Low-Impact Special Trackwork
Research at Transportation Technology Center, Inc.

David D. Davis
Low Impact Special Trackwork for Heavy Haul Freight Operations

Background:

- Heavy Axle Loads
  - Compelling Economics
  - Effects of wheel loads on special trackwork
- Third leading track cause of accidents
- Cost Center – 10-100 x more expensive to operate than conventional track
- Capacity Stealer – many condition related speed restrictions. >$500M per year
- Performance improvements under HAL
  - 50% reduction in maintenance
  - 100%+ increase in service life
Low Impact Special Trackwork for Heavy Haul Freight Operations

Technologies Successfully Implemented:

- Flange Bearing Frogs
  - Diamond Crossings
  - Turnout Frogs
- Improved Switch Geometries
  - Low Entry Angle Switches for HAL
- Frog Running Surface Profiles
  - Conformal Profiles
  - Ramps for High Angle Frogs
  - Curved Entry Guard Rails
- Foundations for Frogs
Load Environment

- Vertical loads on high angle diamond crossing at FAST (315 K hopper)
Vehicle Performance on Diamond Crossings

Pictures of damage to diamonds
Diamond Crossings
Track Transition Problems
Background: Car parts graveyard around diamond
Types of Crossing Diamonds

◆ Conventional Tread Bearing Frog
  • Unsupported flangeway gaps
  • Wheel is tread bearing throughout
  ◆ Advantages:
    — Lower first cost
    — Allowed by FRA Track Safety standards

◆ Flange Bearing Frog
  • Continuous wheel support
  • Wheel transitions from tread to flange bearing
  ◆ Advantages:
    — Lower dynamic loads
Types of Crossing Diamonds

Flange Bearing Frog
Crossing Diamond Dynamic Loads

Potential to Reduce Dynamic Loads

Measured performance
Conventional diamonds

Measured performance
FBF test diamonds

Class 4
Track

DYNAMIC LOAD FACTOR

SPEED (mph)
Flange Bearing Frogs

- First Full FBF Diamond Installed under Waiver
  - CSX Shelby, OH
  - 40 mph
  - Wheel fleet and diamond performance monitored by TTCI
Evaluation of Designs and Initial Performance of FB Turnout Frogs

- **Application:** Mainline turnouts with very little diverging traffic
  - Set out tracks
- **Benefits:**
- **Expected service life:**
  - RBM: 200 MGT
  - FB Frog: 1,000 MGT?
- **Mainline ride quality**
  - Continuous surface
Turnout Geometry and Components Evaluation

◆ Best Practices Prototype(s) for FAST

- Joint-Less Frog
- Double Spiral Geometry
- Thicker Switch Point
- New Helper Arrangement
- Composite Material Rods
- Hollow Switch Ties
**Turnout Performance**

**Next Generation Turnout Key Findings:**

- **Design Features Recommended for Revenue Service Application**
  - Spiral, Tangential switch alignment
    - With Thicker point
  - Switch rods out of ballast
    - Hollow Steel Ties
      - Need a stiffer clip to reduce point roll
    - Over-tie rods
      - Improved vertical stability: lining & surfacing requirements reduced by 60%
SRI 9A STW – Super Turnout

Next Generation Turnout Key Findings:

- Forces lower
  - Lateral forces continue to be ~30% lower
  - Vertical forces are 10% lower than RBM’s
Next Generation Turnout Key Findings:

- Service Life of Switch Points
  - Thicker point and lower forces
  - Longer average life than AREMA style
SRI 9A STW – Super Turnout

Next Generation Turnout Key Findings:

- Design Features Recommended for Revenue Service Application
  - Low dynamic load frog
  - Moveable point or wing frogs
    - Fixed point “Solid” with improved running surface profiles
Frog Profile Design
Cross Section Profile Designs

Current profiles
Point contact on
flangeway corner

“Conventional” prototype
Flat running surface, larger
corner radius
Point contact away from
flangeway corner

“Conformal” prototype
1/20 taper running surface,
larger corner radius
Conformal contact away from flangeway corner

High Stresses

Relocated Corner Stress

Distributed Stress
Frog Cross Section Profile Design

- Conformal
- Conventional
Background:

- **Frog corners are deformed**
  - Castings made to desired shape
  - AMS deforms rapidly to undesired shape
  - Effective flangeway gap goes from ~2” to 3-4”
  - Dynamic forces increase significantly

- **Ramp designed to:**
  - Provide for initial deformation
  - Lift wheel over gap
Running Surface Ramping for High Angle Frogs

![Graph showing the wheel load dynamic augmentation against speed for different ramp conditions.](#)
Guard Rail Entry Analysis

- Dynamic simulation modeling - curved entry will:
  - Lower maximum forces
  - Control wheel path better
  - Circular entry contacts wheel sooner
  - Provides smoother transition instead of abrupt impact

![Graph showing lateral loads vs distance from end of guardrail](attachment:image.png)

Conventional Entry

Circular Entry
Load Environment of the Crossing
Diamond

Two types of impact loads seen at diamond crossings

- Higher frequency load due to wheel impacts.
  - Contribute to broken components
- Lower frequency loading due to wheel bounce.
  - Contributes to:
    - ballast and subgrade breakdown
    - tie deterioration
    - surface and alignment problems
NUCARS Study

Optimal track damping is above measured
Diamond Crossing Foundation Design
Development of Low Impact Special Trackwork

Implementation:

- Flange Bearing Frogs are successful
  - Full FB diamonds being implemented under waiver
  - OWLS diamonds being widely implemented
  - FB turnout frogs in revenue service tests
- Premium turnout components becoming standard for HAL lines
- Ramped running surface diamonds are industry standard
- Curved Entry Guard Rails are being adopted as Industry Standard
- Optimally damped foundations in test by industry