

Wheel Rail Interface

Managing Rolling Contact Fatigue (RCF)

in Rail & Transit

Vinay Mudholkar; MS, MBA

Technical Vice-President ; L Berger, US

Former Principal Engineer; Bechtel, UK &US

Director, Amtrak (NYC), MBTA (Boston)

Chief Engineer: B&M, MEC and D&H

UNDERSTANDING WHEEL RAIL INTERFACE FOR SAFE TRANSPORTATION



SAFETY IS OUR PRIME CONCERN

- Millions of Passengers on Transit and Surface lines
- Millions of Ton/Miles of Freight
- Chemicals and Hazmat
- Nuclear Fuels and Waste
- Strategic Commodities

THANKS TO RAIL SYSTEMS, ORGANIZATIONS & RAILROADERS!

- Vin Terrill; VP B&M;
President of AREMA,
REMSA
- Tom McCarthy; VP Bechtel
- David Ventry, Richard
Spoors; CEs NETWORK RAIL
- Bill Gath; Welding Mgr CN
- John Staples; Welding Mgr
Bechtel, UK
- Mark Rovnyak; Holland, US
- **B&M, MEC, D&H USRR**
- **MBTA TRANSIT, US**
- **AMTRAK, NEC, US**
- **UK: NETWORK RAIL**
- **US & UK TRANSITS**
- **AREMA, US**
- **AAR/ TTCI**
- **NRC, CANADA**

PASSENGER TRANSPORTATION MODES & CHARACTERISTICS



Low to Medium Speed Transit
Low Dynamic Forces
Frequent Stops
Higher Degree of Curves
Difficulty in Pavement for inspection and grinding



High Speed and Impact
High Dynamic Forces
Limited Stops
Lower Degree of Curves
Shared Corridor with Freights

EQUIPMENT TYPES & OPERATIONS IN UK

DIFFERENT TRAIN TYPES



MECHANICAL CHARACTERISTICS

- **LIGHT WEIGHT, FAST DMU FOR INTERCITY TRAFFIC**
- **HEATHROW EXPRESS
HS ELECTRICAL IN TUNNELS AT AIRPORT TERMINALS**

TRANSIT CHARACTERISTICS: IN GENERAL



Global Growth In Transit Systems

- New as well as Old Systems
- Low to Medium Speeds
- Lighter Vehicles
- More Stop & Go action due to multiple stations stops
- Safety and Ride Quality are critical
- Noise and Vibration control
- Limited night access for work

TRANSIT CHARACTERISTICS : IN GENERAL

Complex Layouts In Terminal Areas: Multiple-lines and Switches:

- **Tight Geometry**
- **Low Speed but intense wheel rail interface due to multiple lines and switches**
- **Difficulty for access for inspection and repairs**
- **High noise levels**
- **Limited time for vehicle maintenance**
- **Cylindrical wheel issues**



UNDERSTANDING TRACK, VEHICLE AND OPERATIONAL CHARACTERISTICS



TEAM EFFORTS ARE NEEDED

- ORGANIZATIONAL TEAM
- TRACK/ CIVIL
- ROLLING STOCK/ MECHANICAL
- OPERATIONS
- FINANCE
- EQUIPMENT SUPPLIERS

RAIL: MOST VALUABLE, SAFETY CRITICAL ASSET of RAIL & TRANSIT SYSTEMS



- GOAL: PUBLIC SAFETY FIRST**
- **PROVIDE SAFE AND COMFORTABLE RIDE TO PASSENGERS**
 - **MINIMIZE NOISE & VIBRATIONS: IMPACT ON ENVIRONMENT**
 - **PROVIDE RELIABLE, DERAILMENT FREE SERVICE**
 - **PASSENGER CONFIDENCE**
 - **RAIL IS SAFE MODE OF TRANSPORTATION**

TRAIN/ VEHICLE CHARACTERISTICS



COMPLEX ISSUE

- **WHEEL TYPES:
CONVENTIONAL
CYLINDRICAL**
- **WHEEL MAINTENANCE**
- **SUSPENSION SYSTEMS**
- **BRAKING CHARACTERISTIC**
- **WEIGHT, SPEED, IMPACT**
- **CURVE NEGOTIATIONS**
- **TRAIN LENGTH/ HANDLING**

WHEEL/RAIL INTERFACE:WRI

ROLLING CONTACT FATIGUE

Steel Wheel On Steel Rail

- **Minimum Dynamic Friction**
- **Best Advantage for Rail:
Low Energy Consumption**
- **Unavoidable WRI**
- **Fatigue: Natural
Phenomenon to metals due
to loading cycles**
- **Must be controlled for
minimizing failures**

Critical Events

- **UK: Hatfield Accident on
Great Western RR
Gauge Corner Cracking**
- **Germany: HS Rail wheel
brake; train crashed into
bridge abutment**
- **India: Serious Rail brakes**
- **Rail breaks in switches
common problem**

VISUAL SITE INSPECTION DURING DAY FOR SCOPING

FIELD MARKING OF SCOPE

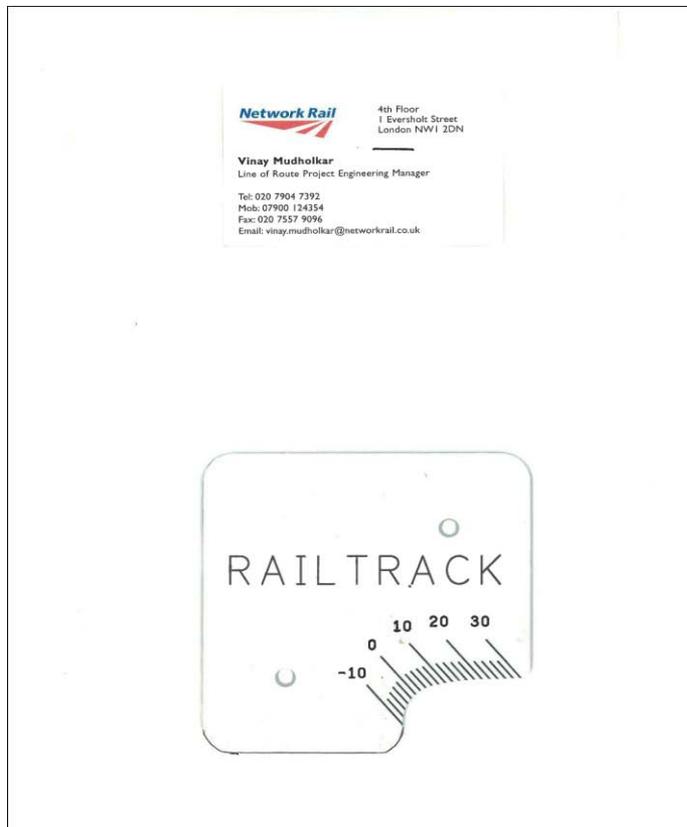


DETERMINE EXTENT OF WORK

- TIME & MANPOWER
- MACHINERY REQUIRED
- WELDING & GRINDING SCOPE

System Specific Design and Optimization of Rail Wheel Profiles

Gauge Corner Template



Rail Track / Network Rail

- Multiple Wheel Types
- Mixed Traffic HS Passenger & Freight
- R&D For Optimum Wheel Profile
- Selection of suitable Rail Grinding Profiles for Tangent and Curves

DEFECT CLASSIFICATION FOR DATABASE



GENERAL RISK EVALUATION

- **CRACK LENGTHS, SPACING**
- **10 MM UNDER: LIGHT**
- **10 TO 20 MM: MEDIUM**
- **20 TO 30 MM: HEAVY**
- **30 MM AND OVER: SEVERE**

RAIL DEFECT TYPES DUE TO ROLLING CONTACT FATIGUE

SEVERE GCC AT SWITCH



DEFECT TYPES

- HEAD CHECKS: C, V, S
- HEAD CHECKS WITH SHADOWS
- SPALLING
- TONGUE LIPPING
- SQUATS
- FALSE WHEEL FLANGE DAMAGE
- WHEEL BURNS

PROXIMITY OF FREIGHT AND PASSENGER LINES TO HIGH TENSION POWER LINES , CRITICAL UTILITIES: FIBER OPTICS



Wheel Rail Safety Critical

- Close clearances between various modes of transport
- Shared Corridors: HS Passenger, Commuter and Freight: NORTHEAST, US WESTCOAST MAINLINE, UK
- Rail lines over and under major bridges
- Transit lines over elevated structures in downtowns

MODERN RAIL FLAW DETECTION EQUIPMENT



ESSENTIAL FOR MILLIONS OF MILES OF RAIL SYSTEM

- HIGHER SPEED OF INSPECTION
- ACCURATE TIMELY FEED-BACK FOR REMEDIAL ACTION
- VISUAL INSPECTION CRITICAL FOR SWITCHES
- VISUAL SPOT CHECK IS ALSO CRITICAL FOR CURVES, BRIDGES, TUNNELS, SWITCHES
- HIGH RISK LOCATIONS ON SYSTEM: ELEVATED STRUCTURES, HIGH EMBANKMENTS ETC.

SUPPORT CONDITIONS

DAMAGED TIE CONDITION



MOVEMENT OF RAIL

- NO FASTENING ACTION
- SHIFT IN CONTACT BAND
- IMMEDIATE REPLACEMENT NEEDED

UNDERSTANDING START OF PROBLEM: RISK



Developing Defect Database

- Identify Defects by location, responsibility
- Risk Register: High, Medium, Low Categories
- Assign Priorities for repairs
- Continuous Monitoring
- Action Plan to Control Risks
By Adopting Repair Plan Schedule

UNDERSTANDING RISKS & ASSIGNING PRIORITY



Head Defect

- Wheel burns
- Crushed head
- Cracking
- Material flow: lipping
- High Risk
- Repair Priority

POOR TIMBER SUPPORT ON OPEN DECK



RAIL MOVEMENT

- **WIDE WHEEL CONTACT BAND**
- **SPIKED RAIL IN POOR CONDITION TIMBERS**

DEVELOPMENT OF CORRUGATIONS IN STATION AREAS



Development of Corrugations

- Starting and Stopping areas
- Excessive braking to control excessive speeds
- Speed monitoring is critical

TRANSIT ACCESS: UNDERGROUND STATION PLATFORMS TO TUNNELS



Preparation of Night Work

- Planning of “Possession”
- Portable Hand Grinding Equipment
- Power Generators
- Welding Equipment
- Access to Crew Members
- Health and Safety facilities

TUNNEL RAIL SUPPORT CONDITIONS: POOR DRAINAGE CAUSING DEGRADATION OF CONCRETE



Good Foundation Support Is Essential to Rail

- Drainage systems must work to protect concrete slabs and ties
- Observation of Wheel Contact Band before and after Repairs and Grinding

RAIL IN TUNNELS & AT STATIONS

GCC GROWTH IN THE DIRECTION OF TRAFFIC



**Moderate Curve: Vertical
Coming to Station from tunnel**

- **Shining Gauge Corner and Commencement of moderate Gauge Corner Cracking (GCC)**
- **Control growth by grinding Gauge Corner at early stage**
- **Planned Grinding and Welding Program is critical for preserving Rail Investment**

PRINCIPAL TREATMENT TO CONTROL RCF AND OTHER HEAD IRREGULARITIES



GRINDING & WELDING

TWO MAJOR REASONS:

- 1. Remove and Reduce the size of crack and avoid complex fractures**
- 2. Mitigate future crack development by re-profiling the rail head to reposition and reduce contact stresses**

RAIL DEFECTS: HEAVY TRAFFIC

DEFECTS IN SWITCHES



DEFECT TYPES

- SEVERE HEAD CHECKS
- TEMPORARY SPEED RESTRICTION IMPOSED
- DAMAGED CROSSINGS

CRITICALITY OF PERIODIC GRINDING FOR HEAVY TRAFFIC: SHARED CORRIDORS AND HEAVY HAUL

INTRODUCTION IN UK NETWORK RAIL FOR SHARED CORRIDORS



HEAVY AXLE AND IMPACT FACTORS

- **SHARED CORRIDOR: MIXED FREIGHT AND HS INTERCITY PASSENGER TRAFFIC**
- **UNIT COAL, GRAIN AND MINERAL TRAINS**
- **UNIT PETROCHEMICALS**
- **DEDICATED FREIGHT CORRIDORS: CONTAINERS, MIXED TRAFFIC**

GRINDING: FINISHED PROFILES

PROFILE FIELD CHECK



CURVE NORMAL PART
LOW RAIL SMPH



CURVE NORMAL PART
HIGH SMPH



IN CURVES

- LOW RAIL

- HIGH RAIL

POST GRINDING CHECKS

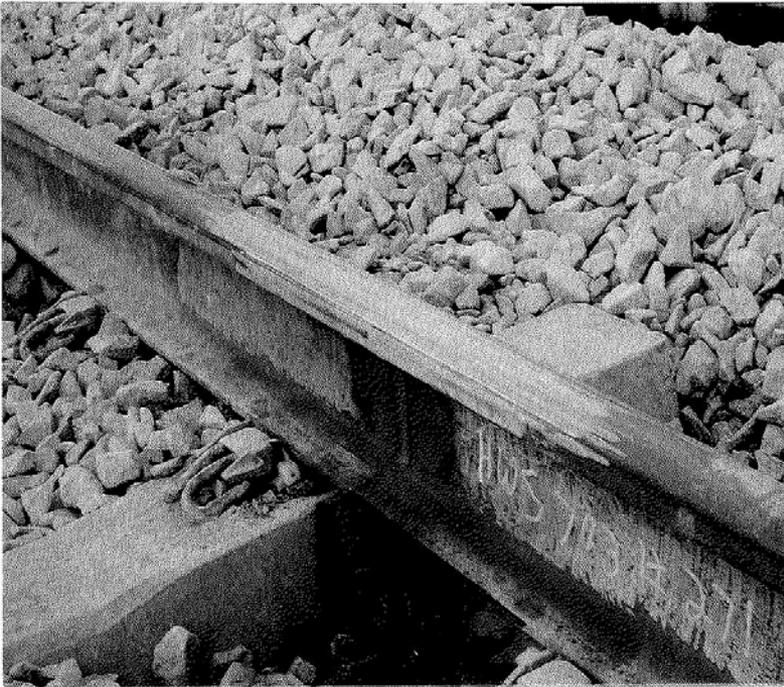
CONTACT BAND IN CENTER



RAIL PROFILE CHECK



PERFECT WELD ALIGNMENT



- **MIS-ALIGNED WELD CAUSES START OF GCC DUE TO WHEEL IMPACT**
- **ALIGNMENT MUST BE PERFECT**
- **DEFECT FREE WELD ARE CRITICAL FOR HS AND HEAVY HAUL LINES**
- **APPLICATION OF SIX SIGMA FOR ZERO DEFECTS**

TRAINING & REMEDIATION WORK AT NIGHT SHIFT



- TRAINING ON SITE
- PREPARATION
- SAFETY PLAN & PROCEDURES
- SIGNAL TESTING FOR
HANDBACK



MEASUREMENT OF GEOMETRY AND RPROFILE



- **CHECK GEOMETRY COMPLIANCE**



CHECK PROFILE COMPLIANCE

ACCEPTANCE FOR FULL SPEED



WHEEL SHOP: WHEEL PROFILING

WHEEL SHOP



SYSTEM OPTIMUM PROFILE



LESSONS LEARNED

- IDENTIFY PROBLEMS BY PAIR OF EYES AND NOT BY PAIR OF WHEELS!

QUESTIONS?

UNDERSTANDING OF WRI IS CRITICAL

- TEAMING EFFORT IS NEEDED
- TRAINING OF STAFF
- VISUAL INSPECTION IS EQUALLY IMPORTANT TO MECHNIZED VEHICLES
- DATABASE MONITORING
- PRIORITAZTION FOR ACTION PLAN
- CONTINUOUS PROCESS