Frontal Side Swipe Collisions

MARC1 SOLUTIONS

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Short Paper PCB1 – 2014

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Frontal side swipe collisions are frequently difficult to reconstruct. The basic engineering concepts are discussed in "Motor Vehicle Accident Reconstruction and Cause Analysis", 7th edition and in PCB 3-2006. The underlying equations were derived from linear momentum and energy balance. The some-what complicated equations were then reduced to an inline collision by making approach and departure angles equal to either zero or 180 degrees. *See* Section 33.04[4] for details.

While reviewing the 2005 DaimlerChrysler EES-Broshure, I saw the controlled crash test data of a frontal side swipe. A Series 201 and 116 were tested. The 116 series is the S-Class, the 201 the 190 "compact" model.

To help users of MARC1, I have applied the measured test data to MARC1-X3 to calculate impact/test speeds.

The impact configuration and rest positions are shown on page 105 of the "Broshure". The damaged vehicles are also shown on page 105. The test engineers at Daimler assigned energy-equivalent-speeds of 48 km/h to the 201, and 40 km/h to the 116. The input data are shown on page 106. The results are shown on page 107, including the test speeds of 68.43 km/h for the 201, and 47.19 km/h for the 116. After impact the vehicles rotated 82 degrees (201) and 78 degrees (116). The velocity changes or ΔV were 28.30 km/h for the 201 and 19.79 km/h for the 116. The after-impact speeds were 41.60 km/h (201) and 28.40 km/h (116).

Since the vehicles rotated after impact, the rotational energies after impact are calculated by MARC1-A4 as 5,522 lbft (201) and 8,031 lbft (116). These values are input data in MARC1-X3 as secondary impact energies. The after-impact speeds measured in the test are calculated by the appropriate input data in MARC1-X3. Inspection of the diagram showing the vehicles at rest was used to obtain approximate after-impact distances travelled such as 44 ft (201) and 19 ft (116).

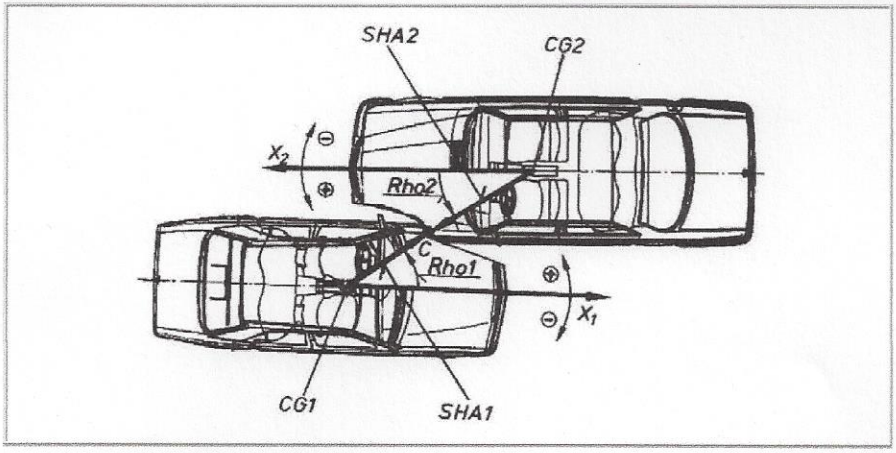
The crush data, such as A and B stiffness coefficients, crush width and crush depth were chosen to obtain the identical EES speeds as specified by Mercedes engineers. The German text at the bottom of page 106 indicates that the EES values were obtained with the help of the deformation photographs. The exactness of the numbers such as 48.00 km/h (29.83 mph) and 42.00 km/h (26.10 mph) might be questioned. A reasonable range of +/- 3 km/h or greater should probably be assigned to each value.

The MARC1-X3 input and output data are shown. Duplicating the Mercedes input data in X3 yields impact speeds of 41.17 mph (201) and 28.68 mph (116). The measured impact speeds were 42.53 mph (201) and 29.32 mph (116). Increasing the crush energies by approximately 10% by changing the B-stiffness coefficients from 98 to 110 psi for each vehicle yields crush energies of 95,473 lbft (instead of 86,531 lbft) and impact speeds of 42.46 mph and 29.58 mph, respectively.

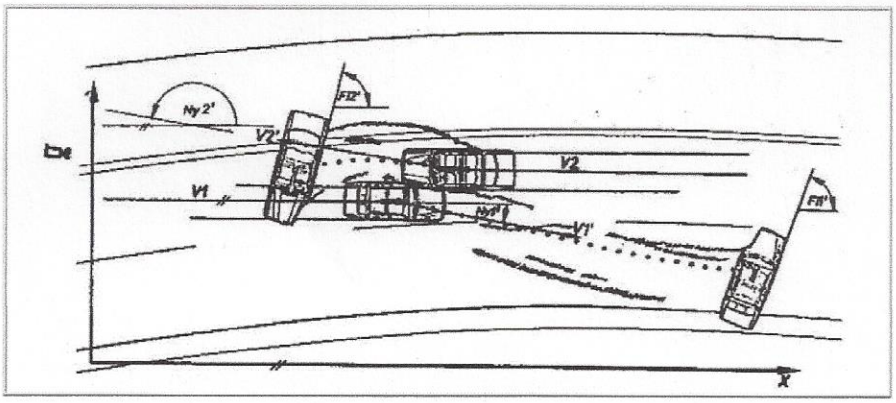
The velocity changes are $\Delta V_1 = 42.46 - 25.48 = 16.98$ mph and $\Delta V_2 = 29.58 - 17.71 = 11.87$ mph. The Mercedes delta-Vs are 17.59 (201) and 12.30 mph (116). The difference in delta-V data is probably explained by the departure angles of V1 (201) of -10 degrees (or 350 degrees in the polar coordinate system) and 171degrees of V2 (116). Consequently, each vehicle has a small delta-V component in the y-direction which is not considered in MARC1-X3.

EES von Fahrzeug 1 für den Mercedes-Benz-Pkw-Baureihe 201 wurde mit 48 km/ h ermittelt.

EES von Fahrzeug 2 für den Mercedes-Benz-Baureihe 116 wurde mit 40 km/ h ermittelt.



Aufprallsituation zum Zeitpunkt des Stoßes.



Unfallskizze mit Endlagen und Aufprallpunkt.

11.2 Unfallrekonstruktionsprogramm

Eingabegrößen und Ergebnisse zum gleichen Beispiel.

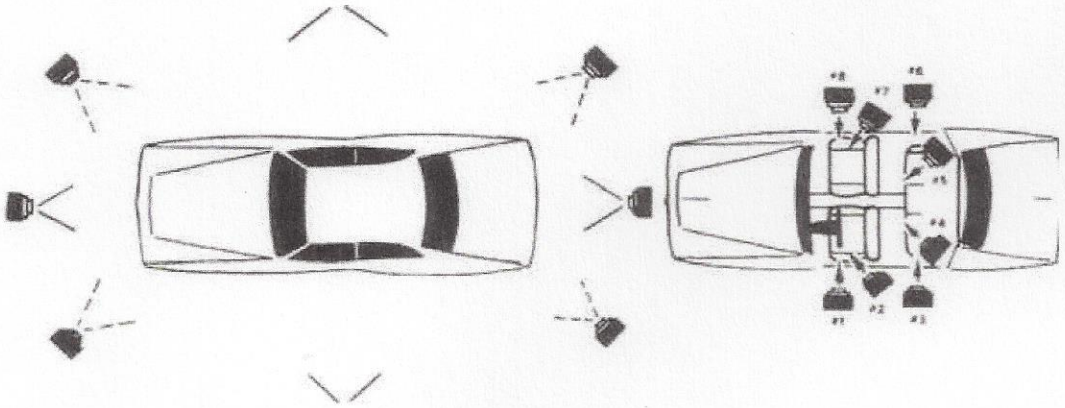
Unfallrekonstruktionsprogramm
Eingabegrößen Teil 1

1. Angaben zu den Fahrzeugen:	Fzg. 1	Fzg. 2
Länge (L)	4,42	4,96 m
Breite (B)	1,68	1,87 m
vorderer Überhang (Ü, v)	0,75	0,85 m
Schwerp. bis Vorderachse (dSpkt.)	1,20	1,40 m
Radstand (R)	2,67	2,87 m
Gesamtmasse (M)	1,325,00	1,895,00 kg
2. Angaben zu den Auslaufbewegungen		
Auslaufgeschwindigkeit (V')	41,60	28,40 km/h
Auslaufwinkel (Ny')	-10,00	171,00 °
Drehwinkel (Fi')	82,00	78,00 °
seitlicher Reibbeiwert (MyR)	0,15	0,10 -
3. Angaben zu den Einlaufbewegungen und zum Antriebs-Balance-Verfahren		
Gierwinkel (Psi)	- 0,00	-179,00 °
Winkelgeschwindigkeit (Om)	0,00	0,00 rad/s
Richtung Kollisionsgeschwindigkeit (Ny)	0,00	
4. Angaben für die Berechnung mit EES-Werten		
Energie-äquivalente Geschwindigkeit (EES)	48,00	42,00 km/h
Deformationstiefe (ETD)	0,90	1,00 m
5. Angaben für die Kontrolle mit dem Drehimpulssatz		
Stoßkrafthebelarm (SHA)	1,10	1,50 m
Hebelarm-Winkel (Rho)	35,00	32,00 °

Zur Ermittlung der EES muss das Deformationsbild des Fahrzeugs herangezogen werden. Für die Fotoaufnahmen sollten definierte, Kamerapositionen gewählt werden. Zusätzlich empfiehlt sich eine Überkopfaufnahme nach der in (3) beschriebenen Methode. Die folgenden Beispiele zeigen einige extreme Fälle zur Bestimmung der EES.

Ergebnisse

1. Geschwindigkeiten:	Fzg. 1	Fzg. 2
Kollisionsgeschwindigkeit (V)	68, 43	47,19 km/h
Geschwindigkeitsänderung (dV)	28,30	19,79 km/h
EES (eingegeben) (EES)	48,00	42,00 km/h
EES (berechnet) (EES)	47,82	42,15 km/h
2. Impulse (für das Antriebs-Balance-Verfahren)		
Einlaufimpuls (I)	25151,26	24840,22 Ns
Auslaufimpuls (I')	15311,11	14949,44 Ns
Stoßantrieb (S)	10417,75	10417,75 Ns
Winkel des Stoßantriebs (Gam)	194,79	14,79 °
3. Kontrollen		
Richtung von V2 (Ny)		180,74 °
Auslauf-Winkelgeschwindigkeit (OM')	1,94	1,46 rad/s
Induzierte Winkelgeschwindigkeit (OM*)	2,00	1,43 rad/s
Hebelarm (Spkt.-Stoßantrieb) (e*)	0,38	0,47 m
Massenträgheitsmoment (J)	1980,60	3417,25 kgm²



Aufnahmen gemäß Nato- Report

Monday, September 01, 2014

MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
***** PROGRAM 'X-3' RUN FOR EES-Brshure - MB 201 v. MB 116 *****
FRONTAL SIDE-SWIPE COLLISION

Information For Vehicles		0 MB 201	1991 MB 116
Vehicle Weight, Lbs:	===>	2922	4178
NO PRE-IMPACT SURFACE INFORMATION			
Surface #1			
Distance Traveled After Impact, FT:	===>	44.00	19.00
After-Impact Deceleration, g-UNITS:	===>	0.45	0.45
Max. Force Not Causing Damage, LBS/IN:	=>	250.00	250.00
Stiffness/Inch of Width, PSI:	===>	98.00	98.00
Force Angle Offset from Perpendicular, DEG:	===>	0.00	0.00
Width of Crush Region, IN:	===>	20.00	20.00
Number of Crush Measurements:	===>	2	2
Crush Measurement #1, IN:	===>	30.00	30.00
Crush Measurement #2, IN:	===>	30.00	30.00
Secondary Impact Energy, FT·LBS:	===>	5522	8031
Pre-Impact Speed, MPH:	===>	41.17	28.68
Speed at Impact, MPH:	===>	41.17	28.68
After-Impact Speed, MPH:	===>	25.48	17.71
Crush Energy, FT·LBS:	===>	86531	86531
EES Speed, MPH:	===>	29.77	24.90

Monday, September 01, 2014

MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
***** PROGRAM 'X-3' RUN FOR EES-Brshure - MB 201 v. MB 116 *****
FRONTAL SIDE-SWIPE COLLISION

Information For Vehicles		0 MB 201	1991 MB 116
Vehicle Weight, Lbs:	===>	2922	4178
NO PRE-IMPACT SURFACE INFORMATION			
Surface #1			
Distance Traveled After Impact, FT:	===>	44.00	19.00
After-Impact Deceleration, g-UNITS:	===>	0.45	0.45
Max. Force Not Causing Damage, LBS/IN:	=>	250.00	250.00
Stiffness/Inch of Width, PSI:	===>	110.00	110.00
Force Angle Offset from Perpendicular, DEG:	===>	0.00	0.00
Width of Crush Region, IN:	===>	20.00	20.00
Number of Crush Measurements:	===>	2	2
Crush Measurement #1, IN:	===>	30.00	30.00
Crush Measurement #2, IN:	===>	30.00	30.00
Secondary Impact Energy, FT·LBS:	===>	5522	8031
Pre-Impact Speed, MPH:	===>	42.46	29.58
Speed at Impact, MPH:	===>	42.46	29.58
After-Impact Speed, MPH:	===>	25.48	17.71
Crush Energy, FT·LBS:	===>	95473	95473
EES Speed, MPH:	===>	31.28	26.16

Stiffness coefficient B = 110 (instead of 98).

Sunday, August 31, 2014

MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
****** PROGRAM 'A-4' RUN FOR EES Broshure - MB vs. MB ******
POST-IMPACT ROTATION

Information For Vehicle 1	1991 MERCEDES BENZ 201	
Vehicle Weight, LBS:	===>	2922.00
Vehicle Length, FT:	===>	14.50
Vehicle Wheelbase, FT:	===>	8.80
Rotational Coefficient of Friction, D'LESS:	===>	0.30
After-Impact Angle Rotated, DEG:	===>	82.00
Mass-Moment of Inertia, FT·LBS·SEC·SEC:	===>	1491.39
Angular Velocity, RAD/SEC:	===>	2.72
Rotational Energy, FT·LBS:	===>	5522.20
Time to Rotate After Impact, SEC:	===>	1.05

Sunday, August 31, 2014

MOTOR VEHICLE ACCIDENT RECONSTRUCTION AND CAUSE ANALYSIS
****** PROGRAM 'A-4' RUN FOR EES Broshure - MB vs. MB ******
POST-IMPACT ROTATION

Information For Vehicle 2	1991 MERCEDES BENZ 116	
Vehicle Weight, LBS:	===>	4178.00
Vehicle Length, FT:	===>	16.27
Vehicle Wheelbase, FT:	===>	9.41
Rotational Coefficient of Friction, D'LESS:	===>	0.30
After-Impact Angle Rotated, DEG:	===>	78.00
Mass-Moment of Inertia, FT·LBS·SEC·SEC:	===>	2558.62
Angular Velocity, RAD/SEC:	===>	2.51
Rotational Energy, FT·LBS:	===>	8031.34
Time to Rotate After Impact, SEC:	===>	1.09