Lateral Resistance of Ballasted Tracks for Various Shapes of Sleepers Based on Limit Equilibrium Methods

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Background

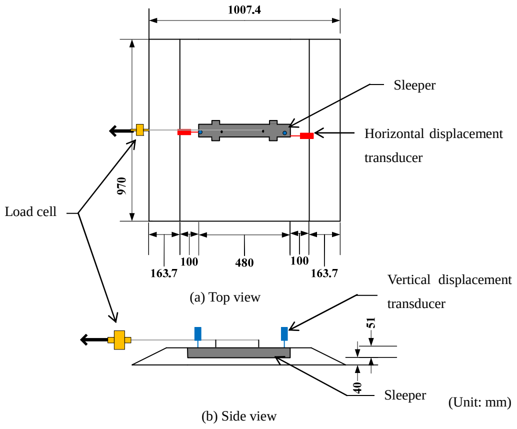
The buckling of longrail

Ballasted track sleepers have important functions of providing sufficient ***lateral resistance*** to prevent lateral movement of the rails.

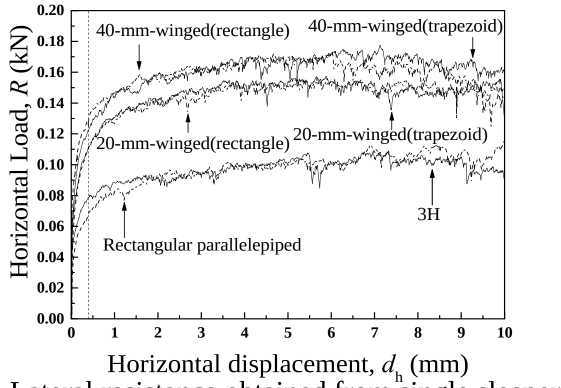
The need of the estimation of Lateral Resistance at the time of earthquake is increasing

Enforcement of the estimate of Lateral Resistance using the "Limited Equilibrium Methods" which it is **simple** and **easy**, and is **high in extensibility**

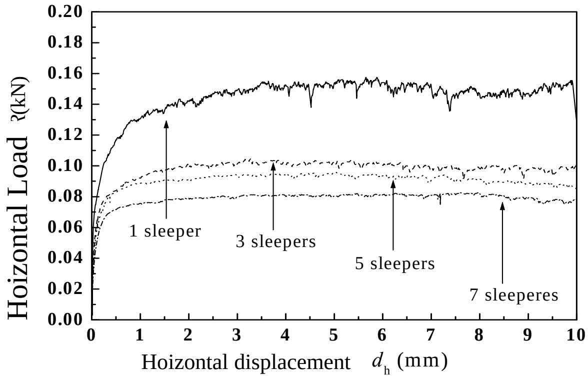
Past research



Schematic image of single-sleeper pull-out loading tests (after Koike et al. 2014)



Lateral resistance obtained from single sleeper pullout tests using different shapes of sleepers (after Koike et al. 2014)



Lateral resistance obtained from track panel pullout tests using different number of winged sleepers (after Koike et al. 2014)

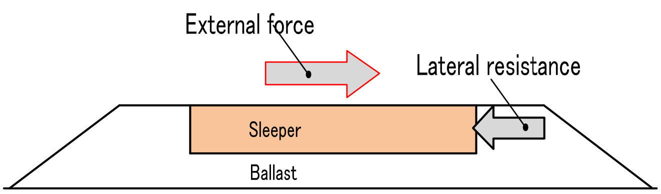
Purpose of research

Purpose

Investigating the applicability of Limit Equilibrium Methods.

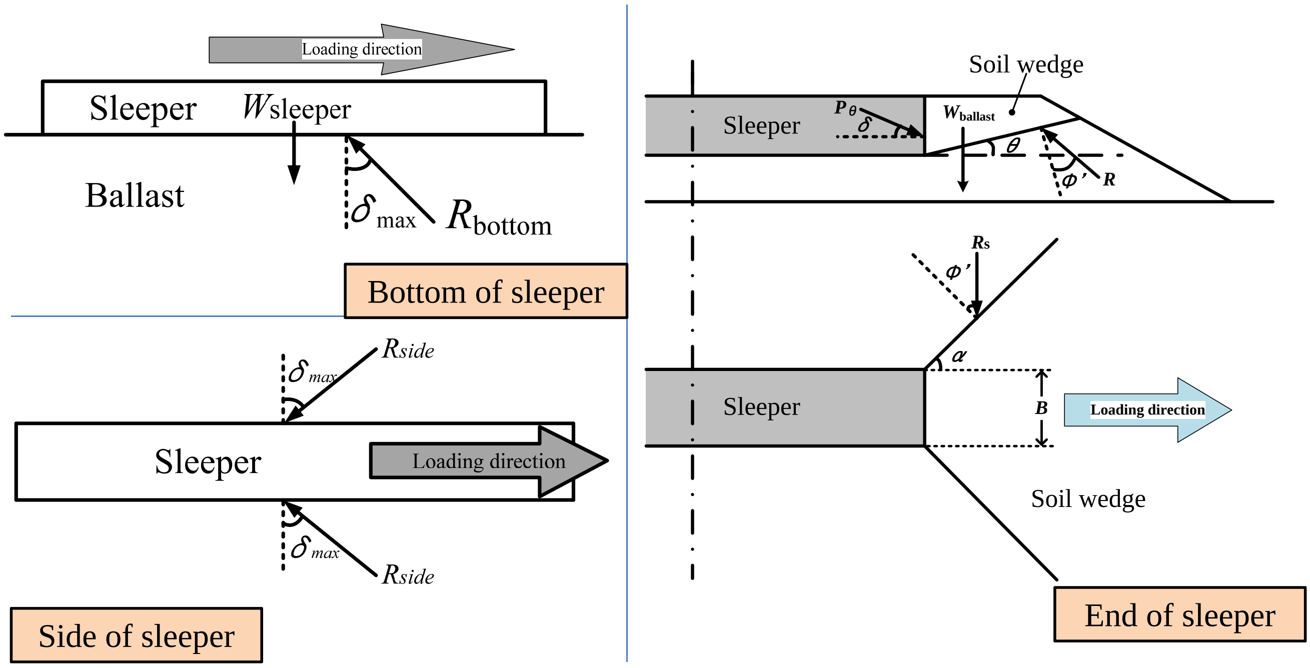
Flow

- Single-sleeper pullout test using Rectangular sleeper
- Single-sleeper pullout test using Various shape of sleeper
- Track panel pullout test



Schematic view of lateral resistance

Method of estimation of lateral resistance by Limit Equilibrium Methods with single-sleeper pullout tests



Suppose lateral resistance is shared by the Bottom, Side and End of sleeper.

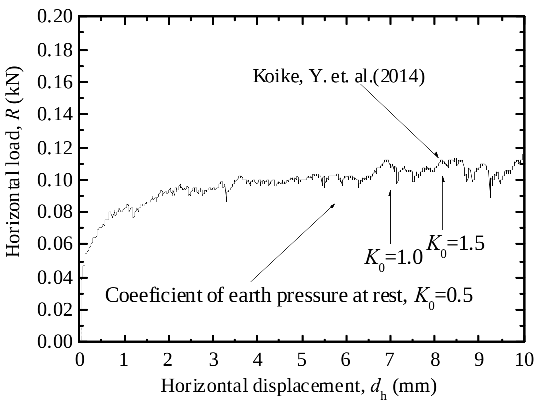
Estimation of lateral resistance with single-sleeper pullout tests using Rectangler sleeper

The frictional angle φ' = 55 degrees.

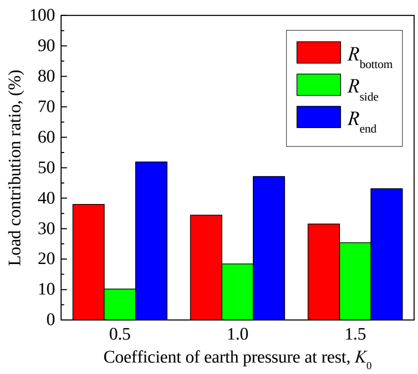
$\delta_{sleeper}$ = 42 degrees.

($\delta_{sleeper}$ is the angle of friction between the sleeper and ballasts)

Effects of K_0 on the lateral resistance characteristics
(case: Rectangular parallelepiped-shape sleeper)



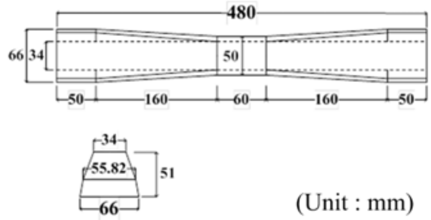
Lateral resistance



Contributions of R_{bottom}, R_{side} and R_{end}

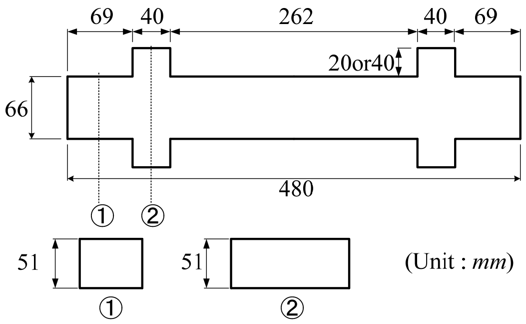
Suggesting that model test results can be reasonably explained by the limit equilibrium method in which K_0 equals to 1.5.

Method of estimation of lateral resistance with single-sleeper pullout tests



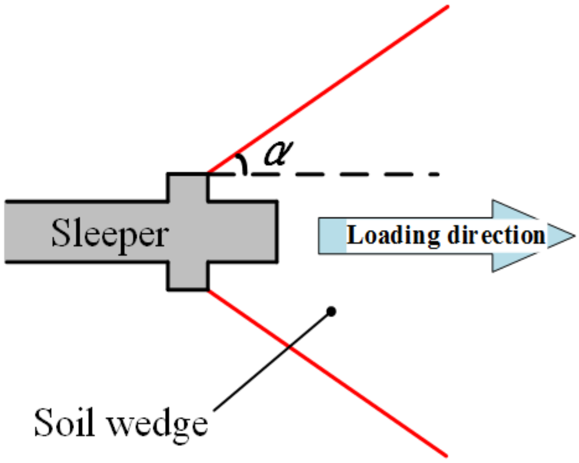
Sleeper : 3H

- Doing calculations in consideration of the stress component in accordance with the inclination angle of the sleepers sides.

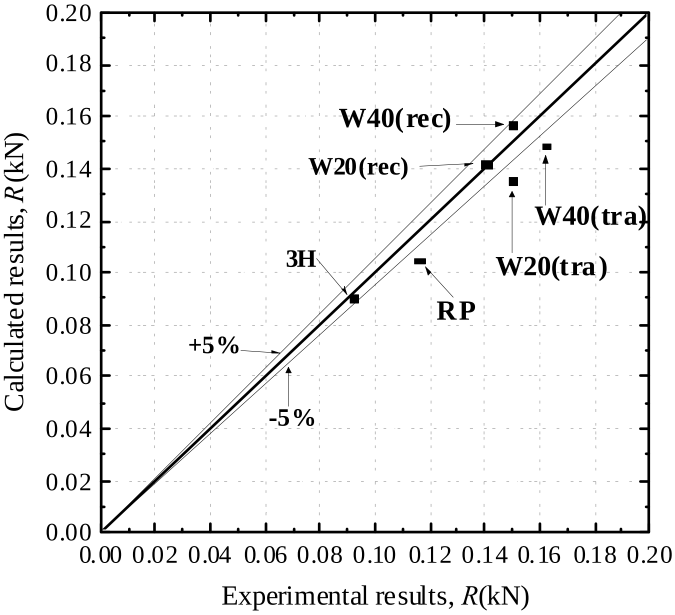


Sleeper : winged sleeper

- Overall shape and weight is not changed
- All soil wedges is assumed to result from the part of the wing of sleeper



Estimation of lateral resistance with single-sleeper pullout tests using various shapes of sleeper



The high-precision calculation results

3H: 3H sleeper

RP: Rectangular sleeper

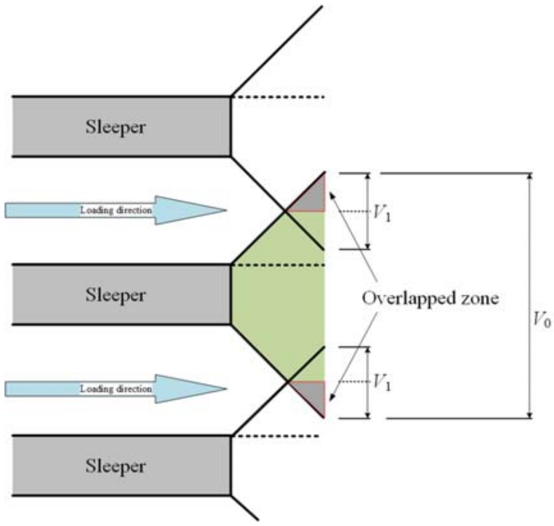
W20(rec):20mm winged sleeper (cross-section : rectangule)

W20(tra):20mm winged sleeper (cross-section : trapezoid)

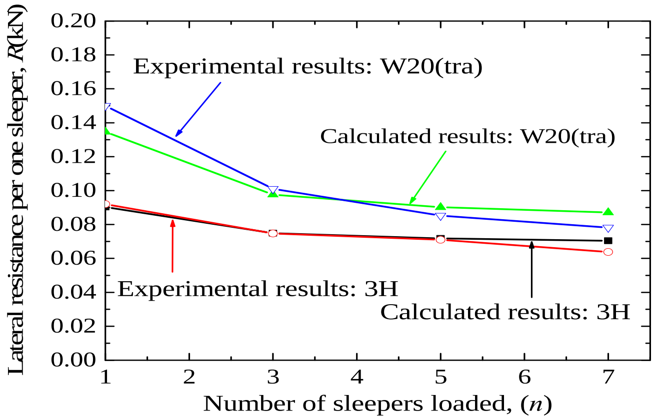
W40(rec):40mm winged sleeper (cross-section : rectangule)

W40(tra):40mm winged sleeper (cross-section : trapezoid)

Estimation of lateral resistance with track-panel pullout tests (case: 3H, W20(tra))



Overlapping volumes of sliding soil wedges caused by the neighboring sleepers.



Lateral resistance per one sleeper based on the limit equilibrium method plotted against the number of sleeper loaded in track panel pullout tests.

Conclusion

It was found that the proposed limit equilibrium method could well predict the lateral resistance not only for a rectangular parallelepiped-shape sleeper but also for winged-shape sleepers having rectangular or trapezoid sections.

It was also found that the lateral resistance under track panel conditions could be reasonably predicted by the method.

Conclusion

まくらぎの一本引き時:

- 実験値から得られる既知のパラメータを用いて,荷重分担率まで考慮したまくらぎの道床横抵抗力の再現が可能である。

複雑形状まくらぎの一本引き時:

- 3Hまくらぎ･翼付きまくらぎのような複雑な形状のまくらぎでは,計算において土塊の形状を調整することで再現度の高い道床横抵抗力の計算が可能である。

まくらぎの軌きょう引き時:

- 軌きょう引き時には3Hまくらぎでは再現度の高い道床横抵抗力推定を行うことができる。一方,翼付きまくらぎのようなまくらぎ幅が広く,隣り合うまくらぎどうしで干渉が強いものは全体として干渉具合を過小評価する傾向にある。