined, which is a Swedish abbreviation for specific wear (SPS), stating:

- Abraded quantity of asphalt mix (tonne) per kilometre of road and million vehicles (axle pairs) with studded tyres

or

- Abraded quantity of asphalt mix (gram) per kilometre of road and studded vehicle.

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The volume of stud wear and thus the SPS index depends on various factors. Consequently, the SPS index is not a material constant for a specific object or pavement type but gives the actual wear during a specific period, normally one winter. Some of the most important factors for wear can be summarised under the following headings:

- Pavement
  - aggregate (quality, content, size, etc.)
  - asphalt mixture
  - quality of performance
- Traffic conditions
  - traffic volume
  - proportion of studs
  - speed
  - road width
- Weather conditions
  - temperature
  - water on the surface
- Studs and tyres
  - number of studs
  - design of studs (weight, stud force, protrusion, etc.)
  - quality of tyres

The wear from studs and the current SPS index are above all interesting for the road network with high traffic volumes. On road networks with small and average traffic volumes (AADT 0-4000) actions are seldom taken because of damage caused by wear from studded tyres. Other types of damage factors (fatigue, deformations etc.) influence the cycle of actions, which means that the SPS index is seldom used for these types of roads.

ASPHALT PAVEMENTS

Follow-ups on test roads and other roads (Jacobson, T. 1995 and 1996) show that the annual wear (rutting) from use of studded tyres is about 0,2-2 mm on SMA types with high-qualitative aggregate. This should however only be considered as a normal value and deviations may occur depending on influencing factors such as traffic composition, intensity of winter, pavement characteristics, etc. Using slightly poorer aggregate (e.g. local material), the wear per winter is about 3-4 mm. For roads with high traffic volumes, wear from studded tyres causes the main part of the total rutting or about 50-70%. On roads with low traffic volumes, other factors as for example deformations cause rutting.

The factors influencing wear have been studied thoroughly in recent years through tests with slabs in the field and in the road simulator and in road tests. Factors relating to the material have been studied as for example aggregate quality, aggregate content, largest aggregate size, type of mix and type of binder. The result of the studies shows the importance of these factors.

REDUCTION OF ROAD WEAR

Several investigations of stud wear have been carried out over the years. In the investigation in 1989 (Carlsson et al. 1992) the measured wear values, SPS index, varied between 6-37 g/km for different types of pavements where 6 was measured on very good pavements of the SMA type, while 37 was measured on ordinary dense asphalt concrete with local aggregate. Based on these measurements, an average value for the SPS index on the Swedish network was calculated, weighted for the proportion of vehicle mileage on the respective type of road. This value was calculated to 30 g/km, corresponding a total wear of 450,000 tonnes per winter. In winter 1988/89, this quantity of asphalt mix had disappeared on the Swedish road network through wear from studded tyres. Earlier in the 1970's and 1980's, wear was considerably larger and an SPS index of about 50 g/km was not unusual. The reason for the improvement was above all that the regulations for studded tyres and their use had become more severe and that more wear resistant pavements were used. The cost of pavement wear in the winter 1988/89 was calculated for the Swedish road network to amount to MSEK 250-300.

Since 1989, further improvements have been made concerning the wear from studded tyres. The reason is the increasing use of lightweight studs with less wear on the road and the increased use of high-class pavements.

The difference in wear between steel studs and the new so-called lightweight studs has been studied in the VTI's road simulator (Gustafson, 1992). Five different types of SMA and AC pavements were tested and in all cases wear was less than half when using the lightweight studs.

Today, the Swedish National Road Administration's strategy in pavement work is that roads with high traffic volumes with speed limits of 90-110 km/h (above all motorways and expressways) must have SMA mixes with aggregates of good quality. In 1994, the proportion of SMA pavements was 28% on state-owned roads with an AADT >8000. The corresponding figure of dense asphalt concrete was 56%. In the traffic class AADT 4000-8000, the proportion of AC was approximately the same (55%) while that of SMA was slightly less frequent (18%). In the future, the proportion of high quality pavements (SMA and Drainasphalt types) will increase while the dense AC types of pavement will be reduced.

In the 1994/95 study (Carlsson et al. 1995), which can be considered as a revision of the 1989 study of studded tyres, it has been estimated that in the year 2000, the road network will have 85% SMA pavements on roads with an AADT >8000. In AADT 4000-8000, SMA is calculated to cover 45% of the road network.

In the current study, an average weighted SPS index for the Swedish road network was calculated in the same way as in the previous study of 1989. The average value is now 24 g/km (cf. 30 g/km in 1989) and the reduction depends to some extent on a larger proportion of pavements with lower SPS index and to some extent on the 20% use of lightweight studs, the actual use winter 1994/95. Total wear is now reduced to 300,000 tonnes per winter and to a cost of MSEK 150-200.

A forecast concerning road wear is that it will decrease heavily in the future due to three factors:

- Technical improvements (better pavements) which mean that the SPS index can be expected to decrease by some more units by the turn of the century (for conventional steel studs).

- More roads with high quality pavements, which will reduce the SPS index further. However, this applies mainly to roads with heavy traffic (AADT over 4,000).
- The introduction of lightweight studs, which is the most tangible factor. All new sales of studded tyres consist of tyres with lightweight studs. These generally reduce wear by 50% compared with conventional studs.

By the turn of the century, when all vehicles have lightweight studs, a mean SPS index of only 10 g/km can be expected compared with the value of 24 g/km today (1995).

On the assumption of an unchanged proportion of studded tyres and the same vehicle mileage as today, pavement wear from studs at the turn of the century will be less than half of today's level. This is equivalent to about 130,000 tonnes, including 88,000 tonnes on the State-owned road network.

At today's prices, this corresponds to a cost of only MSEK 65-90.

CONCLUSIONS

The problem of wear caused by studded tyres has gradually been mastered on the Swedish road network and is currently not particularly urgent. The deep ruts, more a rule than an exception on the large traffic routes 5-10 years ago, are mainly gone.

The improvement was caused by:

- wear resistant pavements
- less aggressive studs
- regulations for using studs

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The wear resistance of bituminous mixes to studded tyres - the Swedish experience

Torbjörn Jacobson[1]

INTRODUCTION

In Sweden, studded tyres are used in the winter, causing considerable surface wear on roads with high traffic volumes thus resulting in rutting. For a long period, the VTI (Swedish National Road and Transport Research Institute) has been working on the development of wear-resistant asphalt pavements and equipment/methods for measuring the wear resistance of aggregates and asphalt surfacings. The choice of wear-resistant aggregates, introduction of stone-matrix asphalt and a change towards studded tyres more favourable to the pavement resulted in a considerable reduction of stud wear (Figure 1), which is now on an accetable level. VTI activities have been carried out as follows.

- Development of test equipment and measurement methods for wear studies
- A survey of influencing factors
- A survey and estimation of various pavement (surfacing) types
- Development of a forecast model for rutting, cross-profile and annual costs based on the wear caused by studded tyres

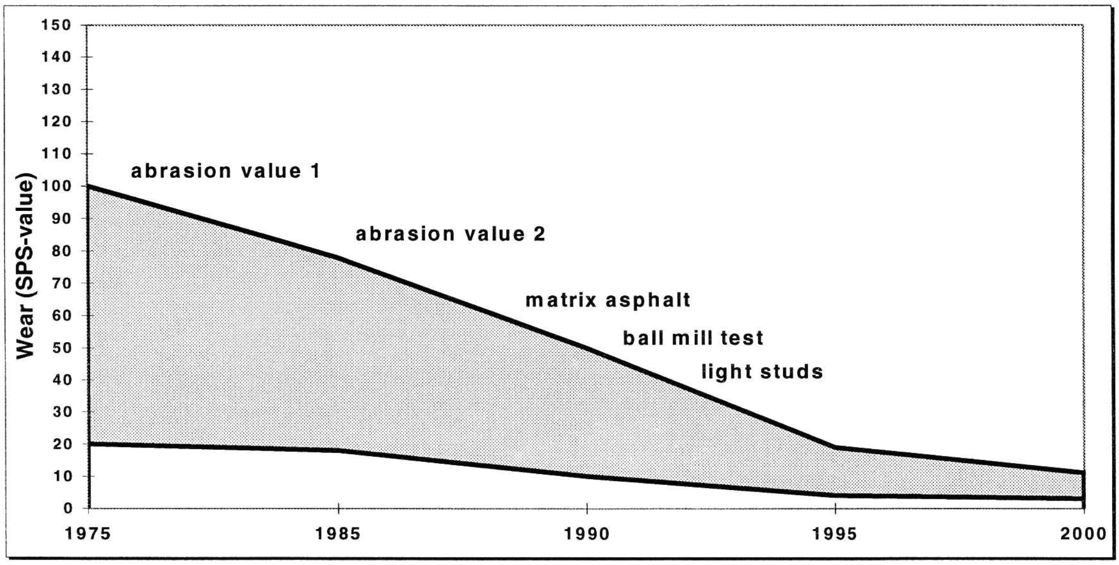

Figure 1: Wear development on roads with high traffic volumes, in principle, and development of test methods and mix types. (SPS-value = wear in gram per vehicle and kilometre).

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METHODS FOR MEASURING THE WEAR RESISTANCE OF AGGREGATES

At an early stage, the interest was focused on the quality of the aggregate and test methods were designed. The abrasion value and later the "Nordic" wet ball mill value are such examples. The correlation between the "Nordic" wet ball mill value and road wear is shown in Figure 2. In recent years, the "Nordic" wet ball mill test has also become a Nordic method and has been proposed as a European method in the harmonisation of standards in Europe.

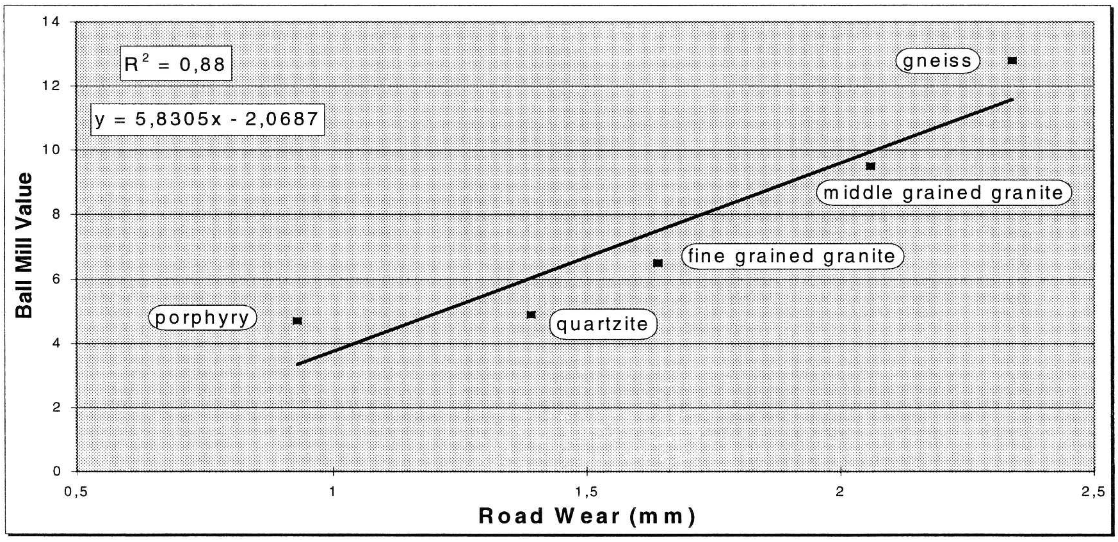

Figure 3: Correlation between "Nordic" ball mill test and road wear.

METHODS/EQUIPMENT FOR MEASURING WEAR RESISTANCE OF ASPHALT PAVEMENT

The design of laboratory methods measuring the wear resistance of asphalt specimens proved to be difficult, which resulted in the activities being concentrated on road tests. At the beginning of the 90's, there was however a breakthrough thanks to new test methods where small slabs of asphalt mixes were tested carefully and in realistic conditions. The slabs can either be tested in the field by placing them in existing pavements and measuring the wear from traffic or by performing accelerated tests in the VTI's road simulator (circular simulator with a diameter of 5 m). The method of using test slabs has facilitated a systematic survey of the factors influencing stud wear. Since the start at the end of the 1980's, approximately 600 slabs have been tested. Initially, the slabs were tested in the road, but in the course of time most of the tests have been moved to the road simulator, which is now the most important method for wear studies. This has been possible as a result of the very high correlation between the road simulator and road wear.

Wear measurements in the field and in the road simulator were carried out with a laser profilometer consisting of an approximately one metre long monitoring beam with support. The profilometer is based on non-contact distance measurements between the measurement beam and the road surface using laser technique. The crossprofile is registered with a reading precision of approximately 0.01 mm and with a sampling density of 400 measurement points per metre. The measurement data is stored and processed in a PC. Wear is calculated from the difference between the zero measurement and the final measurement which is carried out in the autumn and spring, respectively, just before and after the period with studded tyres.

FACTORS INFLUENCING STUD WEAR

The following parameters influence the wear resistance of asphalt pavements considerably:

- the quality of the coarse aggregate (wear resistance)
- the content of the coarse aggregate
- the maximum aggregate size

The wear resistance of the coarse aggregate (>4 mm) is important to the ability of the pavement to resist wear caused by studded tyres (Figure 3). The maximum aggregate size (Figure 4) and the proportion of coarse aggregate are other parameters important to pavement wear. A modified binder can improve the wear resistance of dense asphalt concrete but not an SMA.

Other factors influencing pavement wear are: compaction of the pavement, traffic volume and frequency of studs, speed, lateral distribution of traffic (road width), distribution wet/dry wear and the type of studs, stud protrusion and stud force. Wet wear is often much greater than dry wear but the difference depends on the type of aggregate. Pavement wear caused by studs will be halved with lightweight types of studs (0,7-1,0 g) compared with steel studs (1,8 g)

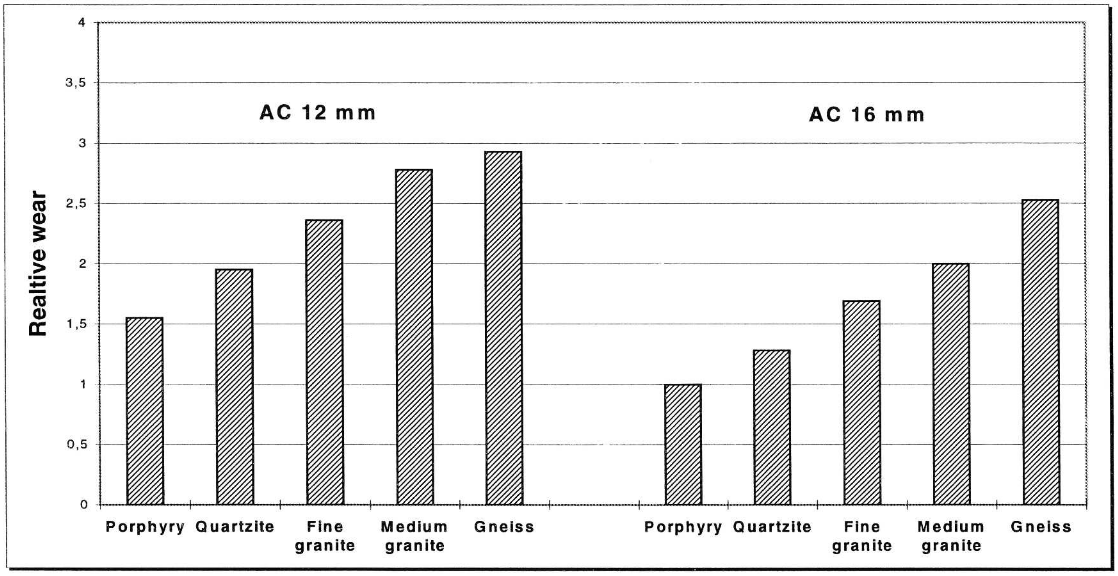

Figure 3: Influence of aggregate quality. Tests in the road simulator.

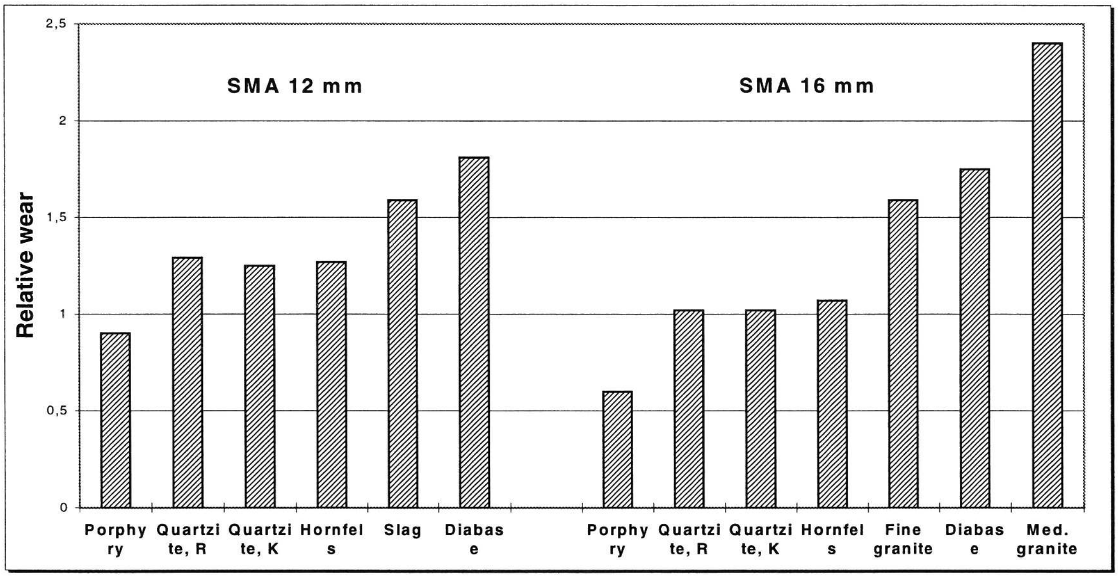

Figure 4: Influence of maximum aggregate size. Tests in the road simulator.

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Winter Tyres – Socio-Economic Calculations

Gudrun Öberg[1]

BACKGROUND TO THE WINTER TYRE PROJECT

During the winter 1993/94, the Swedish National Road Administration received considerable criticism for its winter maintenance and in particular for the high consumption of road salt. This led to discussions on changing the rules for winter maintenance, allowing a little ice/snow on the road and more roads with ice/snow were to be permitted. In addition, certain changes intended to influence vehicle equipment and driver behaviour were to be studied.

The purpose of the investigation described here is to calculate the socio-economic consequences that may be expected from a requirement on winter tyres in various circumstances.

The calculations were made for winter 1993/1994 and for winter 1999/2000. The conditions in winter 1993/1994, a fairly normal winter, form the basis for the calculations. The conditions in 1999/2000 are the same except for the assumptions that all those using studded tyres then will be using lightweight studs and that wear resistant pavements will be more common. All other factors, such as winter maintenance, will be the same as in 1993/1994. About 64 % of the cars used studded tyres in December 1993 and the vehicle mileage on ice/snow was 76 %. Summer tyres was used of 23 % and the vehicle mileage was 9 %. The rest stands for other winter tyres.

STUDIED EFFECTS

The following effects are included:

- Accidents (direct: at slipperiness; indirect: because of pavement wear)
- Road wear (pavement and road markings, cleaning signs)
- Car costs (tyres/rims, fuel consumption, washing)
- Environment (car washing)

<u>The effect of the use of winter tyres compared to all cars using summer tyres.</u>
The effects on road safety that are used are a 40 % decrease in accidents in icy/snowy road conditions on rural roads when using studded tyres and a 35 % decrease in accidents in built-up areas compared with summer tyres. The corresponding figures for other winter tyres are 25 % and 20 %. Each type includes both good and bad tyres in use at the beginning of 1990.

From 1 November 1993 to 15 April 1994 the police reported 38,248 accidents and out of that 33,735 car accidents (in icy/snowy conditions 16,271 car accidents). The results obtained that the use of studded and other winter tyres indicate an accident decrease of about 7,500 accidents/winter. There are also indirect accident effects, caused by the use of studded tyres, such as higher wet friction on pa-

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vements, since the studs create a coarse surface texture. They produce wheeltracks and dirt spray. The sum of these indirect effects is an accident decrease of 600-700 accidents because of the use of studded tyres. The number of fatalities in road accidents have decreased by somewhat about 40, seriously injured around 350 and slightly injured about 1,500. The values are uncertain.

When measuring road wear from traffic with studded tyres, the SPS index is normally used. SPS is the Swedish abbreviation for specific wear and indicates the number of tonnes of abraded asphalt per kilometre of road and million vehicles with studded tyres, or the number of grams of abraded asphalt per kilometre of road and vehicle with studded tyres. The average SPS index has been calculated after measurements on roads with various AADT. With steel studs, the SPS index varied between 22 and 35 g/km for the various classes of traffic, with an average of 26 g/km. The SPS index for lightweight studs is half these figures.

During winter 1993/94, it is estimated that 17 % of the vehicles with studded tyres had lightweight studs. This gives a weighted SPS index of 24 g/km, which implies total wear of 300,000 tonnes, valued at approximately SEK 150 million. To compensate for winters with more troublesome wear levels, the cost of wear can be said to be in the range of SEK 150-200 million. Wear on road markings and washing dirt spray from road signs is estimated to cost SEK 35-70 million/year.

In 1999/2000 the average SPS index is calculated to be 11 g/km, giving total road wear of about 130,000 tonnes worth SEK 65-90 million at today's prices. Wear on road markings and dirt spray on road signs is put at SEK 20-35 million/year.

The costs for motorists using winter tyres have increased compared to if they use summer tyres the whole year. The motorist pays for winter tyres and extra rims, and also the cost of wheel changing. The annual cost will be about SEK 330 million.

Petrol consumption is calculated to increase by SEK 90 million owing to an assumed difference of 2 % between summer tyres and winter tyres. It is also assumed that no difference exists between studded and studless winter tyres.

The use of studded tyres, means that vehicles need to be cleaned more often since road wear increases. In this study the studs necessitate 2-4 extra washes during a winter. It entails a cost to car owners of SEK 300-700 million which could be avoided. Owing to the road wear in 1999/2000, the cost will be only SEK 130-300 million.

Vehicle washing requires stronger agents than would be necessary if tyre studs were not used. Emissions of petroleum-based solvents, attributable to studded tyres would then amount to 1,500-3,000 tonnes for 1993/94. Based on the Swedish National Road Administration's environmental valuation, this would lead to an environmental cost of SEK 25-50 million/year. In 1999/2000, the environmental cost of vehicle washing necessitated by the use of studded tyres will have fallen to SEK 10-20 million.

Table 1. The use of winter and studded tyres entails the following cost changes compared to if all cars use summer tyres (SEK million/year).

	Decrease	Increase	
		1993/1994	1999/2000
Accidents direct indirect	 2,750–3,370 240–290		
Road Wear pavement road markings sign		 150–200 35–70	 65–90 20–35
Car costs tyres/rims fuel consumption washing		 330 90 300–700	 330 90 130–300
Environment car washing the rest		 25–50 ?	 10–20 ?
Total	2,990–3,660	930–1,440 +?	645–865 +?

The effect of winter/studded tyres on accidents is considerable and the cost of the decrease in accidents because of the use of such tyres is not offset by other cost increases. The effect on the environment is, however, difficult to measure and evaluate, and therefore only vehicle washes are included in the above table. With the above results for the other effects, this means that the total environmental effect may become fairly large before equilibrium is reached.

<u>Requirement on winter tyres in slippery conditions</u>

In the case of a requirement on winter tyres in slippery conditions, it is possible that:

- all vehicle mileage with summer tyres on ice/snow will be eliminated
- vehicle mileage with summer tyres in icy/snowy conditions will be replaced by travel in bare road conditions
- motorists will change to winter tyres.

In the calculations the requirement of using winter tyres are compared with the use in the winter 1993/1994. The distribution of vehicle mileage among different tyres controls the change in benefit/cost implied by the various alternatives, based on conditions in winter 1993/1994. The distrubution used here is that out of the 23 % that now use only summer tyres in the winter will after a requirement 15 % use studded tyres, 5 % use winter tyre and the last 3 % will not drive when it is slippery on the road.

Table 2 Requirement on winter tyres in slippery road conditions compared to the use of tyres in the winter 1993/1994 (SEK million/year).

	Decrease	Increase	
		1993/1994	1999/2000
Accidents			
direct	385–485		
indirect	75–95		
Road Wear			
pavement		25–35	10–15
road markings sign		10	5
Car costs			
tyres/rims		200	200
fuel consumption		30	30
washing		50–120	20–50
Environment			
car washing		5–10	0–5
the rest		?	?
Total	460–580	320–405 +?	265–305 +?

The road safety benefit with this requirement is greater than the known negative effects of the requirement. In sudden slipperiness, it is possible that some vehicle mileage with summer tyres will take place, which will decrease the highest traffic safety value above.The number of car accidents reported by the police will decrease by 1,100–1,400.

CONCLUSIONS

The requirement of winter tyres in slippery conditions will, compared to summer tyres, cause a decrease in accident costs by SEK 3,450–4,240 million/year. The increase in in road, car and environment costs will be SEK 1,250–1,845 million in 1993/1994 and SEK 910–1,170 million in 1999/2000.

The decrease in police reported accidents will be about 9,200–9,600 accidents/winter. This is a reduction of almost 30 % during the winter. The number killed in traffic will decrease by almost 50, the number seriously injured by about 400 and the number slightly injured by more than 1,500. The values are uncertain

The government suggested a requirement of winter tyres during slippery conditions. The suggestion has been referred to authorities for consideration. The decision will be taken in the winter1996/97.

REFERENCES

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The Swedish National Road and Transport Research Institute (VTI) has laboratories and know-how for advanced research commissions in transport and welfare economics, road safety, vehicles and the environment. It also has research capabilities for the construction, operation and maintenance of roads and railways.

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