“Here in the place of that Hijli detention camp stands this fine monument of India, representing India’s urges, India’s future in the making”

--- Pandit Jawaharlal Nehru – 1st Prime Minister
Centre for Railway Research

- First Centre for Railway Research (CRR) set up by Indian Railways (IR) at IIT Kharagpur for a long-term research framework MoU signed on February 13, 2010.
- Projects with RDSO collaboration funded by IR on the following major thrust areas:
  - High Speed Rail
  - Heavy Haul Technology
  - Advanced Materials and Manufacturing
  - Advanced Maintenance and Operation
- New Areas of Research
  - Computational Intelligence, Analytics and Optimization
- Human Resource Development
  - Short term courses on railway research
  - M.Tech. program on Railway Engineering
  - Ph.D. students working on Railway Research
Plan for growth of CRR

- Science universal – National/Foreign collaboration for Research and HR development
- Technology local - National R&D for local adaptation
Research Capacity Building

Design of Bolsterless bogie for 250kmph & 350kmph passenger coach – academic interaction with KTH (Sweden), U of Tokyo

Performance Enhancement of Ballasted Rail Tracks – potential for heavy haul and high speed

Vision
Build resources
Master the technology
Develop & transfer new technology

High-Speed

Heavy-Haul

Materials

Safety

Maintenance

OHE Monitoring System – indigenous product development to save cost

Rail wheel creep and warping research to help set operational standards

Validate signalling interlocks to eliminate human error in signal design – formal verification methods developed for VLSI circuits being applied to railways

Designed Steel: 370VHN

Develop new rail steel to carry increased axle load from 25MT to 32MT and increase rail life – academic interaction with Cambridge U
Research Capacity Building

Wind Tunnel Facility with Moving Floor

Aerodynamic Design of High Speed Rolling Stock

Safe Seating and Berthing Arrangements for Indian Rail coaches

Fault Diagnostics for Motors and Bearings of Locomotives for preventive maintenance

High Speed

Civil Infrastructure

Malfunctions

Physical System

Numerical Model

Simulation

Location of Sensors and Structural behaviour

Health Monitoring for Railway Bridges

Water level monitoring for flood

Development of Standards for Steel Concrete Composite Bridges for high speed trains
A Roadmap for CRR

• Where are we?
  • Projects on Track, Bridge, Maintenance, Materials, Vehicle Dynamics, Signal, Heavy Haul, High Speed
  • Essentially directed basic research up to TRL 3-4
  • To take it up to TRL 7 it is essential that Teams get connected to IR technology units

NASA Steps to mature technologies and integrate them into systems

• To develop global technology standard essential to connect to global railway research
Maturing Technologies to Products

Institute activity

- Suspension and bogie design
- Bainitic steel for railway tracks
- Online monitoring system of OHE traction parameters.
- Modelling and validation of interlocking for railway signalling systems

Lab R&D
- Concept
- Lab demo

Scaled up
- Economics and viability

Product
- Reliability, Optimization for cost and quality

Industry
- Industry Partners
  - BEML
  - SAIL
  - National/Multinational Industry (discussion stage)

Institute activity

- Fog vision
- Rail/weld defect detection
Implementation of Shinkansen-like Design

- Implements air spring, laminated rubber (chevron) spring, lateral and anti-yaw dampers, steering mechanism, graded circular wheel profile, directional primary spring stiffness, friction damping, etc.
- Ride comfort on test track
- Derailment speed: 288kmph on 4km radius irregular curved flexible track; 360kmph on straight track.
- Maximum speed on turnouts and frog-points limited to 108kmph
Accurate characterization of material behavior at high temperatures
Valid material models for creep response
Propose possible changes in material and manufacturing procedure, brake design, braking pattern and wheel design.

**Recommendations:**
- Brake blocks used on locomotives and coaches/wagons must be of a single make
- Maintenance practices must be altered to ensure effective braking of all wheel sets.
- For better troubleshooting in event of failure, sensor data must be stored for over 90 days
- Mechanisms must be evolved to monitor wheel gauge even during running condition.

**Creep and Warping in Wheel Sets**

**Temperature Profiles**

**Sensor locations**
Online monitoring system for OHE traction parameters

Tested technology with offline processing done at IIT Kharagpur in 1999.

- Carry out live scanning of contact wire in dynamic condition
- Measure contact wire thickness, height, stagger and slope with location
- Thickness of contact wire up to 16.5 mm, target resolution 0.3 mm
- Stagger up to 700/350 mm, target resolution 5mm
- Height of the contact wire, target resolution of 5mm

All above targets achieved in laboratory and in initial trial run. Refinement of algorithms and field prototype in progress
Development of bainitic rail steel of low carbon low alloy or low carbon micro alloyed steel possessing good weldability properties.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Present 880 Grade</th>
<th>Lab. Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microstructure</td>
<td>Pearlitic</td>
<td>Bainitic</td>
</tr>
<tr>
<td>Ultimate Tensile Strength (MPa)</td>
<td>880 (Min.)</td>
<td>1000 (Min.)</td>
</tr>
<tr>
<td>Impact Energy (Joules)</td>
<td>10</td>
<td>2 times higher</td>
</tr>
<tr>
<td>Fracture Toughness (MPa.m⁻⁰.⁵)</td>
<td>29</td>
<td>50</td>
</tr>
<tr>
<td>Wear Resistance</td>
<td></td>
<td>Twice of present grade</td>
</tr>
</tbody>
</table>

Steel compositions (wt%)

<table>
<thead>
<tr>
<th>Steel</th>
<th>C</th>
<th>Mn</th>
<th>Si</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Rail Steel (Gr. 880)</td>
<td>0.74</td>
<td>1.04</td>
<td>0.31</td>
</tr>
<tr>
<td>Designed Steel</td>
<td>Low C, low alloy steel containing Mn, Si, Cr, Mo, Ni</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thermomechanically Processed High Strength Bainitic Steel Rails

Present Rail Steel
260VHN

Designed Steel
370VHN
Seating Arrangements for Occupant’s Safety

Study occupants’ injury severity level for current seating/berthing arrangements in IR coaches and possible alternative seating/berthing strategies/orientations/materials

Recommendations:

- Seating arrangements where passengers face train rear: effective way of reducing injuries
- Use of aluminium foam padding sharply reduces the chances of head injury for chair car passengers, and abdomen injury, for passengers seated behind a snack table
- Open bay berth type arrangements in sleeper coaches are not safe in general for passengers in lying down positions.
- Side berths resulted in higher injury severities.
- Use of Geonet netting in sleeper berths can prevent passengers from flying off their berths following a crash.
• Data logger will send sensed data to the remote server for analysis and alerting using GSM/3G.
• Energy of the network is optimized using event detection scheme based data collection. The data collection and transfer to remote site are automatic.
• Scaled model developed for health monitoring.

Water level measurement system consists of radar water level sensors and data logger.

Modelling to find optimum location of sensors.
On-board Intelligent Embedded Platform for Detection of Weak Failure Modes and Prognosis of Severe Faults in Locomotives and Associated Equipment

Fault diagnosis system developed using signature analysis of stator current.
- Development of fault models
- Detectability vs. severity of faults
- Design of intelligent algorithms
- Design of embedded platforms

<table>
<thead>
<tr>
<th>Type of Faults</th>
<th>Stator faults</th>
<th>Rotor bar, end ring, and various eccentricity faults</th>
<th>Bearing faults</th>
<th>Spring faults</th>
</tr>
</thead>
</table>

Detection statistics for Rotor fault

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Missed Detection</th>
<th>False Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.015</td>
<td>7.4%</td>
<td>39.4%</td>
</tr>
<tr>
<td>0.021</td>
<td>10.9%</td>
<td>36.8%</td>
</tr>
<tr>
<td>0.030</td>
<td>15.9%</td>
<td>21.1%</td>
</tr>
<tr>
<td>0.039</td>
<td>19.51%</td>
<td>2.63%</td>
</tr>
</tbody>
</table>
Development of Composite Brake Block

Improvements:
Low specific wear rate
Low optical smoke density
High thermal conductivity

<table>
<thead>
<tr>
<th>SL. No.</th>
<th>Tests as per existing specification</th>
<th>Brake blocks developed at IIT KGP</th>
<th>Existing Samples of brake blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compositon ‘A’</td>
<td>Compositon ‘B’</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Hardness (HRR Scale)</td>
<td>87.7</td>
<td>85.6</td>
</tr>
<tr>
<td>4</td>
<td>Cross Breaking Strength(kg/cm²)</td>
<td>94.3</td>
<td>167.56</td>
</tr>
<tr>
<td>5</td>
<td>Modulus of Elasticity (N/mm²)</td>
<td>1958.48</td>
<td>1390.36</td>
</tr>
<tr>
<td>7</td>
<td>Specific wear rate (cc/kwh)</td>
<td>1.464</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Thermal Conductivity (w/m.k)</td>
<td>0.67</td>
<td>0.64</td>
</tr>
<tr>
<td>9</td>
<td>Optical Smoke Density</td>
<td>11.51</td>
<td>83.63</td>
</tr>
</tbody>
</table>
India has started replacing all interlocking equipment with software controlled EI equipment.

Manually developed application logic used to program electronic interlocking equipment. This may lead to proliferation of errors (even after rigorous FAT and SAT testing).

Cases reported from UK and Australia.

The use of formal methods has been recommended in EN50128 railway systems.
Aerodynamic study of traction rolling stock for high speed

- Drag studies on existing Indian Railways train shapes
- Convergence to more efficient shapes for aerodynamic drag and noise reduction

Flow over a WAP-7 locomotive pulled train at 125kmph and a streamline body train at 300 kmph

Design of Low noise wind tunnel

Vortex shedding around simplified model of high speed train under side wind
Manpower Development

**Degree course**
M.Tech in Railway Engineering started in July 2015
(20 seats for Indian Railways, 10 seats for others)

**Railway officers pursuing degree programs:**
MTech. – Six (continuing)
PhD. – Three (continuing)
MS – One (continuing)

Students working on sponsored railway research projects
M Tech. – Twenty four (completed)
PhD. – Three (completed) and Three (continuing)

**Short Courses**
GIAN (Micro-credit course)
  High Speed Rail Systems (Winter 2014)

1 week courses under Continuing Education
  Design and Analysis software for railway applications
  RAMS for railways

**Lectures/Workshops by International experts**

2. Algorithm of fog removal from images – Patent filed, received award under DST-Lockheed Martin India Innovation Growth Programme (IIGP) 2016

**Possible patents**
1. Bainitic Steel
2. Instrument for OHE monitoring
3. Validation of interlocking for railway signalling systems

**Awards**
Uchchatar Avishkar Yojna – UAY-2016 (Pradhan Mantri Yogana Scheme)

Project Title: Advanced bogies and rail wheel traction control for meeting high standards of comfort, safety and performance of metro coaches

**Publications (2014 – 2016)**
- Journals – 14
- Conference proceedings – 7
- Book chapters – 3
Centre for Railway Research

G+7 building under construction

G+7 building

- G+4 with 4500 m² floor space completed (funded by IR)
  Research and teaching laboratories in railway engineering
Strategies to build and nurture the missing links needed!
THANK YOU!