

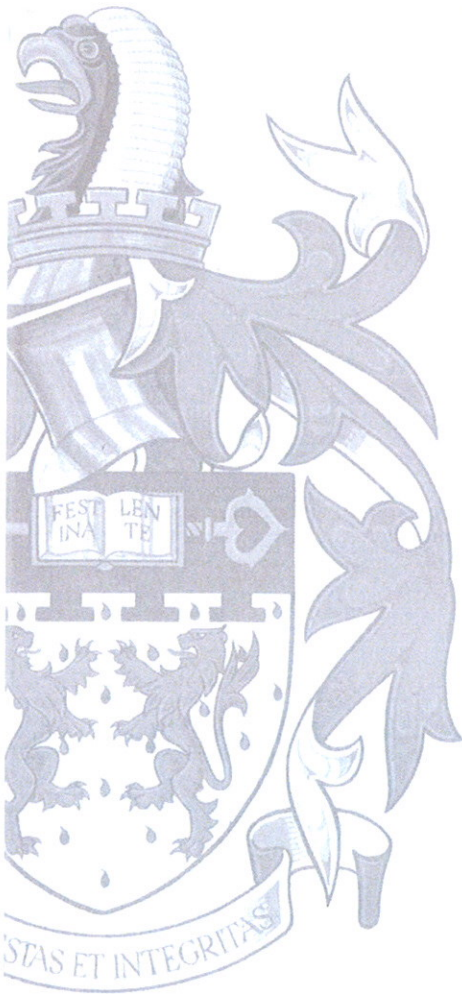


Impact

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A Study of 'Extreme Partial Collisions'.

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INTRODUCTION

In August 2009 a series of crash tests was undertaken using a variety of vehicles as part of the ongoing research programme at GBB(UK) Ltd.

Previous research at GBB had found that partial collisions severely restricted the amount of momentum that could be transferred when one vehicle collides with another. Those tests involved structural damage but led to the question; how partial can a partial collision be?

Two of the tests, referenced CT08/09 and CT09/09, were dedicated to understanding what happens in extreme partial collisions.

Kenneth S. Baker¹ describes two types of impact: full and partial. In a full collision "some parts of the colliding surfaces attain the same speed during impact...Motion between parts in contact will cease momentarily."

Baker explains that in a partial impact "no substantial parts of colliding surfaces attain the same speed during collision...The parts of the vehicle engaged are not strong enough to stop any substantial part of the vehicle. It continues to move onward until disengagement."

To investigate extreme partial collisions the GBB tests CT08/09 and CT09/09 were designed to analyse a collision between exterior mirrors.

These incidents are commonplace.

Increasingly, such contacts are being suggested as causing acceleration or deceleration of a vehicle and thus unusual occupant movement.

In theory the hinged mechanism attaching the mirrors should not be capable of transferring sufficient force to alter the acceleration of either vehicle but has this been tested in practice? A search of the SAE International database suggested not.

The GBB collision test day was overseen by members of Sheffield Hallam University Engineering Department and Biosciences Department and the University of Central Lancashire School of Forensic & Investigative Science. Copart supplied one of the test vehicles.

TESTING

The vehicles used for the test were as follows.;

- 1 Ford Focus, medium-sized 5-door hatchback 1.6l (bullet).
Approximate mass: 1180 kg.
- 2 Volvo 960 3.0 medium to large-sized 5-door estate 3.0l (target)
Approximate mass: 1490 kg.

Each vehicle was fitted with a 2g dual-axis accelerometer and an occupant in each vehicle had tri-axial accelerometers attached at the head (25g "Crossbow") and chest (10g "Crossbow").

In each test the Volvo was stationary and the Ford was accelerated from rest into a collision of wing mirrors before being decelerated back to rest.

Test CT08/09 involved the vehicles orientated head-on. The collision was then repeated for CT09/09 but the orientation was changed so that the Ford approached from the rear of the Volvo. Altering the orientation in this way allowed for any differences in resistance between the Volvo mirror deflecting rearwards or forwards.

The test set up is shown in figure 1.

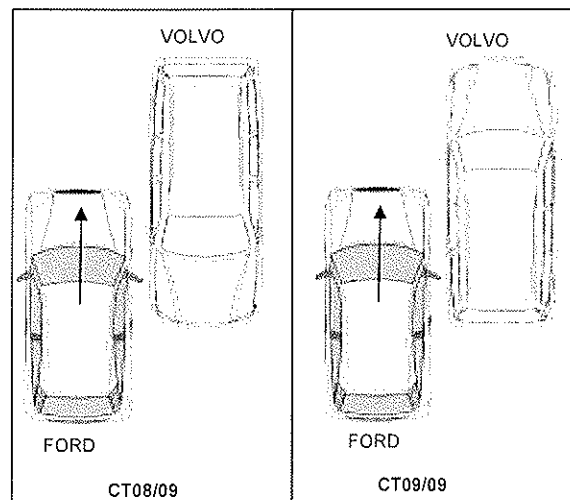


Figure 1

There was no electronic method of starting recording of the sensors. An audible alarm was sounded and the occupants of the vehicles operated the data recorders. The occupants with accelerometers were asked to maintain a normal, straight ahead seat position.

RESULTS

CT08/09

The Ford Focus began its acceleration shortly after 5 seconds after the accelerometer was switched on. It accelerated hard to 24km/h and from the video footage it can be established that during the acceleration phase the door mirror of the Ford struck the door mirror of the Volvo.

Peak speed occurred at 7.5 seconds. The vehicle was braked steadily to a stop.

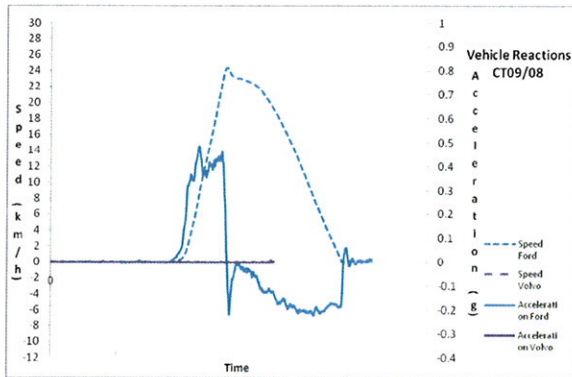


Figure 2

The collision occurred during that 2.5 second period.

From the speed/acceleration graph (figure 2), it is impossible to determine when the collision took place as there was no untoward acceleration or deceleration of the either vehicle. The acceleration of the Volvo fluctuated consistently within the range +/-0.003 g. (Note that the recording equipment for each vehicle was not started at the same time. Although the results share a common axis to allow a comparison of magnitudes the graph should not be used to compare speed or acceleration between vehicles at a specific time.)

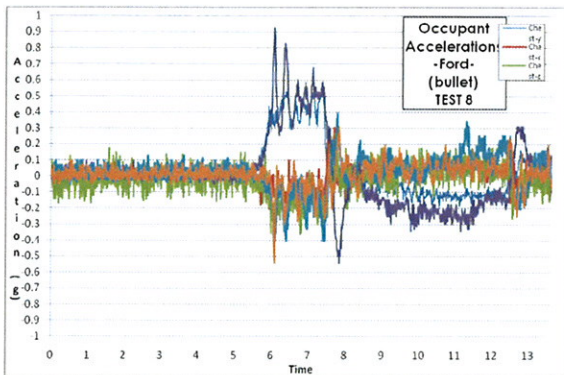


Figure 3

A study of the occupant acceleration graph for the Ford (figure 3) shows movement of the occupants as the vehicle is accelerated and decelerated.

From that graph too, it is not possible to determine when the collision took place.

In other words there was no unusual movement.

A study of the occupant acceleration graph of the Volvo (figure 4) shows the normal movement of the occupant (simplified occupant acceleration graphs can be found at appendix 1).

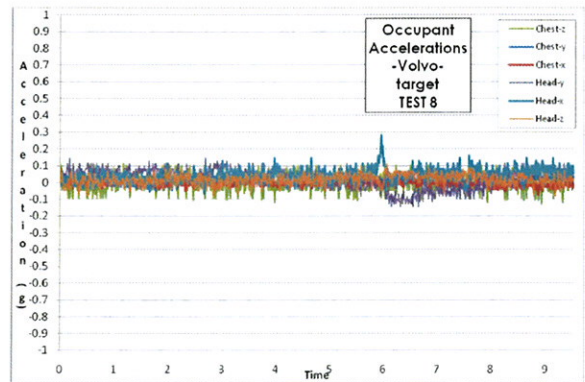


Figure 4

There is slight negative movement of the head in the y-axis (upwards) at around 6 seconds together with positive movement in the x-axis (left). There are no corresponding spikes on the vehicle graphs and this suggests that the occupant movement was self-propagated: perhaps an uncontrollable flinch or more likely an undisciplined glance towards the collision or other vehicle.

In terms of magnitude, it is the same as normal movement prior to the test taking place and provided a disparity between peak head and chest acceleration in the y-axis of around 0.1g.

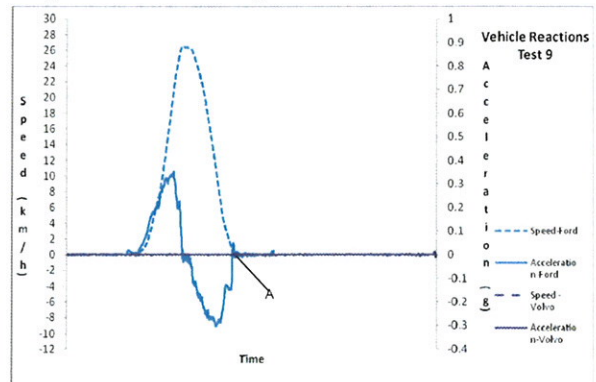


Figure 5

In the second test the Ford was accelerated hard to approximately 27km/h.

Once again video footage confirmed that contact took place during the acceleration phase.

The Ford was braked reasonably hard (0.3g) to a stop.

The speed/acceleration graphs for both vehicles can be seen in figure 5.

The effects of this collision were similar to CT08/09 insofar as there was no untoward acceleration of the Ford. Acceleration readings from the Volvo were generally between +/-0.003 g, as with the first test with the exception of one area (highlighted as A in figure 5) where the acceleration of the Volvo rose to 0.006 g then fell to -0.008 g and back to 0. Since the exact point of contact on the graph cannot be identified, the small blip at A could indicate an effect of the collision, though the limited period of just 0.015 seconds could indicate an anomalous result.

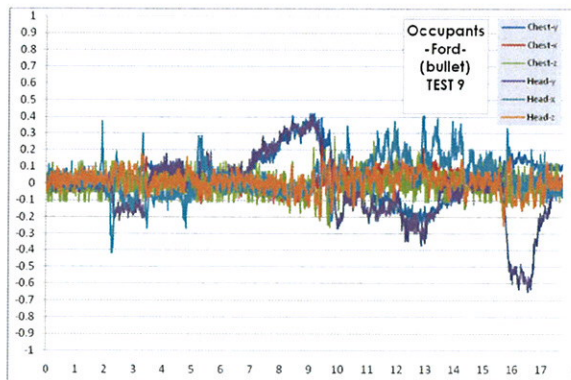


Figure 6

When the Volvo occupant movement accelerations (figure 7) are considered alongside the video footage, the most likely reason for the blip at A becomes clear. As the Ford approaches, the test subject can be seen to be tilting his head to the left and watching in the nearside mirror. As contact occurs the test subject (a male of height approximately 1.9 m) swings his head away abruptly to look in the opposite direction. Spikes reaching -0.4 and +0.5 g occur in the left and right axis and correspond with the deliberate movements seen in the video footage. It is these deliberate motions that appear to have induced the minor fluctuations on the Volvo acceleration graph.

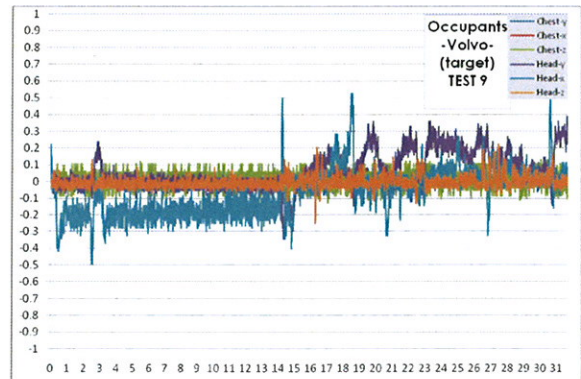


Figure 7

It was impossible from either the speed or acceleration graphs from the vehicles or the occupant acceleration graphs to positively establish where any contact took place.

Movement of the occupants of the Ford could be seen during the normal vehicle acceleration and deceleration phase (figure 6).

CONCLUSIONS

Two tests were undertaken whereby the mirrors of two vehicles were in contact at speeds of 24km/h and 27km/h to investigate the effect of extreme partial collisions upon vehicle and occupant movement.

No movement of either vehicle could be determined from the accelerometer data obtained and attributed to the collision.

Normal accelerations were measured before, during and after the collisions. No unusual movement of occupants could be determined from acceleration data or video footage.

There was no movement of the Volvo visible in the video footage.

The conclusion drawn from these tests is that a 'collision' between mirrors attached to the body of the two motor vehicles did not accelerate either vehicle and did not cause any unusual occupant movement. The parts of the vehicle engaged were not strong enough to move any substantial part of either vehicle.

The video footage of these tests will shortly be available for viewing together with other technical papers at www.gbbuk.com.

REFERENCES

¹Kenneth S. Baker, 2001. Traffic Collision Investigation. Northwestern University Center For Public Safety.

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APPENDIX 1

