ACCIDENT RECONSTRUCTION CASE ANALYSIS OF CENTERLINE CROSSING ACCIDENT

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Abstract: This study presents the accident reconstruction case analysis for a centerline crossing accident between passenger car and bus on curved highway sections through the process of impacted vehicle investigation, accident site survey, and reconstruction analysis. The accident case was reconstructed by using such physical marks and evidence as skid mark, yaw mark, collision scrub, gauge mark, imprint, oil trace, damaged vehicle conditions, and final stopped vehicle position. The principal direction of force on the impacted vehicle and vehicle dynamics after impact are analyzed from comprehensive evaluation of physical evidences. It is found that the passenger car was keeping his lane by 0.13m inside from the centerline while the bus was crossing the centerline by 0.39m.

Key Words : Accident, Reconstruction, Centerline, PDOF, Maximum Engagement

1. INTRODUCTION

South Korea has experienced 255,205 accidents per year for the past five years. 1,726 fatalities per year, 16.3% of the total fatalities and 7.3% of the total accidents, have been caused by centerline crossing accidents of 18,679 accidents per year. These results show severity of centerline crossing accidents. This paper analyzes one of the centerline accidents based on case study.

The results of this study will be useful to minimize the costs for individuals involved in accidents by providing sufficient accident details, and expediting analysis periods.

In this study one accident case on two-way rural highways is analyzed: When a bus is traveling a curved section, its traveling behavior may be described as "Out-In-Out" for minimizing centrifugal forces. This accident is occurred between a bus and a passenger car when the bus goes back to its original lane after observing the passenger car traveling the opposite lane.

This case is comprehensively analyzed using in site physical marks and evidences such as skid mark, yaw mark, collision scrub, gauge mark, imprint, oil trace, damaged vehicle condition, and final stopped vehicle position. The principal direction of force on the impacted vehicle and vehicle dynamics after impact are analyzed from comprehensive evaluation of physical evidences.

The research steps are as follows:

(1) Human characteristics analysis using police reports
(2) Geometrics survey
(3) Vehicle characteristics
(4) Vehicle damages analysis
(5) First contact and maximum engagement
(6) PDOF and turning directions
(7) Final stopped positions
(8) Analysis of in site evidences
(9) Vehicle locations at the time of accidents
(10) Vehicle path reconstruction before and after accidents

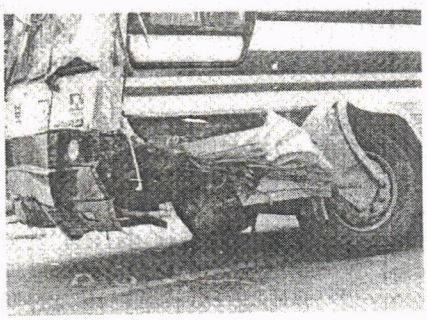
2. ACCIDENT RECONSTRUCTION PROCESS

A bus traveling at about 75kph on a leftward curved section collided with a passenger car traveling opposite. The accident happened at the curved section on a two-way rural highway, asphalt paved and undivided.

2.1 Bus damages

Pictures 1 and 2 show damages on the front and the left body of the bus.

Picture 1. Front Side of Damaged Bus



Picture 2. Left Side of Damaged Bus

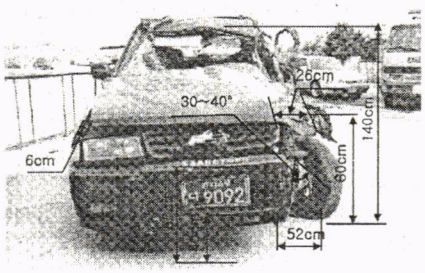
2.2 Passenger car damages

Damages on the front

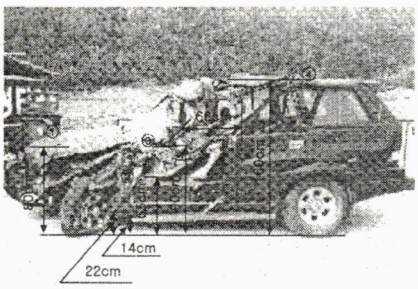
The heights of the grill guard which may be the first contact range from 40 cm to 60 cm. Front part of the left hood was damaged. Its height and depths are 80 cm and 26 cm, respectively. Meanwhile. The left front tire was twisted about 30° ~ 40° (52 cm away from towing hook) toward left side of the vehicle body at the time of colliding.

Damages on the left side

Damages were observed at four different parts, as shown in Picture 4: spot ① 80cm high, spot ② 65cm high, spot ③ 90cm high, and spot ④160cm high from the road surface. Spot ④ was a little reshaped by towing. The body of the passenger car is 22 cm high and the step of the driver seat is 14 cm high.



Picture 3. Damages on the front



Picture 4. Damages on the left side

2.3 First Contact and Maximum Engagement

From the damage characteristics of bus and passenger car shown on the pictures 1, 2, 3, and 4, the first contact is observed at the left-most bumper of the bus and the left of passenger car's grill guard while maximum engagement is observed at two points of the bus; (1) left low part of the body and (2) air vacuum tank, and three points of the passenger car; (1) front left fender, (2) front left filler and (3) inner part of the front left tire.

It appears that when the subpart of the bus body penetrated to the inside of passenger car's front tire, the bus and passenger car instantaneously stuck together and turned counterclockwise.

2.4 PDOF and Turning Directions

Figure 1 shows the possible PDOF's(Principal Direction of Force) of the bus and passenger car judged from the vehicle's damage characteristics. Turning direction of two vehicles after colliding would be counterclockwise. The passenger car seemed to experience the rapid turning by relatively higher turning force than the bus because of the higher impact force of bus upon passenger car.

2.5 Final Stopped Positions

The bus turned counterclockwise after colliding, crossed the centerline, passed through the opposite lane, hit the concrete drainage wall and stopped. The passenger car initially turned by 40° ~ 50° counterclockwise at the time of collision as described, separated from the bus,

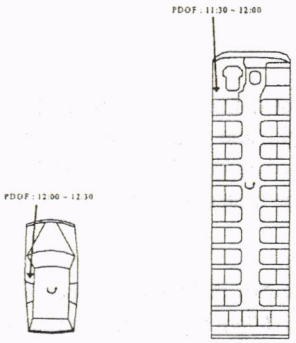


Figure 1. PDOF and Turning Directions

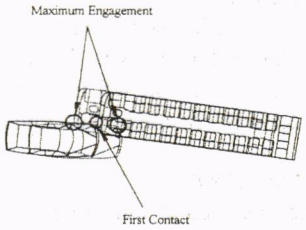


Figure 2. First Contact and Maximum Engagement

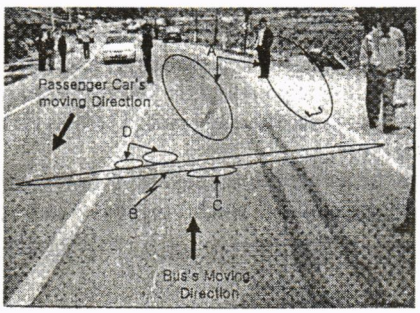
crossed perpendicularly to centerline by racing engine's forces and by damaged part(tire and frame cross member), passed through the bus lane, hit the electric pole stood in the edge of the road and finally stopped.

2.6 Analysis of Physical Evidences in Site

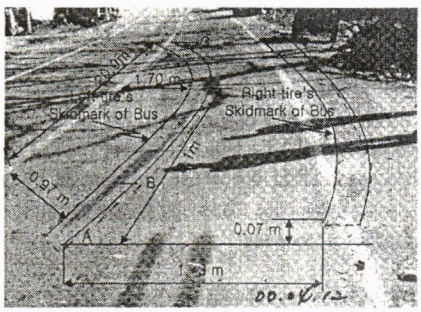
There were tire marks, gauge marks, oil traces and etc. These physical evidences are very important to reconstruct first contact, maximum engagement, separation location, path characteristics before and after colliding and vehicle dynamics.

Physical Evidences on the Bus Path

Two tire marks (A, C), two gauge marks (D), and oil trace (B) were shown in Picture 5. Their characteristics and causes are as follows.



Picture 5. Physical Evidences on the Bus Path



Picture 6. Evidence A

• Evidence A

Evidence A is the skid mark of the bus. Picture 6 shows that left tire mark from A to B is skid mark, and from B to thereafter is yaw mark. That is, skid mark was printed by linear moving caused from bigger driving forces than turning forces of the bus while yaw mark was created by bigger turning forces than driving forces.

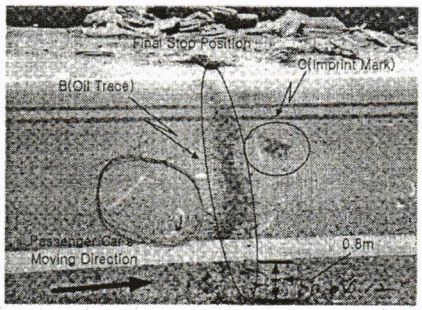
The skid mark of A by the left tire shown on Picture 6 was started at the point of 0.97 m right side from the centerline. The width between left and right tires is about 1.73 m. The skid mark of the left tire is shown 0.07 m earlier than the right tire skid mark. Rolling movement of the

bus might cause this result. After traveling 8.1 m from the first skid mark, where curvature of the mark changes, the mark was at 1.70m right side from the centerline. This means that the bus traveled diagonally not parallel to the centerline before collision.

Futher, it is shown on Picture 6 that the bus crossed the centerline after about 20 m skidding along the centerline from its starting mark of the left tire. Then, it passed the opposite lane, got away from the road and stopped. In the mean time, the bus seemed to decelerate until final stop since yaw mark shows right upward diagonal direction instead of axle direction.

• Evidence B

Picture 7 shows passenger car's power oil leaking. It leaked from the lane of passenger car to the final stop position crossed perpendicularly to the centerline. This leaking evidence started about 0.8 m away from the centerline perpendicular to passenger car's moving direction.



Picture 7.Oil Trace and Imprint Mark

• Evidence C

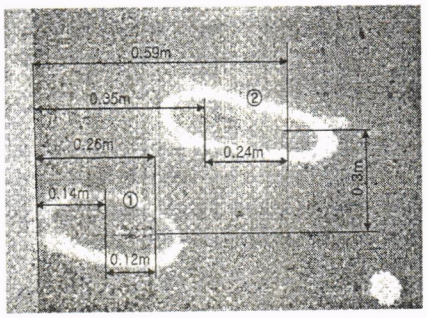
Evidence C in Picture 7 is the tire mark, called imprint mark. Passenger car was separated after maximum engagement and its right rear tire passed through the leaked liquid and imprinted oil mark on the road.

• Evidence D

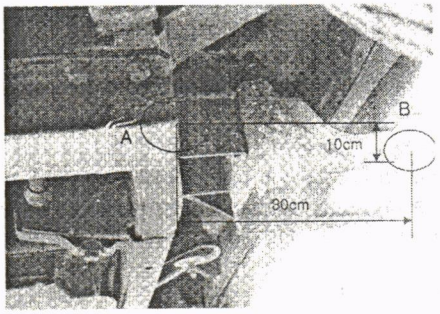
Picture 8 shows two gauge marks (① and ②) on the bus lane. Mark ①, chip, is a kink when heavy metal parts come in contact with the ground with a high pressure. Chip started about 0.14 m right side from the centerline, generated 0.12 m long counterclockwise curve and ended 0.26 m right side from the centerline. Mark ②, chop, is another type of kink when a relatively smaller pressure and wider objects than chip applies. Chop started about 0.21m(0.35m-0.14m) after chip mark ①, 0.35 m right side from the centerline, generated 0.24 m long mark, and ended 0.59 m right side from the centerline. Evidence D was caused through passenger car's path to final stop position after it turned counterclockwise. That is, gravity center of the passenger car abruptly moved into the damaged left front tire and lower part (A, Picture 9) of the passenger car body and contacted the road first and then other lower part (B) of the passenger car body scratched the road surface and finally generated mark ②.

Physical Evidences on the Passenger Car Path

Picture 10 shows three tire marks (A, B and C) on the centerline and passenger car's lane. Evidence A was marked when damaged passenger car's left front tire was crossing the centerline. This centerline crossing stemmed from when the bus instantaneously turned the



Picture 8. Chip and Scratch Mark



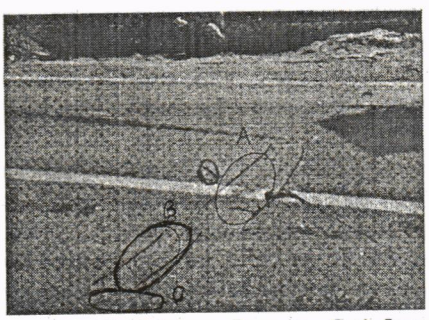
Picture 9. Lower Part Damage of Passenger Car

passenger car counterclockwise just after maximum engagement.

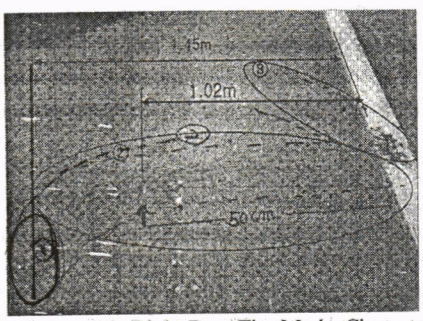
Evidences B and C were caused by the left and right rear tires when they were sliding counterclockwise. Thicker C was formed because side wall of the right rear tire contacted the road when the passenger car quickly turned counterclockwise and gravity center of the car moved into the right rear tire.

These are very important factors reconstructing the location of the passenger car collision. Picture 11 shows three analyzed parts of C. Part ① of evidence C is, as mentioned above, collision scrub when bus impacted passenger car and they stuck together like cogwheel and passenger car's side wall contacted road surface and made tire tread counterclockwise. Therefore, the starting point of collision scrubs is the position of the passenger car's right rear tire at the time of collision.

Evidence ② follows evidence ① counterclockwise, and it continues until evidence ③ starts. Evidence ③'s starting point is where the passenger car completely separated from the bus and advanced forward after finishing turning counterclockwise. Acceleration scuffs of ③ on the road edge line can be explained by the racing engine force of right rear tire. Crossing angle between evidence ③ and edge of the road is 42°.



Picture 10. Tire Marks on Passenger Car's Lane



Picture 11. Right Rear Tire Marks Character

2.7 Vehicle Location at First Contact and Maximum Engagement

To predict vehicles' locations at first contact and maximum engagement, comprehensive analysis including damaged shape of vehicles, damage characteristics, direction of PDOF, physical marks on the road and highway cross section analysis is conducted.

Passenger car

Distance from evidence ① to the edge of the road is 1.45 m, as shown on Picture 11. This tells that passenger car's right rear tire was located at 1.45 m away from the right edge of the road at the time of collision and the passenger car started to turn counterclockwise. By that time, passenger car's left rear tire location was about 2.97 m (1.45 m + 1.52 m of rear track width) away from the edge of the road. This means that the passenger car safely traveled 0.13 m (lane width of 3.1 m – 2.97 m) right side from the centerline at the time of collision.

Bus

• Analysis by position of passenger car and damage characteristics

At the maximum engagement, the passenger car's rear left tire was 0.13m right side from the centerline. After maximum engagement, when passenger car started to turn counterclockwise, bus position was crossing the centerline by approximately 0.39 m (0.13 m + 0.26 m) since front left hood of the passenger car was crashed inside by about 0.26 m.

•Analysis by bus tire marks

Starting point of bus' front left tire mark was approximately 0.97 m away from the centerline as shown on Picture 6. It goes along with the centerline about 8.1 m where mark's curvature changes. At curvature changing point, the left front tire of bus is 1.70m right side from the centerline. This tells that bus traveled a little bit diagonally to centerline (Out-In-Out), not parallel to the centerline. The analysis by Figure 3 revealed that the bus is crossed centerline at 10.8m downstream from the starting point of skid mark by the left front tire of bus. Therefore, this accident can be explained that bus traveled Out-In-Out, realized a passenger car coming from the opposite lane, tried to go back to its original lane but failed, thus finally collided.

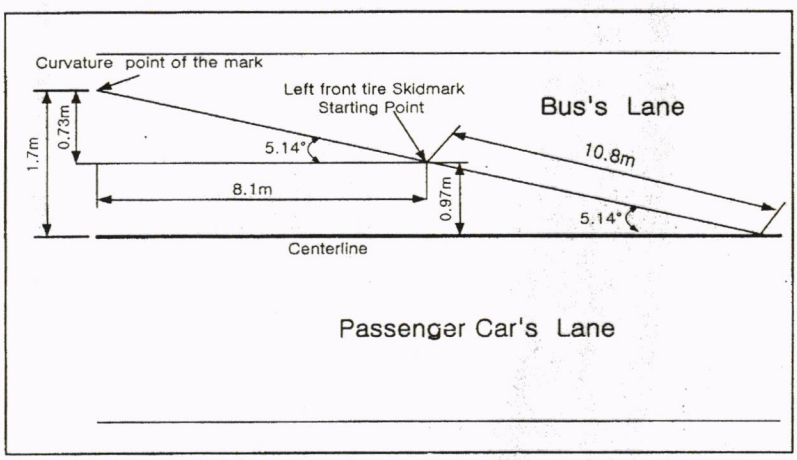


Figure 3. Collision Location Analysis of Bus Left Front Tire

From all the evidences and analysis, the simulated accident reconstruction diagram is drawn as Figure 4.

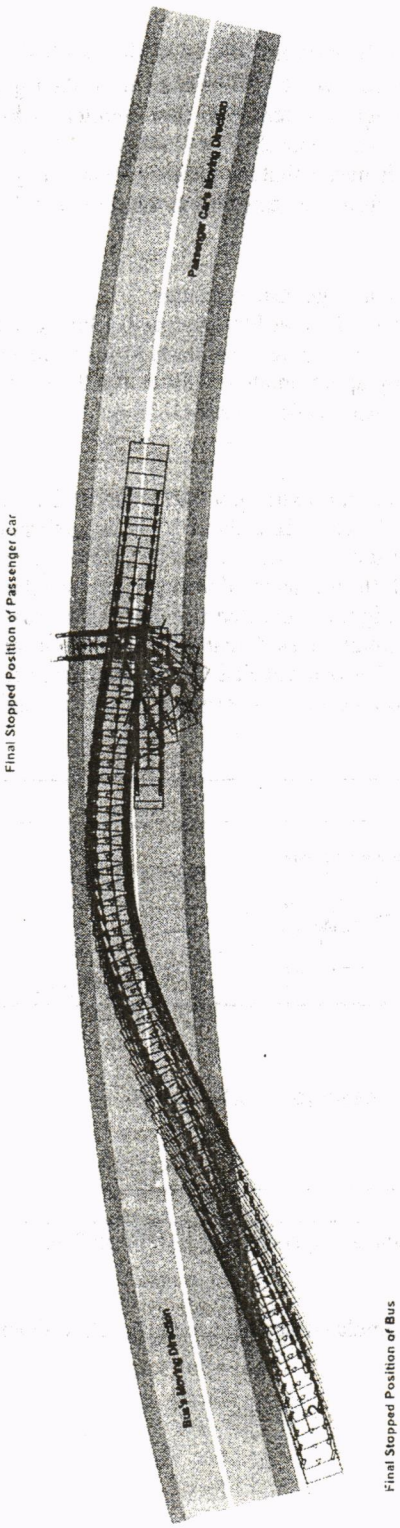


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Figure 4. Simulated Accident Reconstruction Diagram

3. CONCLUSIONS

The centerline crossing accident case involving passenger car and bus was reconstructed using such physical marks and evidence as skid mark, yaw mark, collision scrub, gauge mark, imprint, oil trace, damaged vehicle conditions, and final stopped vehicle position. The principal direction of force on the impacted vehicle and vehicle dynamics after impact are analyzed from comprehensive evaluation of physical evidences. It is found that the passenger car was keeping his lane by 0.13m inside from the centerline while the bus was crossing the centerline by 0.39m.

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