

Rollover Investigation
Dynamic Science, Inc. / Case Number: DS07018
2005 Chevrolet Aveo
California
February 2007

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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16. Abstract <p>This on-site investigation focused on a 2005 Chevrolet Aveo that was involved in multiple impacts and a rollover. This two vehicle crash occurred in February 2007 at 0630 hours on a four-lane interstate highway. The roadway was wet and it was raining at the time of the crash. The 2005 Chevrolet Aveo was a four-door sedan that was being driven by an unrestrained 42-year-old female. The other vehicle was a 2003 Ford Focus. The Chevrolet Aveo was traveling westbound in the outboard lane and the Ford Focus was disabled in the second lane. As the Chevrolet Aveo approached the area where the Ford Focus was disabled, the driver steered to the right and onto the shoulder. The Aveo lost control and struck a concrete barrier with its right side. The Aveo rotated counterclockwise and entered the adjacent travel lanes. As a result, the left side of the Aveo struck the left front of the Ford Focus. The Aveo displaced the Ford and began a left side leading rollover. The Aveo rolled two quarter turns. After the crash, the Ford Focus came to rest facing south partially blocking the right shoulder and the outboard lane. The Aveo came to rest on its roof, facing north, partially blocking the right shoulder and the outboard lane. The Aveo driver sustained a concussive head injury, abrasions to the right knee, and a minor ear laceration. She was transported to a local hospital by a fire department ambulance. The Chevrolet Aveo was towed from the scene due to damage. It was later declared to be a total loss by the insurance company.</p>			
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BACKGROUND

This on-site investigation focused on a 2005 Chevrolet Aveo that was involved in multiple impacts and a rollover. This two vehicle crash occurred in February 2007 at 0630 hours. The crash occurred on a four-lane interstate highway. The roadway was wet and it was raining at the time of the crash. The speed limit at this location was 89 km/h (55 mph). The 2005 Chevrolet Aveo was four-door sedan that was being driven by an unrestrained 42-year-old female. The other vehicle was a 2003 Ford Focus. The Chevrolet Aveo was traveling westbound in the outboard lane and the Ford Focus was disabled in the second lane from the right. As the Chevrolet Aveo approached the area where the Ford Focus was disabled, the driver steered to the right and onto the shoulder. The Aveo lost control and struck a concrete barrier with its right side (**Figure 1**). The Aveo rotated counterclockwise and into the adjacent travel lanes. The left side of the Aveo struck the left front of the Ford Focus (**Figure 2**). The impact pushed the Ford Focus into the barrier. The Aveo overturned two quarter turns and came to rest on its roof.



Figure 1. Impact with barrier



Figure 2. 2005 Chevrolet Aveo. Impact with other vehicle and rollover damage.

After the crash, the Ford Focus came to rest facing south, partially blocking the right shoulder and the first lane from the right. The Aveo came to rest on its roof, facing north, partially blocking the right shoulder and the outboard lane. The Aveo driver sustained a concussive head injury, abrasions to the right knee, and a minor ear laceration. She was transported to a local hospital by a fire department ambulance. The Chevrolet Aveo was towed from the scene due to damage. It was later declared to be a total loss by the insurance company.

This Rollover case was identified by the National Highway Traffic Safety Administration (NHTSA) during a review of police reports. DSI was faxed the report on April 5, 2007. DSI located the case vehicle and obtained permission to inspect the vehicle on May 3, 2007. DSI was assigned the case on May 4, 2007. The case vehicle was inspected during the week of May 7, 2007. It should be noted that a child safety seat (CSS) was present in the Aveo, but was not occupied during the crash.

SUMMARY

Crash Site

This two vehicle crash occurred in the westbound lanes of an interstate highway in February 2007. At the time of the crash, it was raining and the concrete roadway surface was wet. The westbound roadway was configured with four travel lanes that were separated by broken white lines and raised reflectorized markers. Bordering the roadway to the north was a solid white line, an asphalt right shoulder and a concrete barrier (**Figure 3**). Bordering the roadway to the south was a solid yellow line, a concrete curb and a concrete barrier. The posted speed limit at this location is 89 km/h (55 mph).



Figure 3. Approach to area of impact

Pre Crash

The case vehicle was a 2005 Chevrolet Aveo four-door sedan that was being driven by an unrestrained 42-year-old female. The other vehicle was a 2003 Ford Focus that was being driven by an unrestrained 22-year-old male. The Chevrolet Aveo was traveling westbound in the first lane from the right. The driver of the Focus had lost control of his vehicle prior to this crash and the disabled vehicle had come to rest in the second lane from the right facing generally east.

Crash

As the Chevrolet Aveo approached the area where the Ford Focus was disabled, the driver steered to the right and onto the shoulder. The Aveo went out of control and struck the concrete barrier with its right side. The Aveo rotated counterclockwise into the adjacent travel lanes. The left side of the Aveo struck the left front of the Ford Focus. The impact was of moderate severity. The missing vehicle algorithm of the WinSmash program computed a total delta V of 18.0 km/h (11.2 mph), based on the Aveo's left side crush profile. The longitudinal and lateral components were -9.0 km/h (-5.6 mph) and 15.6 km/h (9.7 mph), respectively. The impact pushed the Ford Focus into the barrier. The Aveo displaced the Ford and began a left side leading rollover. The Aveo overturned two quarter turns and came to rest on its roof.

After the crash, the Ford Focus came to rest facing south partially blocking the right shoulder and the first lane from the right. The Aveo came to rest on its roof, facing north, partially blocking the right shoulder and the outboard lane.

Post Crash

The driver of the Chevrolet Aveo sustained a concussive head injury, abrasions to the right knee, and a minor ear laceration. She was transported to a local hospital by a fire department ambulance. She arrived at the hospital with a Glasgow Coma Score (GCS) of 14. She was hospitalized for one

day. The driver of the Ford Focus sustained a concussive head injury, a minor scalp laceration, and a minor left orbit laceration. He was transported to a local hospital by a fire department ambulance. He arrived at the hospital with a GCS of 15. He was treated and released.

The Chevrolet Aveo was towed from the scene due to damage. It was later declared to be a total loss by the insurance company. The Ford Focus was also towed from the scene due to damage.

VEHICLE DATA - 2005 Chevrolet Aveo

The 2005 Chevrolet Aveo was identified by the Vehicle Identification Number (VIN): KL1TD52685Bxxxxxx. The vehicle's odometer could not be read, as there was no power to the instrument panel. The Aveo was a four-door five passenger sedan that was equipped with a 1.6 liter, 4-cylinder engine, an automatic 4-speed transmission, front wheel drive, front disc/rear drum brakes, and power steering. The Aveo was configured with Touring HR Futura P185/60R14 tires. The right rear tire was missing. The manufacturer's recommended tire pressure was 207 kPa (30 psi). The tire manufacturer's maximum pressure was 300 kPa (44 psi). The specific tire information is as follows:

Position	Measured Pressure	Measured Tread Depth	Restricted	Damage
LF	193 kPa (28 psi)	8 mm (10/32 in)	No	None
LR	172 kPa (25 psi)	8 mm (10/32 in)	No	None
RR	Tire missing			
RF	Tire flat	7 mm (9/32 in)	No	Tire debaded

The seating in the Aveo was configured with fabric covered front bucket seats with adjustable head restraints and a 60/40 split folding rear seat. The driver's seat was in the mid track position. The seat back was at 26 degree angle from the vertical and the seat bottom was at a 6 degree angle from the horizontal. The front right seat was in the mid track position. The seat back was at 30 degree angle from the vertical and the seat bottom was at a 6 degree angle from the horizontal.

Vehicle Damage

Exterior Damage - 2005 Chevrolet Aveo

The 2005 Chevrolet Aveo sustained moderate right side damage as a result of the impact with the concrete barrier (**Figure 4**). The direct damage began at the front right bumper corner and extended rearward 325 cm (128.0 in). The right rear tire was torn from the vehicle and was not available for inspection. The front right tire was debaded and flattened. The right mirror was knocked off. The Collision Deformation Classification (CDC) for the barrier impact was 12RDEW2¹.

¹Coded as Wide, not Sideswipe, due to right rear tire snagging

The Aveo sustained moderate left side damage as a result of the impact with the Ford Focus (**Figure 5**). The direct damage began 22 cm (8.7 in) forward of the rear axle and extended 182 cm (71.7 in) forward along the left side plane. Both left side doors were jammed shut. Six crush measurements were documented at the mid-door level as follows: C1 = 0 cm, C2 = 12 cm (4.7 in), C3 = 22 cm (8.7 in), C4 = 14 cm (5.5 in), C5 = 8 cm (3.1 in), C6 = 0 cm. The CDC for the impact with the Ford Focus was 10LPAW3.

The Aveo sustained moderate damage to the top and left side as a result of the rollover (**Figure 6**). The direct damage on the roof began at the windshield header and was 40 cm (15.7 in) wide and extended rearward 70 cm (27.6 in). The maximum vertical crush was located 22 cm (8.7 in) inboard of the right A pillar and measured 11 cm (4.3 in). The rear bumper fascia was apparently knocked off during the rollover. The CDC for the rollover was 00TYDO3.



Figure 4. Damage from impact with barrier and rollover damage



Figure 5. Damage from impact with Ford Focus



Figure 6. Maximum crush to roof from rollover

Interior Damage - 2005 Chevrolet Aveo

The 2005 Chevrolet Aveo sustained moderate interior damage as a result of passenger compartment intrusion and occupant contacts. The left side doors, left B pillar, and left side rail sustained lateral intrusion. The driver's seat cushion was deformed by the intrusion. The steering wheel was locked in place by the left side door intrusion. The roof and windshield header sustained vertical intrusion.

The specific passenger compartment intrusions were documented as follows:



Figure 7. Left side intrusion

Position	Intruded Compartment	Magnitude of Intrusion	Direction
LF	B pillar	29 cm (11.4 in)	Lateral
LF	Door	26 cm (10.2 in)	Lateral
LF	Door	16 cm (6.3 in)	Lateral
RF	Door	12 cm (4.7 in)	Vertical
LF	Side rail	11 cm (4.3 in)	Lateral
RF	Windshield header	9 cm (3.5 in)	Vertical
LF	Windshield header	6 cm (2.4 in)	Vertical

The driver's door exhibited cracking and deformation from occupant contact. The center console and shift lever were shifted to the right from contact.



Figure 8. Windshield header intrusion

Manual Restraints -2005 Chevrolet Aveo

The 2005 Chevrolet Aveo was configured with 3-point manual lap and shoulder belts for each seating position. Both front seat safety belts were equipped with retractor pretensioners and adjustable D-rings that were in the full up position.

The driver's safety belt was configured with a sliding latch plate and an ELR type retractor. At the time of the vehicle inspection, the driver's seatbelt was locked in the stowed position by the vehicle intrusion and the pretensioner actuation. The belt webbing was taut along the B-pillar in an unused position.

The remaining safety belts were configured with sliding latch plates and switchable ELR/automatic locking retractors (ALR).

The second row outboard seating positions were equipped with the lower anchor points that are part of this vehicle's Lower Anchors and Tethers for Children (LATCH) system. All three second row seating positions were equipped with child safety seat top tether anchor points.



Figure 9. Driver's safety belt locked in stowed position

Supplemental Restraint Systems -2005 Chevrolet Aveo

The 2005 Chevrolet Aveo was configured with single stage frontal air bags and safety belt retractor pretensioners for the driver and front right passenger positions. There were no air bag deployments. The driver's safety belt pretensioner actuated while the belt was in the stowed position.

Rollover Discussion

The Aveo had a four-star rollover rating, with a static stability factor (SSF) range from 1.18 to 1.44 with a 10 to 20 percent chance of rollover. The actual SSF for the tested Aveo was 1.32. The Aveo lost control and struck the concrete barrier with its right side. It rotated counterclockwise and into the adjacent travel lanes and the left side of the Aveo struck the left front of the Ford Focus. After the initial impact, the Aveo overturned left side leading two quarter turns and came to rest on its roof. At rest, the vehicle was facing north and was partially blocking the right shoulder and the outboard lane.

OCCUPANT DEMOGRAPHICS - 2005 Chevrolet Aveo

	Driver
Age/Sex:	42/Female
Seated Position:	Front left
Seat Type:	Bucket. Seat track in mid position.
Height:	168 cm (66 in)
Weight:	82 kg (180 lbs)
Alcohol/Drug Involvement:	None
Body Posture:	Unknown
Hand Position:	Unknown
Foot Position:	Unknown
Restraint Usage:	Lap and shoulder belt available, not used.
Air bag:	Steering wheel mounted frontal air bag, did not deploy.

OCCUPANT KINEMATICS

Driver Kinematics

The 42-year-old female driver was seated in an unknown posture and was not using the 3-point manual lap and shoulder belt. The driver's seat was in the mid track position. Prior to the impact, the driver of the Aveo actively steered the vehicle to the right and the right side of the Aveo struck the concrete barrier. This was initially a sideswipe type impact, but the right rear tire of the Aveo snagged some part of the barrier and the Aveo began a clockwise rotation. The left side of the Aveo struck the front of the stopped Ford Focus. The driver initiated a left lateral and slightly forward trajectory. She engaged the door and cracked the door panel with her left hip. The left door intruded and the driver's right hip likely contacted and deformed the center console and shifter. The Aveo overturned two quarter turns and came to rest on its roof. The driver sustained a concussion, a laceration to her right ear, and abrasions to her right knee.

OCCUPANT INJURIES - 2005 Chevrolet Aveo

Driver: Injuries obtained from Emergency Room records and Radiology reports.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Unconscious on admission or initial observation at scene; length of unconsciousness known to be < 1 hour	160414.2,0	Roof	Probable
Laceration, minor (0.6 cm), right ear	290602.1,1	Unknown	Unknown
Abrasions, right knee	890202.1,1	Left lower instrument panel	Probable

OCCUPANT INJURIES - 2003 Ford Focus

Driver: Injuries obtained from Emergency Room records and History and Physical reports.

<u>Injury</u>	<u>AIS Code</u>	<u>Injury Mechanism</u>	<u>Confidence Level</u>
Unconscious on admission or initial observation at scene; length of unconsciousness known to be < 1 hour	160414.2,0	Unknown	Unknown
Laceration, minor (2.0 cm), posterior scalp	190602.1,6	Unknown	Unknown
Laceration, minor (0.5 cm), left orbit	290602.1,2	Unknown	Unknown

Attachment 1. Scene Diagram

