International Union of Railways (UIC)

JRP-2:
Wheel / Rail Interaction

Status Report to World Executive Council

New Delhi
21 October 2005

JRP-2: Objective

- PRODUCE A WORLD-WIDE PERSPECTIVE OF THE CURRENT STATE OF THE ART OF WHEEL / RAIL INTERACTION
- RECOMMEND OPTIMAL DESIGN, MAINTENANCE AND MONITORING PRACTICES FOR A SPECTRUM OF OPERATING CONDITIONS
- IDENTIFY GAPS IN THE CURRENT KNOWLEDGE BASE
- RECOMMEND OR INITIATE JOINT RESEARCH PROJECTS TO FILL THESE GAPS

JRP-2: Membership

- ***All-Russia Railway Research Institute,*** **representing Russian Railways**
- ***China Academy of Railways,*** **representing Chinese Railways**
- ***CVRD,*** **representing South American Railways**
- ***RDSO,*** **representing the Indian subcontinent**
- ***JR East and RTRI,*** **representing Japanese Railways**
- ***Queensland Rail,*** **representing Australasia**
- ***Spoornet,*** **representing Africa**
- ***TTCI,*** **representing North America**
- ***UIC,*** **– European Railways**

JRP-2: Activities

- Initial meetings revealed that individual members had differing needs / problems regarding wheel / rail interaction:
  - Wheel & Rail Wear
  - Rail Stress Issues (head checks, plastic flow, corrugation, rail failure, issues with respect to rail grinding)
  - Derailments (Wheel Climb, Hunting)
  - Rail Joints (weld failure & deformation)
- Interest groups were formed to address these issues

JRP-2: Activities

- Members also expressed a need for:
  - A classification of wheel & rail defects associated with wheel / rail interaction
  - A need to share design, management & maintenance standards
    - Weight & strength of rail steels
    - Differential hardness between wheel & rail
    - Rail weld practices & standards
    - Wheel wear limits
  - A need to understand the mechanisms causing the degradations observed on the track & on vehicles

JRP-2: Deliverables

- ***An "Atlas of Wheel & Rail Defects": Associated with Wheel / Rail Interaction***
  - **Photographs of all known defects categorized according to failure mechanism:**
    - **Mechanical Stress / overload**
    - **Thermal Stress**
    - **Wear**
  - **List of definitive causes for each failure mechanism**
  - **Known remedies / maintenance interventions**

JRP-2: Deliverables

- ***A "Catalogue of Wheel / Rail Interaction Mechanisms":***
  - **A description of all mechanisms considered to be the cause of wheel & rail degradation. This Catalogue is structured according to different "levels" of the wheel / rail science:**
    - **Level 1: Contact Mechanics**
    - **Level 2: The Action of a Wheelset on the Track**
    - **Level 3: The Action of Wheelsets within a Vehicle**
    - **Level 4: Systemic Influences within the Railway Environment on Wheel / Rail Contact (Braking, Rail Welds / Joints, Special Track Work)**
    - **Case Studies: Jointly developed by members through shared experiences during the course of the JRP**

JRP-2: Deliverables

- ***A "Survey of Current Wheel & Rail Interaction Practices": Questionnaire:***
  - **This Survey summarizes the response of different railways worldwide to a questionnaire on:**
    - **Design standards**
    - **Maintenance management methods**
    - **Maintenance standards**
    - **Maintenance Practices**
    - **Anticipated Savings from Improved Wheel / Rail Interaction Practices**

JRP-2: Deliverables

- ***A "Survey of Current Wheel & Rail Interaction Practices": A "flavour":***
  - **Materials:**
    - **"Hardest is best" for both wheel & rail**
    - **Bainitic steels imminent?**
    - **Differentiate rail quality between tangent & curves**
  - **Wheel diameters & rail section:**
    - **915mm diameter wheels a general norm**
    - **Wheel profile control is greater issue than diameter**
    - **60 kg/m a norm**
  - **Wheel / rail design parameters:**
    - **Not much consistency regarding conicity & gauge clearance**
    - **Heavy haul railways with good practices do manage parameters with little control by others**
    - **High speed operating with little gauge clearance**

JRP-2: Deliverables

- *A "Survey of Current Wheel & Rail Interaction Practices": "A flavour":*
  - Bogie design:
    - Nothing new
    - 3-piece the norm with freight
      - Concentration on tolerances
      - Body / bogie interface not managed
  - Wheel / Rail Maintenance Management:
    - Generally, those practicing management are doing well and reaping benefits
    - Generally, those not practicing good management have few metrics and thus do not know of conditions or benefits
  - Limits to wheel /rail contact:
    - Given that management practices are good, limit is rail weld strength & hardness

JRP-2: Deliverables

- ***A "Survey of Current Wheel & Rail Interaction Practices": "A flavour":***
  - **No railways are willing to quote estimated cost savings however the following figures were quoted:**
    - **Wheel flange life: between 4 & 20 times**
    - **Rail life in curves: 4 to 10 times**
    - **Derailment costs: "significant"**
    - **Energy costs: 5%**
- ***A "Summary Report on the Activities of the Project":***
  - **A summary report of the activities of JRP-2 is provided**

Mechanisms on five different levels

Level 1: Contact Mechanics

Level 2: The action of a Railway Wheelset on Track

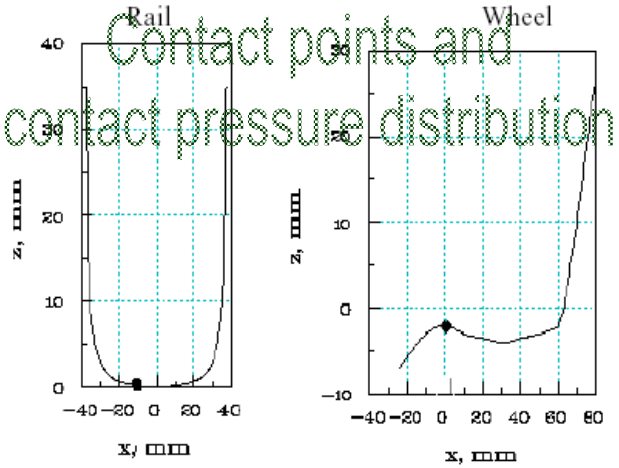
Level 3: The influence of Suspension Systems on the Action

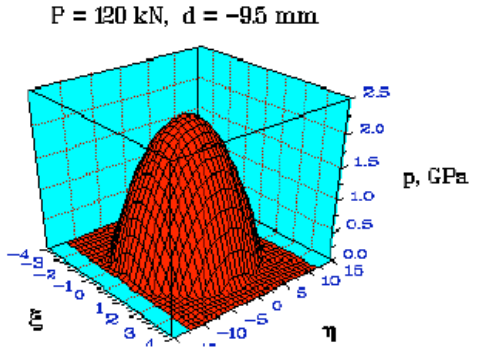
Level 4: Major Systemic Influences on Wheel/Rail Contact associated with the General Railway Environment

Level 5: Systemic Issues associated with Wheel/Rail Interaction including Case

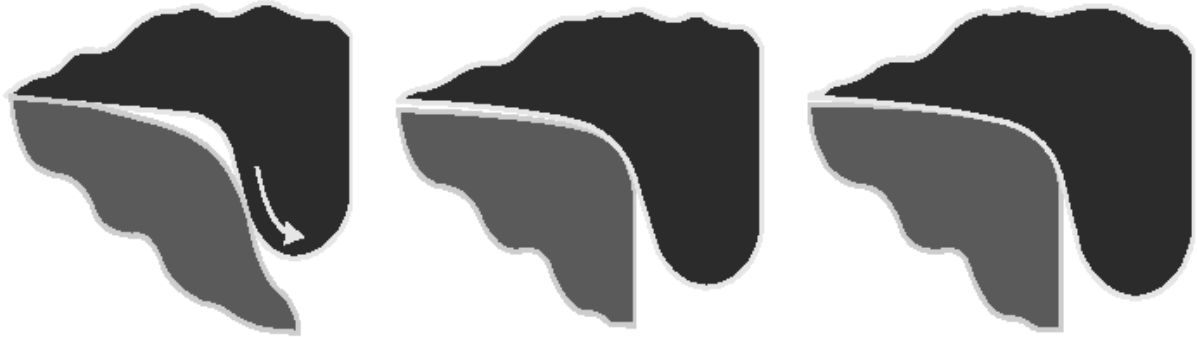
Level 1: Contact Mechanics

Contact points and contact pressure distribution



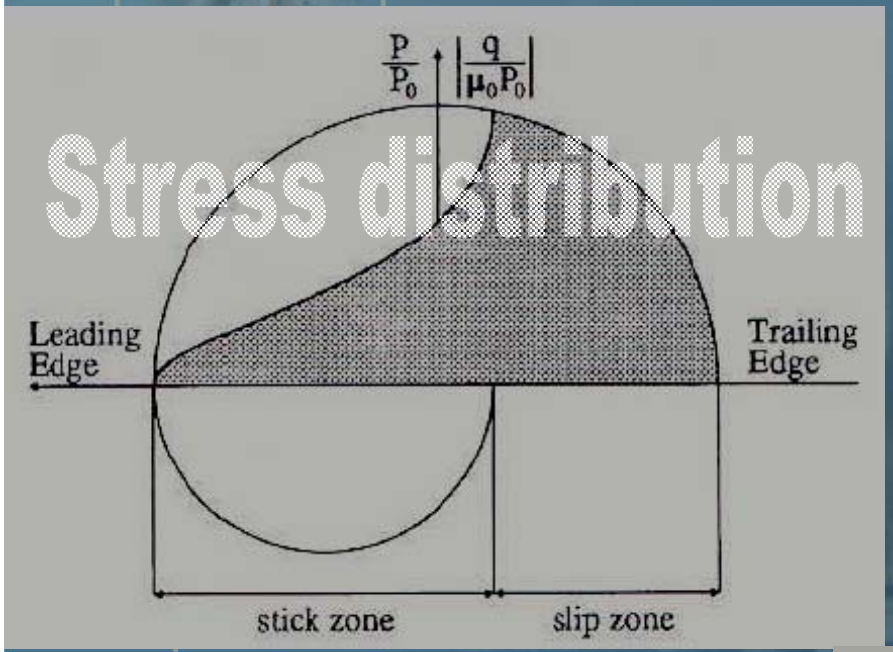


Types of Region B Wheel-Rail Contact

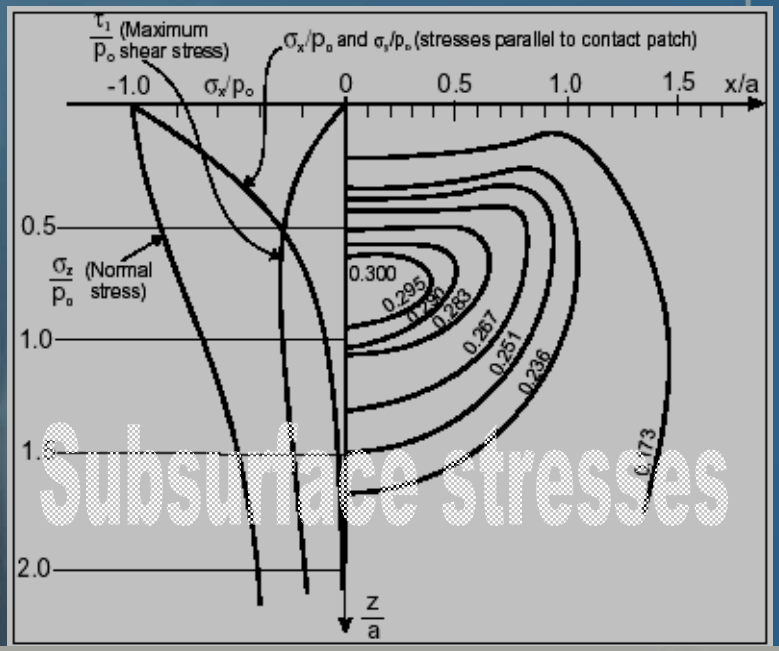


Level 1: Contact Mechanics

COMPLEX STRESS STATE OF WHEEL AND RAIL RESULTED IN ITS DAMAGES

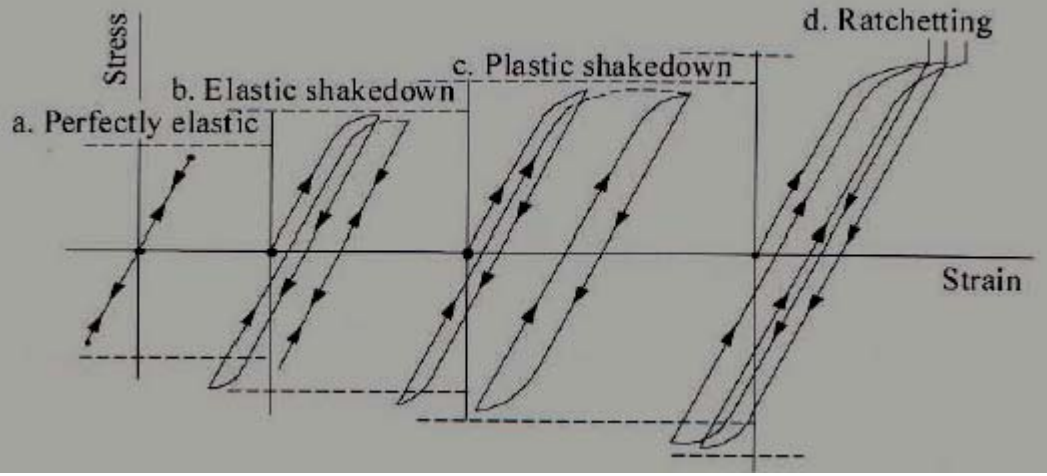


Stress distribution



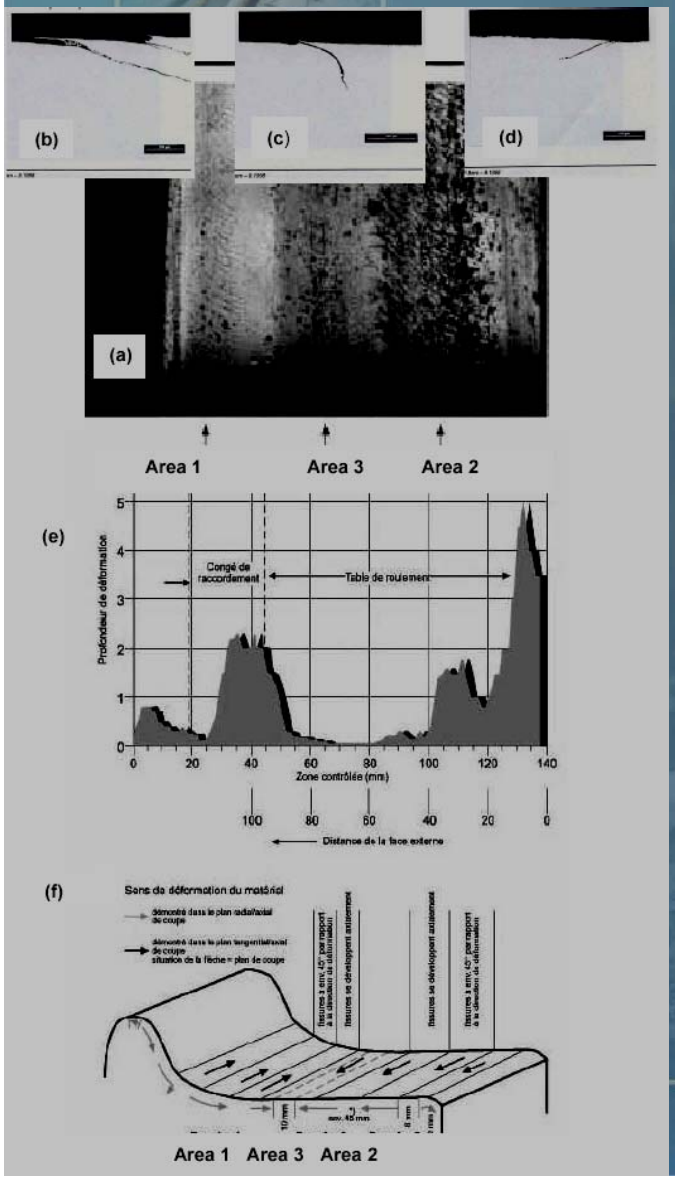
Subsurface Stresses

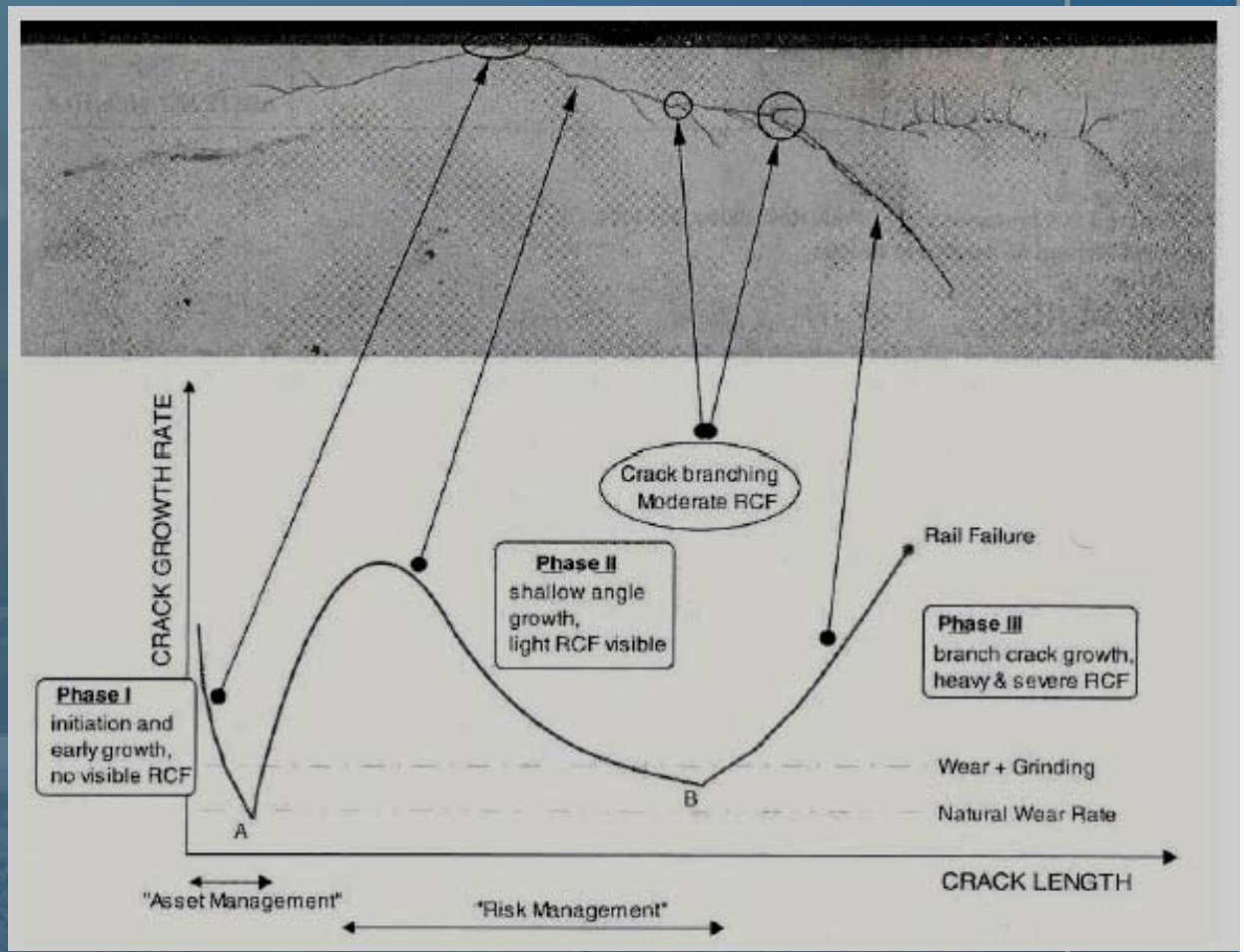
Structural Response of the Material to Cycling Loading



Level 1: Contact Mechanics

FAILURE OF WHEEL AND RAIL MATERIALS UNTER ROLLING-SLIDING CONTACT

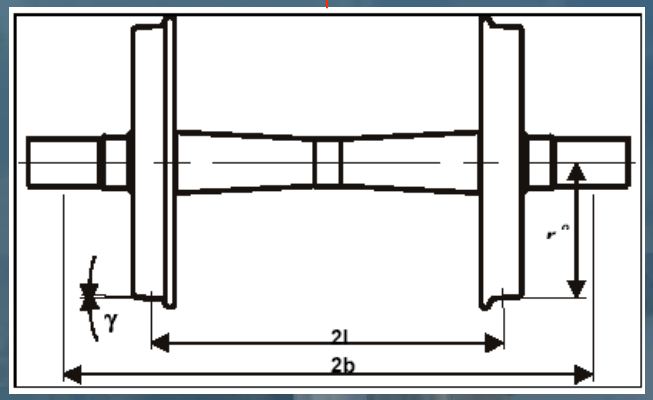


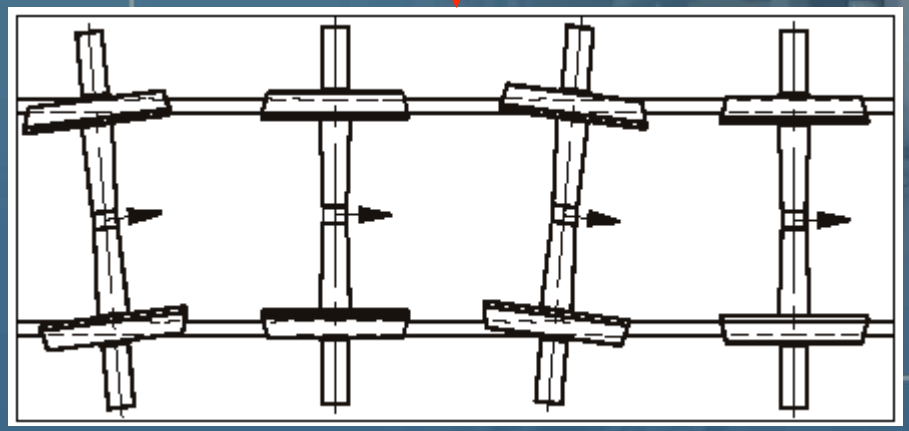


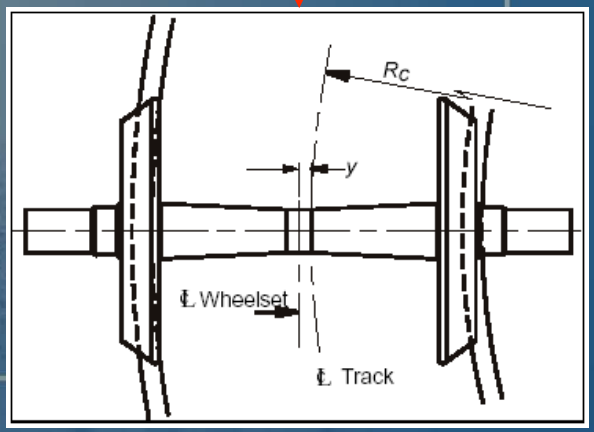
Phases of RCF Crack Development and Growth

Level 2: The Action of Railway Wheelsets on Track

Kinematic Model of a Conventional Railway Wheelset

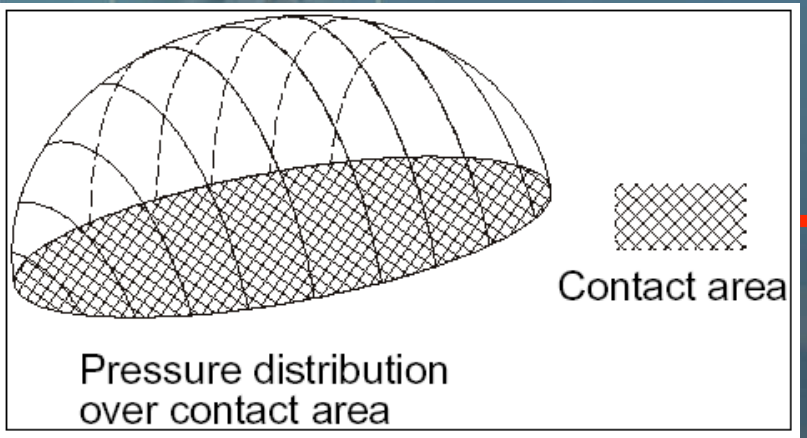


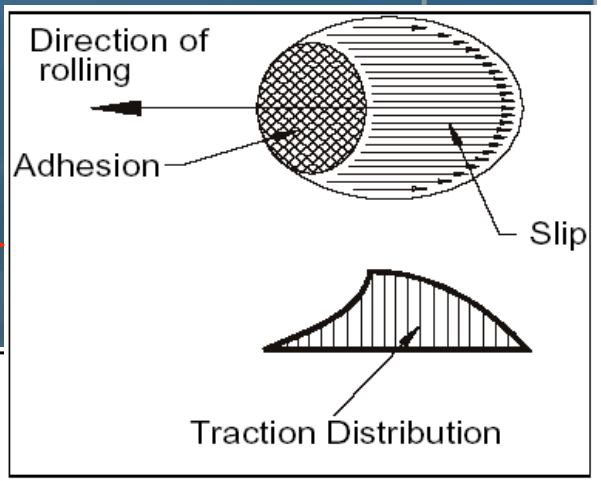


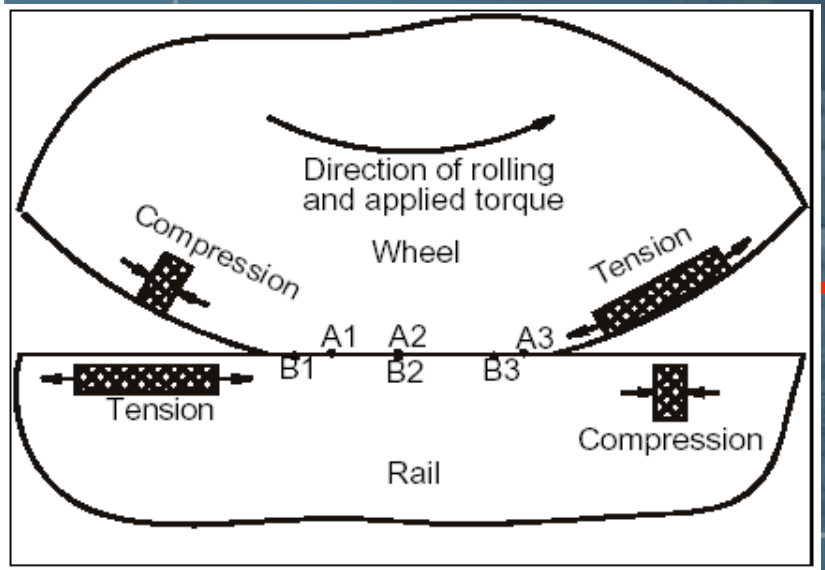


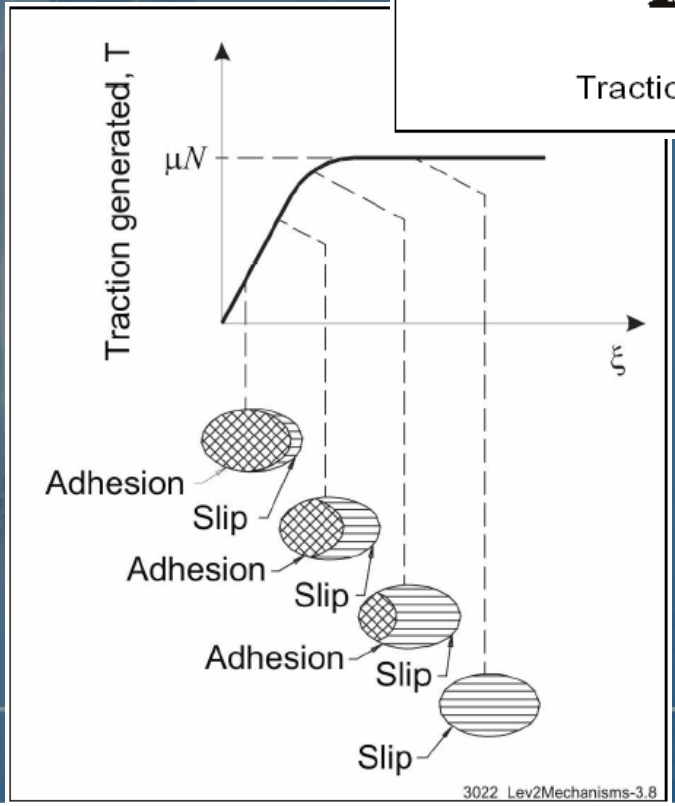
Level 2: The Action of Railway Wheelsets on Track

Quasi-static surface stresses and tractions



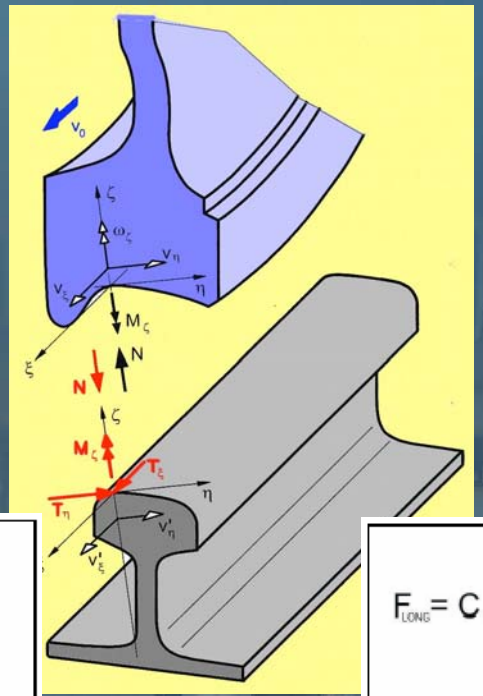


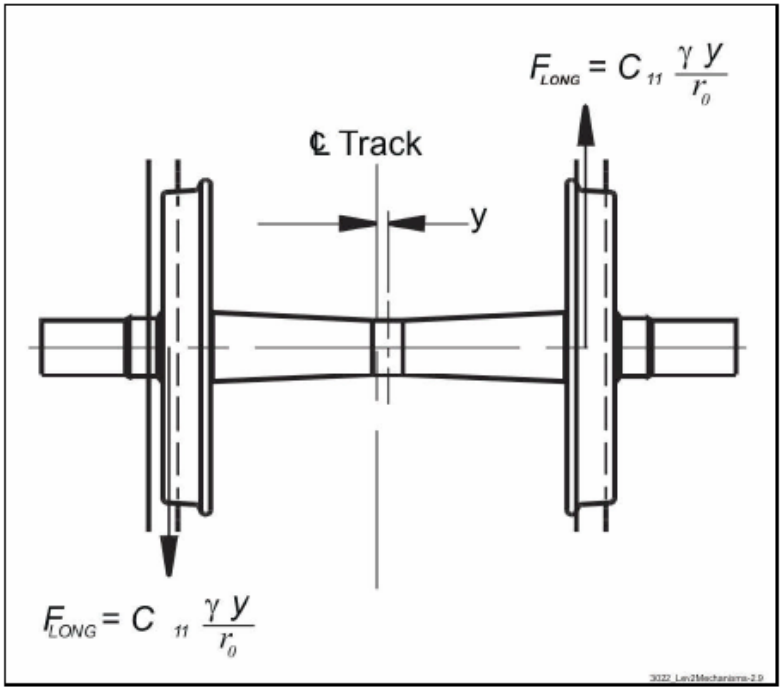


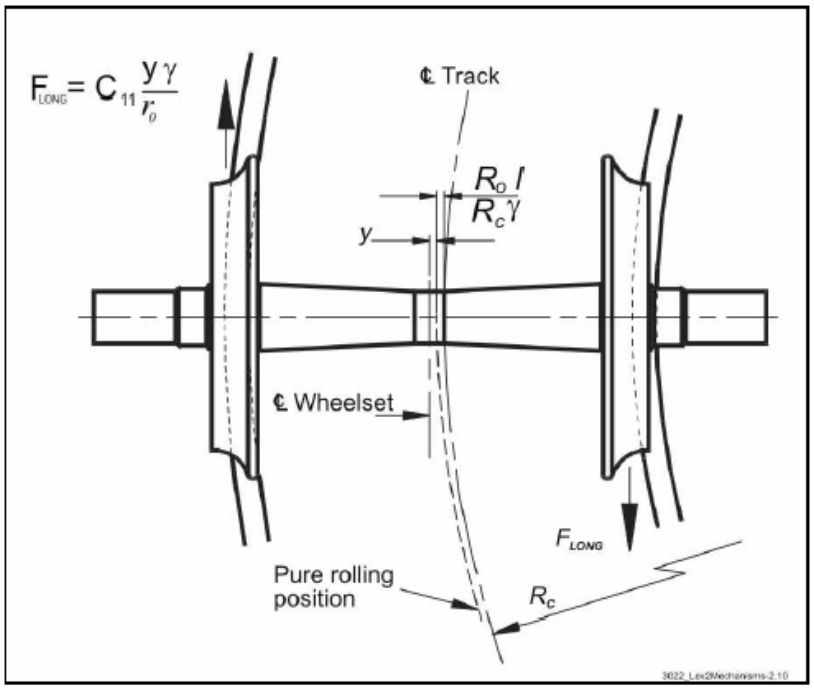


Level 2: The Action of Railway Wheelsets on Track

Longitudinal creep forces

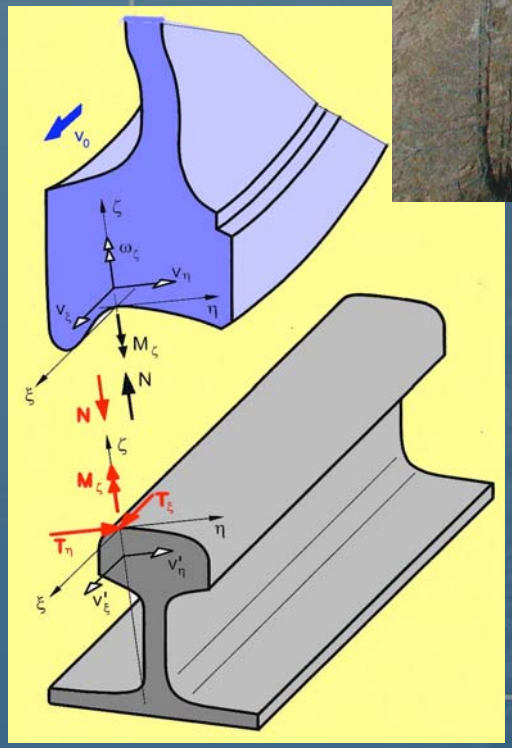


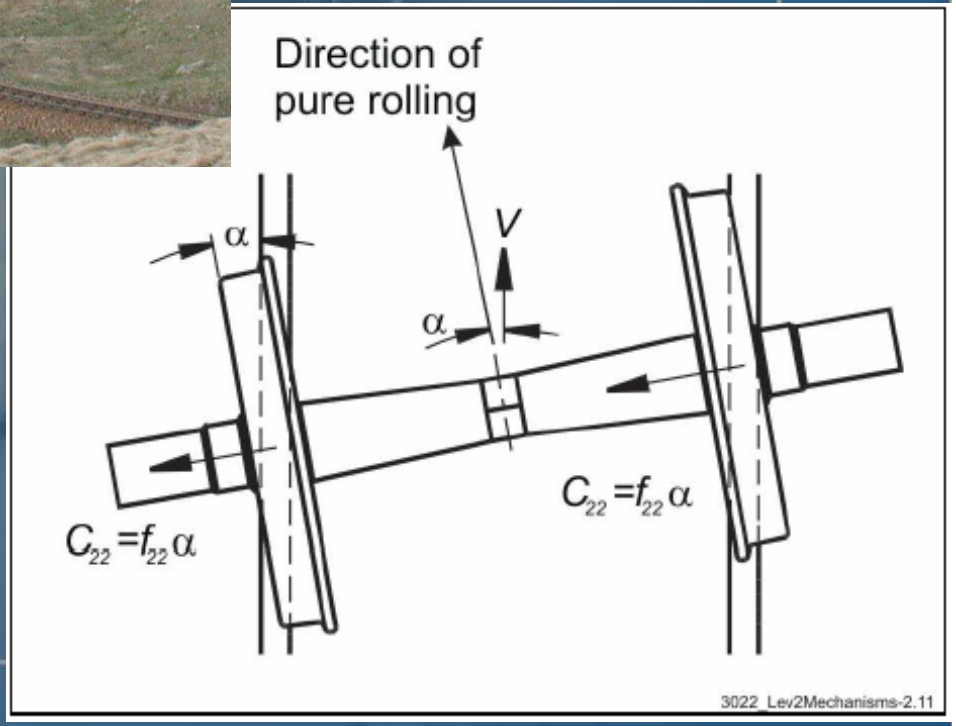




Level 2: The Action of Railway Wheelsets on Track

Lateral creep forces

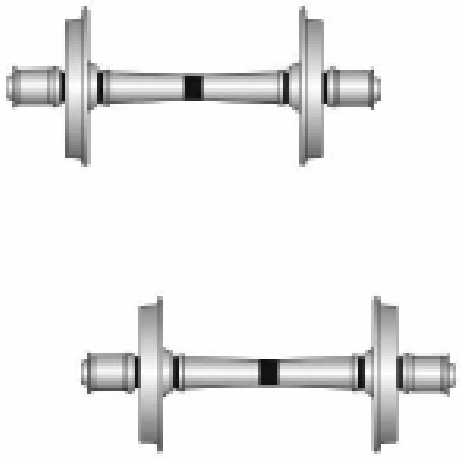




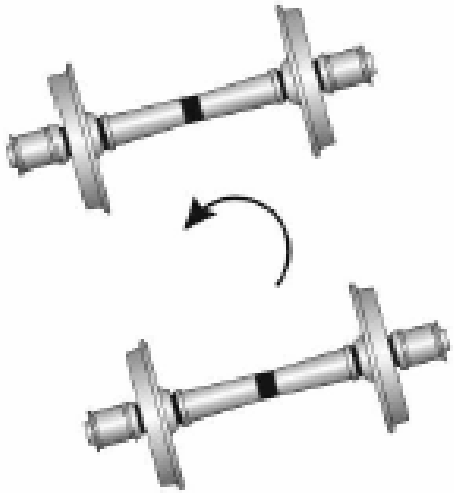
Level 3: The Influence of Suspension System on the Action of a Railway Wheelsets

Influence of Suspension Systems and Continuous Track Geometry on Contact between a Railway Wheelset and the Rail

yaw mode



shear mode



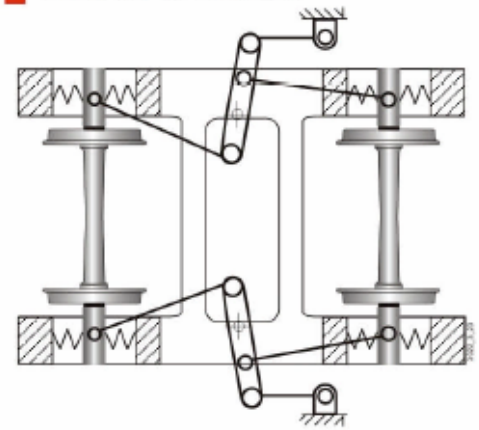
bogie yaw

Level 3: The Influence of Suspension System on the Action of a Railway Wheelsets

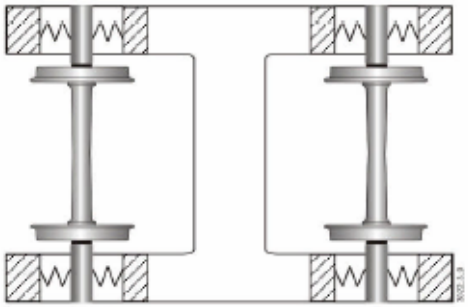
Different Design Approaches

Europe

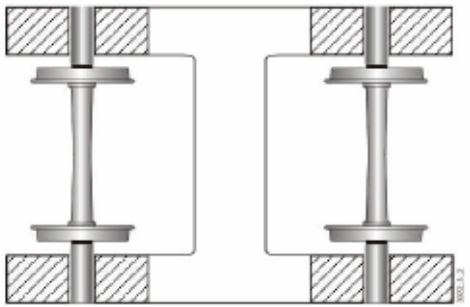
1 Running gear with linkage-steered wheelsets



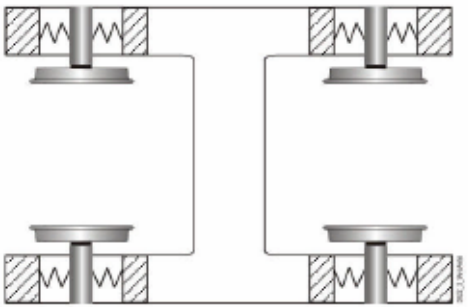
2 Running gear with steered wheelsets (soft guidance)



3 Running gear with steered wheelsets (stiff guidance)



4 Running gear with independent wheelsets



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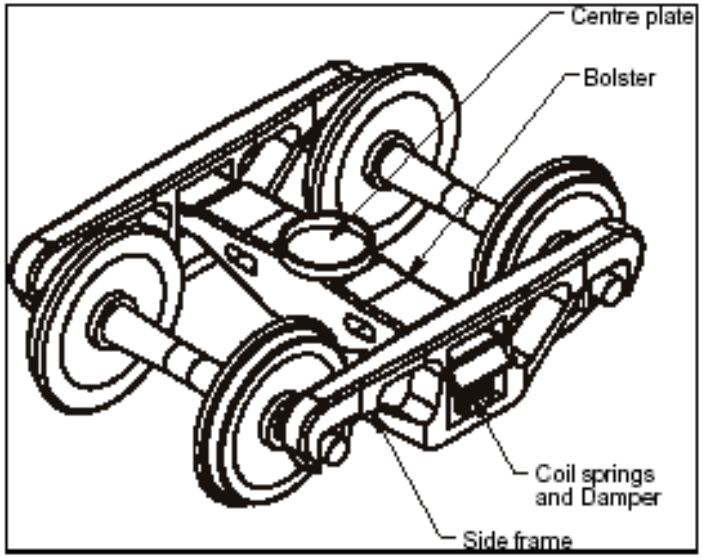
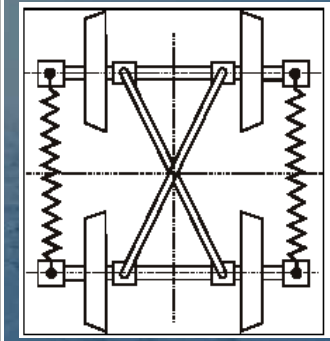
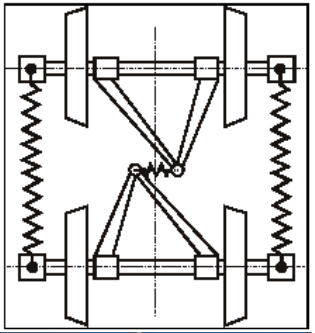
Heavy haul





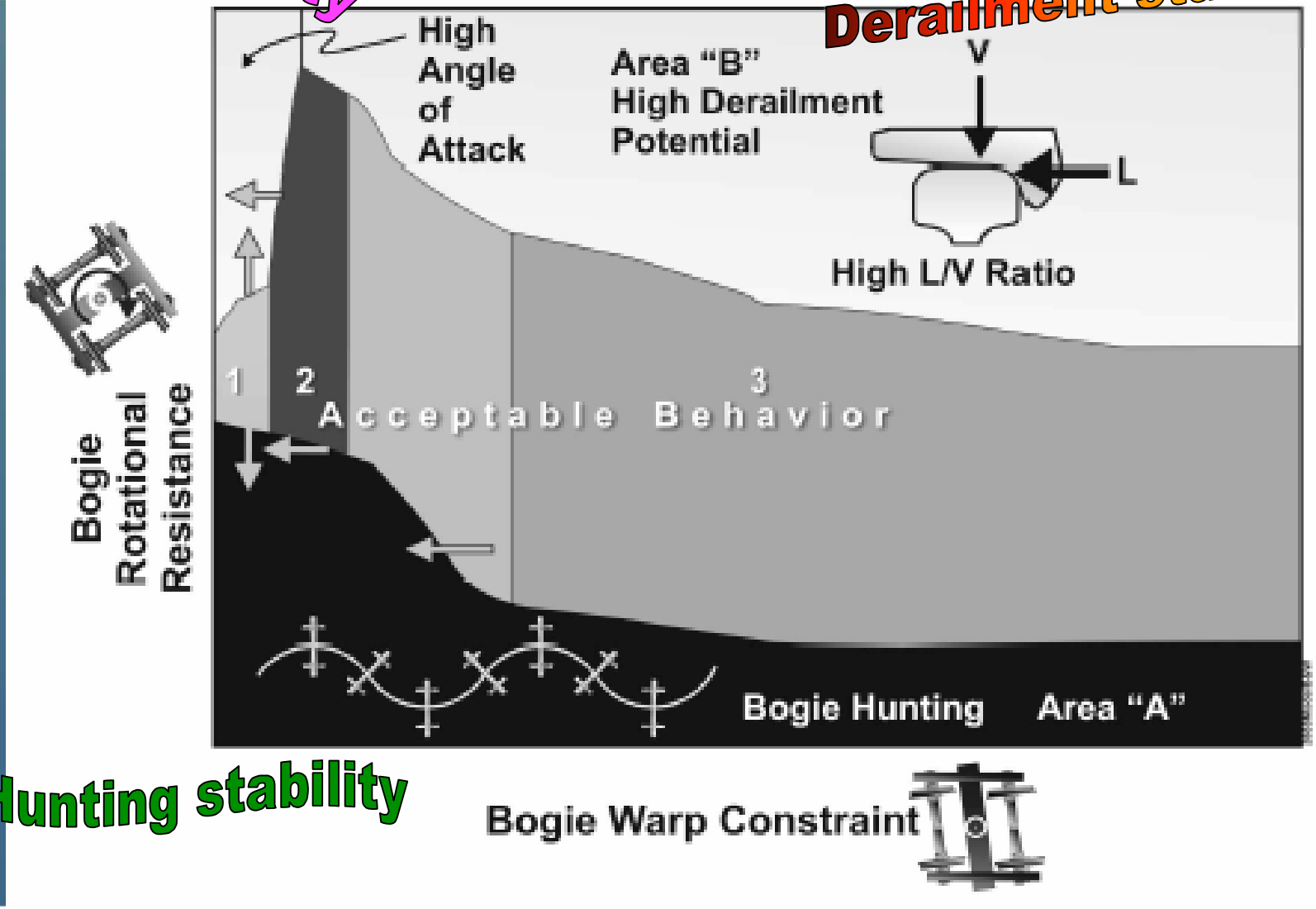


Level 3: The Influence of Suspension System on the Action of a Railway Wheelsets

Balance between rotational constraint and warp stiffness

Curving ability

Derailment stability



Hunting stability

Bogie Warp Constraint