Double Deck Bus Body Structure and Driver’s Cab Design

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AGENDA

• A Brief History
• Bus Body Structures
  – Design and Analysis
  – Materials
  – Validation
  – Quality Control
• Ergonomic Cab Design
• Weight and cost
• Last lifetime of the vehicle
• Occupant protection
• Functional needs (entrance, egress, vision, seating)
• Structural rigidity – vehicle handling
• Legal requirements
• Customer Specification
BUS BODY STRUCTURES

• Structural grade aluminium extrusions are used
• Specification is grade 6082T6 with an Ultimate Tensile Strength (UTS) of 295 N/mm²
• Bus Structure required to withstand a lifetime of road inputs and have a suitable fatigue strength
• ADL alone have designed and manufactured 40,000 bus bodies using aluminium
• Aluminium has the advantage of high strength to weight thus reducing fuel consumption and road damage
ALUMINIUM vs. STEEL

• In service for over 50 years worldwide in road, rail, aeronautical and marine applications
• Corrosion resistant to give 15+ year life
• Steel design considers limitation at 70% yield point which is typically lower than the 0.2% proof stress used for aluminium
• Using a design criteria on stiffness aluminium gives a lighter structure with the same rigidity
• Reduced weight structures in buses means a lower Centre of Gravity thus making it more stable
• All new design carried out using 3D Computer Aided Design (CAD)
• CAD model then “meshed” for Finite Element Analysis (FEA)
• Analysis replicates the structure undergoing a number of load case scenarios
• Any areas of weakness can be modified before any build undertaken
• Once a prototype is built the structure is then strain gauge tested with the “real life” load cases to validate the original FEA
3D CAD MODEL OF BUS STRUCTURE
ACCELERATED DURABILITY TESTING

- Take real life road load data
- Calculate lifetime damage
- Compress raw data against damage intensity
- Measure loads imposed by various test track surfaces
- Correlate a number of test track cycles to give damage equivalent
- Tests prototype vehicle for a number of months to replicate target life
QUALITY CONTROL

• All structural aluminium from traceable sources
• CNC machined in the UK plant for body assembly either in the UK or Hong Kong
• Structure is assembled using jigs and fixtures to ensure design dimensions are followed
• Assembly process uses specialist tools for consistent build quality and joint integrity
• The driver’s cab is a place of work
• Driver needs to be able to maintain concentration for a working day
• Operation of the vehicle must not place undue stress on the driver
• 2 major studies carried out in UK:
  – 1990 ADL / London Transport / MIRA
  – 2000 ADL / ICE
• ISO 16121 – “Ergonomic requirements for the driver’s workplace in line service buses”
• Provide for sizes of driver from 5\textsuperscript{th} percentile to 95\textsuperscript{th} percentile, men and women
• Recommended dimensions between seat, pedals and steering wheel
• Provide for suitable steering wheel and seat adjustment
• Relationship to instruments and priority of controls
• Visibility
• Environmental comfort
CAD MODEL OF DRIVER
LAYOUT OF CONTROLS
SUMMARY

• Passenger and driver safety paramount throughout vehicle life
• Structures need to be strong and durable but not excessively heavy or costly
• Objectives are achieved through a well developed and proven, design, analysis and validation process
• Overall vehicle and passenger safety is optimised by considering the ergonomics of the man-machine interface
THANK YOU