Pedestrian and Cyclist Safety National Conference

9 June 2006, Transport Accident Commission, Melbourne

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Modelling the pedestrian-involved crash: case study.

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Introduction

- Most pedestrian collisions involve walking adults impacted by the front of a car.
- Collision involves the pedestrian following a ‘wrap or somersault’ trajectory.
- Body rotates upwards onto the car.
- Head will either strike the bonnet, windscreen or roof line depending on the impact speed.
1. Most common trajectory. 80-90%
2. Impact Force is applied BELOW the ped's center of mass.
3. Striking car is usually braking.
4. Usually no windshield contact below 25 mph.
3 Phase model

- Throw Distance
- Carry Dist.
- Fall Dist.
- Slide Dist.
Purpose to model the crash and replicate it with testing

- Simulations conducted 2005 in PC Crash.
- Crash Test Conducted February 2006.
- Tests b/w EL Ford sedan and pedestrian dummy 60 kg in weight and 167 cm tall.
- Speeds Estimated for impact by using throw distance evidence, head strike location.
- Results compared with simulation data.
PC Crash Simulation

- Multibody system to model pedestrian
- Select car from database
- Enter measurement, weight and friction data
- Assign 3D shape file for the car
- Position car, set velocity, position & sequence data
- Position multibody assign height & weight
- Set camera, run simulation and render video file.
t=0.00 s
v1=32.0 [km/h]
32 km/h impact @ 0.4 sec.
1.2 sec, head hits road
1.6 sec, car & body @ rest
32 km/h impact

- Head made contact with trailing edge of bonnet
- Previous adult pedestrian head strike research found impacts on the bonnet typically occur at speeds below 50 km/h
- Car stopped 4.72 m after impact
- Body stopped 6.8 m after impact
37 km/h impact

- Head strike on wiper arm
- Car came to rest 6.27 m after impact
- Body came to rest 10 m after impact
Crash Tests February 2006

- EL Ford Falcon
- Esplanade Williamstown
- Prosthetic body to replicate 60 kg, 167 cm
- Car speeds initial 65 km/h slowing down to 32 km/h at impact.
Position of pedestrian dummy prior to impact
Video of Crash Test
Video of Crash Test
Speed by Throw Distance

- Distances from Impact to Final Rest Recorded = Throw Distance (metres) = $d_t$.
- Searles Equations Used. SAE paper 930659. Velocities in m/sec given by...

\[
V_{\text{min}} = \sqrt{\frac{2\mu gd_t}{1 + \mu^2}}
\]

\[
V_{\text{max}} = \sqrt{2u gd_t}
\]
In Searles’ Equations

- $\nu = \text{average friction factor of pedestrian from impact to rest} = 0.66 \text{ on road} \& 0.79 \text{ on grass}.$
- $g = \text{acceleration due to gravity} = 9.81 \text{ m/s}^2$
- *Velocities converted to speed by multiplying by 3.6.*
- *Average Impacting Car Speed} = \text{Min. Speed plus 20%}.$
Speed by Skid Marks

- Skid distances (d) in metres from where car stopped back to location of impact and road to tyre friction (f) measured.
- Impact Speed (km/h) calculated using:

\[ S = \sqrt{254df} \]
Plots of Impact Speed V Head Strike.
Speed V Head Strike

- 9% **bonnet.** 20 to 40 km/h. Injuries were prevalent for these collisions but **no fatalities.**

- 41% **bottom area of the windscreen.** Speed range 50 to 62 km/h. **All but one** of these twelve victims received **fatal** injuries.

- 22% **middle windscreen.** Speed range 72 to 80 km/h. **All fatal injuries.**

- 18% **top windscreen or roof line,** speed range of 95 to 130 km/h. **All fatal.**
Crash 20: $d_t: 26$ metres $= 56$ kph impact.
85 y.o. male, 168 cms tall, 51 kilograms.

- Head Strike
- Hip Strike
- Lower Leg Strike
## Crash Test Results

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Throw Dist. M</th>
<th>Min. Speed</th>
<th>Max. Speed</th>
<th>Av. Car Speed</th>
<th>Head impact damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>34kph</td>
<td>41kph</td>
<td>41kph</td>
<td>Bonnet</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>37kph</td>
<td>45kph</td>
<td>44kph</td>
<td>Screen</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>26kph</td>
<td>32kph</td>
<td>32kph</td>
<td>Bonnet</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>32kph</td>
<td>39kph</td>
<td>38kph</td>
<td>Wiper</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>32kph</td>
<td>39kph</td>
<td>38kph</td>
<td>Wiper</td>
</tr>
</tbody>
</table>
Vehicle & pedestrian dummy during head impact sequence
Rest positions of car & dummy
Damage from test 2, 44 kph
Close up of damage on wiper arm, tests 4 and 5, 32 kph to 39 kph
Wipe Off 5 Reconstruction
Conclusions

- Correlation b/w PC Crash Simulations and Crash Tests
- Consistency in multibody movement to dummy movement
- Consistency in head impact locations
- Consistency in rest positions
- Further validated Searle’s equations
- Further validated PC Crash
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