SAFETY AND CRASHWORTHINESS PERFORMANCE OF PARATRANSIT BUSES

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Project sponsored by: Robert Westbrook (FDOT Transit Administrator) and Erin Schepers
Transit Office, Florida Department of Transportation
RESEARCH BACKGROUND

- What are paratransit buses?
- How are they built?
- Which buses are stronger?

ROLLOVER CRASHWORTHINESS OF PARATRANSIT BUSES
RESEARCH BACKGROUND

- Why is this research important?

- Project goal: evaluate safety and rollover performance of a typical bus by using TWO popular, related standards.
**National:**

**FMVSS Standard 220:**

- Vertical force equal to 1.5 UVW (Unloaded Vehicle Weight)
- Force applied through flat, rigid rectangular plate
- Vertical displacement of the plate < 5.125in
- Design strategy: strong roof bows with light wall columns
**RESEARCH BACKGROUND**

**European:**

**ECE Regulation 66**
- Dynamic rollover test
- Bus on the tilt table (a) rotated into unstable equilibrium (b)
- Bus falls under its own weight into the 800mm deep ditch (c)
- Pass-fail criteria based on the concept of Residual Space (RS)
- RS can not be compromised by any structural part of the bus during and after the impact

![Diagram of bus rollover test](image)
RS defined as a survival zone for passengers

- Deformation Index (DI) introduced by Florida Standard in addition to ECE-R66
- If the value of DI > 1 then the bus fails the rollover test (Residual Space has been compromised)
- Ford Econoline FE model
- Chassis E-150 to E-450
- AutoCAD 2D specs
- AutoCAD 3D model
- Full FE Model
- Exploded view
- Model summary

<table>
<thead>
<tr>
<th></th>
<th>Chassis model</th>
<th>Bus body</th>
<th>Whole model</th>
</tr>
</thead>
<tbody>
<tr>
<td># of elem</td>
<td>189,079</td>
<td>735,407</td>
<td>1,014,489</td>
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<tr>
<td># of nodes</td>
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<td>851,510</td>
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<td># of parts</td>
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<tr>
<td># of 1-d elem</td>
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<td># of 2-d elem</td>
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<tr>
<td># of 3-d elem</td>
<td>15,676</td>
<td>53,250</td>
<td>68,926</td>
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Comparison of a full scale rollover test with a FE model simulation
VALIDATION OF FE SIMULATION

ROLLOVER CRASHWORTHINESS OF PARATRANSIT BUSES

800mm Rollover

Front of the bus 800mm

Back of the bus 800mm

DI Experiment

DI FE Simulation

Deformation Index DI

Time After Impact (sec.)

Experimental deformations at time t=0.25sec.

Computational deformations at time t=0.25sec.
- Investigated bus **failed** the ECE-R66 rollover test
- Excessive side walls deformations lead to the penetration of bus structure into the residual space
- DI exceeds the value of DI > 1.20
- Evenly distributed load of 1.5 UVW (68,219 N) was applied to the roof structure of the bus.
- Force application plate deflection was monitored during the loading procedure.
Selected paratransit bus **passed** FMVSS 220 test

- Roof structure deformed only by 4.76in (limit 5.125in) under the load of 1.5 UVW
- Strong roof bow structure supported all the prescribed load

Selected paratransit bus **failed** ECE-R66 rollover test

- Deformation Index reached a pick value at DI=1.23
- Strong roof bow structure did not prevent failure during dynamic rollover test

For further reference please refer to the 2011 TRB paper: “COMPARISON OF ECE-R66 AND FMVSS 220 TESTS FOR A SELECTED PARATRANSPORT BUS”
RESEARCH NEEDS STATEMENT

- State of Florida buys 300-350 paratransit buses annually
- The bus type considered is the most popular
- Would like our research to have broader (national) impact.
- What are the most popular paratransit buses built, sold and operated in the US?
- Research Needs Statement developed and supported by ANB70
QUESTIONS?
RESEARCH RESULTS

Standard:
*Crash and Safety Testing Standard for Paratransit Buses Acquired by the State of Florida*, approved by the Transit Office Florida Department of Transportation August 10, 2007

Peer reviewed journal publications: