- Supplementary material –

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Prediction of a Representative Point for Rail Temperature Measurement Considering Longitudinal Deformation

SungUk Hong[1], Hyunsuk Jung[1], Chan Park[1], Hyunwoo Lee[1], HyongUk Kim[1], NamHyoung Lim[2], HyunUng Bae[2], KyungHo Kim[3], HongJip Kim[1], and Seong J. Cho1[1,*]

[1]School of Mechanical Engineering, Chungnam National University;

[2]Department of Civil Engineering, Chungnam National University;

[3]A-Best, Inc.;

* Correspondence: scho@cnu.ac.kr; Tel.: +82-42-821-5648

The actual rail is several-km-long and can be assumed to be infinite length. However, the installed rail is 500-mm-long shorter than the actual rail. We have verified by calculation that the installed rail are identical to the actual rail in thermal characteristics. In this calculation, the material properties of the rail are assumed to be carbon-silicon (Mn <= 1%, 0.1% <Si <= 0.6%) considering the components of the rails. The convection transfer coefficient is 15.84 W/m2K according to average wind speed (2.56 m/s).

The heat transfer rate of the rail with the insulated end (qf) can be written as :

$$q_f = M \times tanh(mL) \tag{1}$$

$$m = \sqrt{\frac{hP}{kA_c}} \tag{2}$$

$$M = \sqrt{hPkA_c\theta_b} \tag{3}$$

where h is the convection transfer coefficient, P is the perimeter of rail cross section, k is the thermal conductivity of rail, Ac is the area of rail cross section and θb is the excess temperature.

On the other hand, the heat transfer rate of the rail with infinite length (qf∞) can be written as :

$$q_{f\infty} = M \tag{4}$$

If we can get the tanh(mL) term closer to 1 in Equation 1, then the Equation 1 and Equation 4 are the almost same. This means assuming the actual rail is infinitely long, the end of the actual rail can be considered as insulated end.

$$q_f \cong q_{f\infty} \tag{5}$$

$$M \times tanh(mL) \cong M \tag{6}$$

$$L \cong 2.65 \times \sqrt{\frac{kA_c}{hP}} \qquad (7)$$

As a result, the result of calculation is L = 513.2 mm that is almost same the length of installed rail. This means that installed rail are identical in thermal characteristics to the actual rail.