Gardermobanen – equivalent conicity

- Presentation based on report
  - Equivalent Conicity on Norwegian Tracks: Gardermo Line
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- Presentation at Nordic Seminar:

  Author:
    - Hallstein Gåsemyr, JBV

Jernbaneverket

Gardermobanen – equivalent conicity

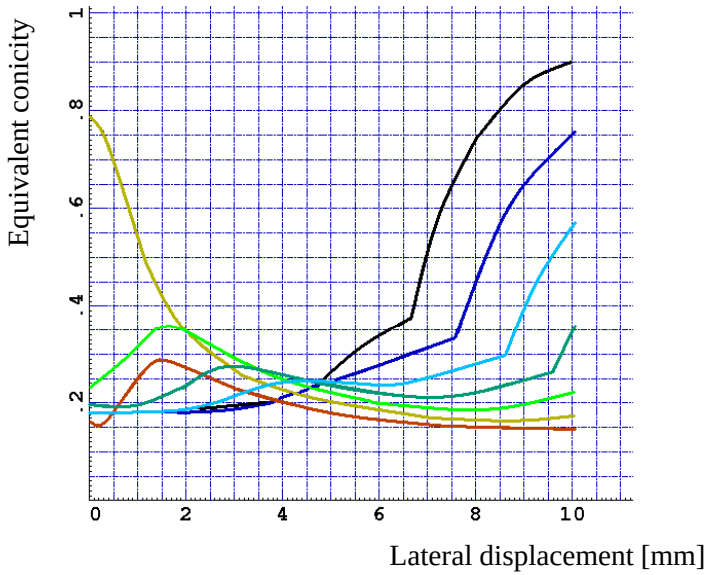
- Contents:
  - Motivation
  - Track recording and wheel/rail profile measurements
  - Calculations and Statistical Methods
  - Gardermoen Track Geometry
  - Calculation of equivalent conicity as a function of track gauge
    - nominal and worn wheel and rail profiles
  - Statistical distribution of equivalent conicity
    - measured track gauge, worn wheel and rail profiles

Jernbaneverket

Gardermobanen – equivalent conicity

- Motivation

Background is that conicity is a local quantity which is valid at one location only on the track for one wheelset
The value obtained depends on the displacement of the wheelset laterally and
on the measured track gauge at the defined location on the track



A method being demonstrated in this presentation is based on a proposal from CEN 256/WG 10 in order to be able to define the conicity for a whole section

Jernbaneverket

Gardermobanen – equivalent conicity

- Description of the method:

Lateral displacement of the wheelset between 2 and 4 mm is considered. If the flangeway clearance is narrow, then a smaller lateral displacement is applied; if the flangeway clearance < 5 mm, then a lateral displacement of 2 mm is used.

Then 2 different local conicities are being calculated, γ_{mid} in the middle of the interval, and $\gamma_{\max}$ which is the largest conicity in the interval 2 to 4 mm.

These 2 sizes are being converted into conicities over a whole defined section; due to calculation of a mean value based on local γ_{mid} , respectively the max. value of the local conicties $\gamma_{\max}$. In this way informations are given what conicities the wheelset will be exposed for when running on the actual section.

The method presupposes rail profiles being measured continuously over the section. This is not the case in this project. On the contrary, rail profiles have been measured at 12 locations in order to illustrate the method. Hence, the method will give an apprehension of how it could be working, but is of course not correct. The presenting results will therefore deviate from a correct calculation in accordance with the complete method

Jernbaneverket

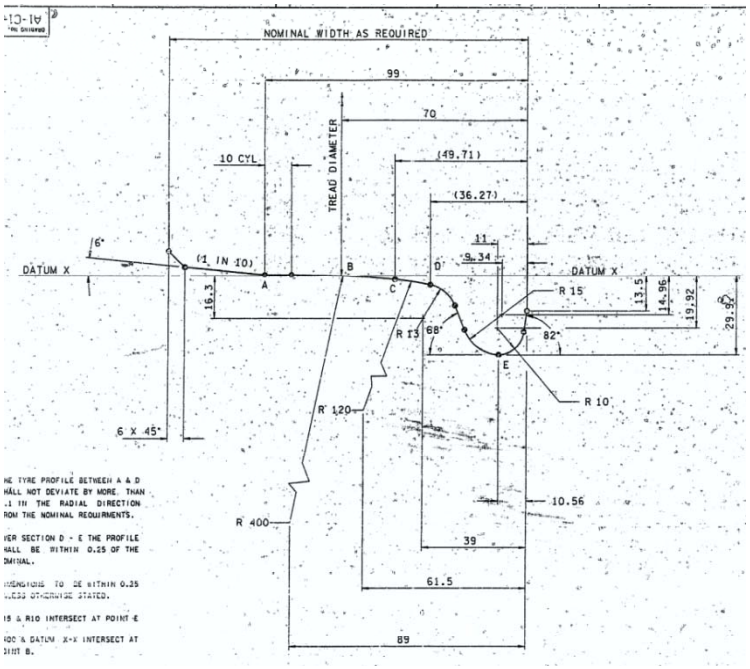
Gardermobanen – equivalent conicity

- Track quality:
  - Measured with the Track Recording car ROGER 1000 between Oslo and Eidsvoll in April 2011
    - In focus: Gauge and curvature
  - Application of Miniprof Equipment
    - Worn rail profiles of type 60E1 on 12 locations measured in June 2008
- Wheel profiles:
  - Application of Miniprof Equipment
    - Worn wheel profiles P8 and RD9 measured in 2008
- Nominal profiles also applied in the study:
  - Rail 60E1
  - Wheel profiles S1002, P8, RD9

Jernbaneverket

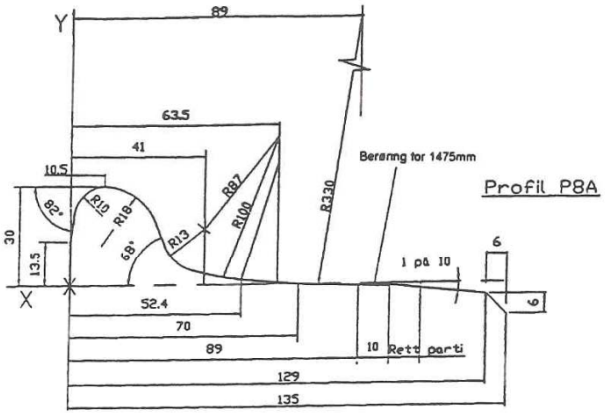
Gardermobanen – equivalent conicity

- Wheel profiles (nominal)



Wheel profil RD9

Distance from back of flange to centre of wheel tread for both profiles: 70 mm



Wheel profile P8

For both profiles:
Flange angle: 68°
Radius in flange root corner: R13
Differencies in geometry of the profiles
P8: R87, R100, R330
RD9: R120, R400

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Gardermobanen – equivalent conicity

- Calculation of equivalent conicity
  - Depending on track gauge (TG) and spacing of active faces (SR), wheelset amplitude y in this work applies:

$$y_{\max} = 4\ mm \qquad if \quad (TG - SR) \geq 9\ mm$$

$$y_{\max} = \left(\frac{(TG - SR) - 1)}{2} \right) \qquad if \quad 5\ mm \leq (TG - SR) < 9\ mm$$

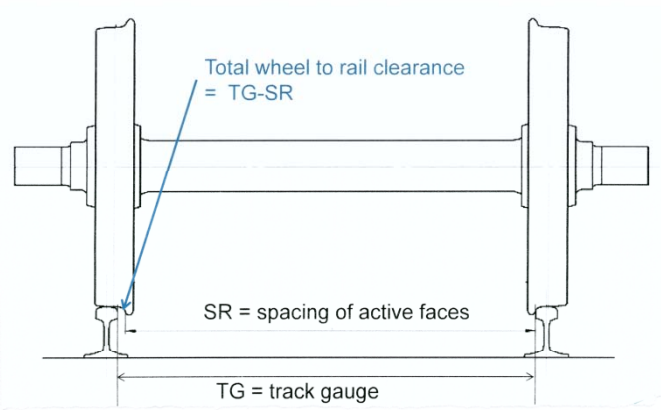
$$y_{\max} = 2\ mm \qquad if \quad (TG - SR) < 5\ mm$$

  - Values to be calculated in accordance with amplitude:

$$(\tan \gamma_e)_{mid} : \quad for\ y = (2 + y_{\max}) / 2$$

$$(\tan \gamma_e)_{\max} \quad the \quad \max imum \quad reached \quad between \quad y = 2\ mm \quad and \quad y = y_{\max}$$

Applied method due to proposals in EN 14363



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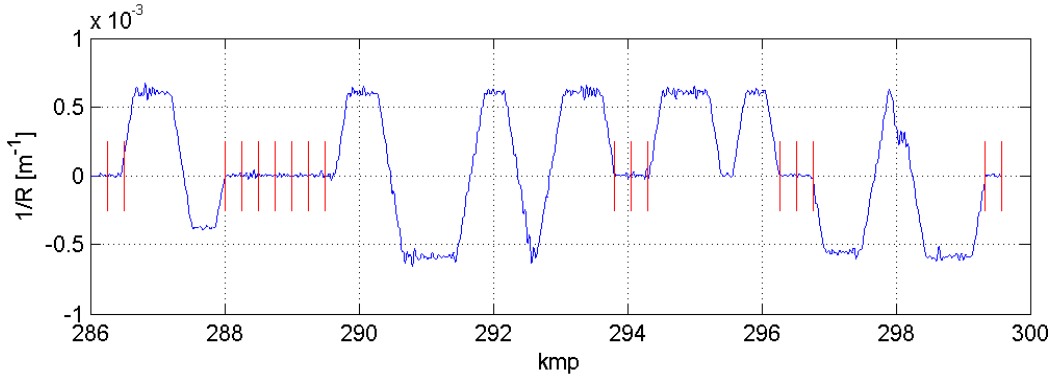
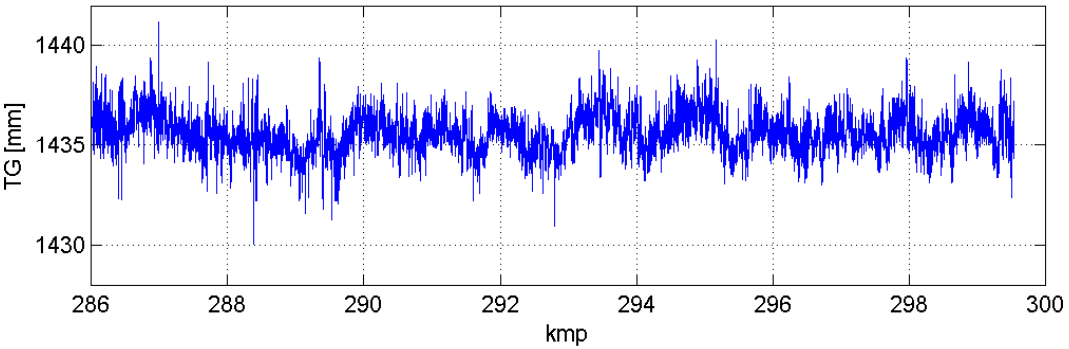
Gardermobanen – equivalent conicity

- Statistical method applied
  - Illustration on Bergen Line (from former work)



Red lines show tangent track sections of length of 250 m



Measured track gauge

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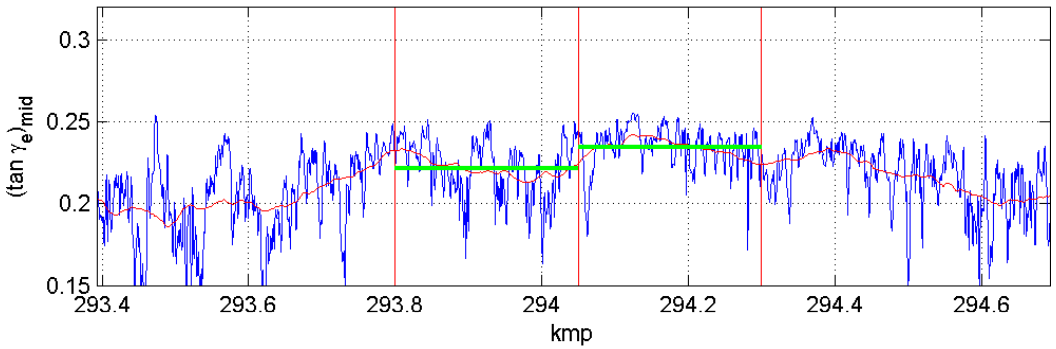
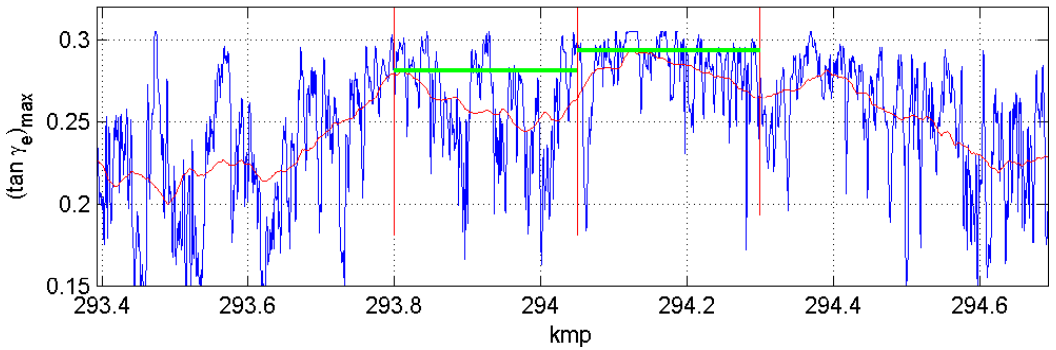
Gardermobanen – equivalent conicity

- Statistical method applied
  - Illustration on Bergen Line (continues); three step method applied for calculations due track gauge and nominal profiles



Equivalent conicity, mean value:
blue lines: local values
red lines: sliding mean values over 100 m
green lines: mean value of red line over a length of 250 m



Equivalent conicity, max value:
blue lines: momentary values
red lines: sliding mean values over 100 m
green lines: maximum value of red line over a length of 250 m

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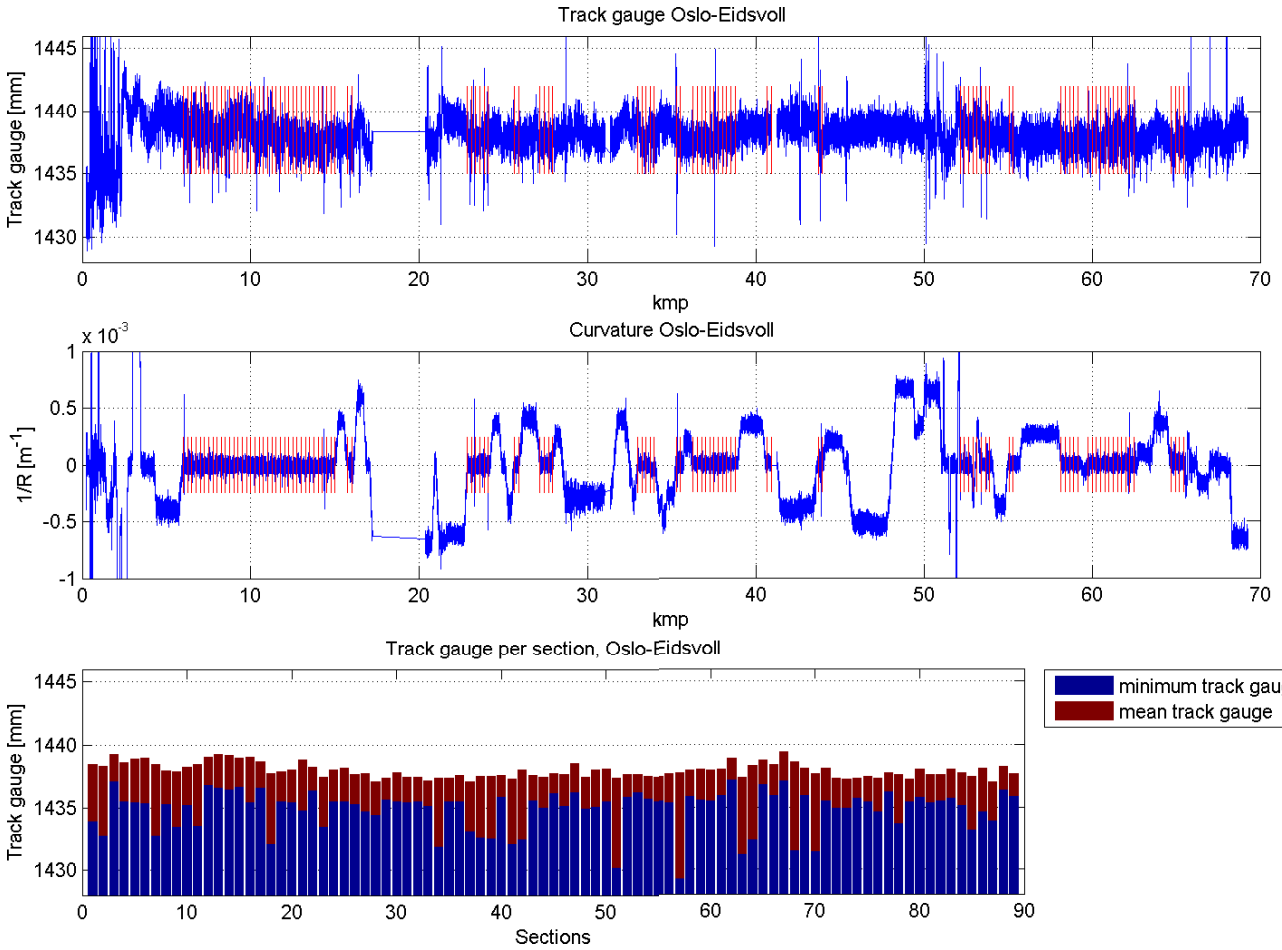
Gardermobanen – equivalent conicity

- Track gauge and curvature, Gardermoen



Red lines: boundaries for the evaluated tangent track sections; gauge, curvature

Track gauge on almost 90 sections: min. value max value

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Gardermobanen – equivalent conicity

- Equivalent conicity
  - has been calculated for nominal and worn profiles

  as a function of track gauges:
    - nominal P8 and nominal 60E1
    - nominal P8 and worn 60E1
    - worn P8 and nominal 60E1
    - worn P8 and worn 60E1
    - nominal RD9 and nominal 60E1
    - nominal RD9 and worn 60E1
    - worn RD9 and nominal 60E1
    - worn RD9 and worn 60E1
    - nominal S1002 and nominal 60E1
    - nominal S1002 and worn 60E1

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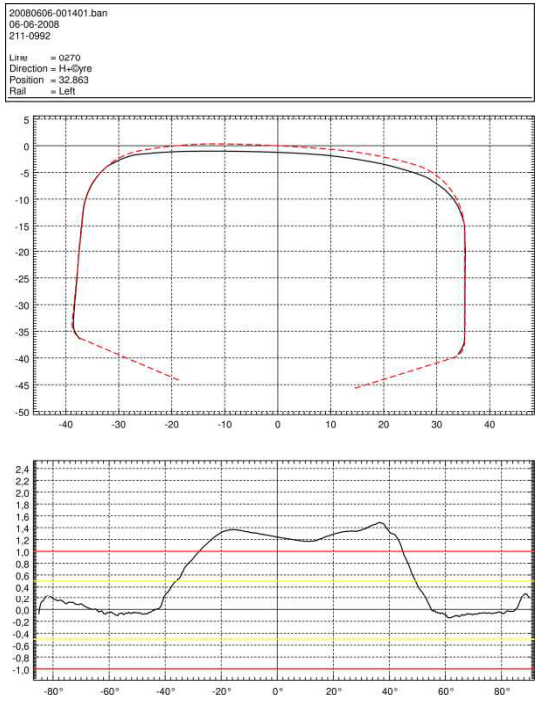
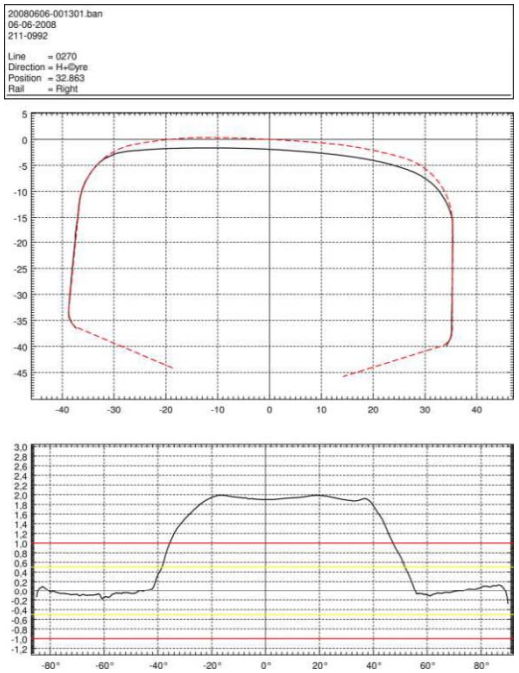
Gardermobanen – equivalent conicity

- Nominal and worn profiles
  - Rail profiles (one example of 12 locations)



Right track, km 32+863
left rail



Right track, km 32+863
right rail

Wear pattern is identified for all rails at 12 locations

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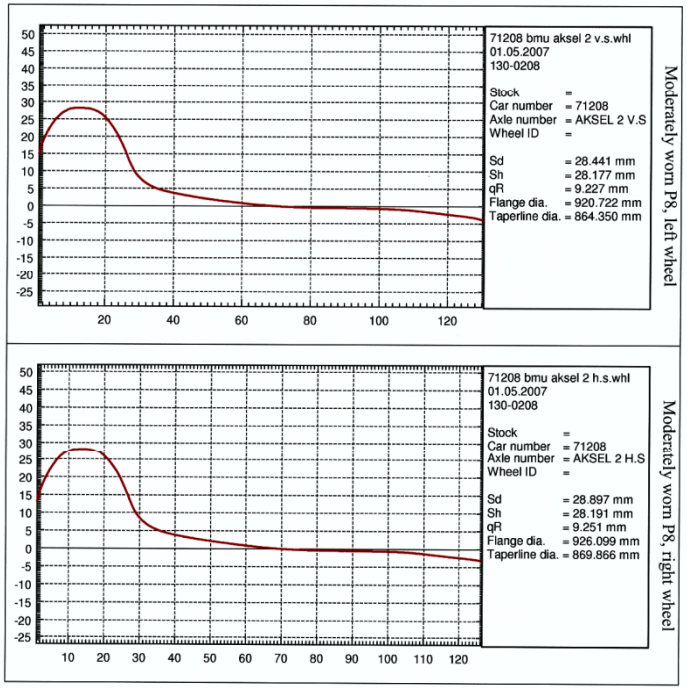
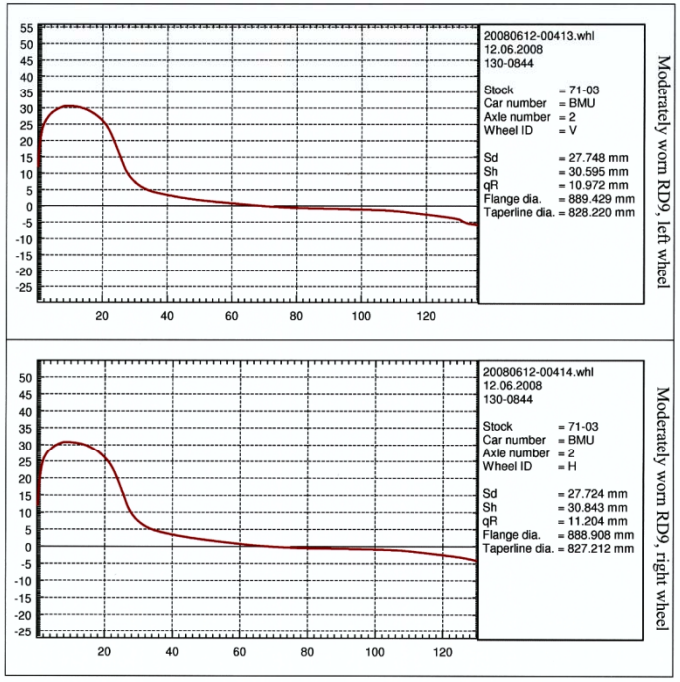
Gardermobanen – equivalent conicity

- Moderately worn wheel profiles; P8; RD9



Wheel profile P8



Wheel profile RD9

Wear pattern is identified

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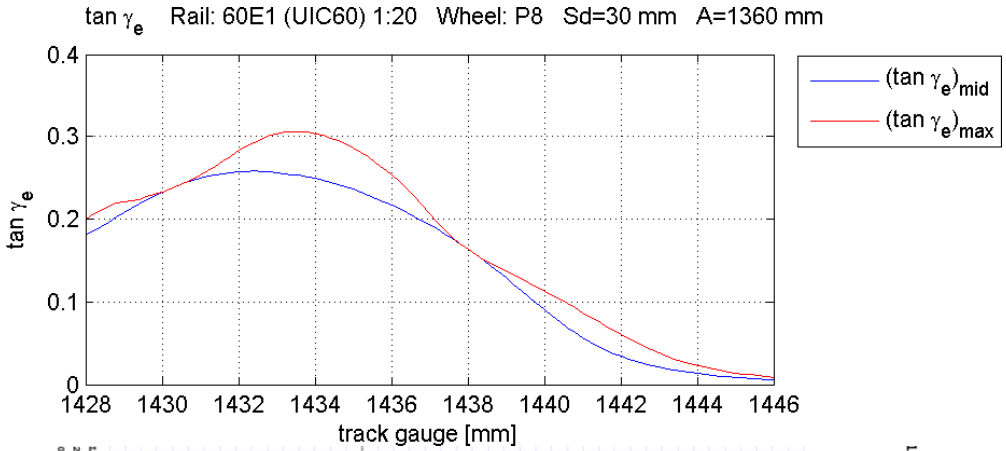
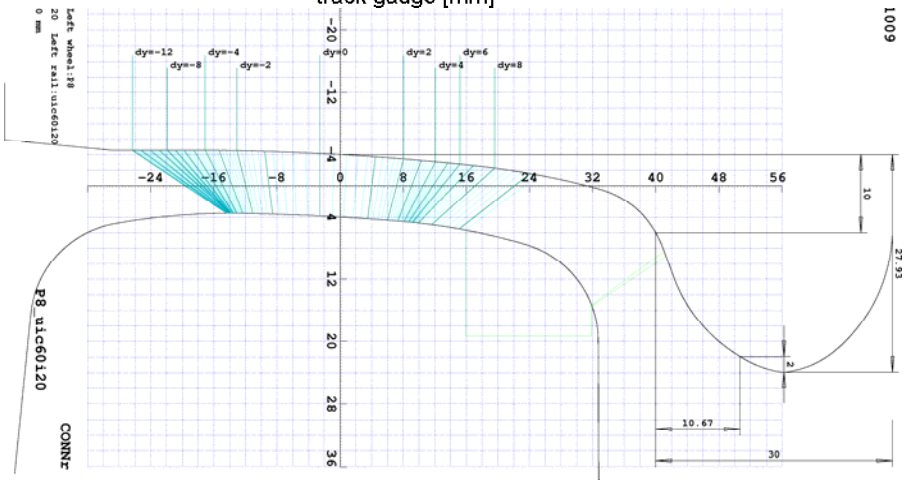
Gardermobanen – equivalent conicity

- Conicity cal., nominal P8 on nominal 60E1





as function of track gauge
Sd: flange thickness
A: spacing of activ faces

Remarks:
Highest values of conicities in interval for nominal track gauge (1433 – 1436 mm)

Wheel – rail contact geometry

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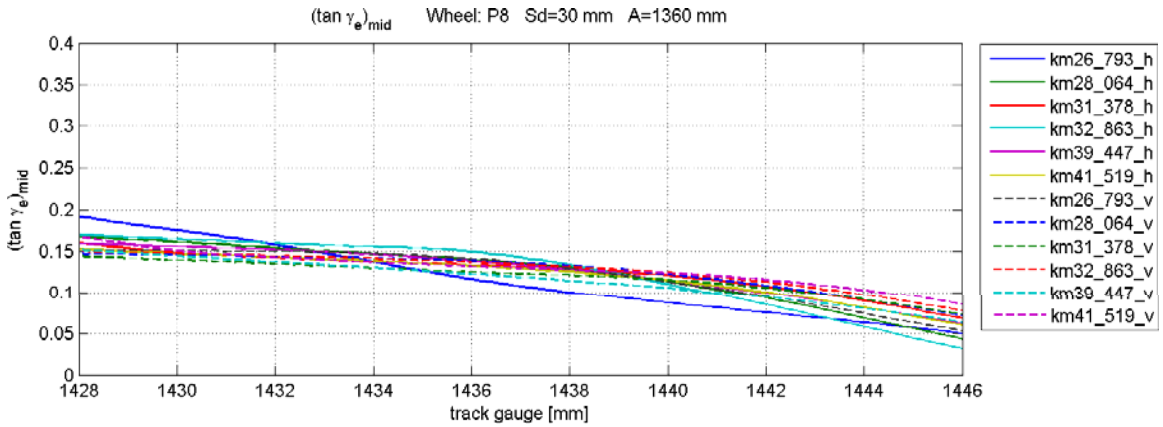
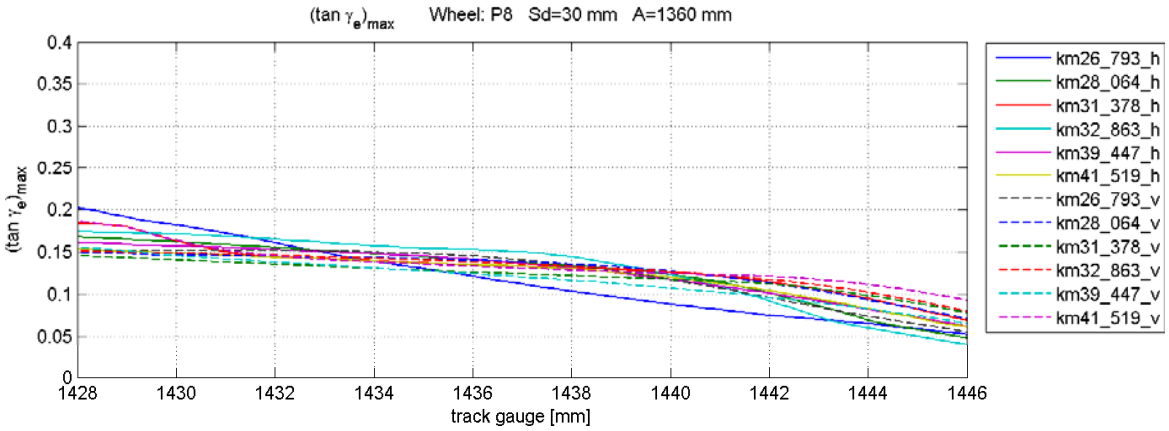
Gardermobanen – equivalent conicity

- Conicity cal., nominal P8 on worn 60E1





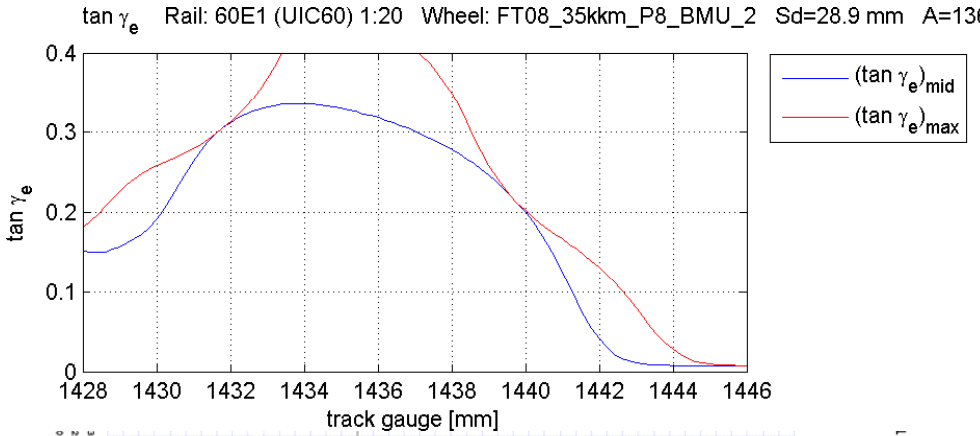
Worn rail profiles measured at 12 locations; equivalent conicity calculated as function of track gauge

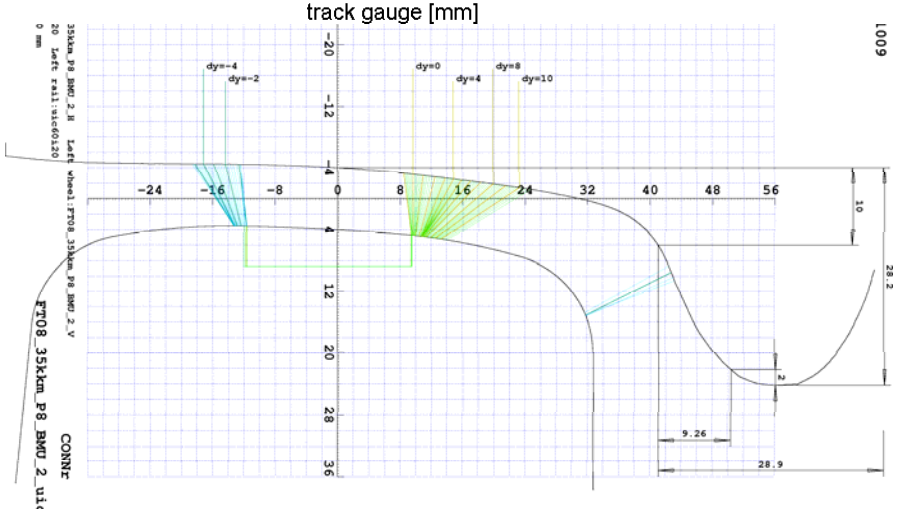
Track gauge at each location of measured rail profile has not been applied

Jernbaneverket

Gardermobanen – equivalent conicity

- Conicity cal., worn P8 on nominal 60E1





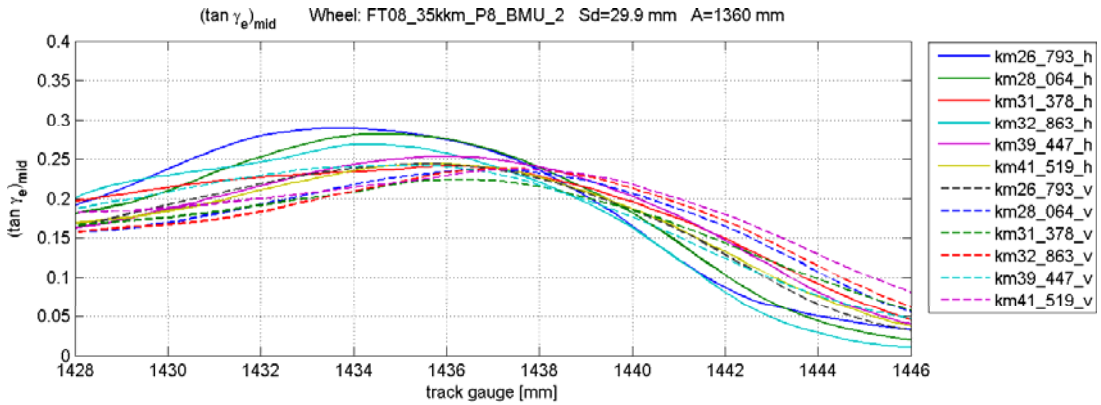
Flange thickness Sd = 28,9
Very high values in the range for nominal track gauge

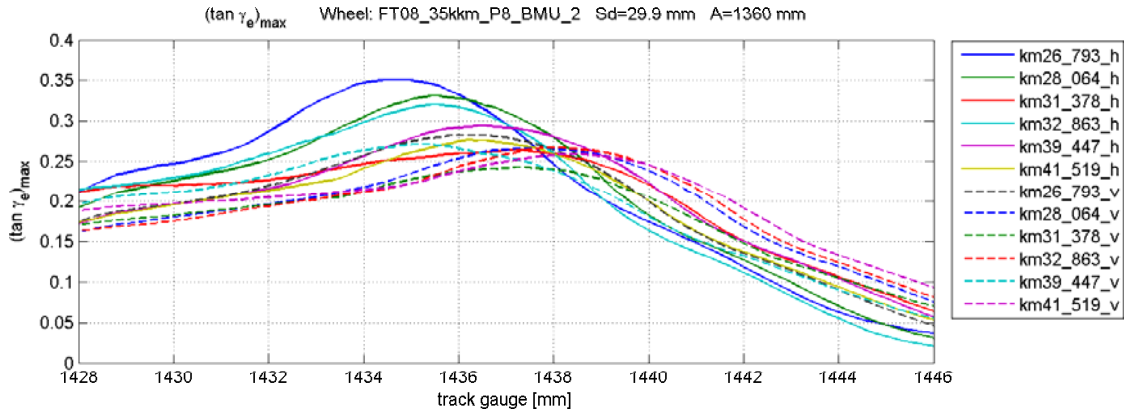
Moderately worn P8
Wheel – rail contact geometry

Jernbaneverket

Gardermobanen – equivalent conicity

- Conicity cal., worn P8 on worn 60E1





Worn rail profiles measured at 12 locations; moderately worn P8 profile (Sd = 28,9 mm); equivalent conicity calculated as a function of track gauge

Track gauge at each location of measured rail profile has not been applied

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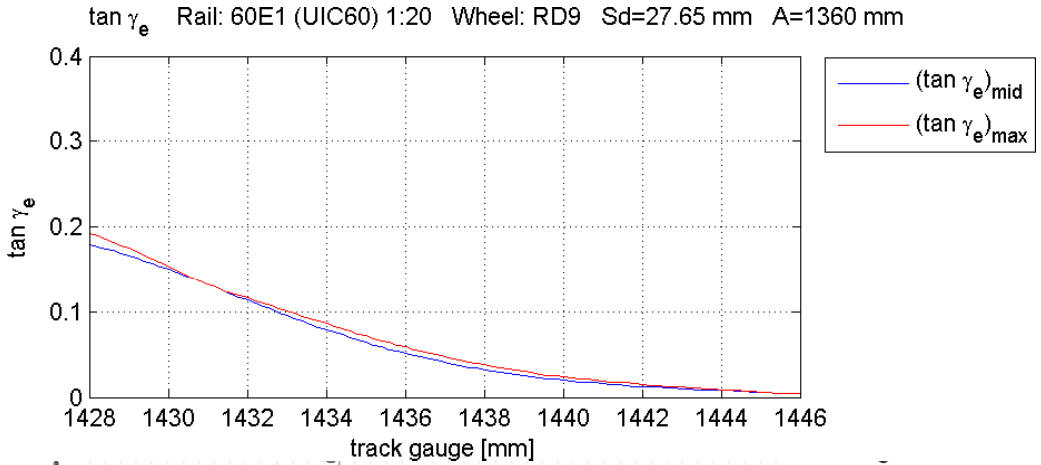
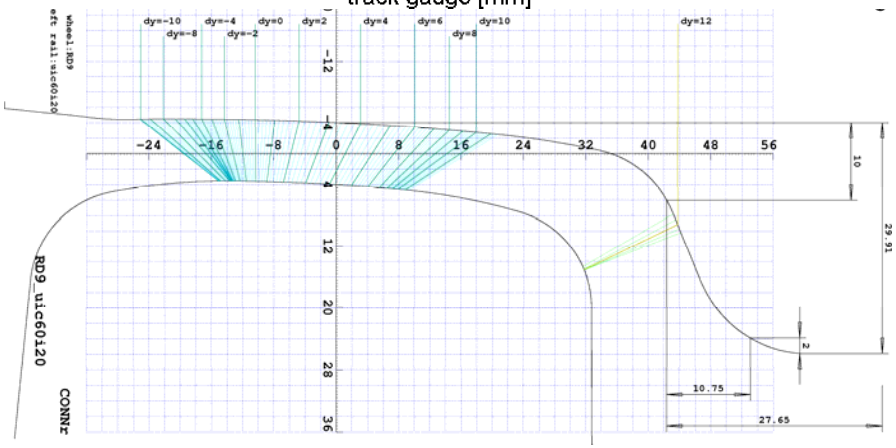
Gardermobanen – equivalent conicity

- Conicity cal., nom. RD9 on nom. 60E1





as a function of track gauge
Sd: flange thickness
A: spacing of active faces

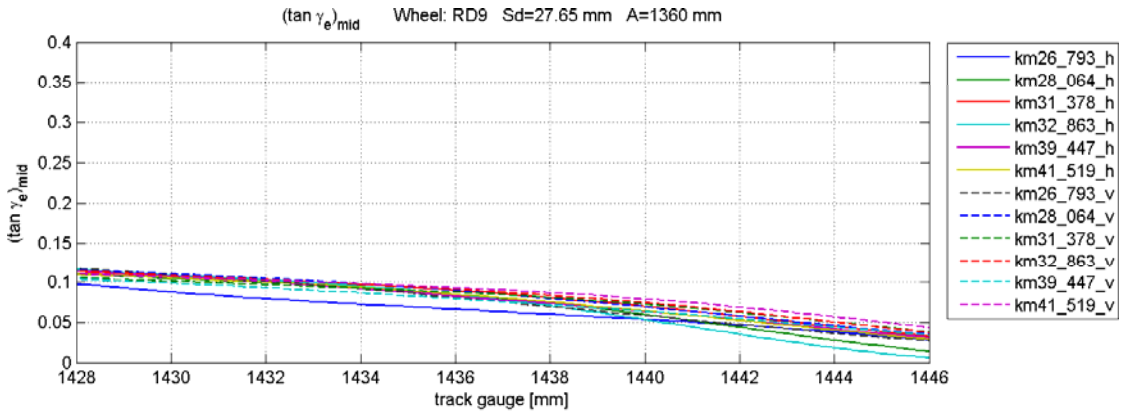
Remarks:
Low values of conicities
in range for nominal
track gauge (1433 – 1436 mm)

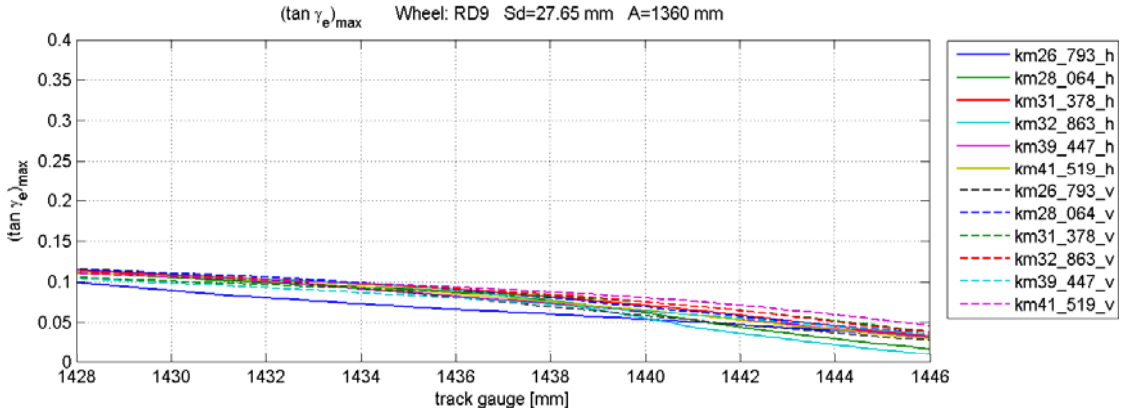
Wheel – rail contact geometry

Jernbaneverket

Gardermobanen – equivalent conicity

- Conicity cal., nom. RD9 on worn 60E1





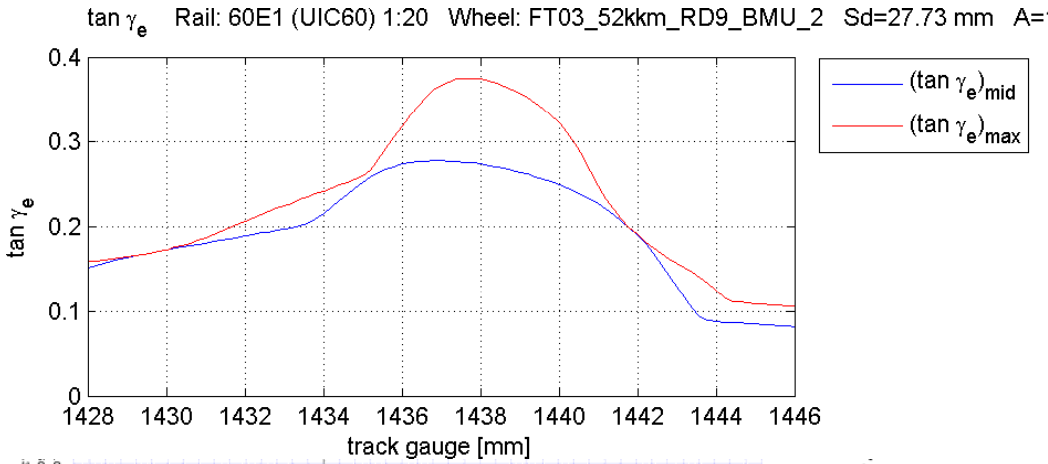
Worn rail profiles measured at 12 locations; equivalent conicity calculated as a function of track gauge

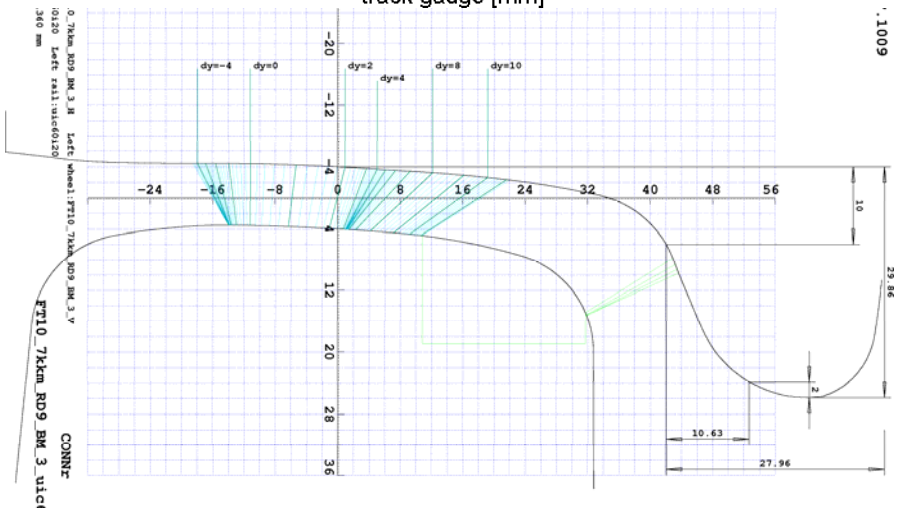
Track gauge at each location of measured rail profile has not been applied

Jernbaneverket

Gardermobanen – equivalent conicity

- Conicity cal., worn RD9 on nominal 60E1





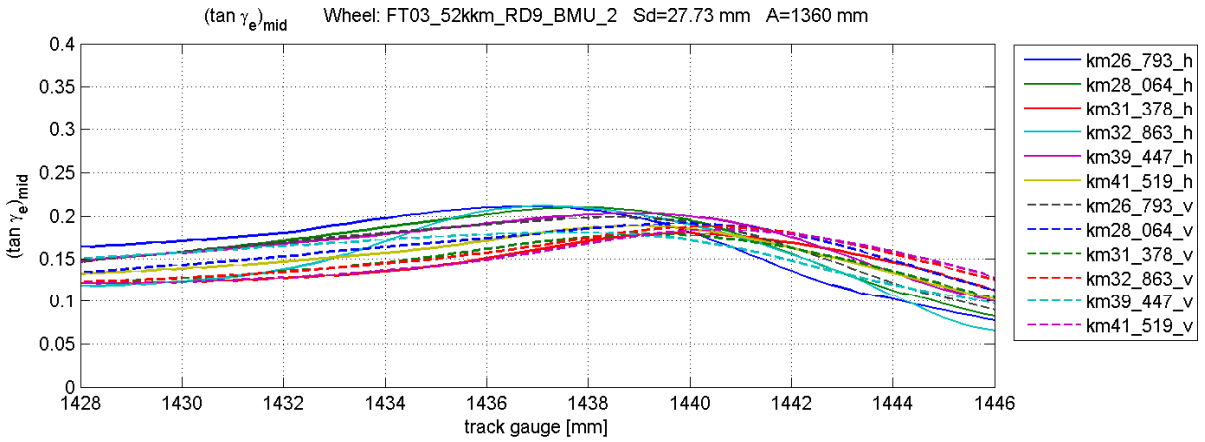
Flange thickness Sd = 27,73 mm
Moderately worn RD9
High values in range of
1436 – 1440 mm

Moderately worn RD9
Wheel – rail contact geometry

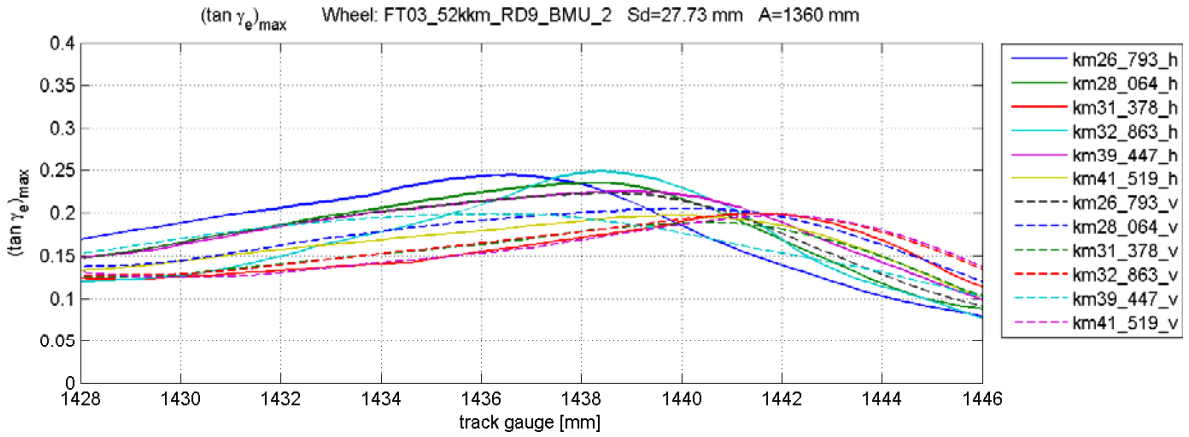
Jernbaneverket

Gardermobanen – equivalent conicity

- Conicity cal., worn RD9 on worn 60E1



Worn rail profiles measured at 12 locations; equivalent conicity calculated as function of track gauge; moderately worn RD9



Track gauge at each location of measured rail profile has not been applied

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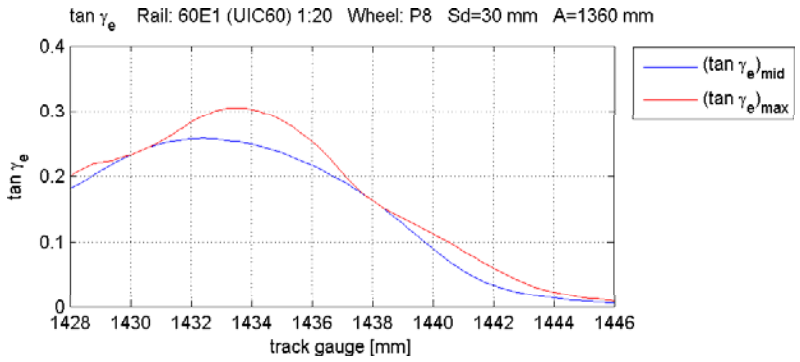
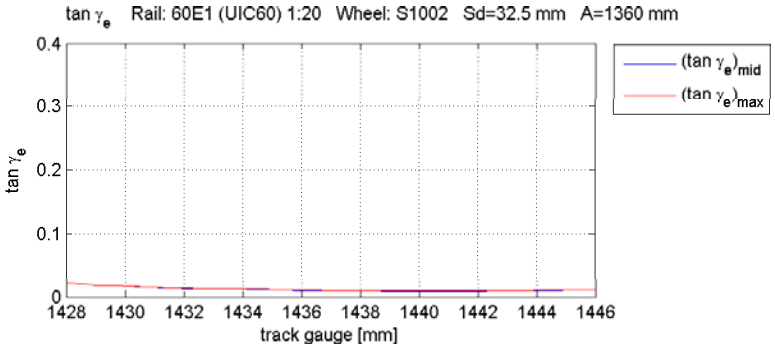
Gardermobanen – equivalent conicity

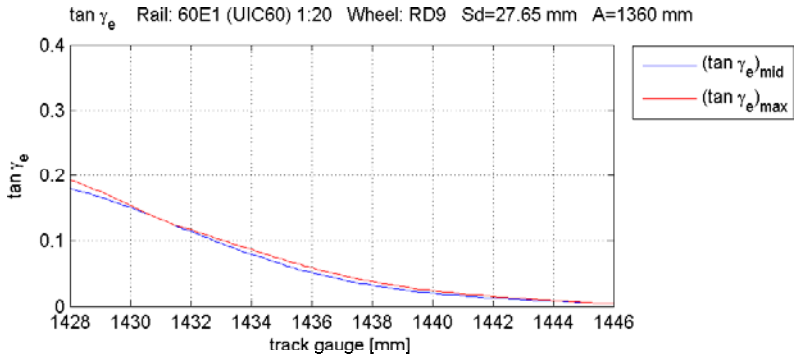
- Conicity cal., nom. P8, RD9, S1002, 60E1



P8 and 60E1



S1002 and 60E1



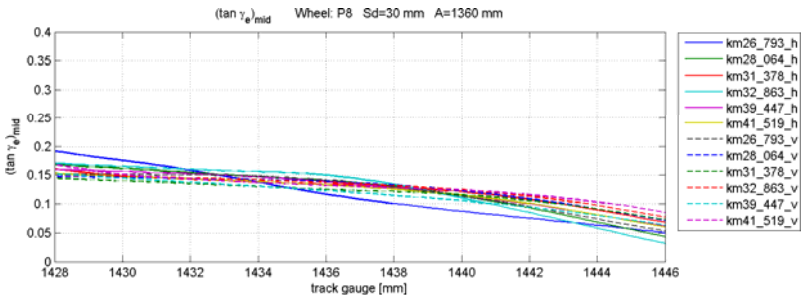
RD9 and 60E1

Comparision of equivalent conicities of 3 nominal wheel profiles P8, RD9, S1002 with nominal rail profile 60E1

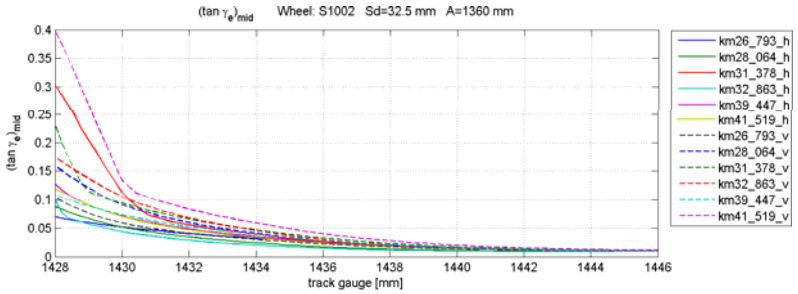
Jernbaneverket

Gardermobanen – equivalent conicity

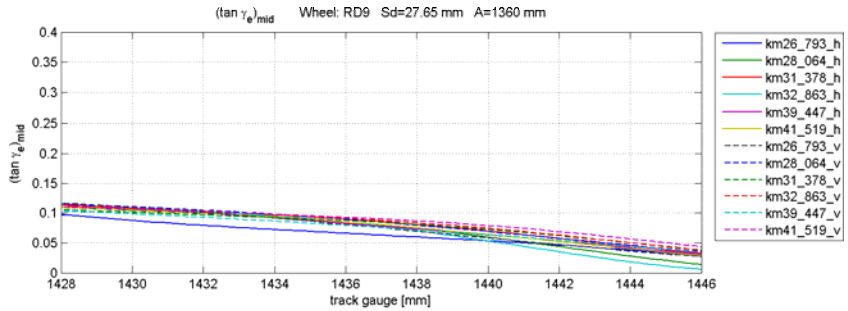
- Conicity cal., nom. P8, RD9, S1002, w60E1



P8 and worn 60E1



S1002 and worn 60E1



RD9 and worn 60E1

Comparision of equivalent conicity of 3 nominal wheel profiles P8, RD9, S1002 with worn rail profile 60E1

Jernbaneverket

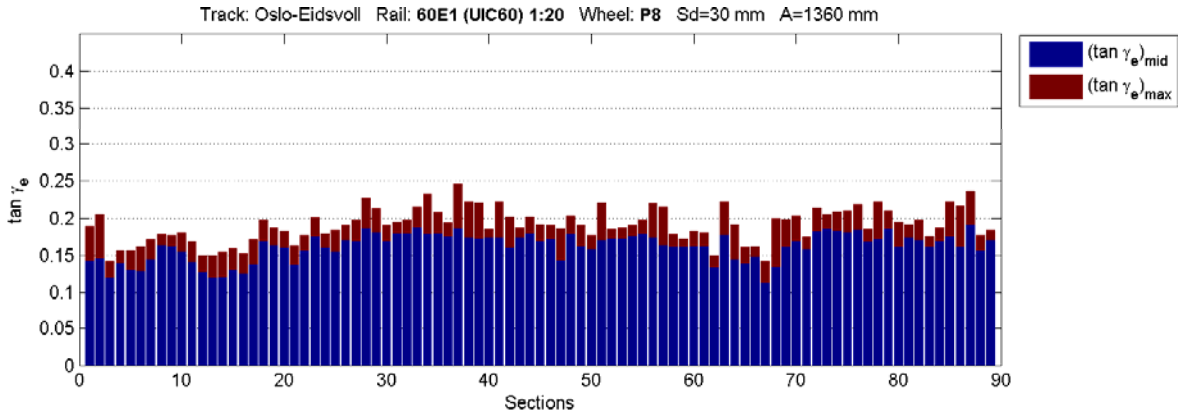
Gardermobanen – equivalent conicity

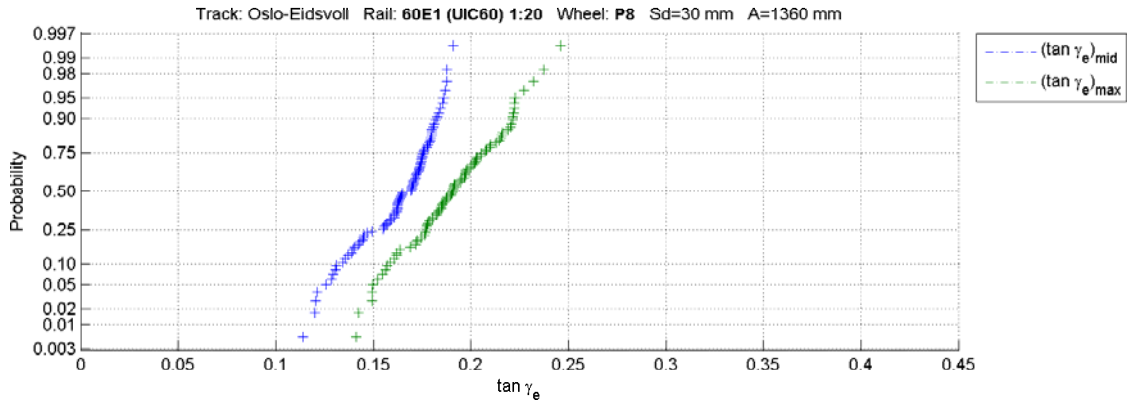
- Statistical distribution
  - Measured track gauge has been applied in order to calculate the conicities along the track
  - Worn rail profiles have been choosen and used randomly from the 12 sets of measured rail profiles
  - There are almost 90 sections
  - The selected rail profile being choosen randomly, is constant for a section
    - no variation of worn rail profile inside of a section
  - In this way a distribution of conicities have been found

Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution, nom. P8 and nom. 60E1





Equivalent conicity has been calculated as explained in previous slides:

$(\tan \gamma_e)_{mid}$

$(\tan \gamma_e)_{\max}$

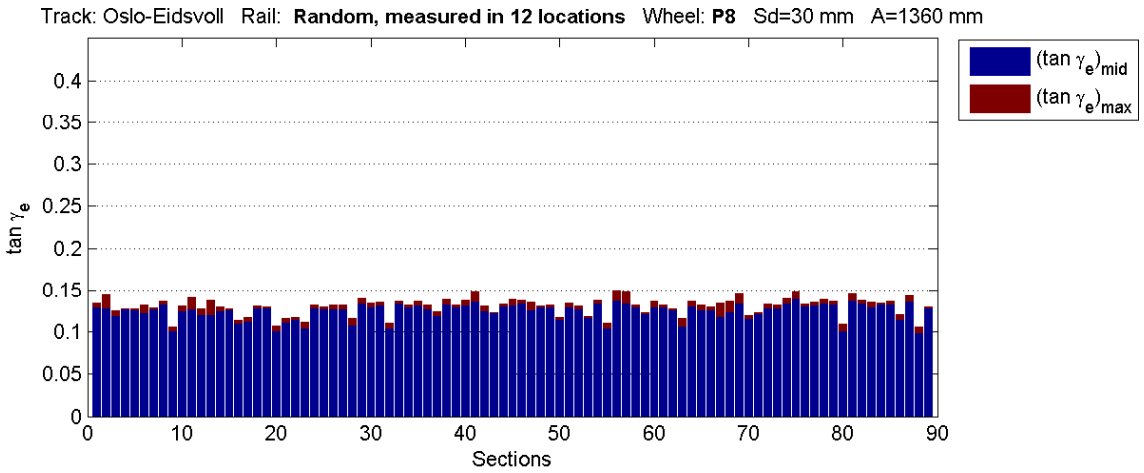
Rail profiles have been choosen randomly from 12 locations and is being held constant in a section

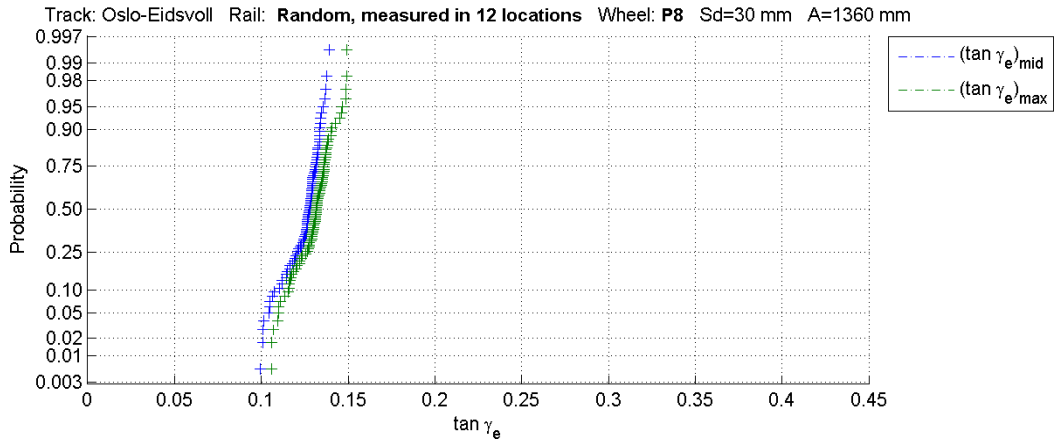
Distribution is shown

Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution, nom. P8 and worn 60E1





Equivalent conicity has been calculated as explained in previous slides:

$(\tan \gamma_e)_{mid}$

$(\tan \gamma_e)_{\max}$

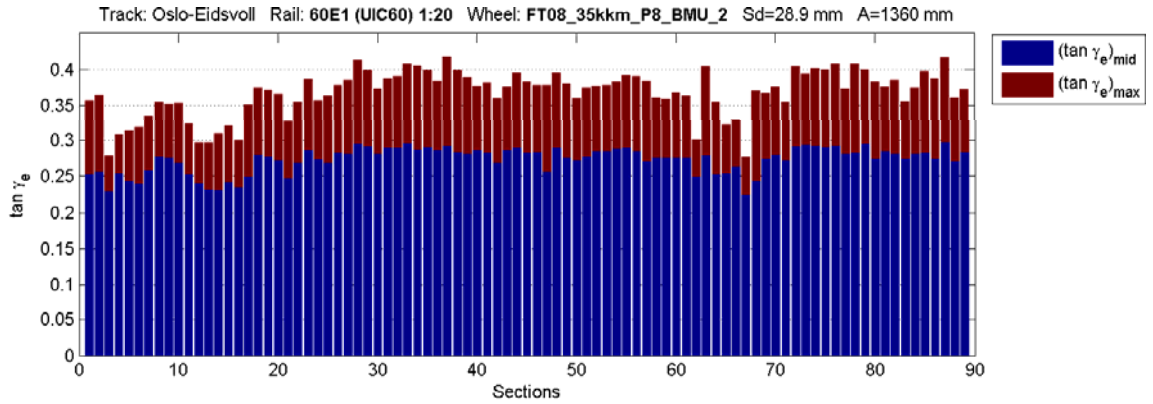
Rail profiles have been choosen randomly from 12 locations and is being held constant in a section

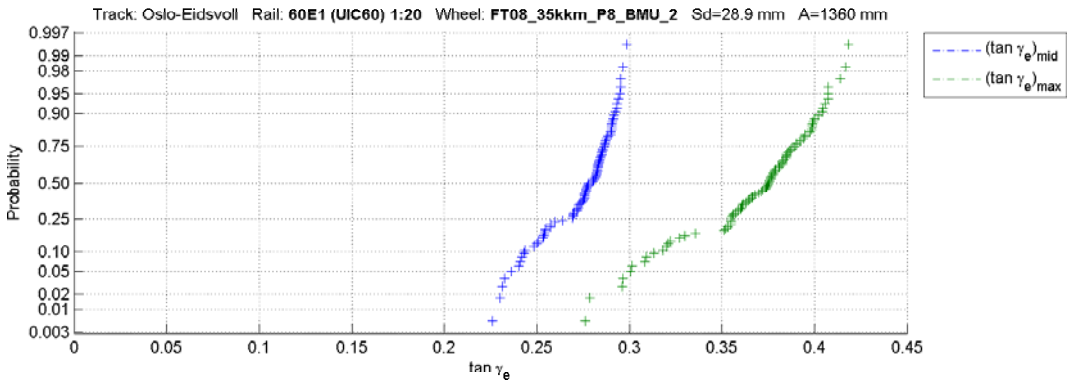
Distribution is shown

Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution, worn P8 and nom. 60E1





Equivalent conicity has been calculated as explained in previous slides:

$(\tan \gamma_e)_{mid}$

$(\tan \gamma_e)_{\max}$

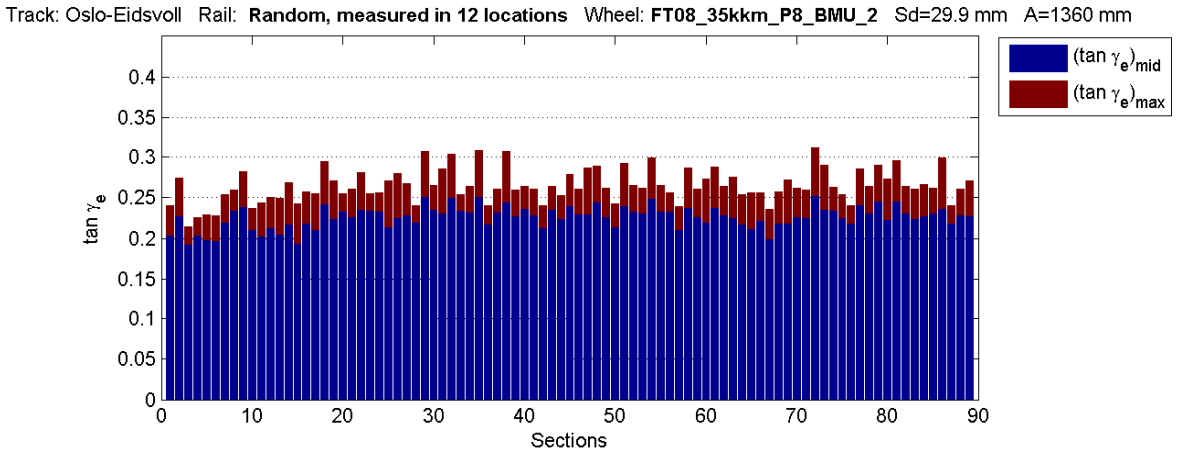
Rail profiles have been choosen randomly from 12 locations and being held constant in a section

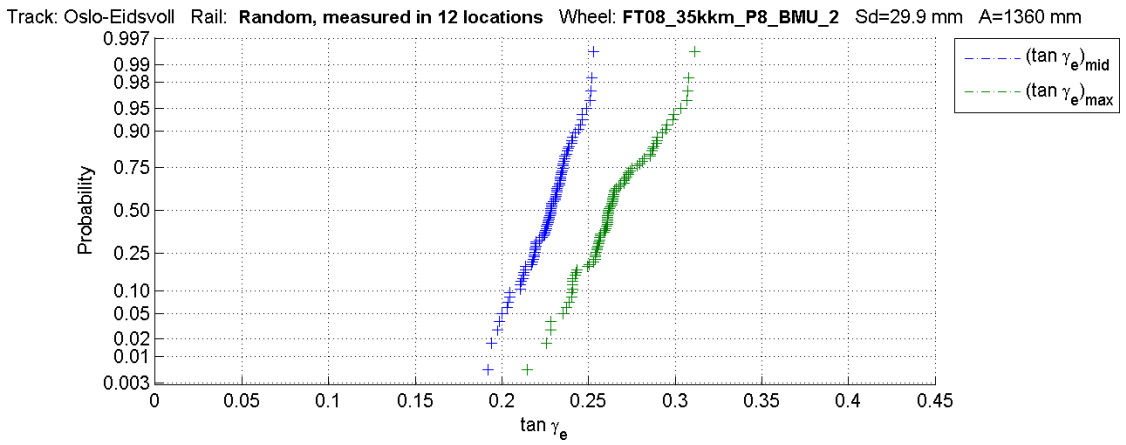
Distribution is shown

Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution worn P8, worn 60E1





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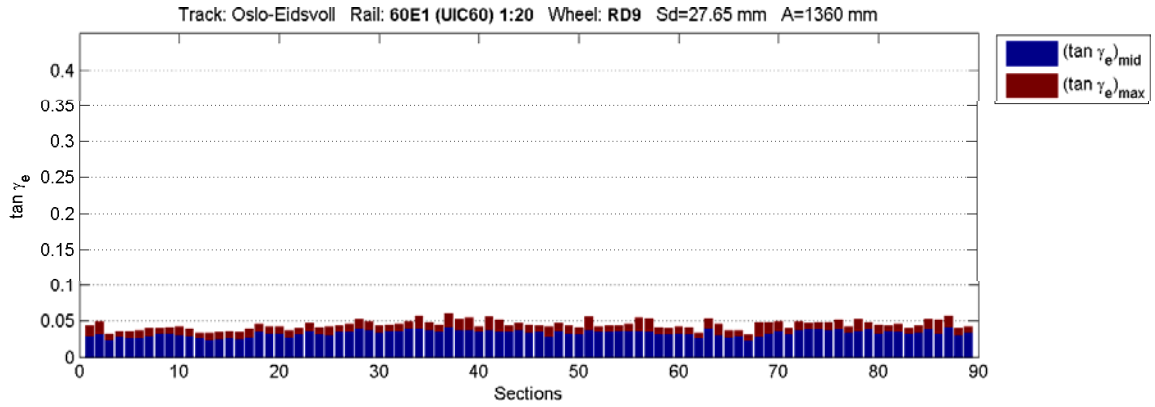
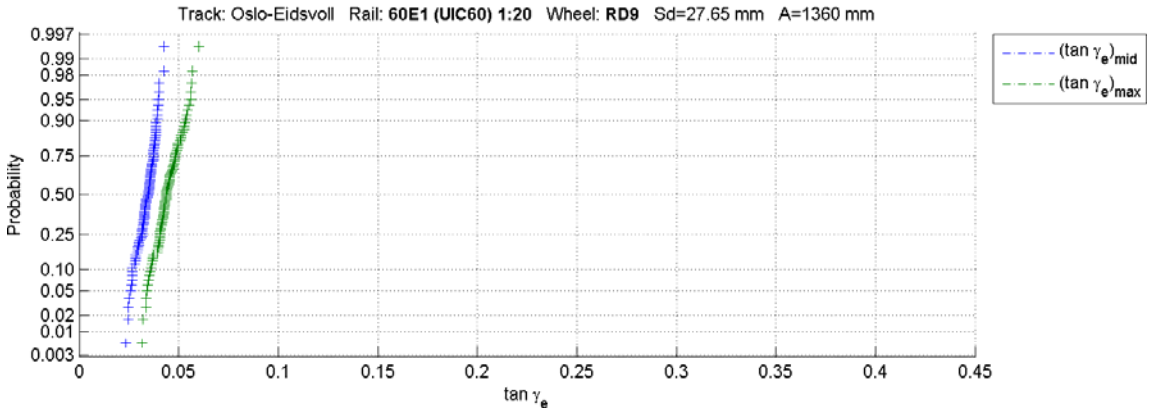
Distribution is shown

Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution nom. RD9 and nom. 60E1





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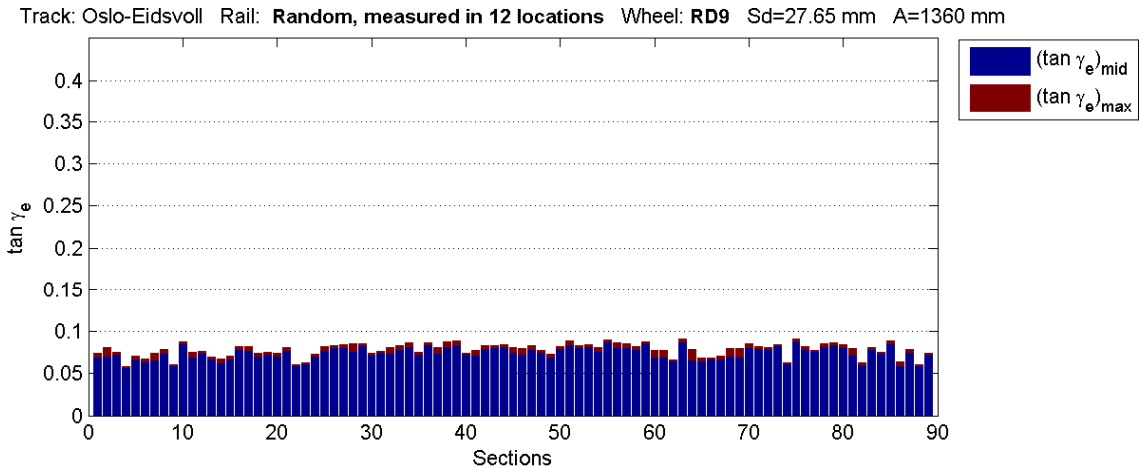
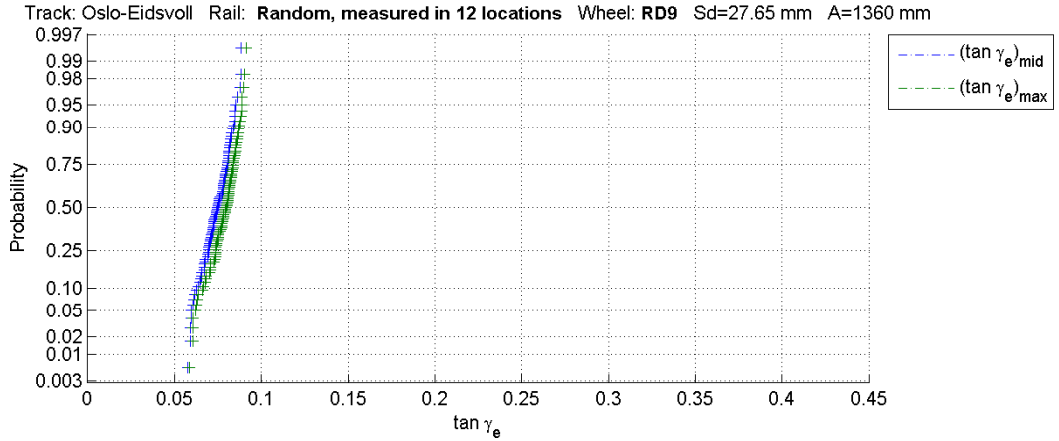
Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution nom. RD9 and worn 60E1





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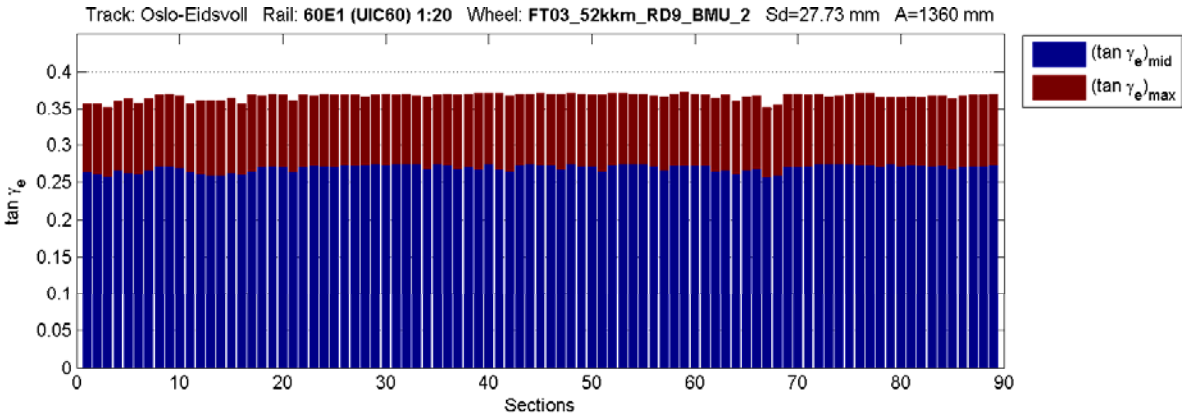
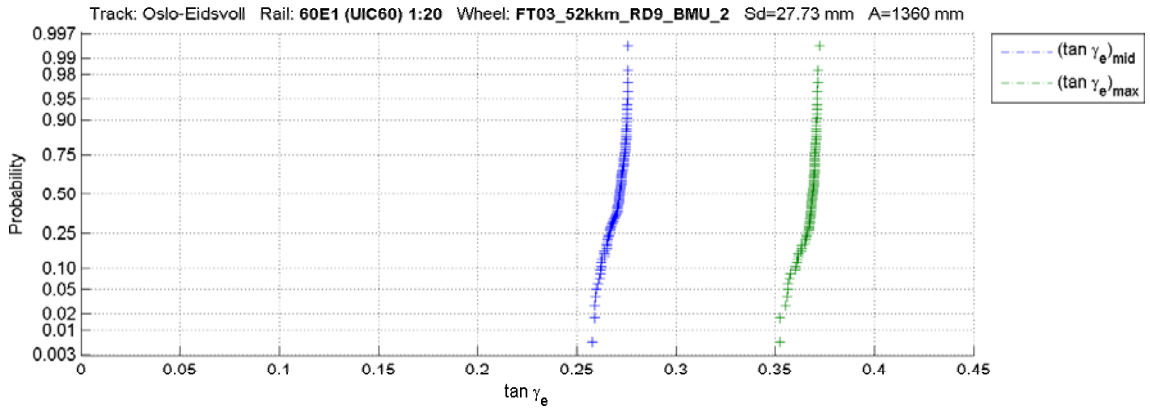
Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution, worn RD9 and nom. 60E1





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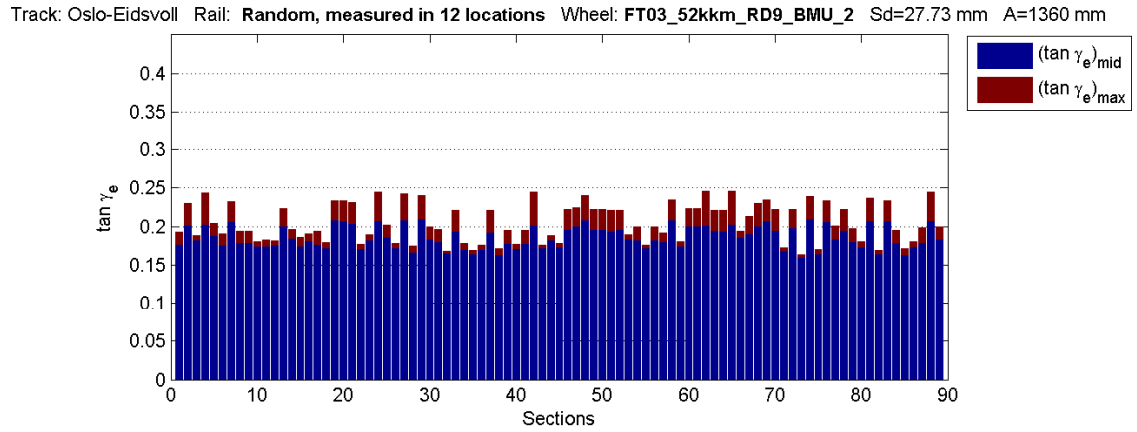
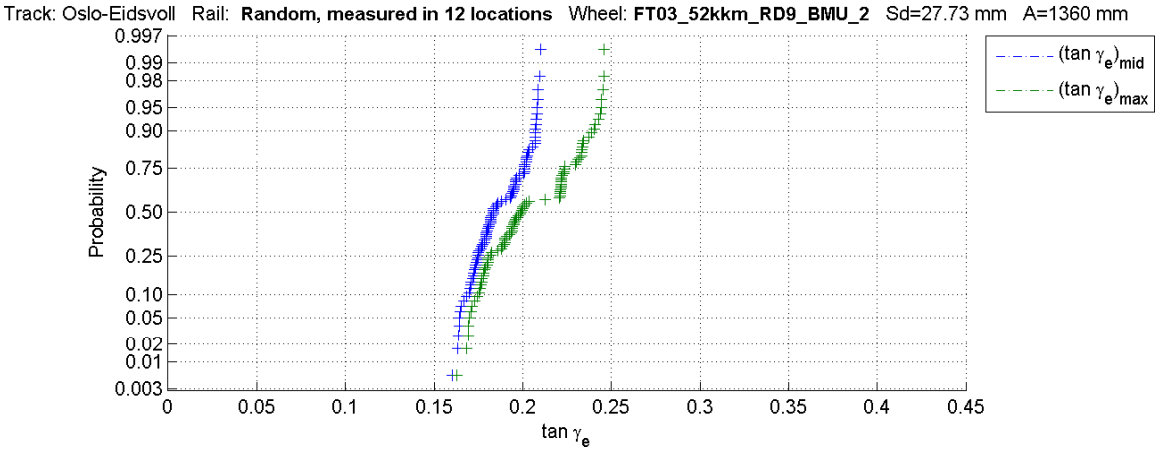
Jernbaneverket

Gardermobanen – equivalent conicity

- Distribution, worn RD9 and worn 60E1





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Rail profiles have been Choosen randomly From 12 locations and is Being held constant In a section

Distribution is shown

Jernbaneverket

Gardermobanen – equivalent conicity

- Conclusions
  - Equivalent conicities of Gardermoen Airport Line have been shown
  - Measurements
    - track gauges
    - nominal and worn wheel and rail profiles
  - Statistical methods have been applied
    - Three step method for mean and max values
  - Results are considered as satisfactorily
    - For most cases the simple formula is satisfied:

$$(\tan\gamma_e) \le \left(0{,}50 - \frac{V_{\lim}}{1000}\right) = \left(0{,}50 - \frac{210}{1000}\right) = 0{,}29$$

Jernbaneverket