THE CONSULTANTS PERSPECTIVE

A SUGAR PUBLICATION

SPRING 1997 PROPERTY/CASUALTY EDITION

Providing Forensic Consulting and Technical Services

LOW SPEED REAR-END IMPACTS: AN OVERVIEW

by David A. Peters, P.E., Ph.D.

INTRODUCTION

A great number of accident injury cases involve the occupants of vehicles involved in low-speed (5-10 mph) impacts. Generally, the claimants are in a front vehicle which has been hit from behind by the rear vehicle. Claims are often of headaches, neck injuries, or back injuries. In many of these accidents there is very little visible damage to either car; and it is, therefore, difficult to assess the magnitude of the forces experienced by the passengers or the likelihood of serious injury. Because of this, testing has been done both on human subjects and on crash dummies in low speed impacts to quantify the effects of low-speed impacts.

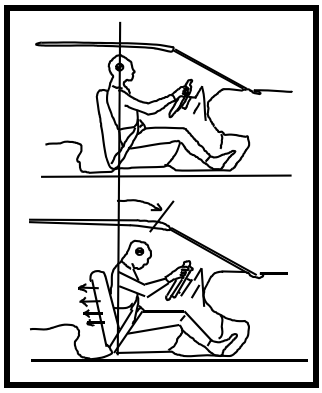
DYNAMICS

The details of any individual collision would depend on the type and weight of vehicles, the type of bumper, the speed of impact, the types of seats, and the size and weights of passengers. However, all low-speed rearend impacts have the same qualitative dynamics. First, what matters is the relative velocity between the two vehicles. Thus, it does not matter whether the front vehicle backs into the rear vehicle or the rear vehicle runs into the front vehicle, the results are the same. Further, it is of little consequence whether or not the stationary car has the brakes applied.

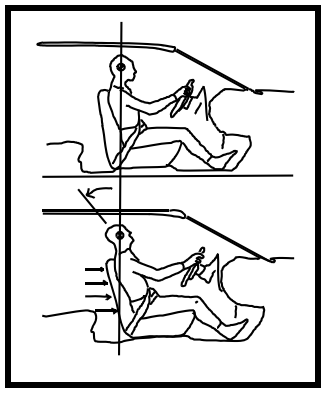
For the sake of explanation, let us assume that the rear car has impacted the front car at a speed less than 10 mph. At the moment of impact, part of the forward momentum of the rear car is transferred to the front car. At a very low speed (less than 5 mph) with little structural deformation, almost all of the momentum is transferred. At speeds above 10 mph, enough permanent deformation occurs that only about one-half of the momentum is transferred. (The other half is expended in the structural deformation process). In any event, the result is a rapid acceleration of the front car within a very short time (on the order of 50-100 msec). This acceleration of the car pushes the seat back of passengers in the forward car into their backs accelerating them forward as well. However, since the head is not usually resting against anything, it tends to remain stationary for longer than the lower body. This has the tendency to make the head initially tilt backwards with respect to the torso. It takes on the order of 200 msec (0.2 sec) for full backward motion, then the head is propelled forward as it catches the rest of the body. This can be quite a rapid forward acceleration. However, the head is propelled only slightly ahead of its original position and then returns back to its normal, vertical location. There is very little forward motion of the body or knees. (See Figure 1)

In contrast, the passengers in the rear vehicle (See Figure 2) are in a reference frame that has been rapidly slowed or stopped. Thus, they feel their bodies being thrown forward against the seat belts and shoulder restraints. When full belt restraint is achieved, the head travels further forward and then is jerked back to the neutral position. It is usually the passengers in the forward vehicle that complain of injuries.

In This Issue



Rear Vehicle
Figure 2



Front Vehicle
Figure 1

Thus, most tests have concentrated on the motions of passengers in the front vehicle. Naturally, the amount of rearward neck motion is limited by the presence of head restraints. Nevertheless, integral restraints and adjustable head restraints have only reduced whiplash injuries by 28% and 17%, respectively. Furthermore, most tests show little effect of restraints on the major dynamics.

ANALYSIS OF DATA

Although data have been gathered under a variety of conditions, most tests fall within certain general, quantitative limits that can help to determine the extent of motions that might be expected in low-speed rear end impacts. In tests at relative velocities of less than 2 mph, we find vehicle accelerations of about .75 g's (75% of the force of gravity) and head accelerations of less than 1.5 g's. The resultant angular head rotations (backwards) are less than 10 degrees. In the range of relative speeds of 3.0 to 4.0 mph, head accelerations increase to about 2.5 to 3.0 g's and head motions reach 20 to 30 degrees. At these speeds, no test subject has reported any pain or injury.

At 5 mph impact, we move into the next level of collisions. Usually, significant vehicle deformations are seen, depending on the details of the impact point. For the occupants of the forward vehicle, head accelerations increase to 6 g's, and backward head rotations reach 45 to 50 degrees. This is roughly the onset of temporary mild neck discomfort due to strain, but healthy subjects report no pain or lasting discomfort from these impacts after they have left the vehicle. On the other hand, some individuals with previous neck or back injuries who are subjected to 5 mph impacts report headaches that last for several minutes or neck stiffness that lasts into the following morning. Still, however, no longer-lasting symptoms have been reported for a period of over a year.

In the range of impact speeds from 5 to 10 mph, accelerations increase from 6 g's to 12 g's and head rotations increase from 45 degrees to 70 degrees. Seventy degrees is about the limit of human tolerance and is approaching the limit at which injuries could be expected. Participants in 10 mph tests report headaches and neck discomfort that last from a few hours to several days. Thus, one would expect the possibility of longer-lasting injury at higher speeds, although well-restrained individuals have withstood much higher g's.

SUMMARY AND CONCLUSIONS

Impact speeds of less than 2 mph leave no test subject with lasting symptoms. The accelerations and forces are about the same as would be expected in normal vehicle stopping. In the range of 3 to 4 mph, forces are typical of a mild amusement park ride, and no test subjects have reported any lasting effects. At 5 mph, we reach the lower edge of where after-effects can be felt. Accelerations are typical of those felt jumping off a step or "plopping" into a hard chair. In the range from 5 mph to 10 mph (for which vehicle damage is possible), some temporary headache and neck discomfort is reported for hours or days, and persons with previous neck or back injuries feel the effects for a longer period after the collision than do healthy subjects. Nevertheless, all effects have disappeared after this time with no long-term results. For impact above 10 mph, injury is certainly possible but not always necessary, and head restraints can be a mitigating factor.

ABOUT THE AUTHOR
David A. Peters

FORCON consultant David A. Peters received his B.S. and M.S. in Applied Mechanics from Washington University and his Ph.D. in Aeronautics and Astronautics from Stanford University. He is currently a Professor of Mechanical Engineering and Director of the Center for Computational Mechanics at Washington University and has been a FORCON consultant since 1989 when he was a Professor at Georgia Tech.

Dr. Peters has extensive experience as a forensic consultant and expert witness and has authored over 100 publications in areas of vibration, dynamics, structures, stresses and aerodynamics. His consulting/Expert witness experience has been associated with dynamics of vehicles including rail cars, amusement park rides, aircraft and helicopter dynamics, seat failures, shoe friction, exercise equipment, lawn mowers, and other mechanical devices. He is a registered Professional Engineer in Georgia and Missouri.

Dr. Peters also conducts investigations of low speed impacts wherein he determines the relative velocity between the vehicles at impact and then provides an assessment of the liklihood of injury using data contained in the studies he references in the above article.

If you have any change of address,
please mail corrections to:

FORCON International Corporation
1216 Oakfield Drive
Brandon, FL 33511

CASES INVOLVING INSERTS IN CHILD RESTRAINTS

All 50 states require children under a specified age to be properly secured in a child restraint system when in a motor vehicle or an aircraft. The National Highway Traffic Safety Administration (NHTSA) regulates child restraint systems through its Federal Motor Vehicle Safety Standards (FMVSS) 213 for restraining or positioning children.

However, the standard is silent regarding the use of a variety of available inserts to be installed in and used with a child car seat. Such inserts are intended to provide head support for infants riding in a child (infant) restraint.

FORCON International is working on two recently received cases involving infants. The three infants were riding in child restraint seats (two infant and one convertible) each with an insert. The infants were ejected or thrown from or out of the child restraints and were subsequently injured or killed in two separate motor vehicle accidents.

In both cases, FORCON Consultant Dr. Michael L. Romansky has been retained by defense attorneys to analyze the "Second Collision" portion of the respective accidents (that which occurs between the vehicle occupants and the vehicle interior) and reconstruct the resultant injury causation sequence based on infant/child occupant kinematics. Investigative and analytical efforts focus not only on the insert itself but also on the "chain of infant/child coupling" involving the child restraint system and the vehicle restraint system. Working with Dr. Romansky in one of the cases is FORCON Consultant Steve Chewning, who is reconstructing the "First Collision", i.e., that occurring between and involving the vehicles at the moment of impact.

FORCON will be examining the extent and magnitude of vehicular accidents involving child restraints having inserts. It appears that no collective data base currently exists for reporting and tracking accidents of this type.

FORCON International Offices Providing Forensic Consulting and Technical Services:

Atlanta, GA	**(770) 390-0980**
Avon, CT	**(860) 674-8101**
Morristown, NJ	**(201) 326-8822**
Richmond, VA	**(804) 285-7870**
Tampa, FL	**(813) 684-7686**
Washington D.C.	**(301) 670-1262**

ACCIDENT RECONSTRUCTION SEMINAR

FORCON will be conducting its training seminar entitled "Accident Reconstruction - A Primer for the Insurance Claims Professional" in Atlanta and Tampa this year.

This will be the third year for the Atlanta seminar which has been approved for 4.0 CEU credits by the Georgia Insurance Department. Over 250 claims professionals have attended prior sessions. The date this year is March 24th from 8:00 AM until 12:15 PM. For further information contact our Atlanta office at 770-390-0980.

Due to the popularity of this seminar, we are planning to present it later this year for the first time in Tampa. A date and location have not yet been selected. If you are interested in attending the Tampa seminar, please contact Bob Dwyre or John Holland in our Tampa office at 813-684-7686.

CONSULTANT PROFILE
Reuben Clarson, P.E.

FORCON Consultant Reuben Clarson has over 30 years experience in the design, construction, and evaluation of marine structures including piers, port facilities, marinas, docks, sea walls, bridges, bulkheads, subaqueous utilities and pipelines, and sheet piling. He has consulted to Realtors, developers and home / condominium owners on condition of and required repairs to sea walls and docks, and has worked with appraisors on valuation of marinas. Reuben has also served as an expert witness in 2 marine construction lawsuits.

Reuben is a member of the Florida Engineering Society and National Society of Professional Engineers.

BACK ISSUES OF NEWSLETTER AVAILABLE

Those recipients of this newsletter who are recent additions to the FORCON mailing list may not be aware that we have been publishing our Property/Casualty newsletter since the fall of 1991. In each issue of this newsletter we have tried to make the lead article an educational type of article, an article where we provide you with useful information on a property or casualty claim issue that forensic engineers or scientists typically investigate. Dave Peter's article in this issue is an example of this type of lead article.

We have compiled copies of these back issues of our P/C newsletter into three ring binders which can be used to store future issues as well. We hope that this will be a useful reference document. If you would like to receive one of these binders with the back issues please feel free to contact any one of our FORCON offices.

FORCON INTERNATIONAL CORPORATION

PRESENTS

THE CONSULTANTS PERSPECTIVE

IN THIS ISSUE ! - AN ARTICLE ON

Low Speed Rear-End Impacts: An Overview

AND MORE !

BULK RATE
US POSTAGE
PAID
PERMIT No. 116
BRANDON, FL

FORCON INTERNATIONAL CORPORATION
1216 Oakfield Drive
Brandon, Florida 33511