SOFTWARE USED

- UNIGRAPHICS (NX) CAD
- TEAM CENTER PDM
- ANSYS FEM
- MSC Nastran Fatigue Analysis

CAD - COMPUTER AIDED DESIGN
PDM - PRODUCT DATA MANAGEMENT
LOCOMOTIVE UNDERFRAME
DETAIL OF UNDERFRAME
LOCO UNDERFRAME WITH SUB ASSEMBLIES
PIPING & ROUTING
HOOD OVER ENGINE ASSEMBLY
LOCOMOTIVE CAB
ELECTRICAL CABINET
LOCOMOTIVE SHORT HOOD
CONTROL STAND
DIGITAL LOCO DIESEL
PROJECT/LOCO DESIGN COMPLETED
WDM3D END CAB
PROJECT/LOCO DESIGN Completed

BG Sri Lanka 2300 hp

BG Bangladesh 2600hp

MG Vietnam 1300hp

MG Malaysia 2300hp
COACH BOGIE DESIGN AND AIR SUSPENSION

- TOPICS ON BOGIE DESIGN
  - MODES OF COACH BODY OSCILLATION.
  - DESIGN OF BOGIE COMPONENTS.
  - DESIGN OF SUSPENSION ELEMENTS.
  - VEHICLE DYNAMICS SIMULATIONS.
  - FIELD TRIALS.
- TOPICS ON AIR SUSPENSION
  - NEED FOR AIR SUSPENSION.
  - DETAILS OF AIR SUSPENSION.
  - CONTROL EQUIPMENTS.
  - DESIGN.
  - ADVANTAGE.
DESIGN REQUIREMENT

- GAUGE
- SPEED
- AXLE LOAD
- MAX MOVING DIMENSION
- MIN CURVE NEGOTIATION
- ANY OTHER SPECIFIC REQUIREMENT.....
BOGIE DESIGN

- VEHICLE MOTION QUANTITIES.
- DEGREES OF FREEDOM.
- VIBRATION EXCITATION.
- SUSPENSION DESIGN.
- SAFETY AGAINST DERAILMENT.
- RIDING QUALITY.
- RESONANCE AND HUNTING
- VEHICLE DYNAMICS SIMULATIONS.
- OSCILLATION TRIALS.
Figure 7.1  Degrees of freedom
RESONANCE ACCLN.

FIRST: \( \omega_1^2 \cdot x_0 \cdot \sqrt{1 + 4D^2} \)

SECOND: \( \frac{\omega_1 \cdot \omega_2 \cdot x_0 \cdot \sqrt{(\omega_2/\omega_1)^2 + 4D^2} \cdot \sqrt{1 + 4D^2}}{(M/\gamma) \cdot (\omega_2/\omega_1) \cdot 2D_2 + 2D_1} \)

\[ D \approx \frac{P_C}{2(n_1m + M) \cdot \omega_1} \]

\[ P_C \approx C \cdot n_1^2 + C_2 \cdot n_2^2 \]

\[ n_1 = \frac{d_1}{(d_1 + d_2)} \quad \text{and} \quad n_2 = \frac{d_2}{(d_1 + d_2)} \]

\[ d_2 = \text{STATIC BOLSTER SPG. DEF.} \]
\[ d_1 = \text{STATIC AXLE BOX SPG. DEF.} \]

EFFECT OF VISCOUS DAMPING ON ACCLN. TRANSMISSIBILITY
VEHICLE DYNAMIC SIMULATIONS
(MATHEMATICAL MODELING)

SOFTWARE PACKAGES

NUCARS

- VEHICLE RELATED
- TRACK RELATED
- RAIL/WHEEL CONTACT

VEHICLE MODEL

• NUCARS - NEW UNTRIED CAR ANALYSIS REGIEM SIMULATIONS
• ADAMS RAIL – AUTOMATIC DYNAMIC ANALYSIS OF MECHANICAL SYSTEMS

ADVANTAGES

• MODEL OF ANY RAILWAY VEHICLE CAN BE DEVELOPED.
• ASSESMENT OF VEHICLE RIDING AND STABILITY.
• PARAMETRIC OPTIMISATION OF SUSPENSION
• HAZARD FREE
• COST EFFECTIVE
### Loaded Condition Straight Track

<table>
<thead>
<tr>
<th>SPEED (kmph)</th>
<th>Oscill. Trial Results</th>
<th>Phoenix NUCARS</th>
<th>Contitech NUCARS</th>
<th>Oscill. Trial Results</th>
<th>Phoenix NUCARS</th>
<th>Contitech NUCARS</th>
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</table>

#### Vertical Ride Index

- **Oscill. Trial Results**
- **Phoenix NUCARS**
- **Contitech NUCARS**

#### Lateral Ride Index

- **Oscill. Trial Results**
- **Phoenix NUCARS**
- **Contitech NUCARS**

![Graph](image_url)
LOADED CONDITION 2-degree TRACK

<table>
<thead>
<tr>
<th>SPEED</th>
<th>VERTICAL RI</th>
<th>LATERAL RI</th>
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</table>

![Graphs showing vertical and lateral ride index vs. speed in kmph for different conditions and vehicles.](image-url)
AIR SUSPENSION

FOR

COMFORT

SAFETY

AND

RELIABILITY WITH

ECONOMY
ADVANTAGES OF AIR SUSPENSION

- MAINTAINS SAME HEIGHT BY LOAD SENSING.
- ADEQUATE BOGIE CLEARENCES.
- LOW VIBRATIONS AND NOISE.
- LOW SPACE REQUIREMENTS.
- ALMOST SAME NATURAL FREQUENCY UNDER EMPTY AND LOADED CONDITIONS.
- BETTER RIDING QUALITY.
- REDUCED LATERAL FORCES.
- INCREASE IN SPEED POTENTIAL.
- LOW MAINTENANCE.
BOGIE SYSTEM ON WDG2, WDP1 & WDP2 LOCOMOTIVES
BOGIE DESIGN CRITERIA

- Axle load
- Speed Potential
- Adhesion requirement
- Curve negotiability
- Bogie dynamics based on the given track parameters and wheel profile
  - L/V ratio
  - Lateral force
  - Lateral and Vertical Acceleration
  - Ride Index
  - Bogie Swing
BOGIE DESIGN CRITERIA

(Contd.)

- Kinematics of bogie linkage
- Bogie Clearances
- Weight Transfer
- Axle load equalization
- Braking
- Rail bending Stiffness
BOGIE CLASSIFICATION

- Based on Suspension
  - single stage)
  - Flexi-Coil (Two stage)
  - High adhesion (Two stage)
- Based on Wheel/Axle mechanism
  - Rigid
  - Radical – Power Steering
    Self Steering
Dynamics of Vehicle

Wheel set Dynamics

Bogie Dynamics

Carbody Dynamics
BOGIE COMPONENT DESCRIPTION

BOGIE FRAME
- Integral cast Bogie frame
- Fabricated
- Cast

SUSPENSION
- Single Stage
  - Steel helical coil spring
  - Rubber
BOGIE COMPONENT DESCRIPTION

- Two Stage
  - With bolster
  - Without bolster

- Hydraulic dampers
  - Primary (Vertical, Lateral, yaw damper)
  - Secondary (Vertical & Lateral, Yaw Damper)
  - Traction motor damper – used in case of fully suspended traction motor
BOGIE COMPONENT DESCRIPTION

- **Traction Arrangement**
  - Primary
    - Pedestal (Horn)
    - Guidelink or Primary traction rod
  - Secondary traction
    - Chaffing plate
    - Traction bar
    - Secondary traction rod

- **Pivot Pin Assembly**
  - Rigid Pivot
    - Takes vertical carbody load
  - Floating Pivot
    - Used in Two-stage suspension
BOGIE COMPONENT DESCRIPTION

MOTOR SUSPENSION

- Nose suspended
  - Nose Sandwich
  - Nose link type
- Fully suspended
  - Flexible coupling required to take care of misalignment of gear and pinion
- Suspension bearing
  - Plain type
  - Roller type
BOGIE COMPONENT DESCRIPTION

WHEEL, AXLE & BEARING JOURNAL

- Wheel
  - Curved web
  - Straight web (for disc brake fitment)
- Axle
  - Solid axle
  - Hollow Axle
- Bearing
  - Cylindrical Roller
  - Taper Roller
BOGIE COMPONENT DESCRIPTION

BRAKE RIGGING

- Conventional
  - Single or double clasped
  - Cast iron brake block
  - Composite brake block

- TBU

- Disc type (for high speed operation)

- Parking brake
  - In-built in TBU
  - Separately designed by SAB WABCO
BOGIE COMPONENT DESCRIPTION

- **Sanding Arrangement**
  - Bogie mounted
  - Carbody mounted

- **Safety Component**
  - Horn stay plate
  - Lifting connection
  - Lateral & vertical stop component
  - Liners; Horn, pivot and wearing surface
  - Safety strap
HIGH ADHESION BOGIE
Basic design features

- Bogie weight 25t
- Axle load 20.5t
- Wheel base 3800 mm
- Journal centers 2300mm
- Designed speed 110km/h
- Un-sprung mass 13.05t
Basic design features

- Bogie Frame Box Section H type
- Horn guide axle guidance
- 16 nos. primary springs 40.8 kg/mm
- 08 nos. secondary springs 644 kg/mm
- Deflection primary 102mm & Sec. 17 mm
- Damper primary Vertical 750 kg/10cm/sec
- Damper secondary Lat 1150 kg/10cm/sec
Bo-Bo BOGIE
Two Axle (Bo-Bo) Bogie

- Axle Load 20 T
- Bogie weight 15.5 T
- Unsprung weight 4.3T
- Wheel base 2800 mm
- Journal centre 2300 mm
- Speed Potential 120 kmph on Rajdhani Standards track
- Two Axle bolsterless bogie with two stage suspension
- ‘H’ shaped bogie frame of fabricated box type construction
- High strength corten steel (IRS M41) used to reduce weight of bogie frame
Two Axle (Bo-Bo) Bogie (contd.)

- Helical coil springs used both in Primary & Secondary stages
- Floating type centre pivot arrangements for transfer of traction and braking forces between bogie and carbody
- Lateral guidance provided between bogie and carbody by flexi-coil action of secondary springs
Two Axle (Bo-Bo) Bogie (contd.)

- Conventional horn guide arrangement for transfer of traction & braking forces between axle and bogie frame
- Four vertical hydraulic dampers at primary stage, one at each axle box
- Two vertical hydraulic dampers & two lateral hydraulic dampers at secondary stage
- Axle hung nose suspended BHEL 4906 AZ Traction Motors
- Tread brake unit is provided for brake rigging
FLEXI-COIL BOGIE
WDP2 Locomotive
DESIGN FEATURE
OF
FLEXI-COIL MARK-5 BOGIE FOR WDP2 LOCOS

* WHEEL BASE
  (1800+2120) 3920 mm

* JOURNAL CENTRES
  2222 mm

* BOGIE SIZE
  4450 x 2970 mm

* DESIGN SPEED
  180 km/h.

* BOGIE WT.(COMPLETE)
  25.2 t.

* AXLE LOAD
  19.4 t.

* UNSPRUNG MASS
  12.48 t. PER BOGIE

* BRAKES
  CONVENTIONAL

* BOGIE FRAME

* AXLE GUIDANCE

* PRIMARY SPRINGS

* SECONDARY SPRINGS

* DEFLECTION (mm)

* DAMPER CAPACITY
  (Kg/10 Cm/Sec.)

* BOX SECTION-H SHAPE

* HORN GUIDE/GUIDE LINK
  12 x 57.2 Kg/mm
  8 x 55 Kg/mm

* PRIM. = 68, SECY. = 79

* PRIMARY VERTICAL = 600 Kg.
  SECONDARY VERTICAL = 750 Kg.
  SECONDARY LATERAL = 900 Kg.
FLEXI-COIL Mk-5 BOGIE FOR WDP2 LOCO

- Axle Load 19.5 T.
- Speed Potential 160 Km/h on Rajdhani Standard Track.
- Three Axle Bogie with Bolster.
- Fabricated Box Type Bogie Frame.
- Two Stage Suspension with Helical Coil Springs in both the stages.
- Lateral guidance between car body & bogie provided by flexi-coil action of secondary springs.
Four primary hydraulic vertical dampers, one each at end axle box.

Four vertical hydraulic dampers & two lateral dampers at secondary stage of suspension.

On end axles, axle guidance provided by guide links. On middle axle by conventional horn arrangement.

Functions of guide links:
- Provides flexible control of lateral & yaw motion of axle, reduces hunting tendency of bogie.
- Transfer of traction & braking force between axle & bogie.
FLEXI-COIL Mk-5 BOGIE FOR WDP2 LOCO (contd.)

- Two traction bars (fitted with pre-compressed rubber pads) transfer traction and braking forces between bogie & bolster.
- Traction bars located at axle box level to minimise weight transfer.
- Nylatron liners on centre pivot provides yaw damping between bolster and car body.
- Axle hung nose suspended light weight BHEL 5002 AZ TM with roller suspension bearings.
- Conventional type brake rigging arrangement.
## COMPARISON OF DESIGN FEATURES OF BOGIES OF WDP1, WDP2 AND WDG2

### Locomotive

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>WDP1</th>
<th>WDP2</th>
<th>WDG2</th>
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<tbody>
<tr>
<td>1</td>
<td>Axle Load, t</td>
<td>20</td>
<td>19.5</td>
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<tr>
<td>2</td>
<td>Wt. Of bogie frame, t</td>
<td>2.2</td>
<td>3.4</td>
<td>4.5</td>
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<tr>
<td>3</td>
<td>Wt. Of Assembled bogie, t</td>
<td>15</td>
<td>25</td>
<td>25</td>
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<tr>
<td>4</td>
<td>Wt. Of Traction motor, t</td>
<td>3.6</td>
<td>3.69/3.19</td>
<td>3.75</td>
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<tr>
<td>5</td>
<td>Wheel Base</td>
<td>2800</td>
<td>3920 (2120+1800)</td>
<td>3800(1900+1900)</td>
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<tr>
<td>6</td>
<td>Axle Arrangement</td>
<td>Bo-Bo</td>
<td>Co-Co</td>
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<td>7</td>
<td>Design Speed Km/h</td>
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<td>Starting TE, t/loco</td>
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<td>Bogie Frame</td>
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<td>Unsprung mass/axle, t</td>
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<td>Traction motor suspension arrangement</td>
<td>Axle hung nose suspended</td>
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<td>Suspension (a) Primary</td>
<td>Helical coil Spring - do -</td>
<td>Helical Coil Spring - do -</td>
<td>Helical Coil Spring Rubber Sandwich</td>
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<td>(b) Secondary</td>
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<td>Damping – Primary-Vert</td>
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<tr>
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<td>- Secondary – Vert</td>
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<td>- Lateral</td>
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## COMPARISON OF DESIGN FEATURES OF BOGIES OF WDP1, WDP2 AND WDG2 LOCOMOTIVE (contd.)

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<th>WDG2</th>
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<tr>
<td>14.</td>
<td>Longitudinal guidance of wheel set</td>
<td>Horn guides</td>
<td>Guidelink</td>
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<td>15.</td>
<td>Lateral wheel set guidance</td>
<td>Lateral thrust pad</td>
<td>Guide Link thrust pads on end axle boxes</td>
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<tr>
<td>16.</td>
<td>Longitudinal guidance of loco body</td>
<td>Center pivot with rubber bush</td>
<td>Traction bar fitted with rubber pads at both ends</td>
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<td>17.</td>
<td>Lateral guidance of loco body</td>
<td>Secondary flexi-coil springs</td>
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BOGIES FOR EXPORT

- TANZANIA
- ANGOLA
- MOZAMBIQUE
- SUDAN ARE........
TENTATIVE BOGIE GENERAL ARRANGEMENT FOR CAPE GAUGE MOZAMBIQUE LOCO.
Thank You