

Over-run-test

**A report of the stages of the development of the test
and the determination criteria of the type-approval
limits**

Timo Unhola

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FOREWORD

In Finland, the studded tyre regulations and the continuous development of them have been of paramount importance in terms of road wear.

At this point, when the studded tyres have been widely used for 50 years, it can be estimated that, thanks to the regulations the road wear and the costs associated with resurfacing have been reduced to a fraction of what they were in the early 70's before the first studded tyre regulations were introduced. This is described in more detail in Annex 1.

Finland's role in development of this sector has been substantially noteworthy involving all stakeholders. In this context it is important that all relevant parties of co-operation in this field are informed uniformly about backgrounds of the development work done so far. This report should help to understand previous stages of the development of the over-run-test and the reasoning behind determination of the type-approval limits. Hoping also the report serves as a basis for advanced future steps of studded tyre type-approval requirements.

The report was done by Timo Unhola, member of the developing team of the test.

Assigned by Mika Loponen, Trafi

Helsinki 22.9.2015

Marko Sillanpää
Director General of Road Transport

Finnish Transport Safety Agency Trafi

ALKUSANAT

Suomen nastarengasmääräykset ja niiden jatkuva kehittäminen on ollut ensiarvoisen tärkeää teiden kuluminen kannalta.

Nykyisessä vaiheessa, kun nastarenkaita on käytetty yleisesti jo 50 vuotta, voidaan arvioida, että määräysten ansiosta teiden kuluminen ja sen aiheuttamat uudelleenpäällystysten kustannukset ovat alentuneet murto-osaan siitä, mitä ne olivat 70-luvun alussa ennen ensimmäisiä nastarengasmääräyksiä. Tätä on yksityiskohtaisemmin kuvattu liitteessä 1.

Tämän toimialan kehittämisessä Suomen rooli on ollut suhteellisen merkittävä kaikkia sidosryhmiä ajatellen. Tämän vuoksi on tärkeää, että kaikki yhteistyöhön osallistuvat tahot tulevat tasapuolisesti informoiduiksi tähänastisen kehitystyön taustatekijöistä.

Tämän selvityksen tarkoituksena on auttaa ymmärtämään yliajokokeen kehityksen aiemmat vaiheet ja tyyppihyväksynnässä käytettävien raja-arvojen määräytymisen perusteet. Lisäksi toivotaan, että selvitys voisi toimia perustana nastarenkaiden tyyppihyväksyntävaatimusten jatkokehitykselle.

Selvityksen on tehnyt Timo Unhola, yksi kokeen kehittäjistä.

Tilaaajana oli Mika Loponen, Trafi

Helsingissä, 22.9.2015

Marko Sillanpää
Tieliikennejohtaja

Liikenteen turvallisuusvirasto (Trafi)

FÖRORD

Finlands regler gällande dubbade däck- och deras kontinuerliga utveckling har varit av avgörande betydelse när det gäller vägslitage.

Nu, när dubbdäck har använts i stor utsträckning i 50 år, kan man uppskatta att tack vare bestämmelserna har vägslitage och återbeläggningskostnader reducerats till en bråkdel av vad de var i början av 70-talet innan de första reglerna gällande dubbade däck introducerades. Detta beskrivs mer i detalj i bilaga 1.

Finlands roll har varit relativt viktigt för alla intressenter i åtanke när denna sektor har utvecklats. Det är därför viktigt att alla som deltar i samarbetet kommer att vara lika underrättade om bakgrunden till utvecklingen hittills.

Denna utredning borde bidra till att förstå förgående utvecklingsstadier av testen samt anledning till bestämning av gränsvärdena uppsatta för typgodkännande. Dessutom är förhoppningen att rapporten skulle tjäna som underlag när tekniska krav om dubbdäck vidareutvecklas för typgodkännande.

Utredningen gjordes av Timo Unhola, en av utvecklarna av testen.

Beställaren var Mika Lopenen, Trafi

Helsingfors den 22.9.2015

Marko Sillanpää
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Index

Abstract

Tiivistelmä

Sammanfattning

1 Goal	9
2 Before the beginning	9
3 The development stages of the over-run-test	9
4 Number of over-runs	10
5 Further development	11
6 The result of the development: Sawed stone sample	11
7 The criteria of sample stone material selection	12
8 Stud traces	12
9 Vehicular factors affecting wear	14
10 Accuracy review	15
10.1 Comparative Tests	16
10.1.1 Comparing the over-run test with road wear	16
10.1.2 Comparing the results of approved over-run research teams	17
11 The results of the tests and determination criteria of the type-approval limits	18
12 Bibliography	20
Appendix 1 The road wear and wear related research in Finland	
Appendix 2 Methods to research road wear	
Appendix 3 Tyre-stud combinations tested using the Over-run test and type approved by Trafi – road wear test results	

ABSTRACT

Over-run-test is a method for measuring road wear caused by studded tyres, which has been started to develop since 1985 at VTT (Technical Research Centre of Finland), and it is, as a result of purposeful development of the test and, ten years later, after the introduction of the sawn stone samples especially designed for the test, an established wear test.

The test is run by driving at highway speed with a car equipped with studded tyres 200 times over the stone samples, which are weighed before and after the test.

Following the consolidation of the test, it has been commonly used as a method for type approval of studded tyres. Since 2009 sufficient experience was gained from the use of the method that made it possible to present fixed approval limits.

After the authorities were convinced of the validity of the test in 2011, the limits were introduced and further tightened in 2013.

An established test method is described, published by Trafi as a methodological description, which has been applied both in Finland (5 companies) and abroad by different research institutes approved by Trafi.

TIIVISTELMÄ

Yliajokoe on nastarenkaiden tiekuluttavuutta mittaava menetelmä, jota kehitettiin VTT:llä vuodesta 1985 alkaen ja se on määrätietoisesti kehitetty ja kymmenen vuotta myöhemmin koetta varten suunniteltujen sahattujen koekivikappaleiden käyttöönoton jälkeen vakiintunut kuluttavuuskoe.

Kokeessa ajetaan maantienopeudella 200 kertaa koerenkain varustetulla autolla kivistä valmistettujen kulutuskoekappaleiden yli, jotka punnitaan ennen ja jälkeen kokeen.

Kokeen vakiintumisen jälkeen sitä on yleisesti käytetty nastallisten talvirenkaiden tyyppihyväksyntämenetelmänä. Vuoden 2009 aikoihin menetelmän käytöstä oli niin paljon kokemuksia, että niiden perusteella voitiin esittää kiinteitä tyyppihyväksyntärajoja.

Viranomaisten vakuututtua kokeen pätevyydestä vuonna 2011 otettiin käyttöön rajat, joita vielä tiukennettiin vuonna 2013.

Vakiintunut menetelmä on kuvattu Trafin julkaisemana menetelmäkuvausena, jota soveltaen eri tutkimuslaitokset ovat Trafin hyväksyminä käyttäneet sitä sekä Suomessa (5 laitosta) että ulkomailla.

SAMMANFATTNING

Överkörningstest är en speciell metod som beskriver slitaget av vägytan, orsakad av dubbade däck. Den har utvecklats på VTT (Statens tekniska forskningscentral) från och med år 1985. Målmedvetet utvecklingsarbete samt tio år senare införandet av slitprovstycken av sten, sågade och speciellt för testen utvecklade, har gjort den till en väle-
tablerad test.

Testen görs genom att köra väghastighet med en bil utrustad med dubbade däck 200 gånger över slitprovstycken som vägs både före och efter körningen.

Sedan etableringen har testen haft allmän användning som metod för typgodkännande av dubbade däck. Vid år 2009 hade man haft så mycket erfarenhet av användningen av metoden att det möjliggjorde presentation av fasta gränser för typgodkännande.

Efter att myndigheterna nått förtroende för metoden år 2011, infördes gränserna, som fortfarande skärptes år 2013.

Denna metod har beskrivits i en publication av Trafi som en metodbeskrivning. Den har tillämpats i Finland (5 anläggningar) och utomlands av olika forskningsinstitut som har godkänts av Trafi.

1 Goal

The aim of this report is to make clear the criteria for the selection of the various details in the development of the over-run-test in the past, as well as the criteria for determining the type-approval limit values of the test.

2 Before the beginning

In Finland, it was found in the late 1960's that there is a problem with the way the studded tyres wear the surface of the road, initially in the cities. The first studies in this field were done already at that time. Over the years, different agencies had tried to find out the relevant factors, using innovative research methods. See annex 2 for a short presentation of a selection of the various methods and their pros and cons. Investing in increased road wear research has been profitable. Over the years, the road wear caused by the studded tyres has been brought under control and opposing studs or the projects to ban them have been reduced (see Annex 1).

3 The development stages of the over-run-test

The wear research needed new impetus in the 1980's, since the wear test tracks had limitations on speed and slip, laboratory equipment had their own limitations and test roads could not be tested for effects of vehicular factors, such as the effect of the studs and the tyres (see Annex 2).

The method developers at VTT were:
 Research Specialist Risto Alkio (Figure 1, right)
 Research Scientist Jarmo Vuorinen
 Research Scientist Timo Unhola

The dimensions of a trace of the stud contact on the platform ("a pit") was at first attempted to measure on different platforms, such as the polished stone surfaces or aluminium and lead sheets (see pictures on page 5). Metal surfaces will show a clear trace, but it bears no resemblance to the impact on a stone surface: cracks and scratches do not occur at all. Metal surface is only dented, with no wear. An impact on stone surface causes always cracks and fissures. Even if one impact on the smooth stone surface does not necessarily remove any material (see pictures on page 5), is the point of impact already weakened (cracks) and the following stud and pressure impacts at the same point will cause wear.



Figure 1. Assembly of the samples to the mounting base.

A team in Road Laboratory of VTT of that time began in 1985 to develop a simple method, in which a normal car is driven over samples to be weighed against wear. It was (is) a demanding task, since the mass chipped by one impact (hit + scratch) of an early tyre stud was typically only micro grams (μg). Even if the number of contacts (impacts) that can be obtained on the sample area e.g. as a result of 200 car over-runs (400 tyre over-runs) builds up to thousands, the wear loss to be weighted per sample, depending on their type, however, is just milligrams.

At first, the samples were stone core cylinders (h = 20 mm, ø 32 mm, approx. 40 g), which were attached to the plywood base plate, 22, later on rubber plate 23 pieces/plate (see figures 1, 2 and 3)). With these first samples we were already able to show a clear effect of stud weight and driving speed on the wear in 1986.



Figure 2. Early samples.

From the beginning, the preferred stone material has been Kuru grey granite. There are other stone materials that have been tried in connection with the project ASTO, including 12 different stones. Justification for the selection of the material is on the next page.

Keeping the sample area wet will smooth out the effect of the circumstances and adds to wear as on the road (wet surface wears 1.5 to 3 times more than a dry surface).



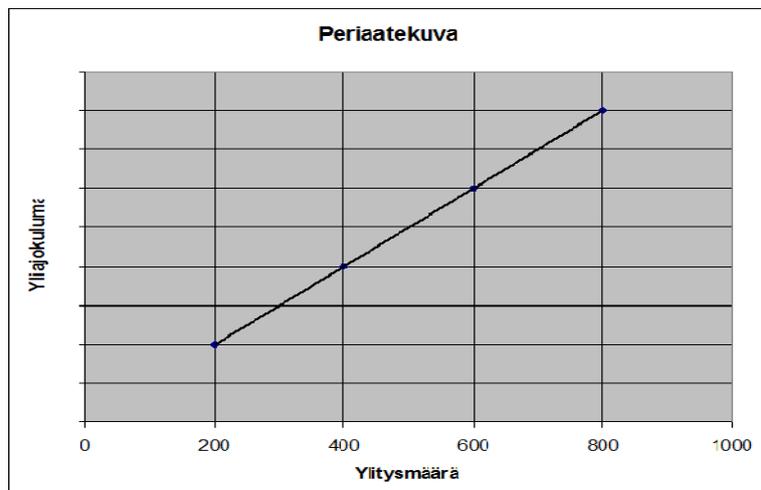
Figure 3. Over-run-test in the 1980's

The ratio between the weight of the specimen and the weighted wear loss is about one thousand, which is why it was soon discovered the handling of the samples to be the most critical. The test samples must be up to the same humidity level (standard mass) during both weighings. This operation called for most of the efforts to develop and experiment.

Perhaps the single most important development was the introduction of the reference samples. They are treated exactly the same as the wear samples, but were not driven over. It is then possible to correct the results obtained from before- and after weighing of the actual samples by the found difference to the results of the reference samples, due to minor condition differences.

4 Number of over-runs

At the beginning of the 1990's took place an experiment, which included a series of 200-400-600-800 over-runs, following the principle of next graph as a result (y-axis: wear, x-axis: number of over-runs). **Conclusion:** there was no reason to add to the 200 over-runs.



5 Further development

The road surface is not made of stone, but asphalt, therefore, there was a reason to try to make test samples of the asphalt. This does not pose any problems with regard to sample preparation or wearing, but it was discovered, that it is impossible to get the samples to the same state before and after the test. In case of drying in the oven the asphalt samples evaporate uncontrolled amounts of volatile material. On the other hand, the use of stone as test sample material is justified because ASTO research project (1987-93) made it clear that the selected stone material mainly determines the wear resistance of the pavement.



Figure 4. Comparing stone samples.

Because of the large number of samples (46 pieces per experiment), however, the handling of stone core samples was a tedious chore and the wear so small, that after the studs got lighter in the 1990 's, it called for either added number of over-runs or to develop a more suitable sample. One test driving without harming the tyres or the car already took for about three hours, so adding driving was not tempting. That is why, after various stages, a new sample was designed containing of crushed stones on epoxy base plate. Stone granules chosen were the same size as max aggregate in asphalt. The method was working, but the standard deviation was too high and making the sample required a lot of slow hand job. Wear was, on average, appropriate to be weighed and the next step was to use milled stone granules, with the sharpest corners rounded. The standard deviation decreased, but the wear was, however, once again too small.



Figure 5. Preparing of the crushed stone samples

6 The result of the development: Sawed stone sample

1996 was introduced on a trial basis a new sample model, especially designed and made for this test, a tile of stone (20 x 75 x 90 mm, weight approx. 300 g) with the upper surface sawn to grooves. It has proven to be practical for measuring of the wear of even the least wearing anti-slip tyres.



Figure 6. Sawed stone sample tile.

The size of the sample tile was selected in order to optimize the handling and weighing accuracy and the saw pattern to correspond the average grain sizes in asphalt and so, that the minerals are divided representatively in each piece. Ridges are of a size large enough to withstand the stress of the test and the number

is as high as possible taking into account the other limit values. In addition, the aggregate comes always from the same quarry.

7 The criteria of sample stone material selection

Kuru grey granite mineral composition is: quartz 40%, plagioclase feldspar 35%, potash feldspar 22% and biotite (dark mica) 3%. The average grain size of quartz grain is approx. 1.0 mm and the average grain size of potassium feldspar and plagioclase is approx. 1.5 mm. Structure of the stone is equigranular. The Kuru grey granite structure is regularly unorganized, that is, the properties are the same in every direction. Quartz has no clear cleave directions and it can cleave in curves. Feldspars have two cleave directions against each other. Quartz as well as feldspar are found in the mineral as irregular grains without a crystal form of their own, which means that the contact between the minerals is good, so there are no weakness zones in the contact sections.

Kuru grey granite is very uniform, perhaps the most uniform in Finland, considering the stone materials that can be found in quarries and structurally very good. This stone, for example, was used to make the high-speed rolling mills found in all paper plants.

The Kuru grey granite stone type is selected for the over-run-test because of the above mentioned mineralogical and structural factors. In addition to these, the stone wear resistance against studded tyre abrasion (strength) is in the middle level of Finnish rocks. The stone material allows to obtain results at a reasonable amount of over-runs and the aggregate is not too weak in terms of cleaving processes. Other stone materials have been tried in the 80's and 90's but none of them appeared to be as uniform in mineral composition, grain size and structure as Kuru granite.

To restrain cleaving of the edges in the upper surface of the slab it was attempted to round them off in the ball mill, but once again, at the expense of reduction of wear. Edge cleaving clearly adds to the wear and some to the deviation, too, but it is justified by the fact that the cleaving of the asphalt stones is also critical.

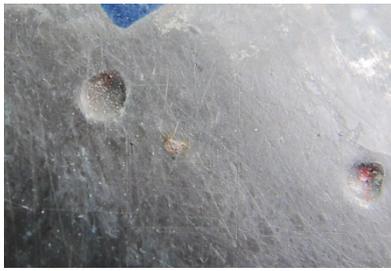
Sawed samples have now been used for almost 20 years without a problem. Run-over wear is about ten times the wear on the road. The main reasons are the above mentioned edge cleaving, the selected stone and the wetness of the wear area, as well as the fact that there are always new studded tyres that have been tested and the high level of the speed, 100 km/h. Therefore the road wear test can be considered an accelerated wear test, the only one in the world, which can be used to simulate the impact of various vehicular factors on the wear of the road in normal vehicle speeds.



Figure 7. Over-run-testing in the 2000's.

8 Stud traces

Macro images (all in the same scale)



Stud traces on the surface of a lead sheet



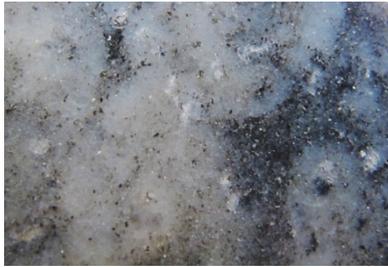
Stud traces on the surface of an aluminium sheet



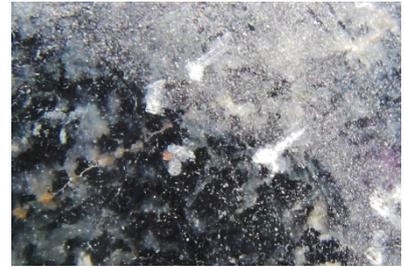
Stud traces on the surface of a polished stone



Stud traces on the surface of a polished stone

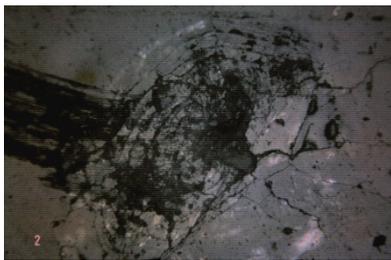


Stud traces on the surface of a polished stone



Stud traces on the surface of a polished stone

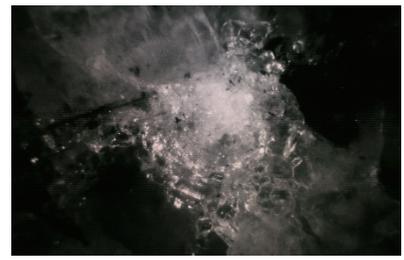
Microscopic images



An impact trace of a stud on the surface of a polished stone with fissures, scratch to the left, no lost material



An impact trace of a stud on the surface of a polished stone with fissures, scratch to the left, some lost material



An impact trace of a stud on the surface of a polished stone with fissures, scratch to the left, some lost material

Stud traces on the surface of a polished stone in various speeds (driving from left)



60 km/h, small impact, long scratch



80 km/h, impact greater, still long scratch



100 km/h, impact significant, minor scratch



120 km/h, dominant impact, scratch negligible

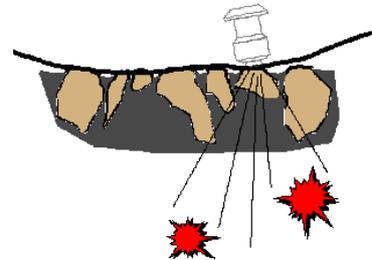
9 Vehicular factors affecting wear

Many other factors affect the road wear than speed (see images, previous page), though it is probably the most important. The following lists also other factors, not necessarily in order of importance. Part of them has been regulated in different years.

Factors affecting road wear

Vehicular and traffic factors (limited on **bold** text)

1. **Stud weight** (mass, limit 1992 -> 1,1 g)
2. Car weight (mass)
3. Aspect ratio of the studded tyre
4. Tyre pressure
5. Driving speed on the road (winter speed limits)
6. **Number of studs / tyre**, (limit 2013 -> 50 stud / m of rolling circumference)
7. Stud technology (plenty of possibilities still)
8. Tyre technology (continuous development e.g. to lower road wear)
9. **Stud protrusion** (streets, limits 1,2/2,0 mm, dictated by practice)
10. **Stud force** (streets, limits 120/180 N, type approval, measuring issues)
11. Popularity (utilization rate, 80 % in Finland in mid-winter, aims to reduce)
12. Traffic quantity with studs (ratio 30/70 % studs/no studs per year in Finland)
13. **Stud use period** (1. Nov. to 1 week after Easter, low reducing expectations)



In addition to these, worth of mentioning are:

- Canalized traffic (all are driving along the same tracks on the lane), which accelerates the rut formation, not so much the total wear, but will bring closer the need for resurfacing. It is most severe if the lane is narrow (with railing).
- Weather, maintenance, and as a result the road surface condition: snowy, slushy, packed snowy, wet or dry. Wet pavement wears 1.5-3 times faster than dry, snowy or packed snowy almost not at all, but these do not often occur on main roads, where the wear is crucial.
- Driven car kilometers with studs were 29% of the total car kilometers a year, according to the latest calculations (from the winter 2014/15) in the North-East of Helsinki. The ratio can be used to calculate the total loss of asphalt tons per year for any road section, provided the following facts are known or can be assessed: the average annual vehicle kilometers as well as a specific wear depending on the surfacing and the studded tyres, as short SPS (specifik slitage, g/vehicle kilometer).

Perhaps there is still reason to remind that ruts are not formed just by wearing. The growth of the depth of ruts will in addition be affected by a number of other factors, such as pavement compaction (in particular the initial compaction) and deformation of the surface of the object as well as the base (and embankment). The proportion of wear of the total rut formation, however, is well known, as it happens in winter, while the compaction and the deformation of the surface and the base typically mainly in summer.

Wear can be distinguished from other components of rut formation by taking rut measurements twice a year, in spring and autumn.

10 Accuracy review

For one test 15 PCs of samples are used, 5 PCs in 3 rows (see figure 8). The dispersion between the total loss of weight of each of the 3 rows gives the possibility of error analysis, the rows may be considered as replicates. Looking at tests with the sawed samples starting from 1996, the error of the average calculated from the row wear deviation with 95% of probability has fluctuated between 0.4% and 24%, an average of 11.2%, expressed as a percentage of the average wear.

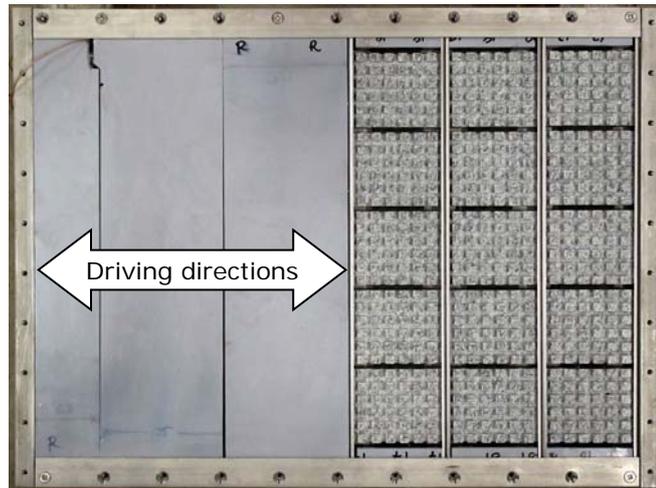


Figure 8. Over-run samples attached to the base.

The results are presented in average row wear in grams and their dispersion as 95% confidence interval. As an example of the results, see results of a test in 2003 (Figure 9, Road wear caused by studded tyres . Over-run and dust measuring vacuum method. Ministry of Transport and Communications, publication 12/2004).

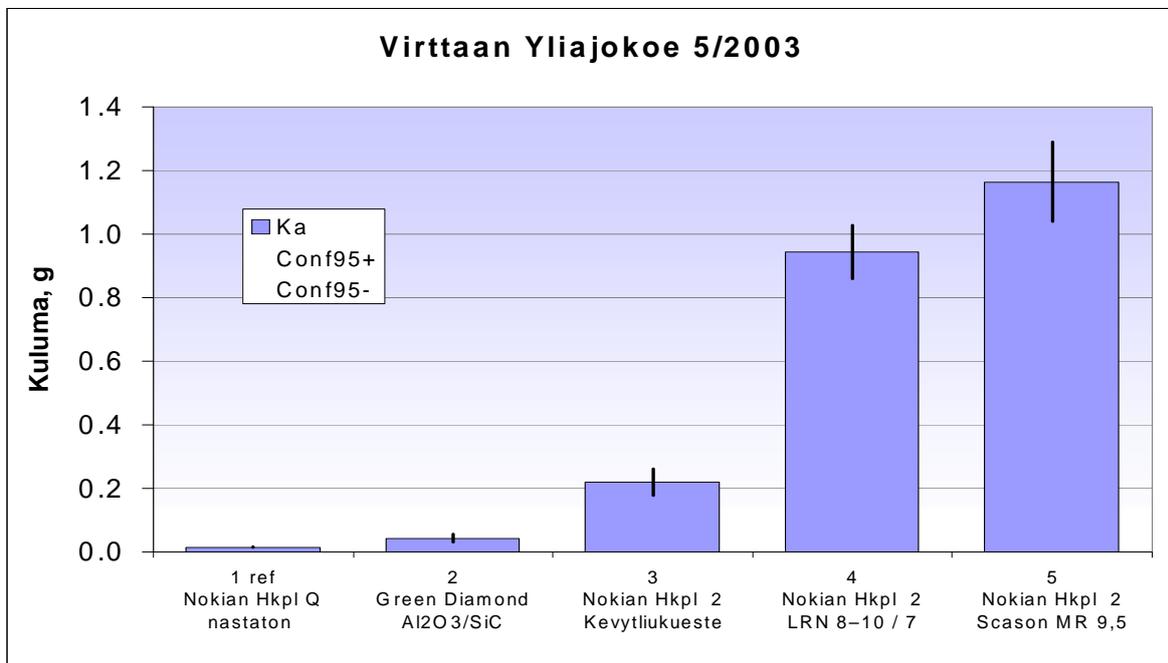


Figure 9. An example of presentation of results of a Over-run test in 2004. (Kuluma = Wear), (Ka=Average) and (95%) confidence intervals.

10.1 Comparative Tests

Decent comparative tests with other methods could not have been possible to arrange for reasons of cost and because of the diversity of the methods.

10.1.1 Comparing the over-run test with road wear

A comparison of the over-run wear to actual road wear was, however, once held in the context of the road trial for stone materials included in ASTO project during the years 1989-91 /n and n/.

In this comparison the same 15 ASTO stone materials (the list in table 1), which were used for a road trial, over-run stone core samples (see Figure 2) were also made and tested at the time. It was then possible to compare the over-run wear to the real road wear of trial asphalts mixed from the same stone materials after two winters (1991). Over-run wear is the total wear of 23 core samples in cubic centimeters and road wear is expressed as the area of worn asphalt in transverse profile in square centimeters, corrected by the curviness and hilliness of the trial section (Figure 10). The results show only moderate correlation. There are several essential degrading elements on dependence: asphalt is made crushed stones (in this case, shaped to more cubical), over-run core samples drilled from stone tiles; the implementation of the road trials always involves a large number of only partially managed operations: aggregate selection, screening (and cubicalisation), the quality and quantity of the fillers, the proportioning, a mixture of bitumen, the mixing, transport and application, traffic, etc. In addition, in this case, the ASTO aggregates had been selected from the most durable of the Finnish stones, while for the over-run test less wear-resistant Kuru granite have been chosen, which is not used in the roads demanding highest durability. In figure 10 the wear of typical Kuru granite would fall outside of the ranges.

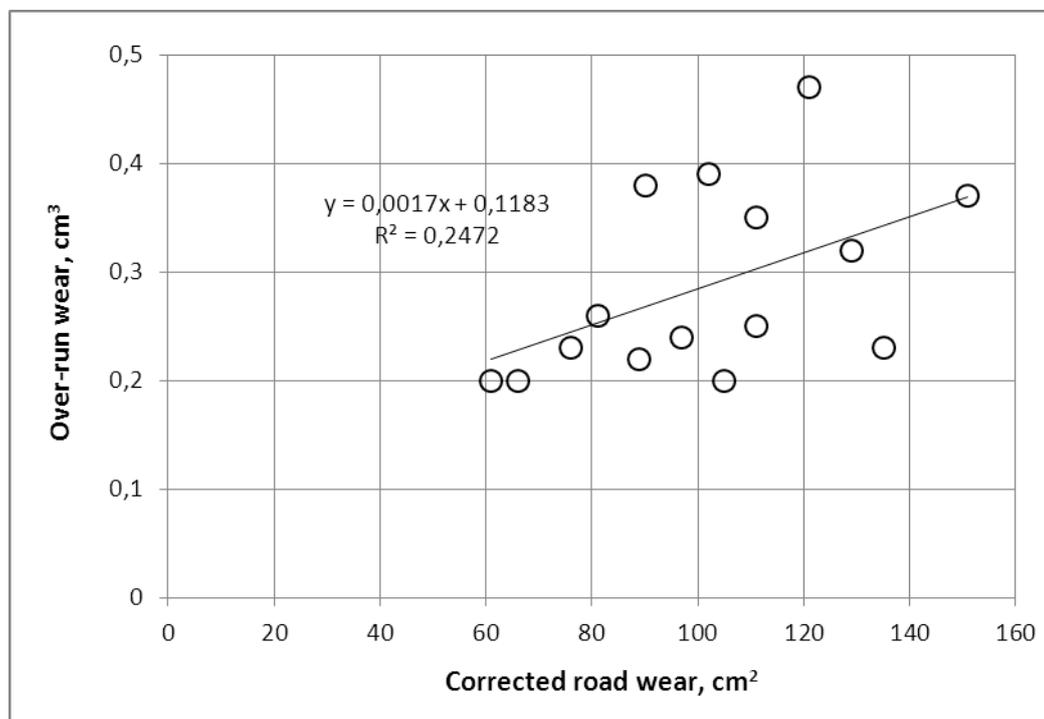


Figure 10. Correlation between over-run wear of stone core samples and the road trial wear of asphalts mixed from the same 15 stone materials.

Table 1. ASTO stone materials

Amfiboli, Kerimäki	Diabaasi, Varpaisjärvi
Hapan vulkaniitti, Pyhäjärvi	Kvarsidioriitti, Kalajoki
Emäksinen vulkaniitti, Siilinjärvi	Gabro, Riihimäki
Hapan vulkaniitti, Saarijärvi	Diabaasi, Lemi
Serpentiniitti, Keminmaa	Vihreäkivi, Tornio
Hapan vulkaniitti, Pernaja	Graniitti, Ylivieska
Gabro, Kemiö	Hornblendiitti, Suomensjärvi
Granodioriitti, Tampere	

As a summary of comparative testing and the development of wear testing methods I could still point out that the results described above were not born without a huge investment. All of that, related to the management of road wear is the outcome of tens of man years of contemplating, planning and executing by the best experts in the field of paving in our country. The largest single investment was ASTO-project (1987-1993), with a total budget of nearly 14 million EUR converted to today's euros.

10.1.2 Comparing the results of approved over-run research teams

Comparative tests with other methods could not be arranged due to the divergency of the methods. Trafı organized in 2014 a comparison (Round Robin) test among research institutions. On the basis of the obtained results the differences in the details were reduced: http://www.trafi.fi/filebank/a/1430729756/bef45563e869170671ce4bafc5552d22/17480-Yliajokoemenetelman_vaatimukset.pdf

11 The results of the tests and determination criteria of the type-approval limits

Included in this review are all the 23 studies with current samples, since 1996, by 2010, a total of 134 different tyre/stud combinations. Each of these has used the same kind of sawn samples. The studies were done by VTT TECHNICAL RESEARCH CENTRE (1996-2007), Roadlux (2007-2009) and Test World (2010). The summary table (annex 3) presents the studies with the test data that the commissioners have given their consent to publish.

The method has been the same in all of these studies. It is described in the method description on the Trafı website:

http://files.kotisivukone.com/nastatutkimus.kotisivukone.com/tiedostot/Kitka/yliajakokeen_testimenetelmakuvaus.pdf

Once the method had been used for more than ten years a stage was reached, where the developers felt that the method could be cemented to produce systematically consistent results, we began to present it to the authorities for type-approval testing, proposing to set the row wear limits.

In the following review of the various studies, the results are compared with each other only to the row wear averages (= over-run wear, ORW, g), even though the various test cars (= body weight), the tyre pressures and tyre aspect ratios are known for their dependence on wear (see the research commissioned by Ministry of Transport and Communications, MTC, see: publications 72/2004):. The study only had four variables, the results of which could be used to correct wear to uniform results. They lead, however, to relatively small changes, so this is not being taken, also for the reason that their total significance is not known.

Each bar of the graphic following presentation of the results represents an average row wear of one tyre/stud combination in grams, corrected by the result of the reference samples (Figure 10). The results were taken between year 1996 and year 2010, using the same kind of sawed wear samples.

The curved line of the chart is a polynomial regression curve that describes the change in the average of the results obtained in the various tests over time i.e. the trend. As within the results there are also other than traditional stud-equipped tyres, the curve can only be considered indicative.

Among the measured 134 tyres 91 were equipped with "normal" studs, 12 of them were heavy studs (more than 1.1 g), 79 light (1,1 g or less), of which 20 tyres or 25%, wore more than 1.1 g, 4 of those "type approved".

On the basis of the chart it was possible with earlier experience, to propose reasonable limit values for the various categories of tyre classes.

After the tightened limit values in year 2013 (table 2), the road wear in the future will not rise again more than the amount of traffic volume, presuming that the weight of the vehicles will not increase. The trend of downsizing because of energy saving is taking care if that.

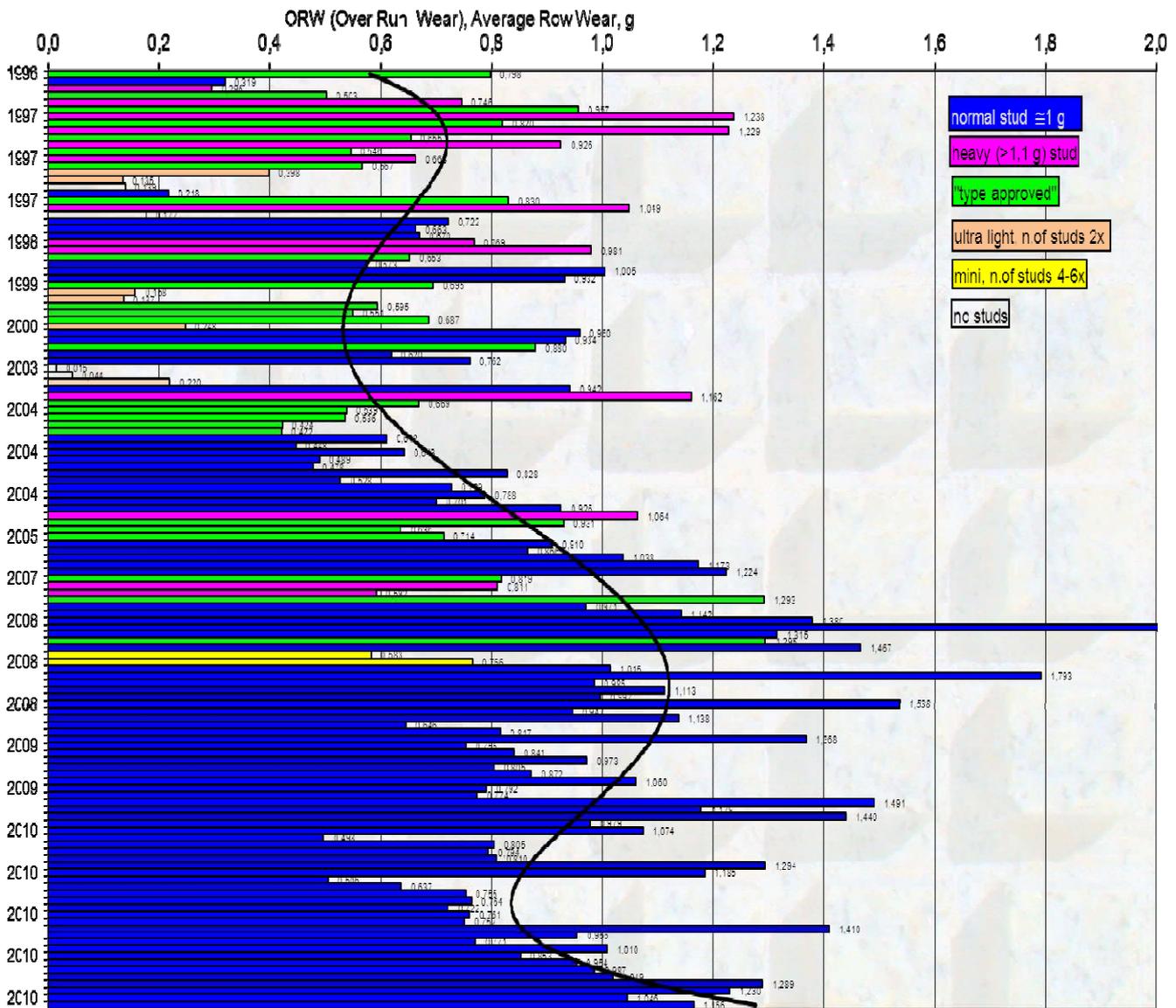


Figure 11. Over-run wear, average row wear in grams 1996-2010.

The limit values of the average row wear according to the regulation, the limit values after 2013 in parentheses:

Table 2. Limit values and test tyre sizes of the vehicle classes

Tyre load class	Tyre size to be tested	Average row wear
< 600 kg	175/65R14 185/60R15 195/55R16	1,1 g (0,9 g)
600-800 kg	195/65R15 205/55R16 225/45R17	1,3 g (1,1 g)
yli 800 kg	235/65R17 255/55R18	1,7 g (1,4 g) ¹⁾
C-tyres	195/70R15C 215/65R16C 225/65R16C LT225/75R16 LT265/70R17	2,2 g (1,8 g)

¹⁾ limit values for load index of over 800 kg filled in by Trafi

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The road wear and wear related research in Finland

Studded tires have come to a man's age. Their use began in the early 1960's spreading quickly during the decade. The peak of the use was in the early 90's, when 96% of the cars used studs. Then came the all season tyres with prominent winter capabilities. They were predicted to take over the winter tyre market. In contrast, the use of studs decreased alright, but stabilized at about 83% in this decade.

Heavy traffic was using a lot of the studs in the 70's, but in recent times only supply trucks, mostly driving the minor roads are using them. They do not pose a problem with the road wear.

The share of the traffic kilometers with studded vehicles (cars and vans) was in Finland 35% of the total traffic in one year, based on analysis over the winter of 2009/2010. This is probably the highest share in the world. More recent studies indicate the share in the past few years have been reduced to about 30%.

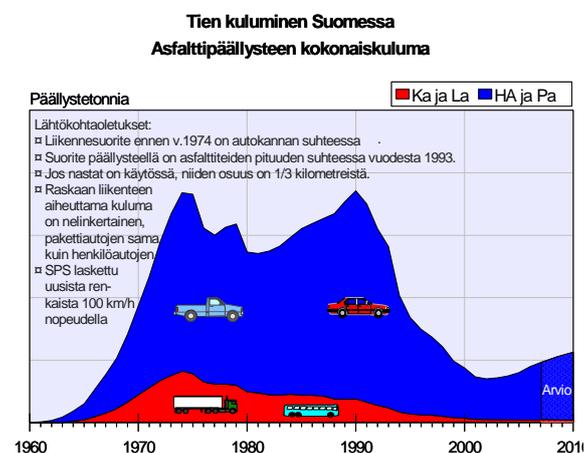
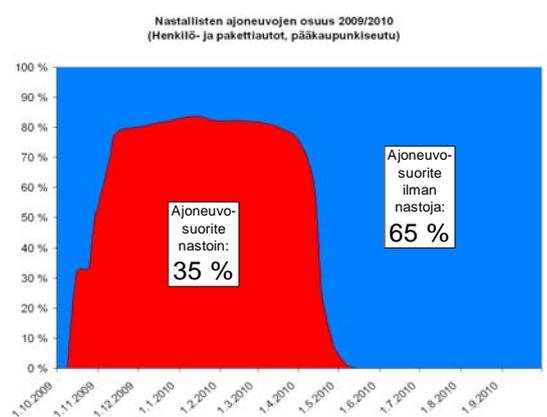
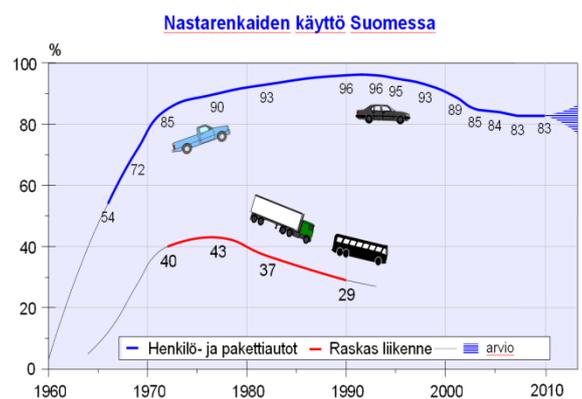
Problems increased through the use of studs: the roads wore. What to do, prohibit the use of studs as Germany and Japan, among others?

Finland chose the way of gradual development. Studded tyres were developed more road-friendly using regulations, and pavements, more durable. Always, when regulations were strengthened, there were complaints, but the wear was brought under control. In order to improve the pavements' wear resistance a lot of work was done from the end of the 60's to the 1990's.

Control over wear was achieved through the determined research, which, probably after a work too well done, was almost ended in the 1990's, blinded by the good development. The main reasons for this positive development were the reducing of stud weight (the effect had to be shown first) and ASTO-project, which found the ways to improve pavement durability (a short summary: the durability of aggregate counts for 90% of the pavement wear resistance).

The pavement wear was not ended, however, but once again, the increase in traffic and in weight of the cars pulled the wear up again soon after the turn of the century.

The reduction of inhalable dust particles has been the main incentive in the last few years to continue the development work. New tyre regulations (reduction of the number of studs in 2013 and the more stringent limits of over-run wear) were introduced to mitigate the growth, expected to prevent a new wear problem.



METHODS TO RESEARCH ROAD WEAR

Wear test tracks

- horizontal (VTT -> 90's, NESTE -> 00's, VTI 60's->10's)
 - + the real pavements and tyres, condition control
 - low speed, tyre slip, expensive, laborious
- vertical (NESTE -> 90)
 - + the real pavements and tyres, no tyre slip
 - bending of test-plate, expensive, very laborious



Test road trials (1:1, main road network, 70's to 90's)

- + the actual weather and traffic conditions,
- uncontrolled distribution of circumstances
- expensive and time consuming (2-5 v)
- not suitable for testing vehicle factors



Mini test roads (slabs) (main road network, 90's to 00's)

- + laboratory made pavements,
- + actual weather and traffic conditions,
- uncontrolled distribution of circumstances
- expensive and time consuming (2-5 v)
- not suitable for testing vehicle factors



Laboratory methods

- **Tröger** (asphalt or stone; core sample, 70's and 80's)
 - + fast, cheap
 - übereffective (sample heats up),
 - just the impact, low correlation
 - not suitable for testing vehicle factors
- **SRK** (asphalt or stone; core sample, 80's and 90's)
 - + fast, cheap, real studs
 - just the scratch, low speed, "a city pavement test"
 - not suitable for testing vehicle factors
- **Pral** (asphalt or stone; core sample, 80's to 10's)
 - + fast, cheap, repeatable (ball bearing spheres),
 - + moderate correlation, standardized
 - just the impact, "a highway pavement test"
 - not suitable for testing vehicle factors
- **Ball mill** (stone materials, 80-00)
 - just for stone materials
- **The impactor** (Lampinen, 80's)
 - überfast



Over-run-test (sawn stone test sample, 80's to 10's)

- + speed freely selectable,
- + suitable for testing vehicle factors (studs/tyres/auto)
- asphalt cannot be used as samples



Tyre-stud combinations tested using the Over-run test and type approved by Trafi – road wear test results

