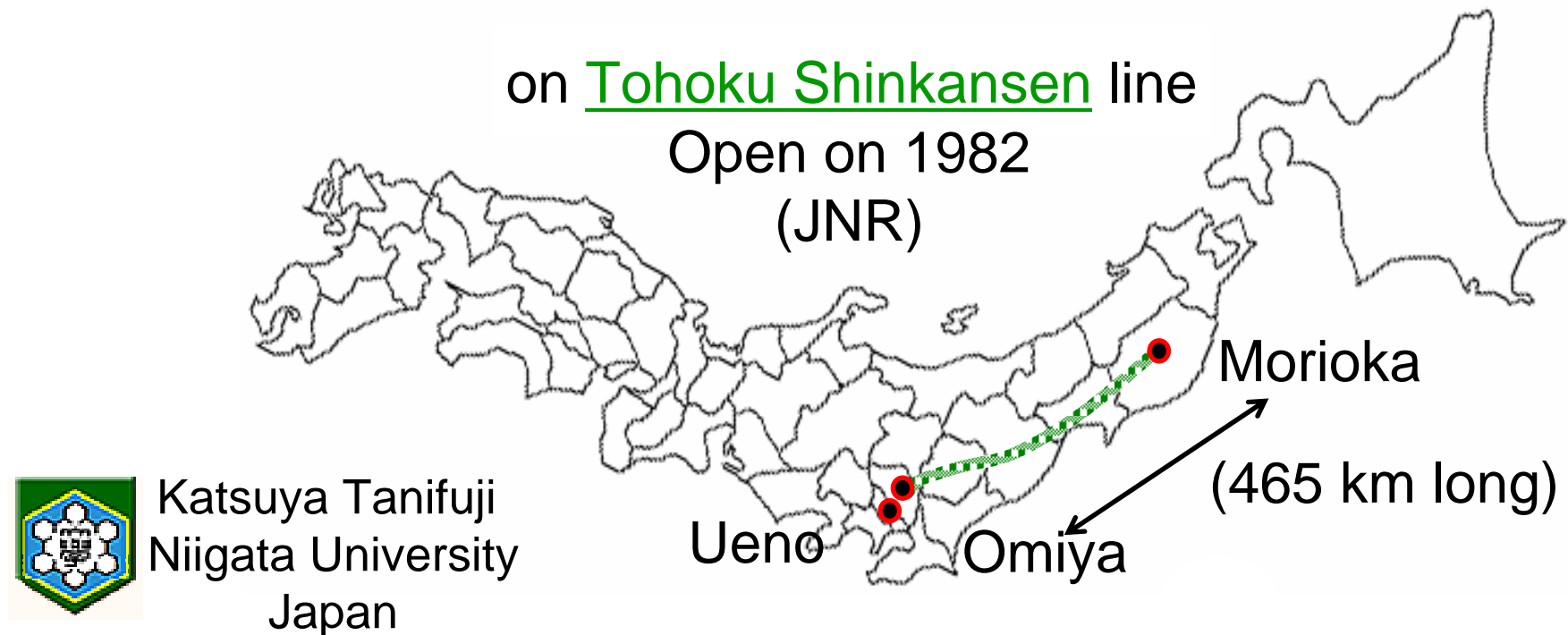


# A Study on Prediction of Wear Progress of Railway Wheel

## Background

“Long-term endurance test” running at 240 km/h  
(from Sept. 1983 till Sept. 1984)



# Test train

(Type 925 electric and track inspection train)

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**6-car train**

**Test running**

Period: 1 year

Running distance:

total 268 000 km

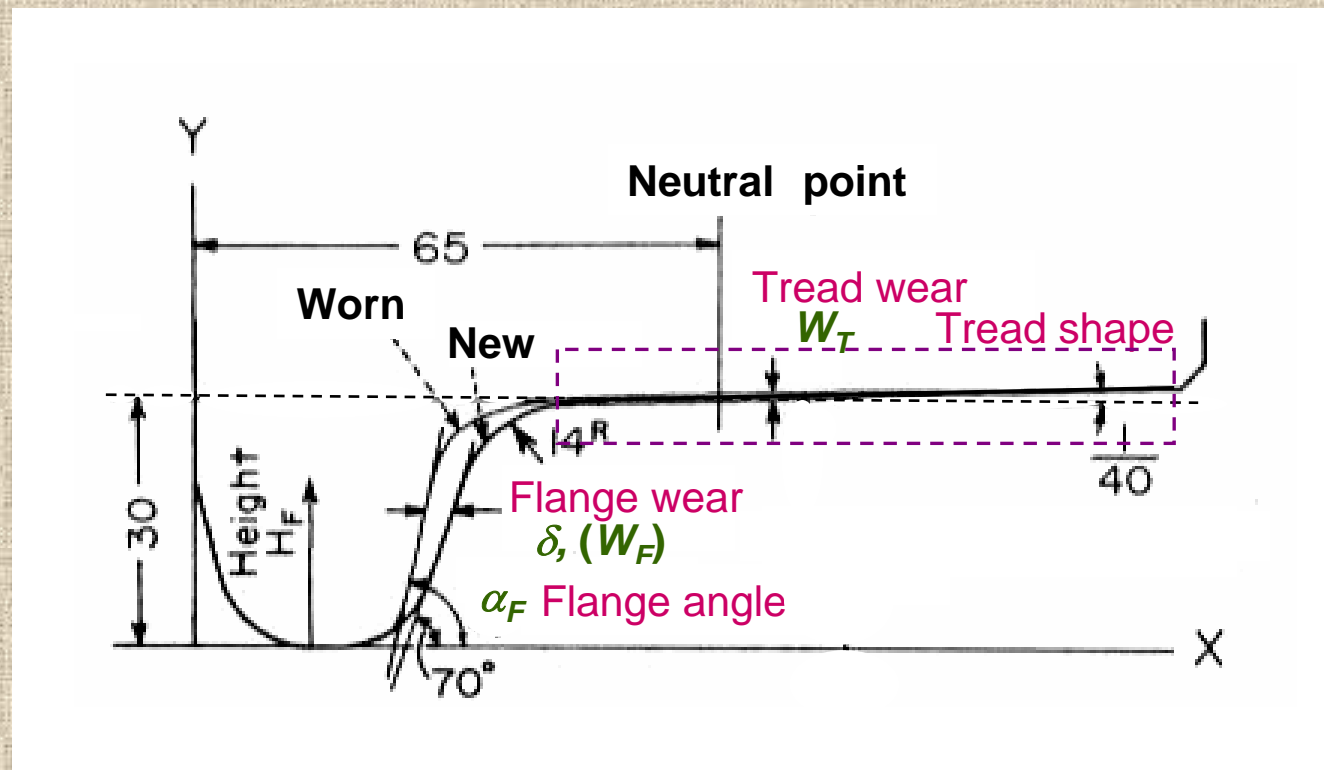


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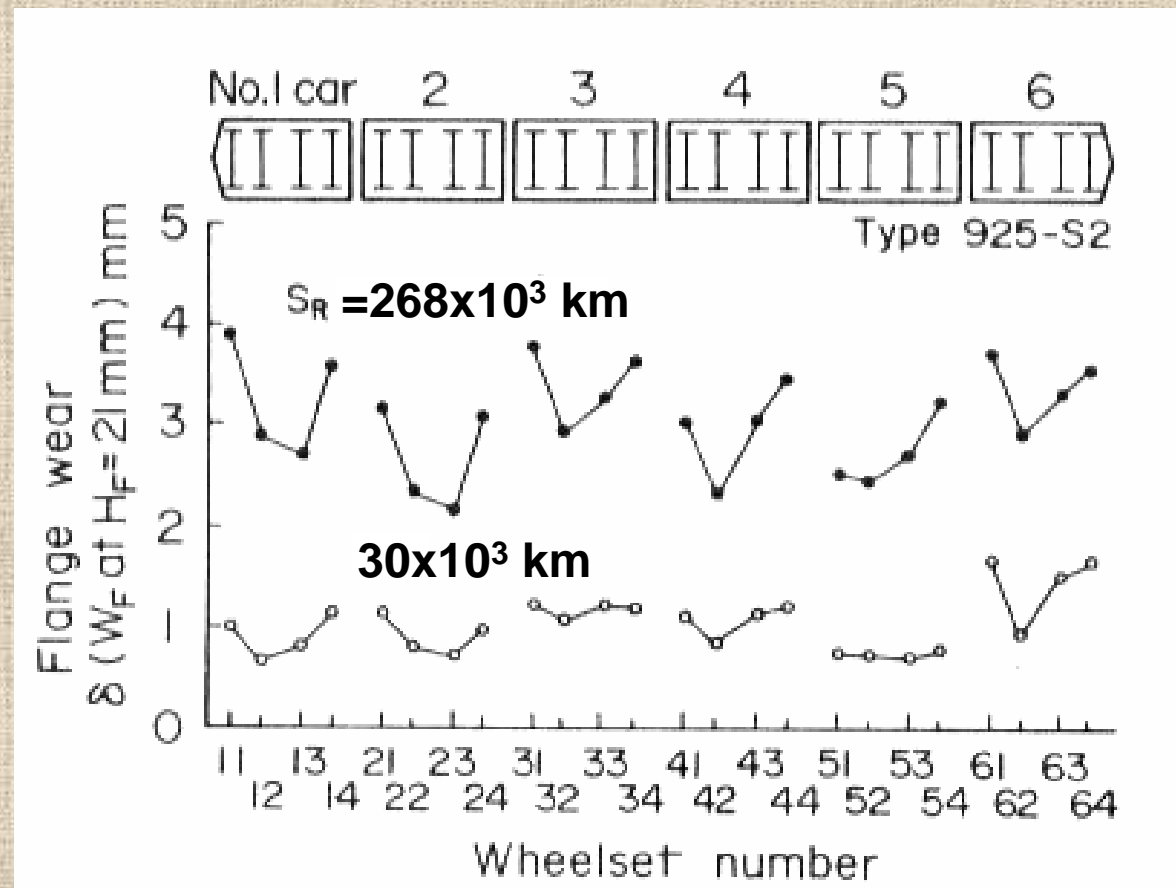
## **Bogie features**

- with side bearers
- wheel of 1/40 conical tread

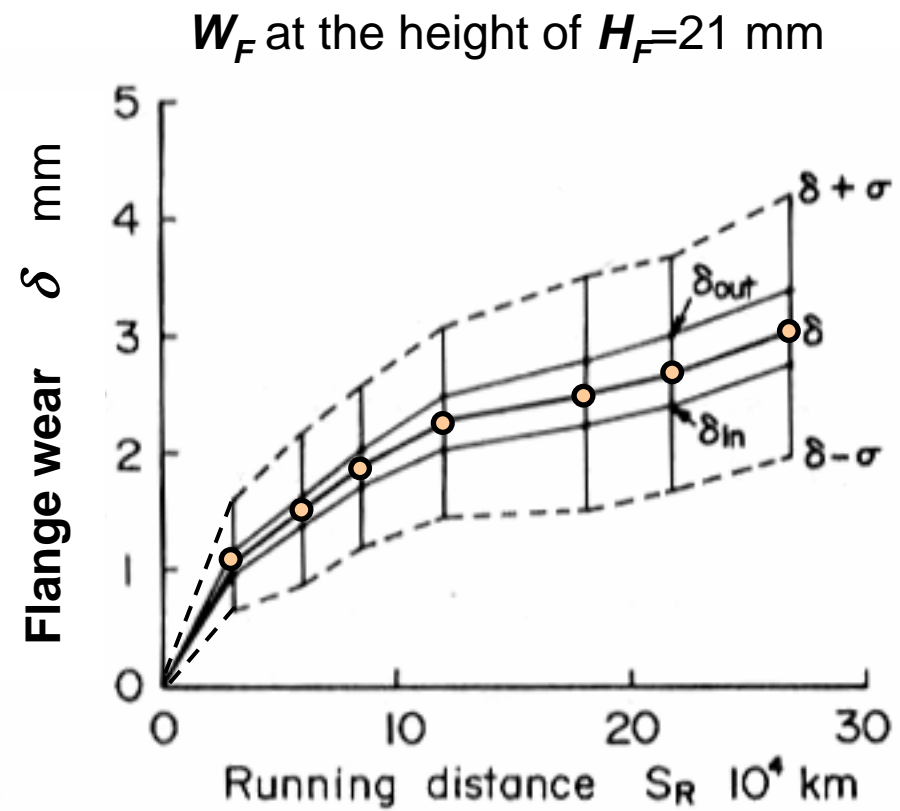
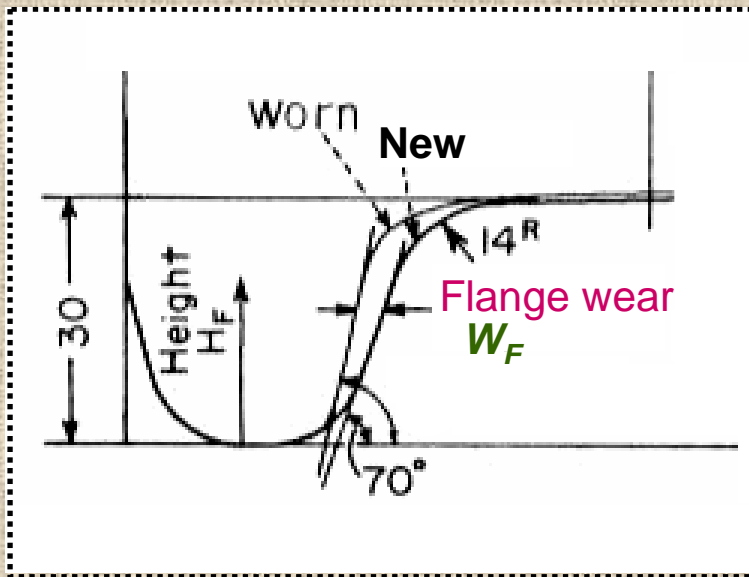
# Wheel shape and object parameters



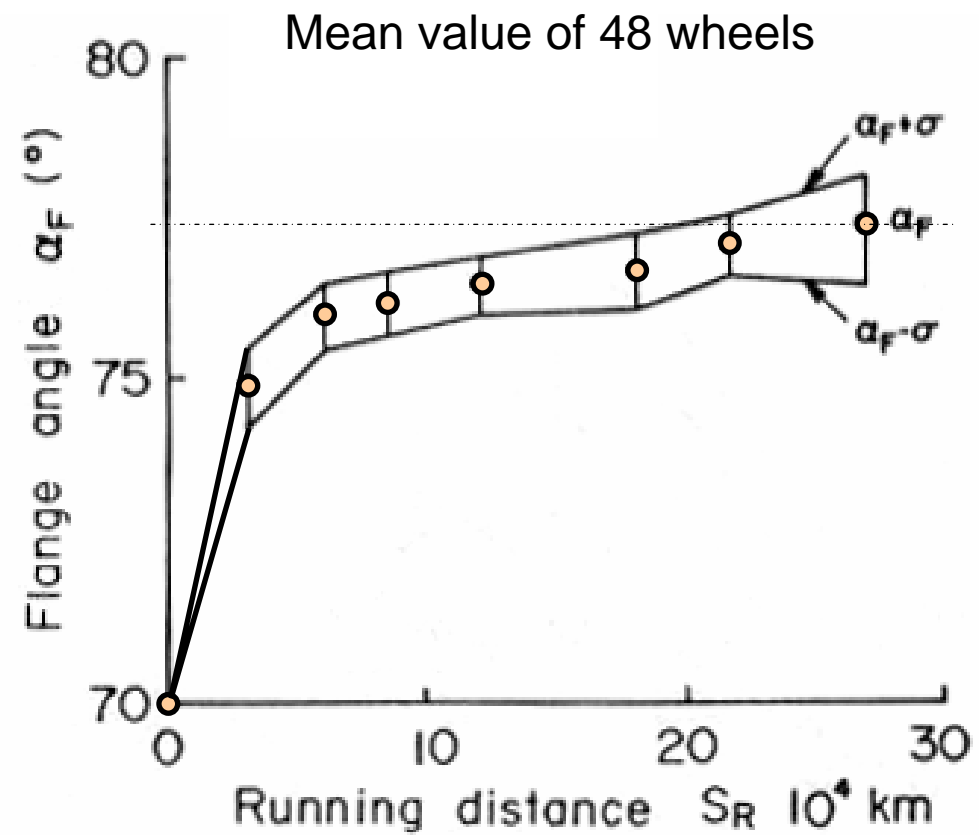
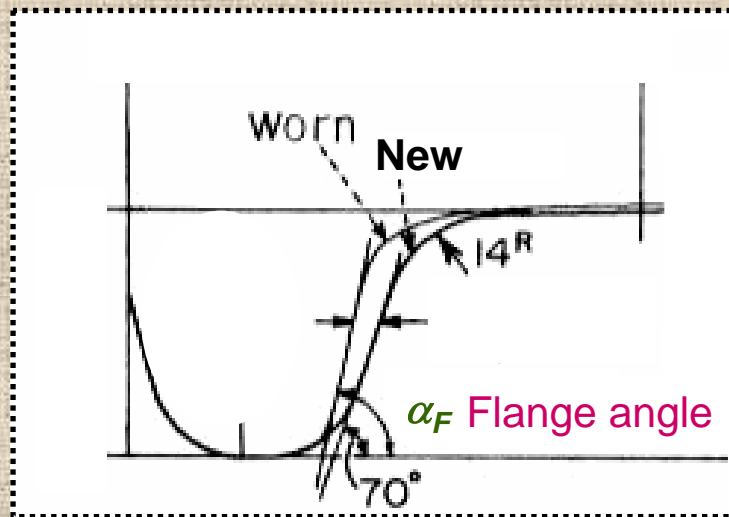
# Comparison of flange wear among wheelset positions



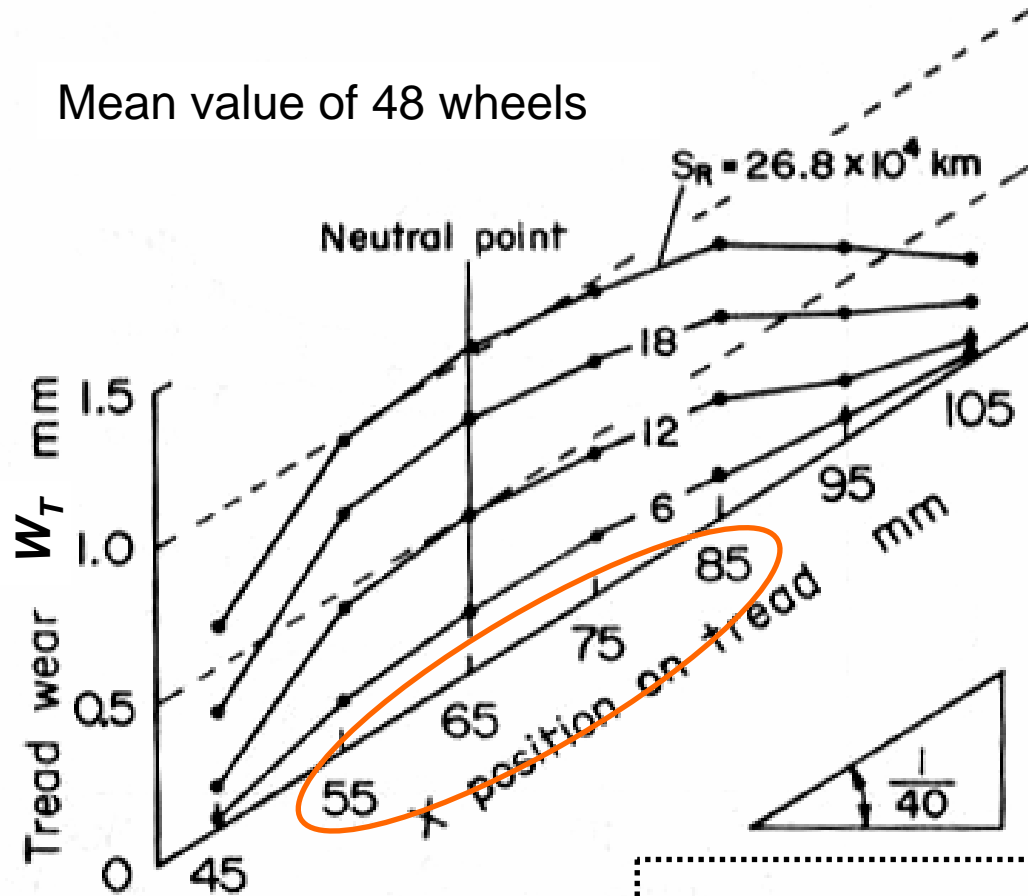
# Flange wear



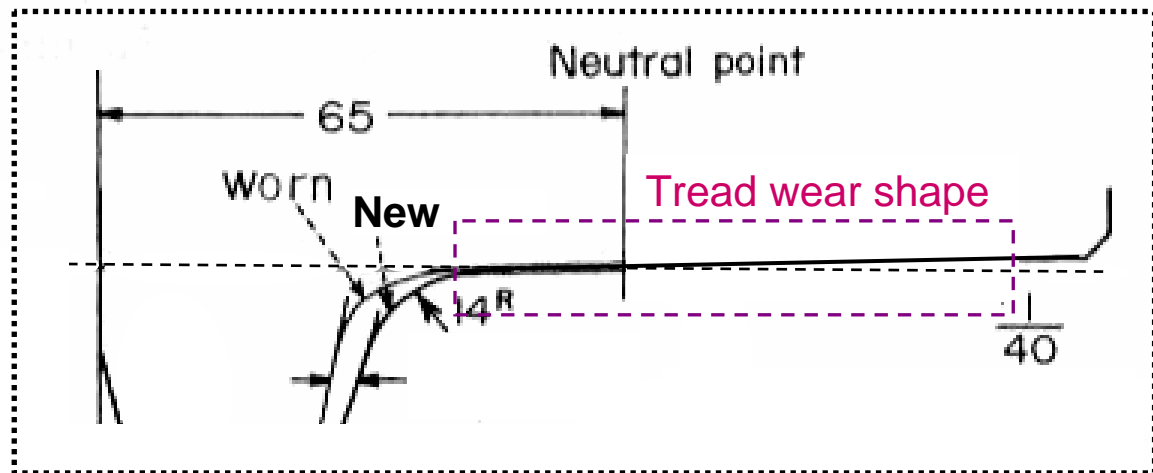
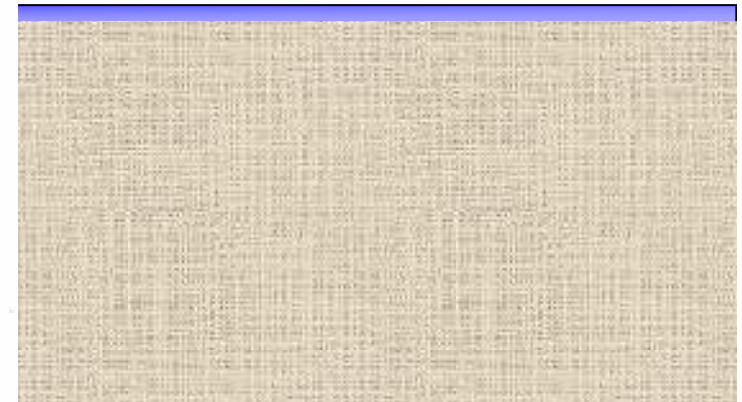
# Flange angle

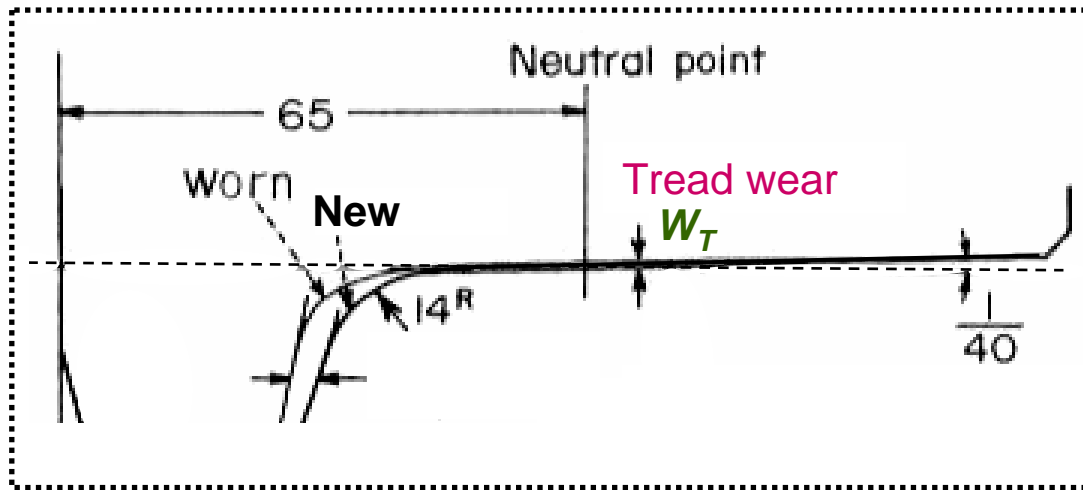


Mean value of 48 wheels

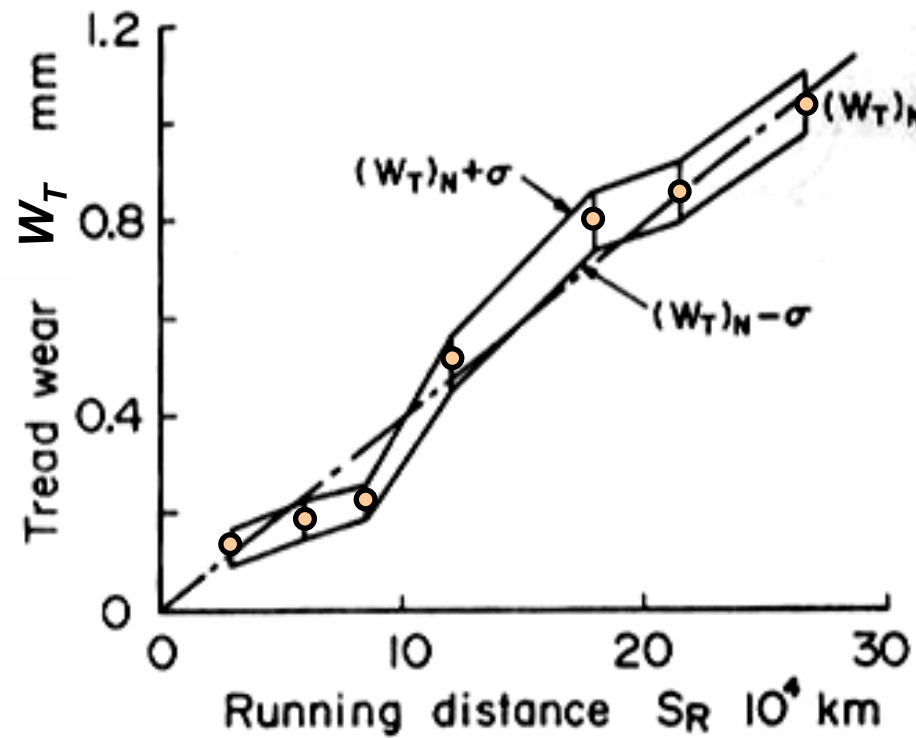


# Profile of tread wear

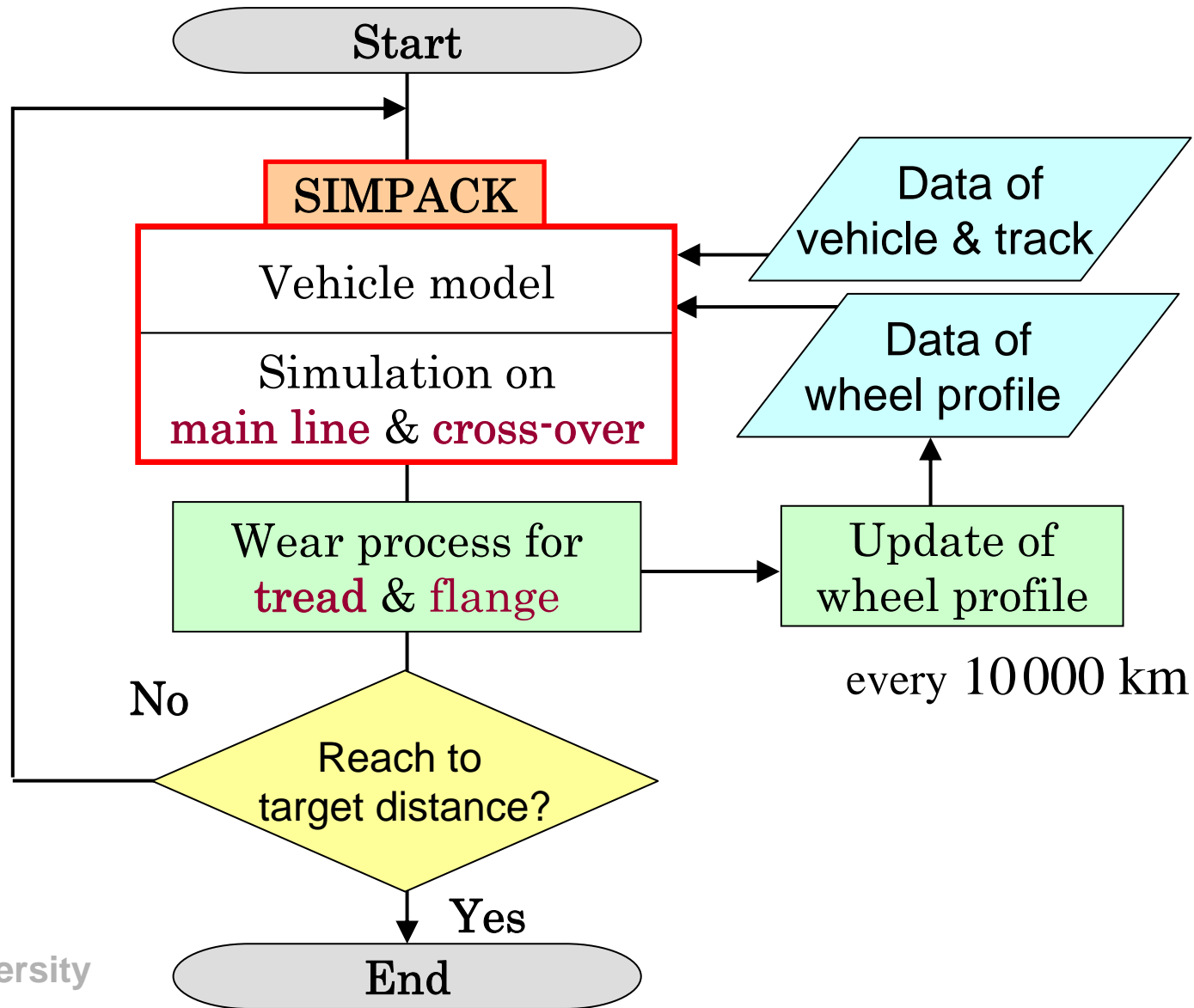




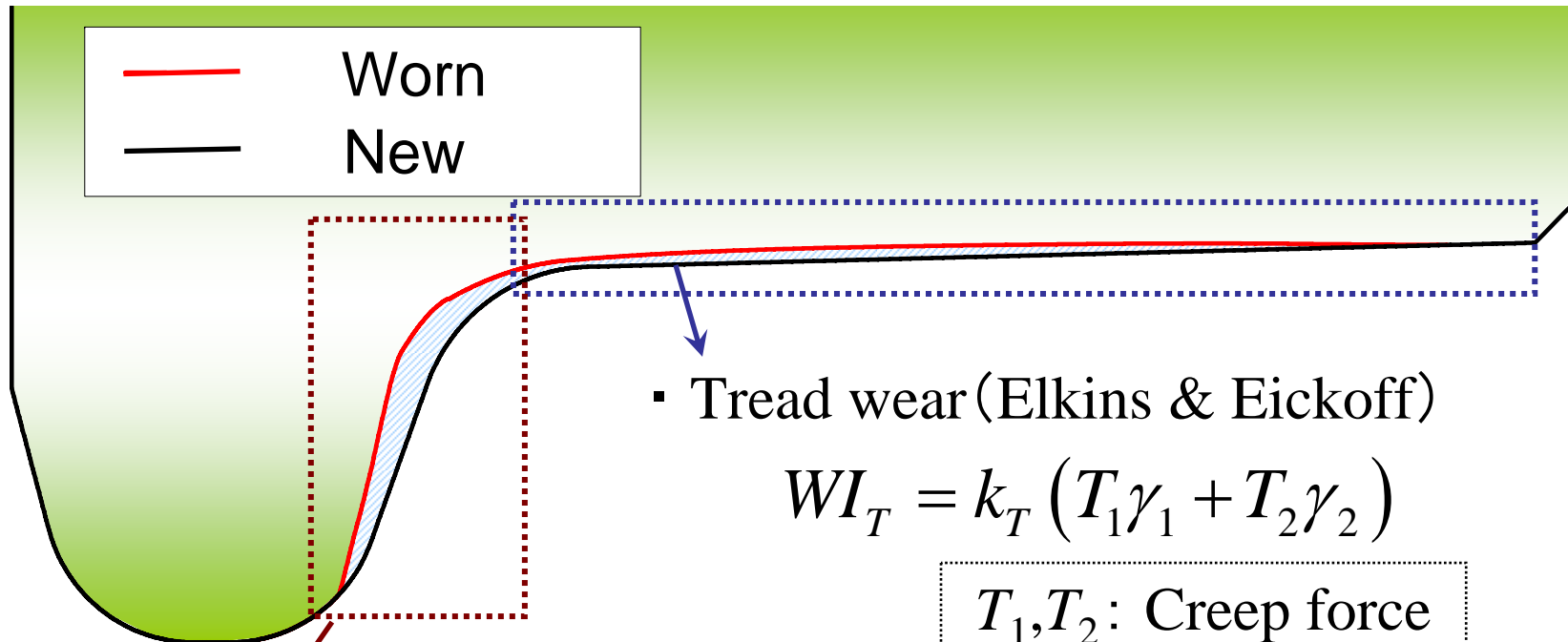
## Tread wear at neutral point



# Flow chart for wear prediction



# Wear indices



- Tread wear (Elkins & Eickoff)

$$WI_T = k_T (T_1 \gamma_1 + T_2 \gamma_2)$$

$T_1, T_2$ : Creep force

$\gamma_1, \gamma_2$ : Creepage

- Flange wear (Heumann)

$$WI_F = k_F (\mu_F F_F \psi)$$

$\mu_F$ : Coefficient of friction

$F_F$ : Flange force

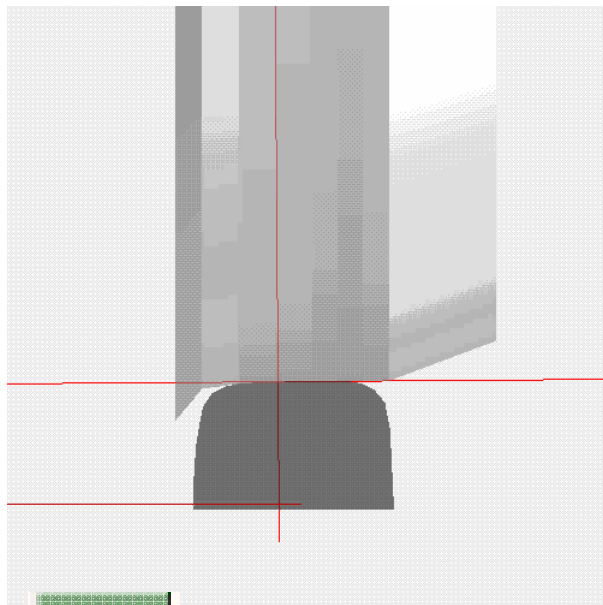
$\psi$ : Attack angle



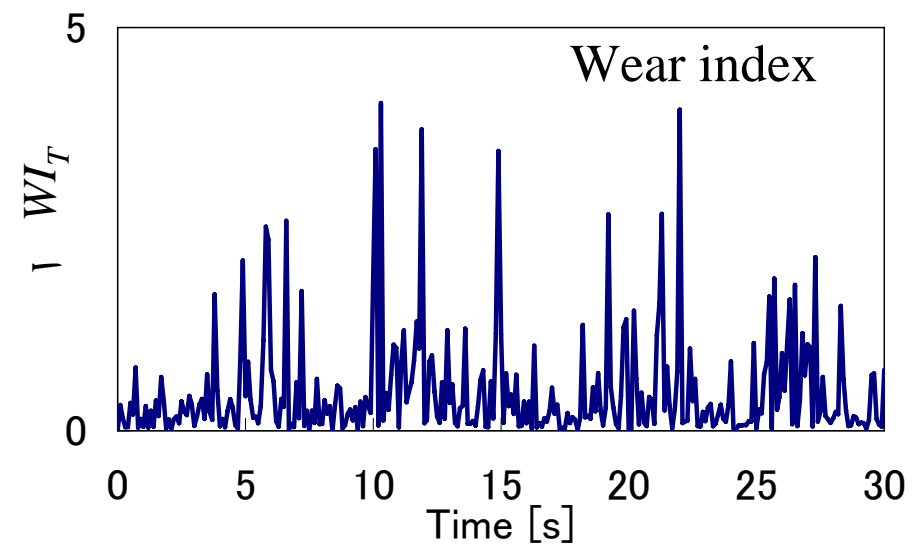
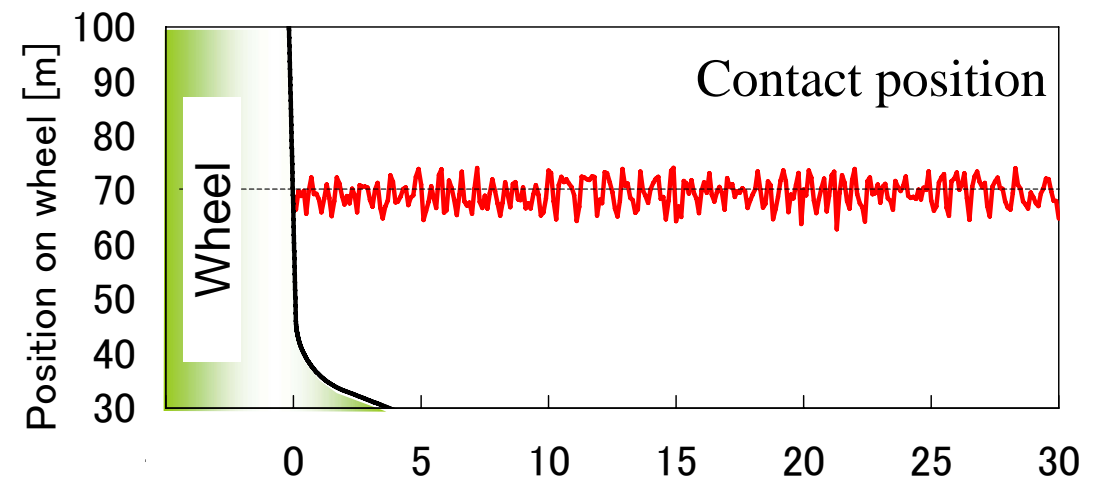
# Wear process on tread

## ① Contact position and wear index

Running simulation  
with SIMPACK



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# Wear process on tread

12

## ② Conversion to wear & accumulation

Interim wear based on Pearce, *et al.*

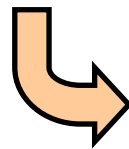
$\delta_T$  : Interim wear thickness [mm]

$$\delta_T = 0.25F / D \quad : F < 100 \text{ [N]}$$

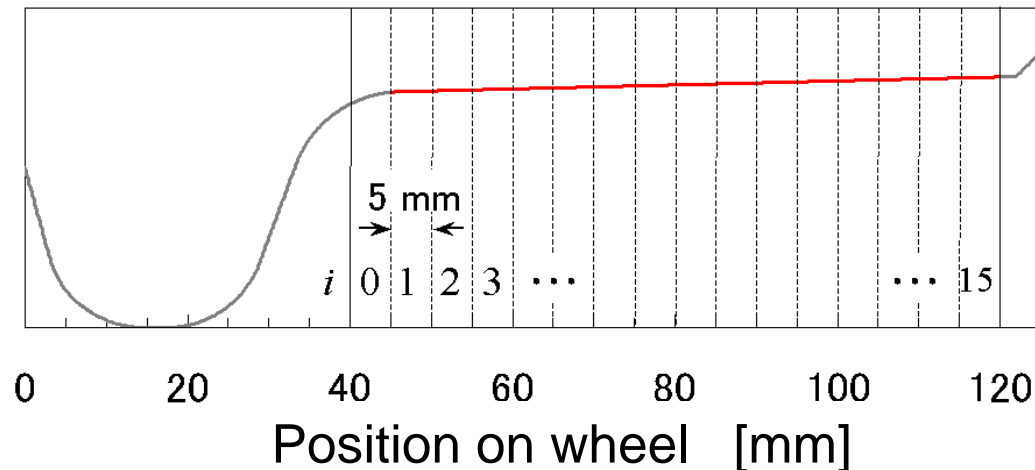
$$\delta_T = 25.0F / D \quad : 100 \leq F < 200 \text{ [N]}$$

$$\delta_T = (1.19F - 154) / D \quad : F \geq 200 \text{ [N]}$$

where  $F = T_1 \nu_1 + T_2 \nu_2$ ,  $D$ : Wheel diameter [mm]



Accumulation  
into 5 mm partitions  
 $H_i$



# Wear process on tread

## ③ Distribution of wear thickness

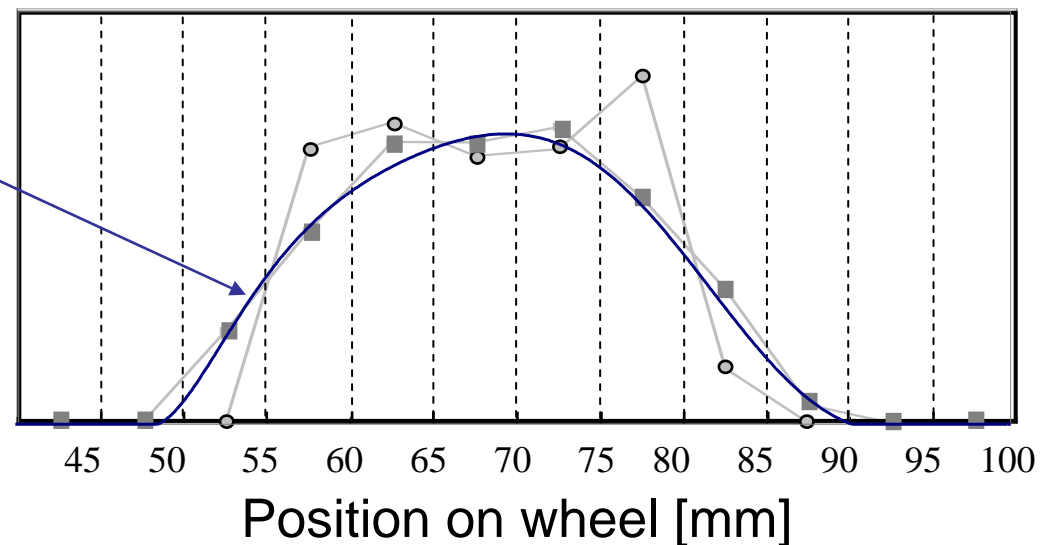
- Wear thickness  $\Delta_{Ti} = c_T \cdot H_i$

$c_T$  : Coefficient determined from measured data  
at running distance **60 000 km**

- Smoothing of distribution

(1) Averaging among 3 partitions  $\Delta_{Ti}' = (\Delta_{Ti-1} + \Delta_{Ti} + \Delta_{Ti+1})/3$

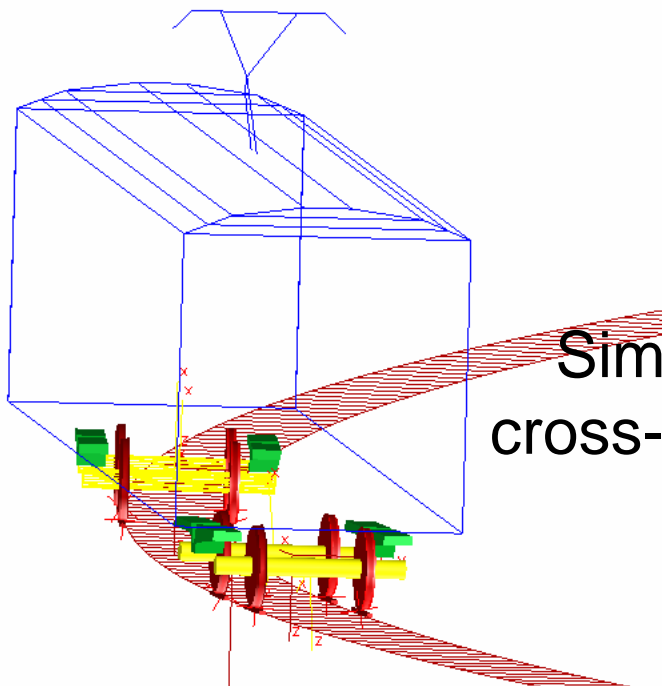
(2) Smoothing of  $\Delta_{Ti}'$   
by polynomial



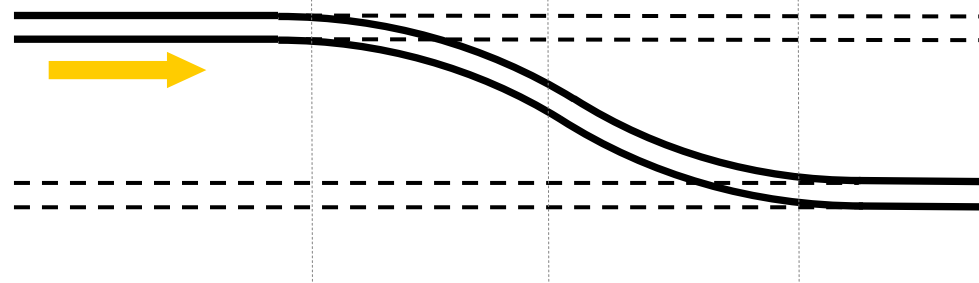
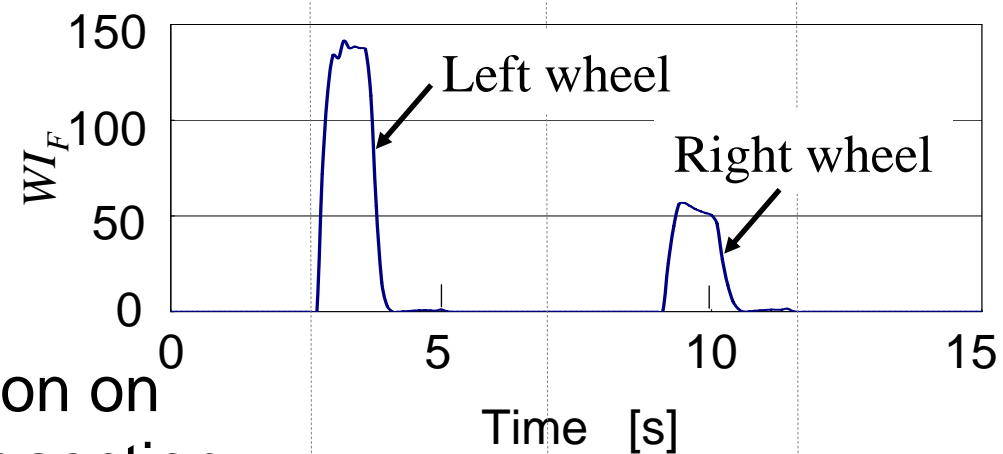
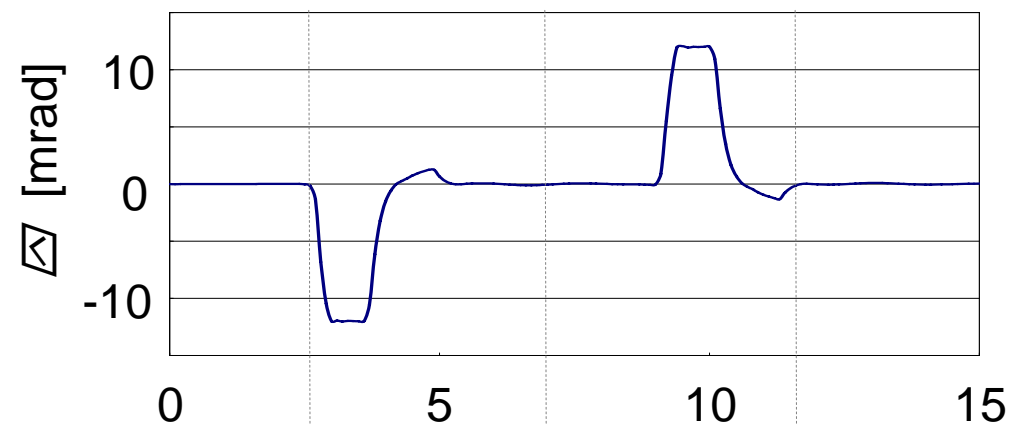
# Wear process on flange

Wear index

$$WI_F = |\mu_F F_F \psi|$$



Simulation on  
cross-over section

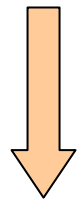


# Wear process on flange

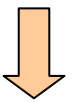
① Wear index in unit area  $w_F$

$$w_F = WI_F / A$$

$A$ : Contact area



② { Accumulation of  $w_F$  into partitions



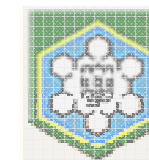
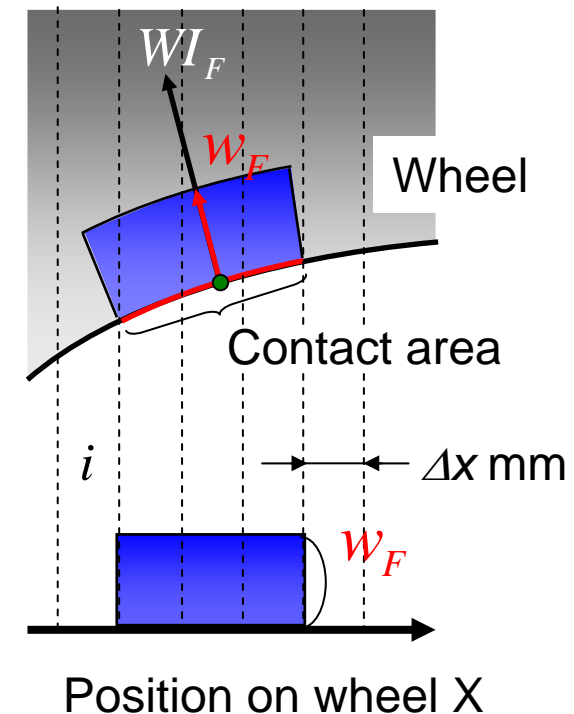
$$W_{Fi}$$

Conversion to wear thickness

$$\Delta_{Fi} = c_F \cdot W_{Fi}$$

$c_F$ : Coefficient determined from  
measured data at running  
distance 60 000 km

③ Distribution of wear  $\Delta_{Fi}$



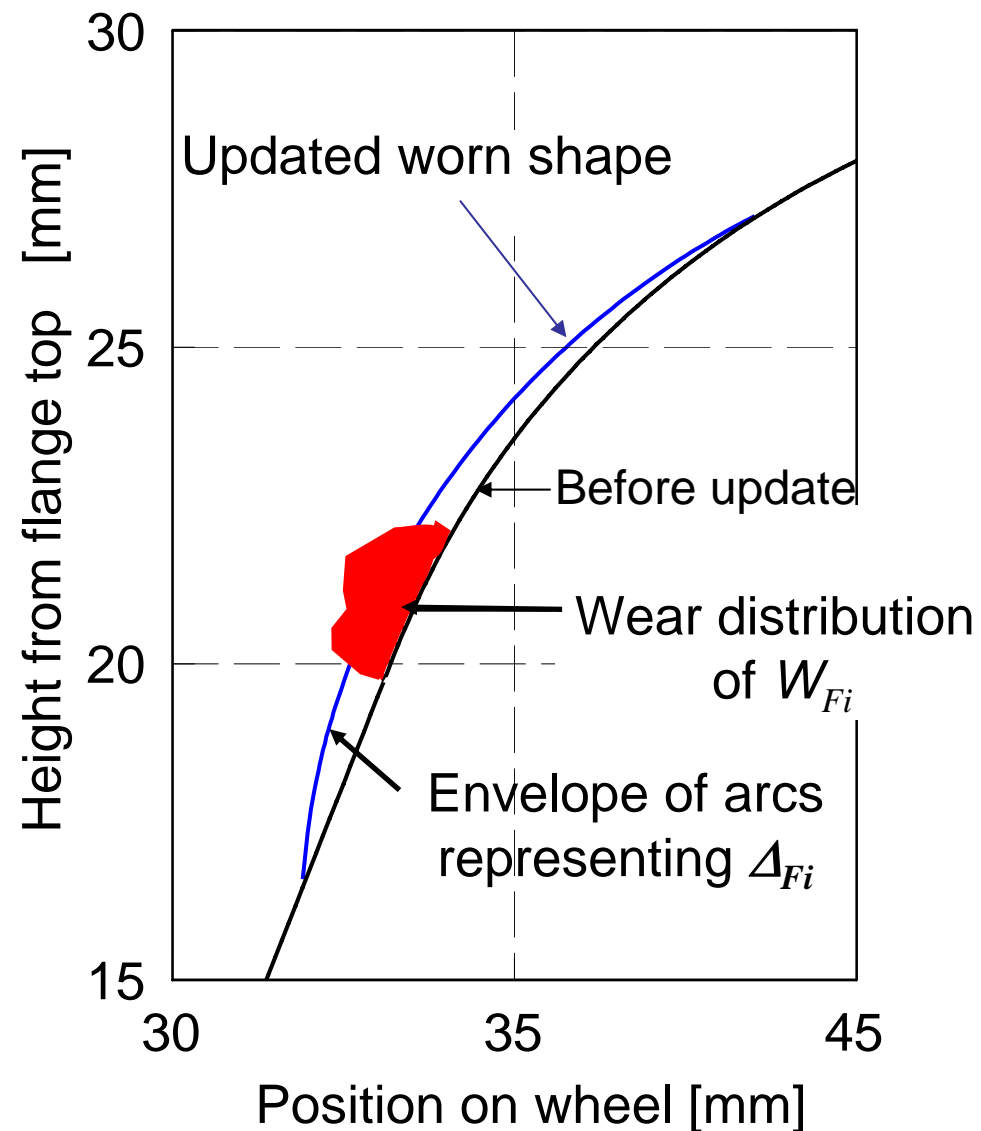
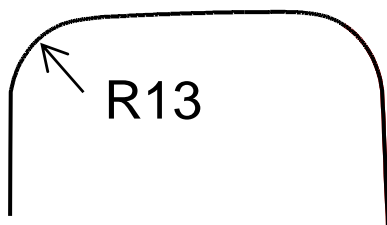
# Wear process on flange

Wear distribution  
around flange root

Wear distribution of  $W_{Fi}$



Envelope of arcs  
with the radius of rail edge  
representing  $\Delta_{Fi}$

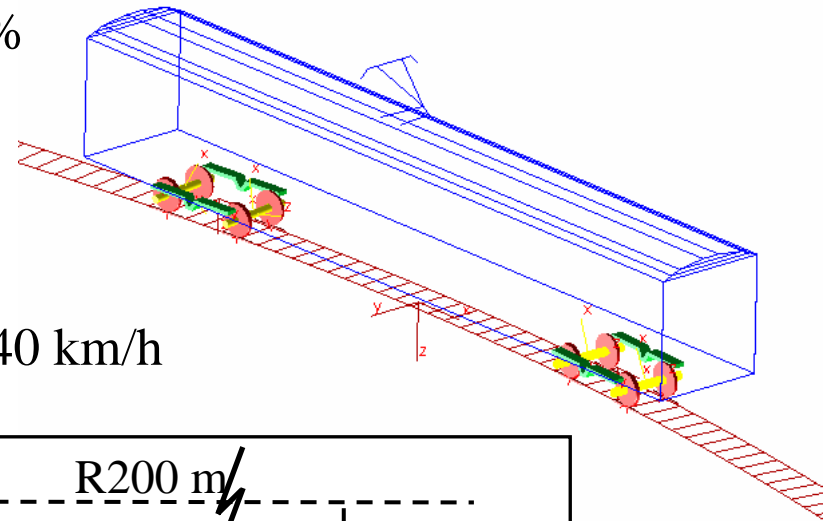


# Track conditions for simulation

## Main line

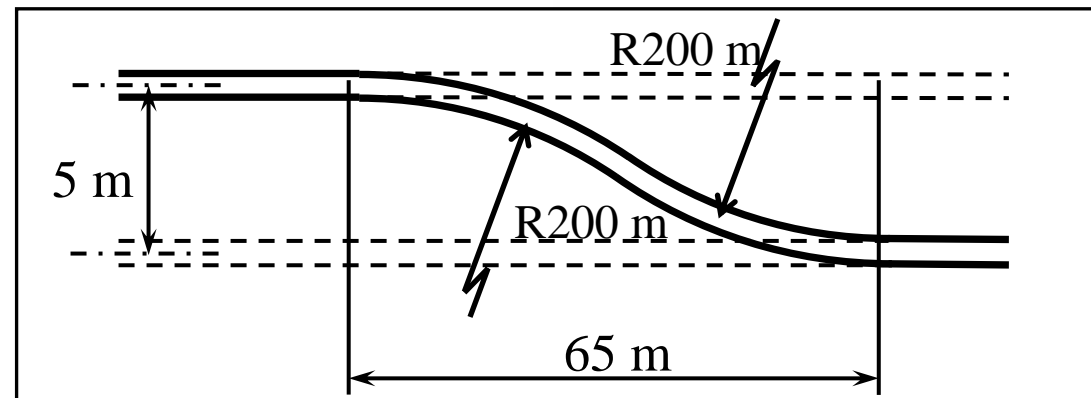
Running speed 240 km/h

- Straight track ···85%
- Curved track (R 4 000 m) ···15%
  - With alignment irregularities
  - New rail of Type 60-kg



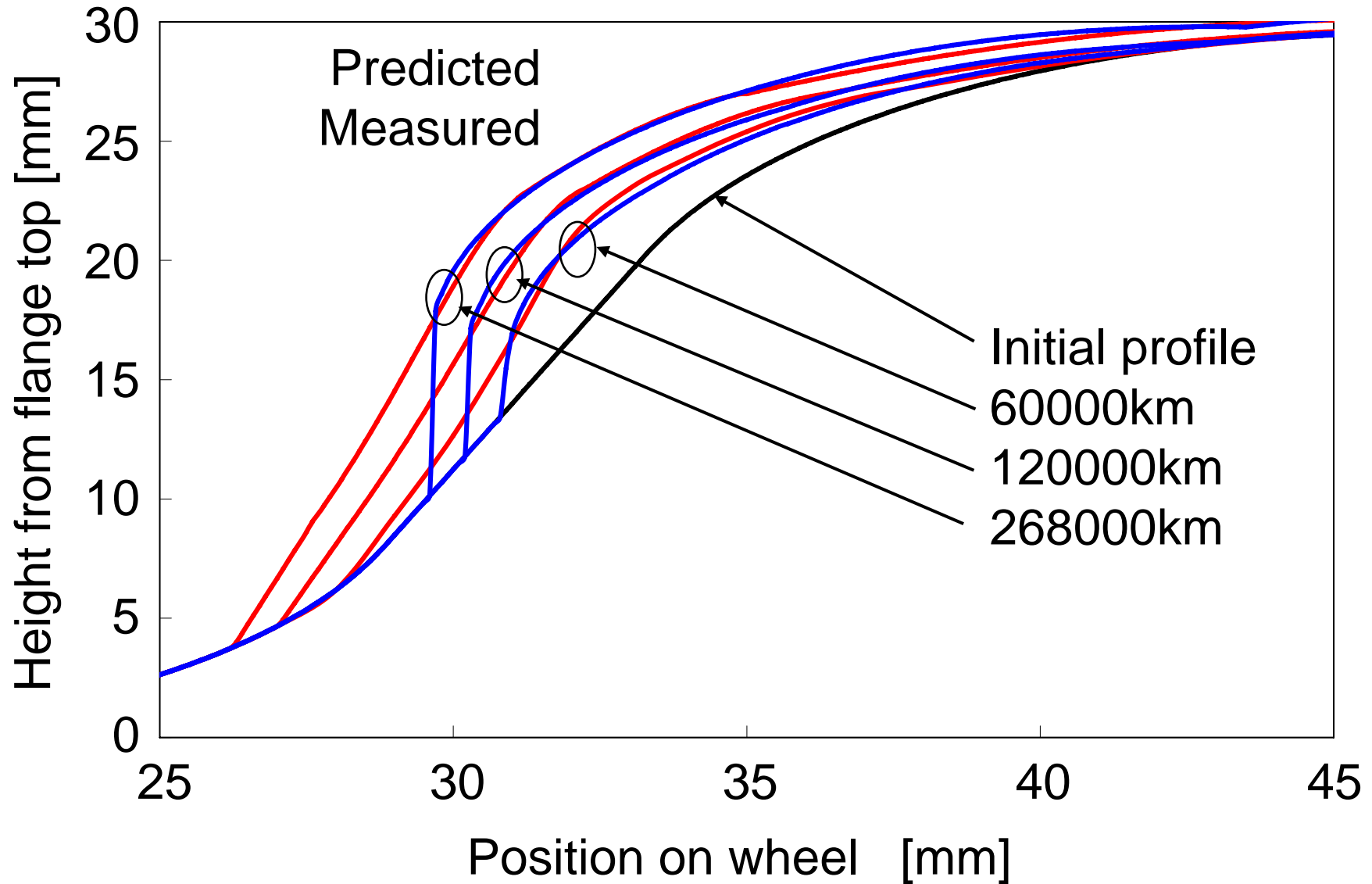
## Sharp curve (cross-over section)

Running speed 40 km/h

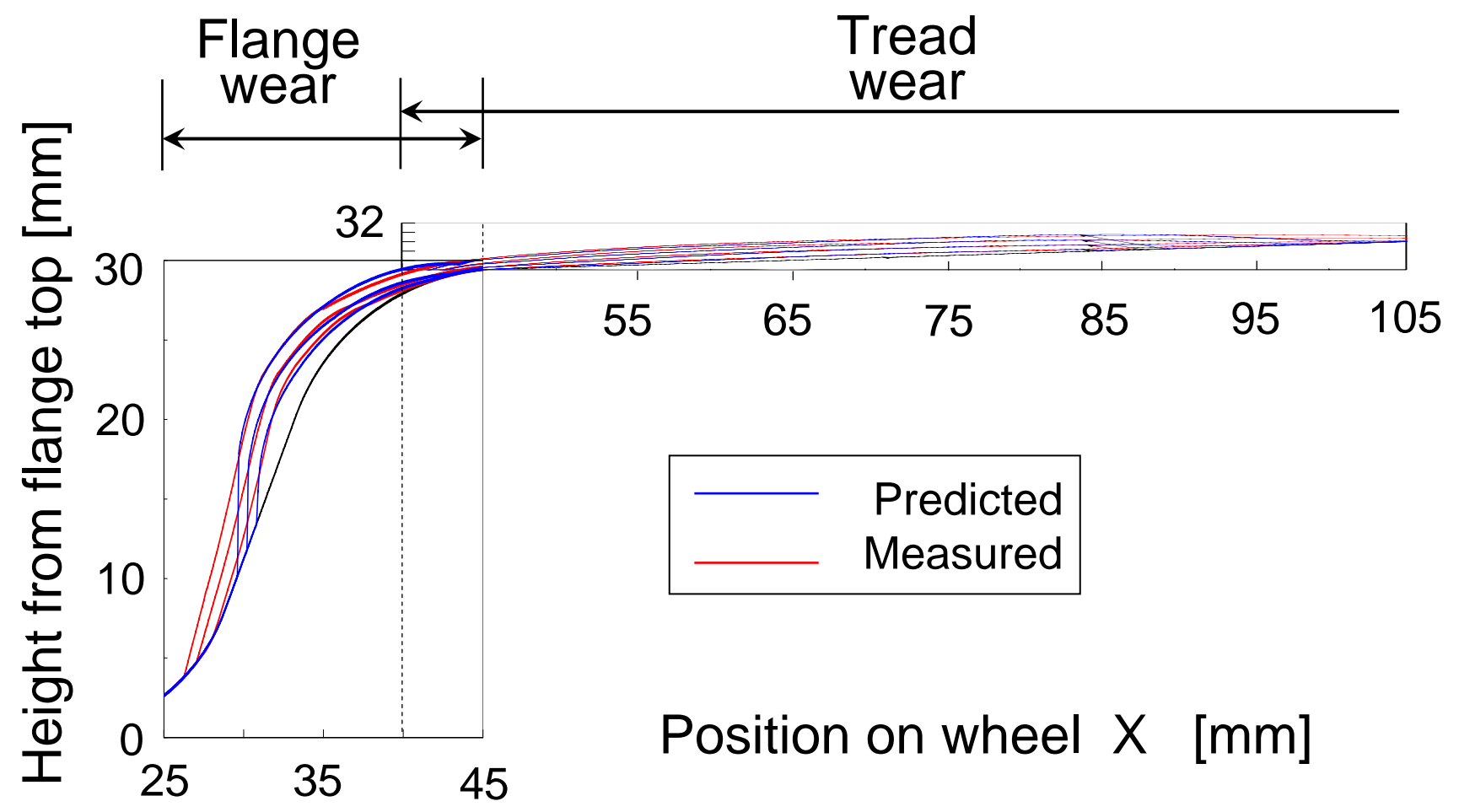




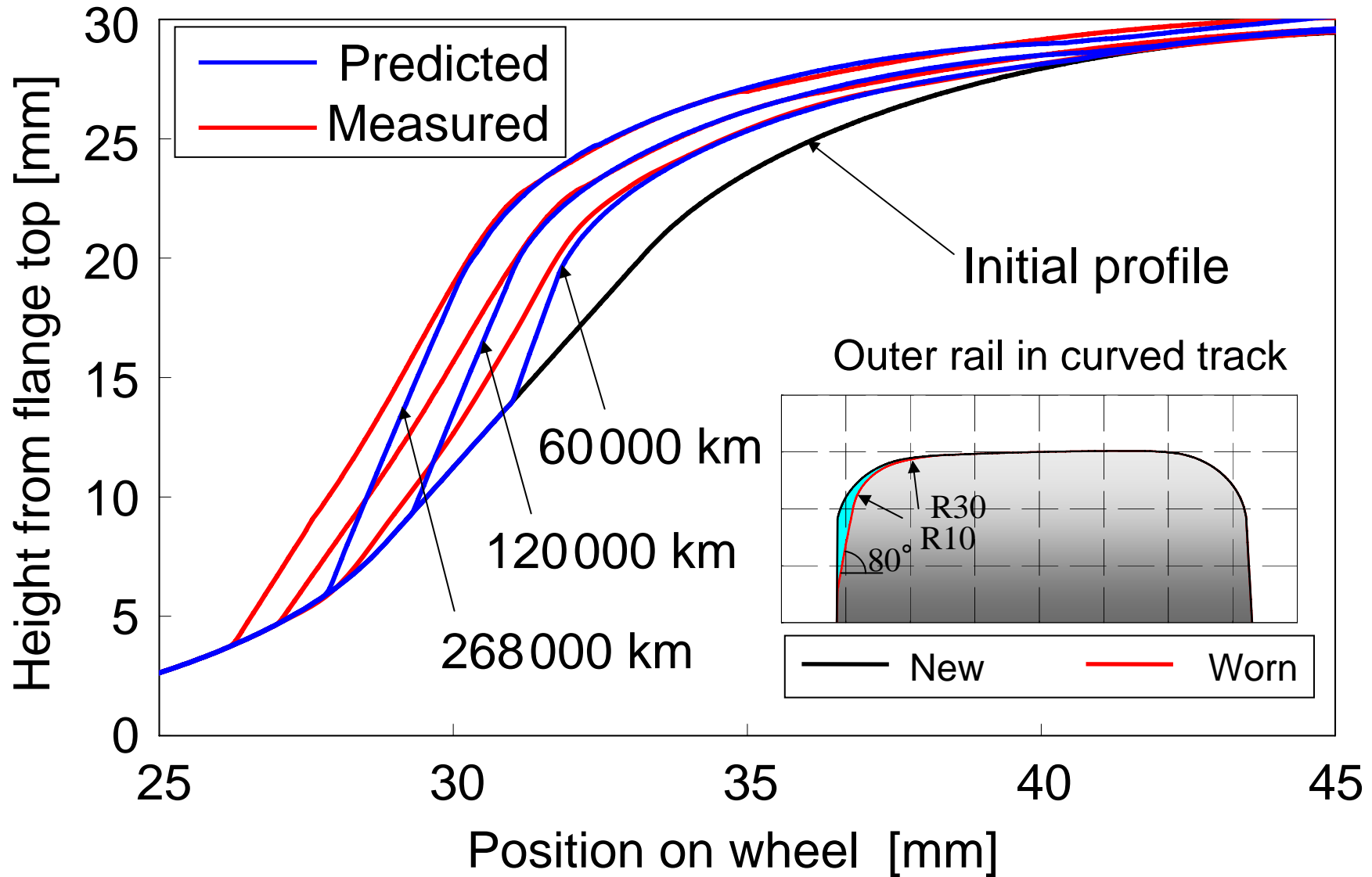
# Comparison of worn profiles between prediction and measurement (wheel flange)



# Composition of wear profiles in equal scales



# Predicted flange shape in case of worn outer rail in sharp curve

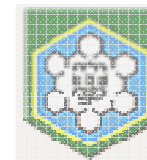


## Concluding remarks

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A wear progress of railway wheel was compared with measured data in a field test.

- (1) For the tread wear, the general tendency is predictable although the wear is limited within the narrower region. It is thought that the difference comes from the rail profile and switch structure which are not considered in the simulation.
- (2) For the flange wear, the predicted profile greatly depends on the inner side shape of the outer rail and tends to follow the worn rail shape in sharp curves.



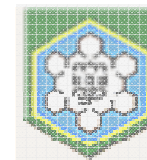
## Concluding remarks

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As mentioned above, it is perceived that practical rail profile is necessary to predict the real wear profile of wheel.

(3) This prediction can be useful, however, if we are interested in the comparison of influences between bogie structures or between railway line conditions such as the rate of contained curved section.

Such examples are as follows:







Thank you for your kind attention



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