Live Loads with Vehicular Centrifugal Force

This document analyzes the vehicular live load force effects by calculating the unit wheel-load factors with the centrifugal force and superelevation.
The calculation is based on LRFD for Highway Bridge Superstructures Reference Manual.

References:
- (Spec) : AASHTO LRFD Bridge Design Specification
- (Manual) : Load and Resistance Factor Design (LRFD) for Highway Bridge Superstructures
  - (Exam) : Design Examples

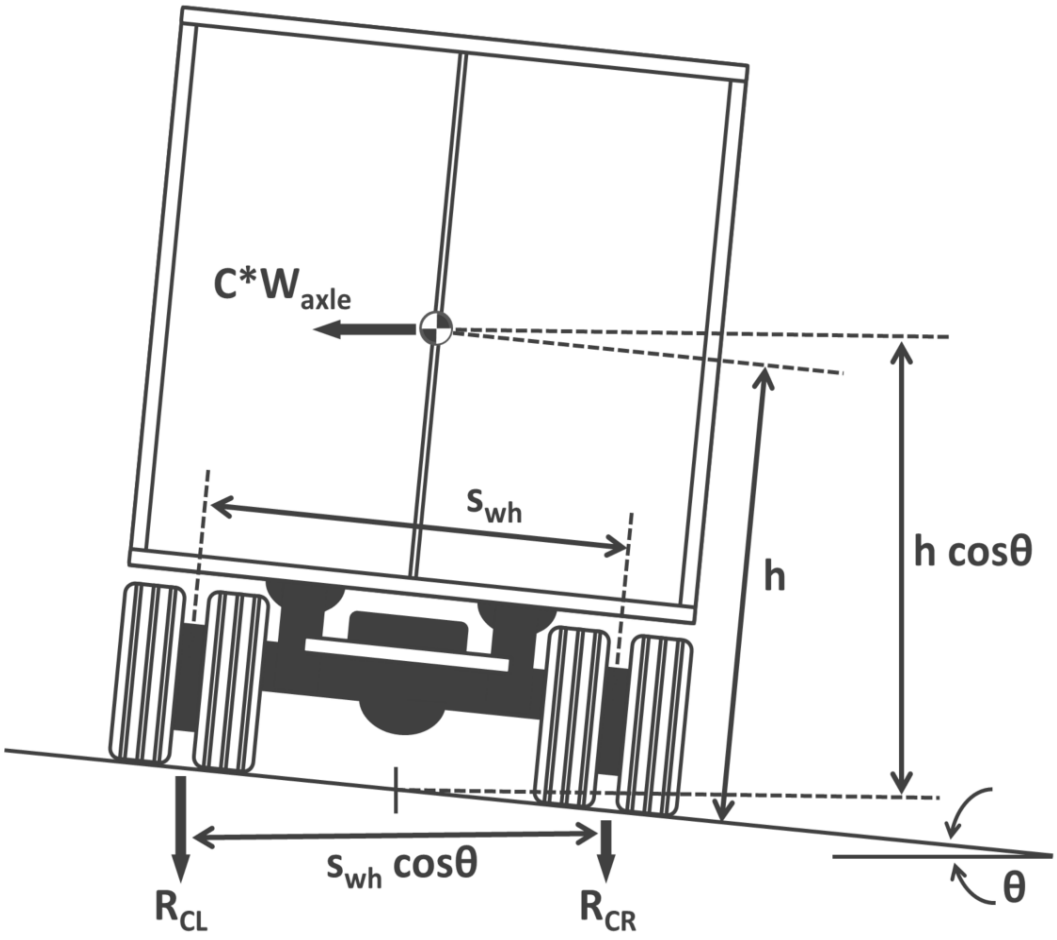

Figure 1 : Vehicular centrifugal force by the wheel-load reactions

1. Parameters and Conditions

Vehicle

Wheel spacing $s_{wh} := 6\ \mathbf{ft}$

Height at which the radial force is applied above the deck $h := 6\ \mathbf{ft}$

Lane and Deck

Radius of curvature of traffic lane $R := 700\ \mathbf{ft}$

Deck cross slope (superelevation) $sl := 0.05$

$sl = 5.00\%$

Design condition

Highway design speed $v := 35\ \mathbf{mph}$

Wheel-load Factor
for fatigue : 1.0
Other than fatigue : 4/3 $f := \frac{4}{3}$

Others

Gravitational acceleration $g := 32.2\ \frac{\mathbf{ft}}{\mathbf{s}^2}$

2. Vehicular Centrifugal Force

The centrifugal effect on live load can be analyzed with the axle weights of the design truck or tandem and the following factor C.

Reference: Spec-Eq 3.6.3-1 $C := \frac{f \cdot v^2}{g \cdot R}$

$C = 0.156$

3. Wheel-load Reactions by the Centrifugal Force Effects

This effects shows in Figure.1.

Left $$R_{CL} := C \cdot W_{axle} \cdot \frac{h \cdot \cos(\theta)}{2 \cdot \left(\frac{s_{wh}}{2} \cdot \cos(\theta) \right)} = 0.156 \cdot W_{axle}$$

Right $$R_{CR} := -R_{CL} = -0.156 \cdot W_{axle}$$

4. Wheel-Load Reactions by the Superelevation Effects

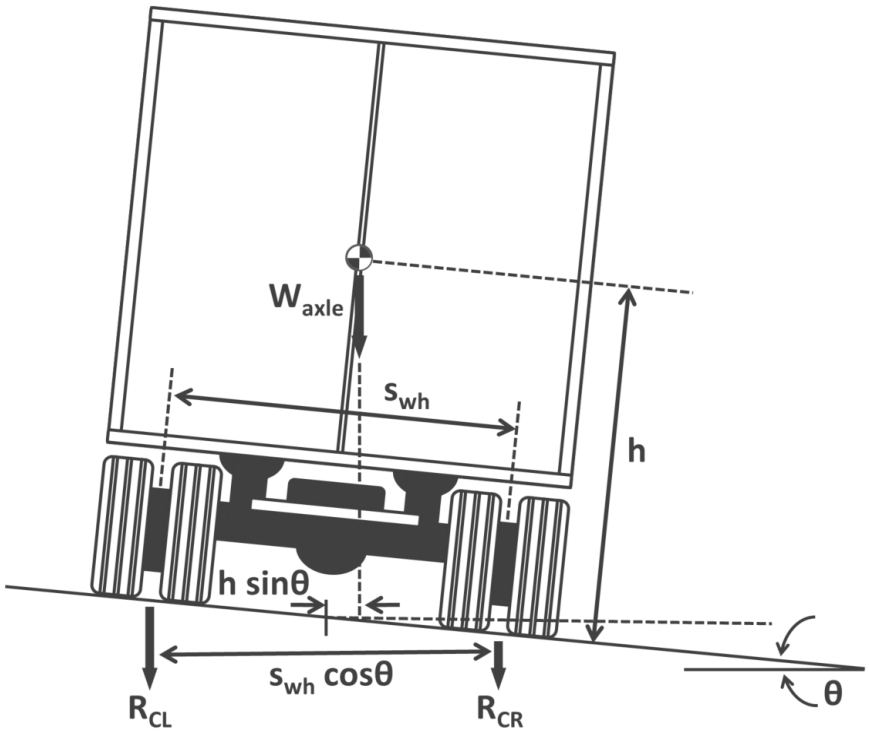

Figure 2 : Effects of superelevation on the wheel-load reactions

Angle of superelevation $\theta := \arctan(sl)$ rad $\theta = 2.862$ arcdeg

Left $$R_{SR} := \frac{\left(\frac{s_{wh}}{2} \cdot \cos(\theta) + h \cdot \sin(\theta) \right) \cdot W_{axle}}{s_{wh} \cdot \cos(\theta)} = 0.550 \cdot W_{axle}$$

Right $$R_{SL} := 1.0 \cdot W_{axle} - R_{SR} = 0.450 \cdot W_{axle}$$

5. Unit wheel-load factors

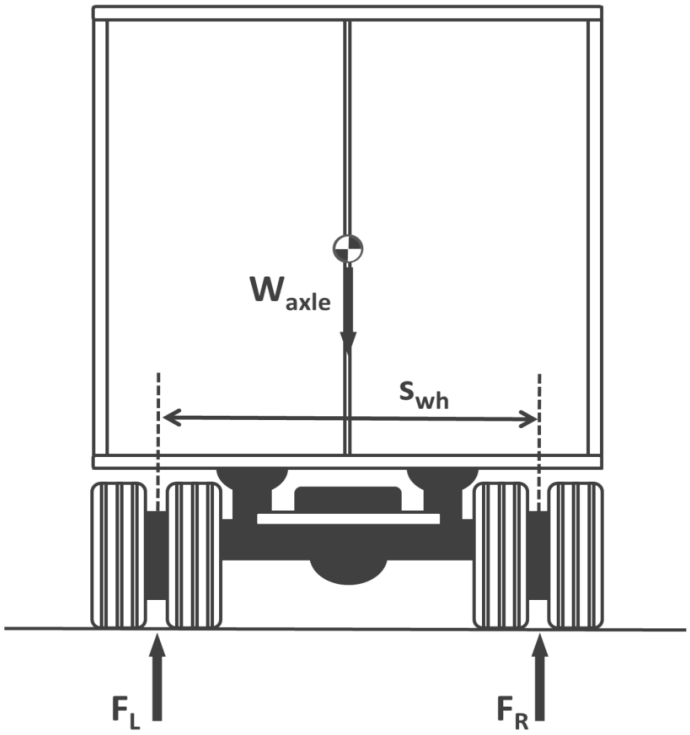

Figure 3 : Effects of superelevation on the wheel-load reactions

Left $$F_L := 2.0 \cdot \frac{R_{CL} + R_{SL}}{W_{axle}} = 1.212$$

Right $$F_R := 2.0 \cdot \frac{R_{CR} + R_{SR}}{W_{axle}} = 0.788$$