Evacuation tests of passenger from buses and coaches in case of fire

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Abstract

Annually in Sweden, about 50 buses are involved in fire incidents; the most serious so far causing 15 fatalities. Typically, the bus compartment may be smoke filled within 30-90 seconds, making a fast evacuation of the passengers necessary.

Evacuation trials were carried out with 52 passengers in three different bus models. The city bus with two free exits had the shortest evacuation times. Fast evacuations were also found from the coach and the double-decker when two doors were in use. Evacuation times were prolonged when one door was blocked, when smoke reduced the visibility and when persons with disabilities were among the evacuates. Evacuation times exceeded 50 seconds in some cases. An additional evacuation door placed on the driver’s side would decrease evacuation times.

Figure 1. Photos of the buses used in the evacuation tests. From left to right: City bus, Coach, Double decker. Photography: Pontus Albertsson and Torbjörn Falkner

Table 1. Description of buses used in the evacuation tests

<table>
<thead>
<tr>
<th>Type</th>
<th>City bus (&quot;Stadsbuss&quot;)</th>
<th>Coach (&quot;Linjebuss&quot;)</th>
<th>Double decker (&quot;Dubbeldäckare&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Volvo B10M60</td>
<td>Volvo</td>
<td>Scania KL124EB</td>
</tr>
<tr>
<td>Seats</td>
<td>54</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>Doors</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Door width front [mm]</td>
<td>600</td>
<td>750</td>
<td>800</td>
</tr>
<tr>
<td>Door width mid [mm]</td>
<td>800</td>
<td>700</td>
<td>850</td>
</tr>
<tr>
<td>Step heights front [mm]</td>
<td>250 (outer), 220, 240</td>
<td>280 (outer), 230, 200, 220</td>
<td>220</td>
</tr>
<tr>
<td>Step heights front [mm]</td>
<td>250 (outer), 230, 240</td>
<td>370 (outer), 250, 280, 230</td>
<td>220</td>
</tr>
</tbody>
</table>
Table 2. Age and sex of persons who participated in the evacuation tests

<table>
<thead>
<tr>
<th>Age</th>
<th>Female</th>
<th>Male</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-18</td>
<td>25</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>31-40</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>51-60</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>61-70</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>70+</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Sum</td>
<td>37</td>
<td>15</td>
<td>52</td>
</tr>
</tbody>
</table>

Table 3. Test matrix and results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Bus type</th>
<th>Evacuation route</th>
<th>Test conditions</th>
<th>Number of tests</th>
<th>Evacuation time [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>City bus</td>
<td>Front/mid</td>
<td>Baseline test</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>City bus</td>
<td>Front/mid</td>
<td>Stroller and walker</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>Coach</td>
<td>Front/mid</td>
<td>Baseline test</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>4</td>
<td>Coach</td>
<td>Front/mid</td>
<td>Mid door blocked</td>
<td>3</td>
<td>53</td>
</tr>
<tr>
<td>5</td>
<td>Coach</td>
<td>Front</td>
<td>Disabilities</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>6</td>
<td>Coach</td>
<td>Front/mid</td>
<td>Disabilities</td>
<td>3</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>Coach</td>
<td>Front/mid</td>
<td>Smoke filled bus</td>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>8</td>
<td>Double decker</td>
<td>Front/mid</td>
<td>Belts on</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>9</td>
<td>Double decker</td>
<td>Front/mid</td>
<td>Belts not on</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>10</td>
<td>Double decker</td>
<td>Mid</td>
<td>Front door blocked</td>
<td>2</td>
<td>41</td>
</tr>
<tr>
<td>11</td>
<td>Double decker</td>
<td>Front/mid</td>
<td>Stroller, wheelchair, walker</td>
<td>1</td>
<td>58</td>
</tr>
<tr>
<td>12</td>
<td>Double decker</td>
<td>Front/mid</td>
<td>Smoke filled bus</td>
<td>1</td>
<td>55</td>
</tr>
</tbody>
</table>

It should be kept in mind that the evacuation times can be expected to be longer in a real scenario since the test persons knew what was going to happen, and since they probably developed their evacuation skills during the tests. In a real scenario additional time will also be required for opening the doors.

Wider doors were found to have a positive effect since the test persons lined up in two queues, instead of one queue for narrower doors.

Only evacuation through doors was investigated. Other escape routes where planned for future tests.