UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
RAIL TRANSPORTATION AND ENGINEERING CENTER
RAILTEC
TECHNICAL NOTE

TECH NOTE NO:	7
TITLE:	Interfacial Forces and Deflections of Individual Components due to a Lateral External Load
AUTHOR:	Brandon Van Dyk
ATTENDANCE:	Zhe Chen, Justin Grassé, Ryan Kernes, Chris Rapp, Moochul Shin, Amogh Shurpali, Brandon Van Dyk, Sihang Wei
CONTACT:	University of Illinois, Dept. of Civil & Environmental Engineering B118 Newmark Civil Engineering Laboratory, MC-250 205 North Mathews Avenue Urbana, IL 61801 Ph: (217) - 244-6063 Email: vandyk2@illinois.edu
DATE/REV:	5/23/12

1. Introduction

This technical note summarizes the results of an extensive discussion focused on the loads at interfaces and deflections of individual components due to a purely external lateral load on the rail for a concrete crosstie fastening system, hereafter referred to as "Tech Note 7". The discussion proceeded and was completed on the basis of several assumptions, which are stated in **Section 3**. This discussion produced a simplified analytical determination of external forces and deflections of the fastening system components from the head of the rail, through the fastening system, to the concrete crosstie.

2. Objectives

a. Understand the demands placed on the concrete crosstie and selected fastening system components
b. Develop a load path map, under static loading, of the concrete crosstie and fastening system from the top of the rail head to the bottom of the crosstie
c. Identify and classify all forces acting on each component and internal forces within each component

3. Assumptions

The following assumptions were made to determine interface loads and component deflections:

a. Neglect self-weight of each component
b. Fastening system consists of:
    a. two-part pad assembly
        i. 0.30-inch polyurethane pad (E = 345 ksi)
        ii. 0.055-inch nylon 6/6 abrasion plate (E = 1.091 ksi)
    b. two insulators
        i. insulator clip bearing area is 1.5 inches wide and 0.3 inches thick (E = 1.091 ksi)
    c. two elastic clips
        i. each with a clamping force of 2500 pounds
        ii. applied perpendicularly to the rail base (approximately 14° to the Z-axis)
c. Axis orientation is as follows:
    a. Z-axis is normal to the inclination of the rail seat
    b. X-axis is parallel to the inclination of the rail seat
    c. Y-axis is parallel to the longitudinal direction of the rail
d. The clip is driven and all fastening systems components are correctly installed
    a. The clamping force and any resulting loads are neglected
    b. The reductions in clamping force are not considered
e. The applied lateral load is 9 kips
    a. Representative of the lateral component in a demanding railroading environment (e.g. high curvature, etc.)
f. The base of the rail is infinitely stiff, thus producing an idealized pressure distribution at the rail seat
g. Neglect tangential forces; where they are necessary, substitute moments
h. The surface bond between the cast-in shoulder and concrete is idealized as a single point load to creates a balanced moment condition
i. The following simplifying geometrical and material assumptions were made:
    i. The rail base is six inches wide
    ii. The clip's geometry is simplified such that moments and deflections can be easily calculated, as shown in **Figure 1**:

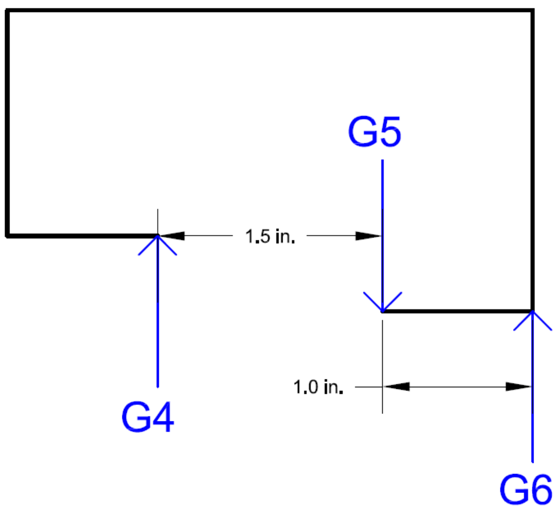

Figure 1 - Simplified Clip Geometry

iii. The location of the forces applied to the rail is as shown in **Figure 2**.

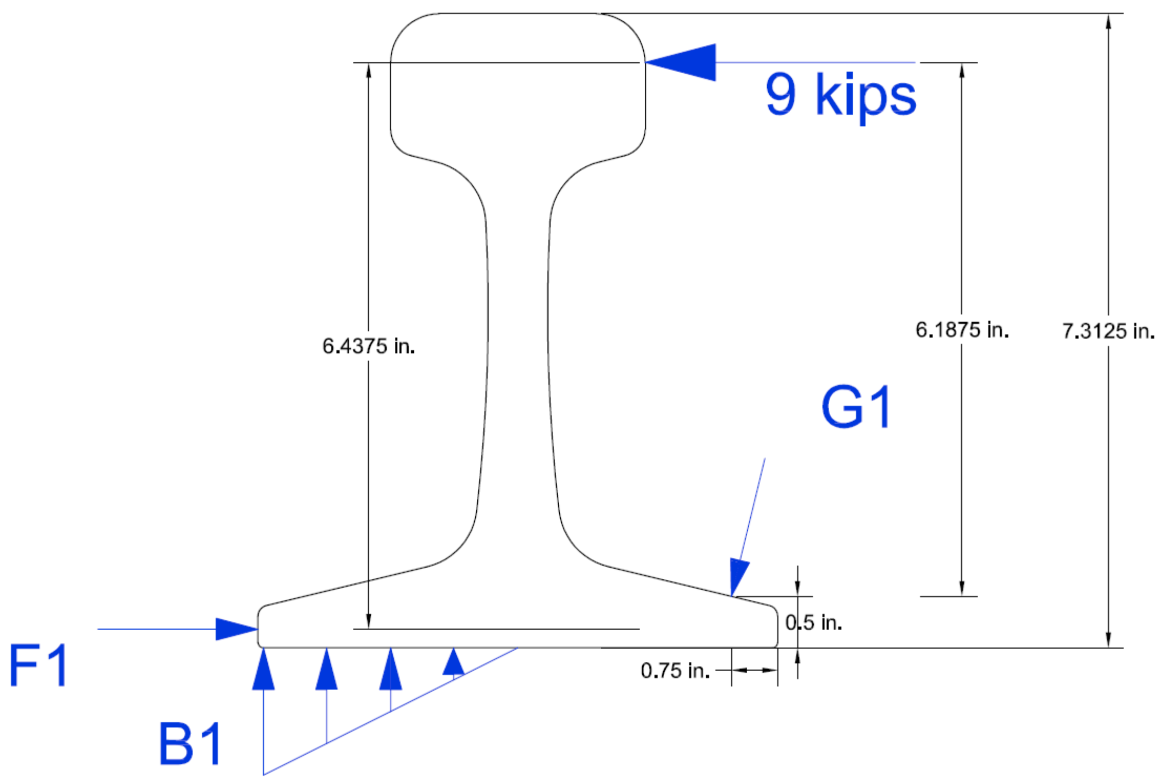

Figure 2 - Rail Geometry and Location of Applied Forces

j. The values calculated are per longitudinal unit (forces are distributed over one inch in the Y direction).

k. The load path as found in **Tech Note 4** is used for the determination of these values, with some modification of distributed forces due to improved understanding (see **Figure 3**).

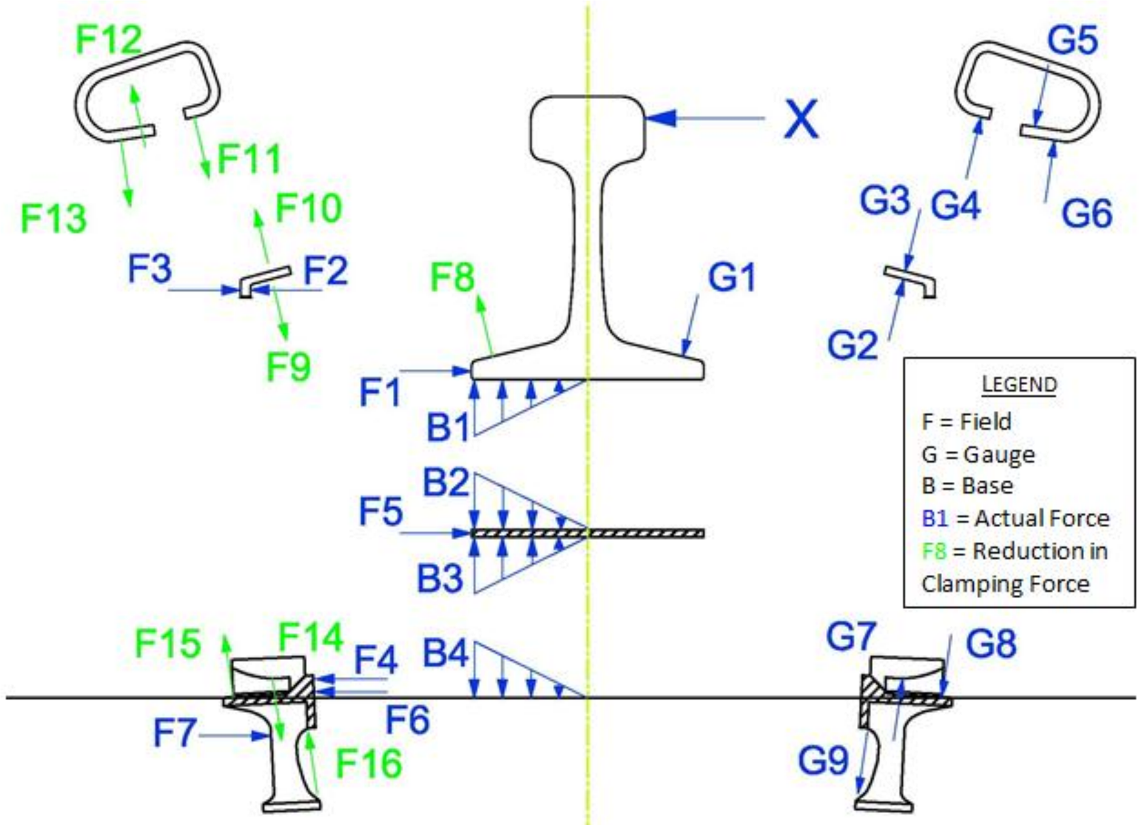

Figure 3 - Concrete Crosstie Fastening System Load Path Map and Component Free Body Diagram: Forces due to Lateral External Load

4. Discussion and Calculation

After accepting these assumptions, loads were applied to the system and deflections were calculated on each component. The findings from this exercise are summarized in **Tables 1** and **2**.

Table 1 - Summary of Component Deflections

Item	Modulus of Elasticity, E (ksi)	Thickness, t (inches)	Strain, ε	Deformation, δ (inches·10^{-3})
Rail Pad	345	0.3	0.0174	5.22
Abrasion Plate	1,091	0.055	0.0055	0.302

Table 2 - Summary of Interface Loads

Distributed Load	Force (kips per inch)
B1	6
B2	6
B3	6
B4	6

5. Final Remarks

The completion of these calculations is a step toward better understanding the demands placed on each component and achieving all objectives set forth in **Section 2**. The next step, to be executed in the coming weeks, is to calculate deflections of individual components under combinations of clamping force and lateral and vertical load. Future applications of this work will include estimation of force distribution, correlation of analytical force distribution calculations and deflections to field and laboratory data, and the development of an initial framework for mechanistic analysis and design of the crosstie and fastening system components.