December 3, 1980

Analysis of the 10 June 1978 accident between vehicles driven by Donald F. Bridges and Charles E. Ash, Jr. on SR 21 in Wayne, County, Ohio.

Submitted to: Mr. Charles E. Kirkwood
Scanlon & Gearinger Co., L.P.A.
1222 First National Tower
106 S. Main Street
Akron, Ohio 44308

Materials and Information:

1. State of Ohio Traffic Crash Report No. 76-1632-85.
2. Xerox copies of photographs of the accident scene.
3. Deposition of Donald F. Bridges; taken on 7 July 1980 before William S. Bish, Notary Public.
4. A 1978 Mack tractor has brakes on all three axles (including the steering axle).
5. Definition of Legal Brakes from the Ohio Revised Code 4513.20 Brake Equipment (H2).
6. Coefficient of Friction data from the Traffic Accident Investigation Manual by J. Stannard Baker (Northwestern University Traffic Institute).

Objectives:

1. To determine the speed of the tractor-trailer rig (vehicle #1) driven by Mr. Bridges just prior to its impact with the 1973 oldsmobile driven by Mr. Ash.

2. To determine the speed of vehicle #1 at the beginning of its 86 ft pre-impact skid.

3. To determine whether or not the Bridges vehicle could have stopped and avoided the impact if it had remained in the curb lane and if it had been traveling 50 mph prior to its 86 ft skid (as Mr. Bridges indicated in his deposition).

4. To determine whether or not the Bridges vehicle could have stopped and avoided the impact if had been traveling 50 mph prior to its 86 ft skid and if it changed from

the curb lane to the southbound passing lane after its 86 ft skid.

Analysis

1. Pre-impact speed of the Bridges vehicle.

Data: a. The tractor-trailer traveled 384 ft from impact to its final resting position.

b. Mr. Bridges stated that he had his brakes engaged from the time of impact until he brought the tractor-trailer to a complete stop.

c. Legal brakes for a tractor-trailer in the State of Ohio require that said vehicle must be able to stop from a speed of 20 mph in at least 40 ft. This condition requires a minimum drag factor of 0.334 for legal brakes.

Calculation:

The energy of motion possessed by vehicle #1 at impact was dissipated as work done against the braking force for the entire 384 ft.

Equation: $v_1^2 = 2 \mu g d$

where v_1 = the impact speed of vehicle #1
μ = the drag factor of 0.334
g = 32.2 ft/sec^2
d = 384 ft

Result: v_1 = 62.0 mph

Comment:

The speed of 62.0 mph is clearly a minimum impact speed for the Bridges vehicle because both the impact itself and the subsequent broadside skid of vehicle #2 after impact dissipated some of the tractor trailer's pre-impact energy of motion. Neither was considered in the computation of the pre-impact speed of the Bridges vehicle.

2. Speed of the tractor-trailer prior to its 86 ft pre-impact skid.

Data: a. The total length from the beginning of the first skidmark to the end of the last pre-impact skidmark of vehicle #1 is 86 ft.

b. The coefficient of friction for rubber tires skidding on dry traveled asphalt from speeds greater than 30 mph is in the range 0.55 to 0.70. (Traffic Accident Investigation Manual)

c. A constant speed of 62.0 mph is assumed for vehicle #1 from the end of its pre-impact skid until impact.

Calculation:

The energy of motion possessed by the tractor-trailer prior to its 86 ft skid is partially dissipated against the frictional force between the skidding tires and the asphalt. If some wheels did not lock they were braking just as effectively as the locked wheels and the energy is dissipated as work done against the brakes. The remainder of the energy of motion shows up as the 62.0 mph end of skid speed.

Equation: $$v_{1o}^2 = 2\mu_1 g d_1 + v_1^2$$

where v_{1o} = speed of vehicle #1 at the instant the skid began
μ_1 = coefficient of friction in the range 0.55 to 0.70
g = 32.2 ft/sec^2
d_1 = 86 ft skid
v_1 = 62.0 mph (= 90.9 ft/sec)

Result: v_{1o} = 72.5 to 75.1 mph

Comment:

If the tractor-trailer slowed down as it traveled from the end of its 86 ft skid to impact then its pre-skid speed would have been greater than the calculated range of 72.5 to 75.1 mph.

3. Determination of the stopping distance for the tractor-trailer from a speed of 50 mph in the southbound curb lane of SR 21 assuming it did not change lanes after its initial skid.

Data: a. The coefficient of friction between rubber tires and dry traveled asphalt from speeds greater than 30 mph is in the range 0.55 to 0.70.

Less on Grade

b. The distance from the beginning of the 86 ft skid to impact is 366 ft.

c. The distance from the front of the tractor-trailer to the rear axle of the trailer is approximately 55 ft.

d. The skidmarks were made by the tires on the rear axle of the trailer.

Calculation:

The energy of motion of the tractor-trailer traveling at 50 mph would have been completely dissipated doing work against the frictional force between the asphalt and the tires in a locked wheel skid to a stop.

Equation: $V_2^2 = 2 \mu_1 g d_2$

where V_2 = 50 mph
μ_1 = 0.55 to 0.70
g = 32.2 ft/sec^2
d_2 = distance to skid to a stop from 50 mph

Result: d_2 = 119 to 152 ft

The distance from the front of the tractor-trailer at the beginning of its pre-impact skid to the impact point is 311 ft. As a result the Bridges vehicle could have come to a complete stop within the range of 159 to 192 ft prior to the impact point (if it had stayed in the curb lane and if it was traveling only 50 mph at the start of its pre-impact skid).

4. Determination of the stopping distance for the tractor-trailer if it was traveling 50 mph when its 86 ft pre-impact skid began and if it changed from the curb lane to the southbound passing lane, reacted to the emergency and skidded to a stop in the passing lane.

Data: a. The coefficient of friction between rubber tires and dry traveled asphalt from speeds greater than 30 mph is in the range 0.55 to 0.70. From speeds less than 30 mph it is in the range from 0.60 to 0.80.

b. The distance required to change lanes is approximately equal to the length of the vehicle. Here the length of the tractor-trailer is approximately 60 ft.

c. The maximum time to react to an already obvious hazard (vehicle #2 skidding in the curb lane) and engage the brakes of the tractor-trailer is 0.5 seconds,

d. The distance from the beginning of the 86 ft skid to impact is 366 ft and the distance from the front of the tractor to tha rear axle of the trailer of the Bridges vehicle is 55 ft.

e, The 86 ft skidmarks were left by the tires on the rear trailer axle of vehicle #1.

Calculation:

A. If the tractor-trailer was traveling at 50 mph prior to its pre-impact skid some of its energy of motion was dissipated in doing work against the frictional force in its 86 ft **skid.** The remainder of the energy of motion shows up as energy of motion at the end of the skid, As a result we are able to compute the post-skid speed.

Equation: $V_2^2 = 2\mu_1 g d_1 + V_3^2$

where V_2 = 50 mph (speed at the beginning of the skid)
μ_1 = 0.55 to 0.70
g = 32.2 ft/sec^2
d_1 = 86 ft
V_3 = the speed range at the end of the skid.

Result: V_3 = 26.4 to 32.9 mph

B. The distance to change lanes is 60 ft.

C. The distance traveled in 0.5 seconds of reaction time for a speed range of 26.4 to 32.9 mph is in the range of 19 to 24 ft.

D. The stopping distance for a skid on dry traveled asphalt in the passing lane from a speed range of 26.4 to 32.9 mph is determined by considering the energy of motion as being dissipated by doing work against the frictional force,

Equation: $V_3^2 = 2 \mu_1 g d_3$

where V_3 = speed range from 26.4 to 32.9 mph
μ_1 = 0.55 to 0.70 from speeds greater than 30 mph and 0.60 to 0.80 for speeds less than 30 mph.
g = 32.2 ft/sec^2
d_3 = stopping distance in the passing lane from a speed range of 26.4 to 32.9 mph.

Result: d_3 = 26 to 66 ft

The total stopping distance from the beginning of the 86 ft skid and including the 60 ft to change lanes, the 19 to 24 ft to react to the hazard while in the passing lane and a 26 to 66 ft range for a stopping skid in the passing lane is in the range 193 to 236 ft. The Bridges tractor-trailer, therefore, could have come to a complete stop in the passing lane between 75 and 118 feet short of the impact point if it had initially been traveling 50 mph.

Conclusions:

1. The tractor-trailer driven by Mr. Bridges (vehicle #1) was traveling at least 62 mph when it hit the car drivrn by Mr. Ash (vehicle #2).

2. If vehicle #1 traveled at constant speed from the end of its 86 ft pre-impact skid to impact, then its speed at the start of its 86 ft skid was in the range of 72 to 75 mph.

a. If vehicle #1 was traveling at 50 mph prior to its pre-impact skid it could have stopped between 159 and 192 ft short of the impact point by skidding to a complete stop in the curb lane. Therefore, Mr. Bridges could have avoided the impact.

4. If vehicle #1 was traveling 50 mph prior to its pre-impact skid, it could have stopped between 75 and 118 ft short of the impact point even *if* had changed from the curb lank to the southbound passing lane after its 86 ft skid.

Submitted by: David L. Uhrich, Ph.D.
Professor of Physics (Kent State University)
707 Berkeley Dr.
Kent, Ohio 44240