Enhancing Lightweight and Production Efficiency of Commercial Vehicles with New Generation Structural Adhesives and Modular Composite Components

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LIGHTWEIGHT TRENDS IN COMMERCIAL VEHICLES

- Introduction of lightweight solutions and modular design for large parts
- New hybrid/mixed material design approaches
- More efficient production of commercial and special vehicles
- Improved passenger safety and vehicle structural integrity
TRADITIONAL BUS BUILDING

Conventional BIW design with several metal segments joined by welding or bolts

24 h production with 3 shifts and several workers on the line

Large and heavy panels that add additional weight

Sources: JCB, Van Hool, Ashok Leyland, Yutong
INNOVATING IN BUS BUILDING

Structurally Bonded Integral Composite Sandwich Roof for Buses and Coaches

- New lightweight solution must show **OEM approved performances**
- Innovation must provide advantages both in **design phase** and in **production**

Heavy metal roof design with separate insulation and exterior/interior claddings

Pre-assembled sandwich module directly bonded on bus/coach walls
Approved Engineering Performance
- Weight reduction of more than 500 Kg
- Enhanced stiffness for all load cases
- Better stress distribution (no concentration)
- Properties stability from -40 °C to 100 °C
- Additional modules and mixed material design

Proven Advantages in Production
- Bus roof ready in 2 hours
- Fewer workers required for assembly
- Less and faster production steps
- Easier adhesive application: compressibility, low viscosity, non-sag, no VOC and no smell
- Suitable for automatization
HOW DO WE ACHIEVE THAT?

INNOVATIVE STRUCTURAL BONDING + SANDWICH PANELS
NEW GENERATION STRUCTURAL ADHESIVES
SIKA PATENTED INNOVATIONS

SikaPower®
1C and 2C Epoxy Adhesives

SikaForce®
2C Polyurethane Adhesives

Sikaflex®
1C Polyurethane and STP Adhesives

Strength, Modulus

Curing by Design & Powerflex Technologies

- Structural elasticity
- Stability over temperature
- Enhanced curing behaviour

Strength = $10 \div 20$ MPa
E-modulus = $20 \div 800$ MPa
Elongation = $100 \div 400$ %
NEW GENERATION STRUCTURAL ADHESIVES
SIKA PATENTED INNOVATIONS

CURING BY DESIGN
SNAP CURE TECHNOLOGY

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CURING BY DESIGN TECHNOLOGY
FIELD APPLICATION

- With standard adhesive technology:
  - Need for 6 people to apply adhesive at same time!
  - Waiting time for next assembly steps: 8-12 h
CURING BY DESIGN TECHNOLOGY
FIELD APPLICATION

- **With Curing by Design technology:**
  - Only 1-2 people can complete the job using cartridges or a pumping system
  - Waiting time for next assembly steps: 2 h
**POWERFLEX TECHNOLOGY**

Dynamic Mechanical Analysis

- **Tg < -40 °C**
- Standard adhesive used in Commercial Transportation
  - too brittle
  - too soft
- **Powerflex Technology**
  - still flexible
  - still stiff

Storage Modulus [MPa]

Temperature [°C]

New Technology

Standard Technology

Service Temperature Range
POWERFLEX TECHNOLOGY
ADVANTAGES FOR DESIGNERS AND MANUFACTURERS

- Risk of substrate, coating or adhesive failure if the joint is too rigid or brittle
- Risk for structural integrity if the joint is too weak to transfer loads

- New SikaForce® adhesives based on Powerflex technology allow designing with smaller reduction factors
- Stable properties over temperature enable more precise and reliable FEM simulations of the joints
TECHNICAL SUPPORT FOR MANUFACTURERS
MATERIAL DATA AND MODELLING

- Providing more than datasheets values to support advance material modelling

- TAST: Thick Adherent Shear Test

- BJTT: Butt Joint Tensile Test

- DCB: Double cantilever

- Unidirectional, Planar and Biaxial tests

INTEGRAL SANDWICH PANEL TECHNOLOGY
DESIGN OF V-NOTCHED ROOF PROFILES

- Load carrying skins made of aluminium
- Pre-painted skins
- Integrated interfaces as cant-rails for structural bonding in hybrid design
- Interior skin with end decor and customized coil coatings
- Tested low-density thermal insulating core material meeting fire requirements for bus and rail application

**Integral design** with freedom to accommodate additional top loads such as battery compartments, ACU climate systems, baggage compartments, etc.
INTEGRAL SANDWICH PANEL TECHNOLOGY
STRUCTURAL, LIGHTWEIGHT, STIFF MODULAR ELEMENTS

- Integral Roofs

- Intermediate Floors

- Structural Low Floor Chassis
  (with heating option)
Reduced weight thanks to design with fewer components and lighter materials.

<table>
<thead>
<tr>
<th>Performance of Roofs under Heavy Load (CNG, Batteries and ACU)</th>
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<tbody>
<tr>
<td>12.1 m busses (engine weight is not included)</td>
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<tr>
<td><strong>High Loads Equip.</strong></td>
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<tr>
<td>Batteries/ Tank</td>
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<tr>
<td>ACU</td>
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<tr>
<td>Equipments</td>
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<tr>
<td><strong>Passengers</strong></td>
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<tr>
<td>Standing</td>
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<td>Sitting</td>
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<tr>
<td><strong>Gross mass of vehicle loads</strong></td>
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<td><strong>Tare mass &amp; Weight reduction</strong></td>
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<tr>
<td>LOW ENTRY BUS</td>
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<td>6’471 kg</td>
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<td>6’674 kg</td>
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<tr>
<td>12’975 kg</td>
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<tr>
<td>12’976 kg</td>
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<td>- 203 kg</td>
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<td>- 562 kg</td>
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</tbody>
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INTEGRAL SANDWICH PANEL TECHNOLOGY
EXPERIENCE IN DESIGN AND PROCESS

Series production tram sandwich roof ➔ Development: battery & fuel cell buses

- Although lighter, the **stiffness is increased** due to better stress distribution using adhesive joints and sandwich structures

- Increased stiffness brings **better roll-over performance** and **safer vehicles**
To show proof of structural crashworthiness (ECE R66), manufacturers can run either full-size tests or FEM simulations of whole large passenger vehicles.

Sources: Bonluck Bus, MAN Truck & Bus AG, Advanced Structures India
Validation: FEM simulations including non-linear material behavior for each component and adhesive

Technical support for segment testing
CONCLUSIONS

- Innovative **structural adhesives** and **customizable sandwich components** enables to maximize reduction of vehicle weight and structural performance

- Sika and 3A Composites developed **modular lightweight solutions** and support technological implementation at manufacturers

- Proven feasibility in production with **higher efficiency** and **fewer costs**

- Compliancy to **standards** and specific needs in **commercial transportation**
THANK YOU FOR YOUR ATTENTION

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