UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

RAIL TRANSPORTATION AND ENGINEERING CENTER

RAILTEC

TECHNICAL NOTE

TECH NOTE NO:	5
TITLE:	Interfacial Forces and Deflections of Individual Components due to the Fastening System's Clamping Force
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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 only the clamping force for a concrete crosstie fastening system, hereafter referred to as "Tech Note 5". 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. The clip is driven and all fastening systems components are correctly installed
d. Axis orientation is as follows:
    i. Z-axis is normal to the inclination of the rail seat
    ii. X-axis is parallel to the inclination of the rail seat
    iii. Y-axis is parallel to the longitudinal direction of the rail
e. The base of the rail is infinitely stiff, thus producing an idealized pressure distribution at the rail seat
f. Neglect tangential forces; where they are necessary, substitute moments
g. The surface bond between the cast-in shoulder and concrete is idealized as a single point load to creates a balanced moment condition
h. The following simplified 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**:

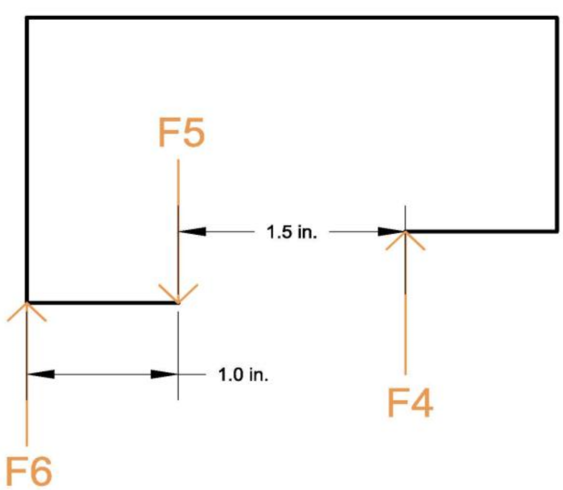

Figure 1 - Simplified Clip Geometry

i. The clip deflects 0.6 inches when it is driven
    a. Based on published load versus deflection curve for the Pandrol Safelok I clip while assuming the simplified geometry and 2500 pounds clamping load
j. The values calculated are per longitudinal unit (forces are distributed over one inch in the Y direction)
k. The deflections of the shoulder are considered negligible when only the clamping force is determined
l. The load path map discussed in **Tech Note 4** is used for the determination of these values (see **Figure 2**).

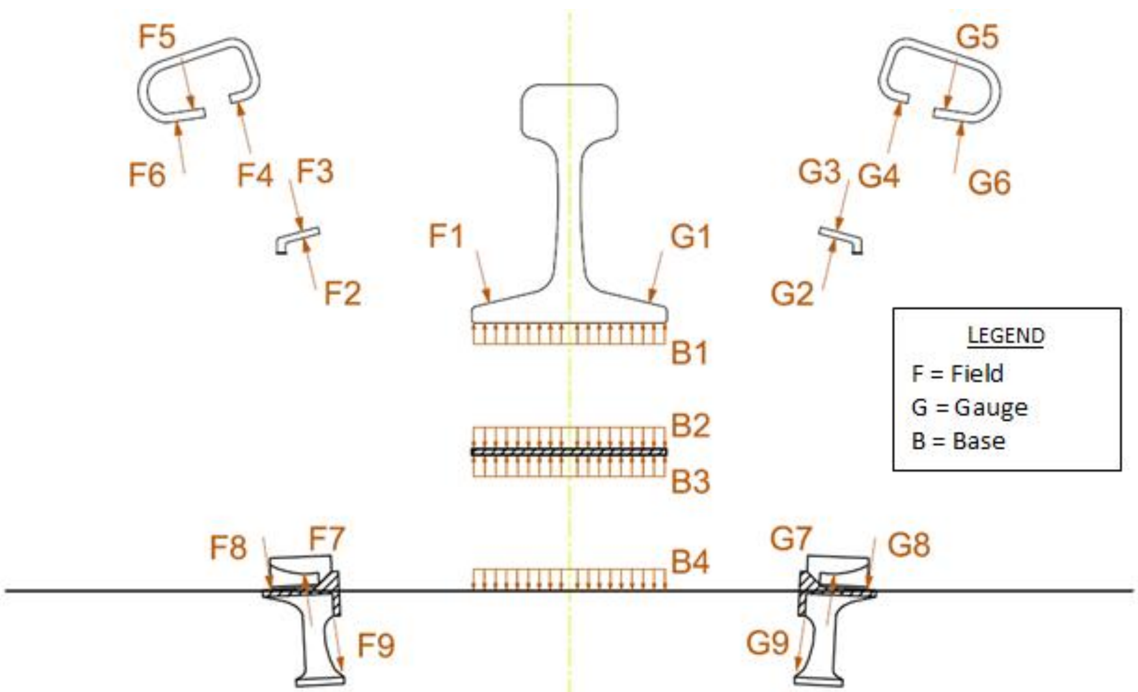

Figure 2 – Concrete Crosstie Fastening System Load Path Map and Component Free Body Diagram: Forces due to Clamping Force

4. Discussion and Calculation

After accepting these assumptions, loads were applied to the system and component deflections were calculated. 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	0.0023	0.703
Abrasion Plate	1,091	0.055	0.00074	0.041
Insulator Body	1,091	0.3	0.0015	0.458
Clip	-	-	-	600

Table 2 - Summary of Interface Loads

Concentrated Load	Force (kips)
F1, G1	2.50
F2, G2	2.50
F3, G3	2.50
F4, G4	2.50
F5, G5	6.25
F6, G6	3.75
F7, G7	6.25
F8, G8	3.75
F9, G9	2.50
Distributed Load	**Force (kips per inch)**
B1	0.81
B2	0.81
B3	0.81
B4	0.81

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 is to begin calculating deflections of individual components using vertical and lateral loads. 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.