FORENSIC ENGINEERING RECONSTRUCTION OF ACCIDENTS

Second Edition

FORENSIC ENGINEERING RECONSTRUCTION OF ACCIDENTS

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PREFACE

The objective is to produce a book that can serve as an introduction to the subject as well as a "refresher course" for the active professional. Thus, we have avoided the temptation to greatly expand or totally rewrite the book. Rather, for this second edition Chapters 3 to 5 have been rewritten and the rest of the text has been edited to bring parts more up to date.

The book covers the important areas of vehicular accidents, automobile, truck, motorcycle and pedestrian. Slip-and-fall accidents and failure analysis are introduced. Techniques such as photography, mapping and measuring as well as the fundamentals of mechanics and dynamics are covered. The material is selected to show the approach to accident reconstruction, the thought processes involved, the range of subjects covered, and the breadth of technical material covered by this field. The material is presented at a level that is appropriate for engineers, lawyers, and others interested in the techniques and details of the accident reconstruction process.

As this second edition of F*orensic Engineering Reconstruction of Accidents* goes to press, John Brown is suffering the latter stages of Parkinson's disease. He was unable to participate in much of the rewriting of the book. Hence, this second edition, as a gentle modification o the first edition, still retains the flavor of John's skillful writing as well as his knowledge and expertise.

Kenneth S. Obenski
Thomas R. Osborn

PREFACE TO FIRST EDITION

From an engineering standpoint this is not an advanced text. Much of the material, however, does deal with various aspects of traffic accident reconstruction. It is assumed that the reader has either gained some practical experience in this subject, or has read basic books on the subject such as *Traffic Collision Analysis*, by Collins and Morris, and *The Traffic Accident Reconstruction Handbook* by J. Stannard Baker.

The engineering principles involved are introduced at the elementary level, and in many cases equations used in freshman physics are derived. The authors believe that the derivations are presented in the simplest manner possible so that this material will be retained by the reader.

This book is the result of an effort over a period of four years to compile useful forensic engineering data, information, and analytical techniques over and above those taught to non-engineers. Many of the mathematical treatments are original. In general, the book reflects the authors' combined 17 years of forensic investigations involving over 1500 cases.

This book offers something for everyone interested in forensic engineering. The experienced investigator will find a wealth of new ideas and relationships to fill in gaps in his knowledge and reinforce his analytical approaches. Those starting new in this work will have a "leg up" on their competition after studying this material. For the non-technical reader, most of the book is eminently readable. To an investigator; attorney, or insurance adjuster with only a nodding acquaintance with freshman physics, the book should be totally comprehensible.

John Fiske Brown
Kenneth S. Obenski

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FORENSIC ENGINEERING RECONSTRUCTION OF ACCIDENTS

Chapter 1

WHAT IS FORENSIC ENGINEERING?

"Forensic engineering" is a relatively new term and is still not used exclusively by the people who are engaged in this work. The more familiar term is "expert witness." Even the general public has some kind of vague notion about who an expert witness is and what he does. Surely, the layman is not aware of all of the details. Usually, however, prospective clients of the forensic engineer will more readily recognize one's professional capabilities as an "expert witness," or simply "expert," than as a "forensic engineer." The term forensic engineer is preferable to "expert witness," and there is a tendency among existing companies engaged in this work to prefer this term. In most investigations, the forensic engineer works first as a consultant. A consultant, just as the term implies, advises his client. Until the "consultant" is disclosed as an "expert," his work is usually protected under the attorney work product privilege. Once an expert is identified, he may then be examined by the adverse parties.

The term "expert witness," of course, is all-inclusive. Some people associate it wrongly with "purchased testimony." A medical doctor, an accountant, or for that matter, a mechanic, or carpenter, could serve as an expert witness. The term "forensic engineer" limits the scope to the engineering profession. The word forensic means applying to or dealing with the process of litigation, or literally debate. A forensic engineer can, of course, be a forensic mechanical, civil, or electrical engineer, etc. Most people are familiar with the term forensic medicine or forensic chemistry. The TV program "Quincy," starring Jack Klugman, did much to put this kind of work in the public eye. It is only a short step from here to apply the same concept to a forensic engineer.

As already implied, a forensic engineer applies the principles of science and engineering to investigations which are part of, or potentially a part of, some litigation process. A forensic engineer's clients, then, will come from two major sources–lawyers and insurance companies. Perhaps one-half of those clients will be insurance companies, and one-half will be attorneys. On very rare occasions, a forensic engineer may work for an individual, or a corporation. Even though one may start working for an insurance company, he may, however, eventually work with that company's attorney. Therefore, most of the time, the work will be closely associated with attorneys and the legal profession.

The history of forensic engineering is as old as written history. Hammurabi's Code had a section that dealt with punishment for the designer of a house if the roof collapsed or if the foundation failed. More recently, an accident in 1916 involving a Buick ultimately resulted in litigation that traced the fault to defective manufacture. Probably the Industrial Revolution, especially as it moved into the 20th century, was responsible for the present concept of forensic engineering. As more and more complex devices moved into the public realm, accidents were unavoidable, and the ability of laymen to comprehend them decreased. First came steamboats and railroad trains in the 1830s and steel bridges in the late 1800s. Railroads experienced many disastrous accidents, and later bridge collapses were not uncommon (the early metal bridges were iron, not steel, so that failures could have easily been predicted in the light of present-day metallurgy). As the 20th century progressed, the automobile appeared on the American scene, and in large numbers after World War I. Along with the automobile, came home appliances. Meanwhile, the commercial aviation business began to thrive. It is significant that aircraft accident investigation has always been an integral part of the aircraft industry. Whenever an airplane crashes, both government and industry investigators are on the scene immediately. This has always been the case, and this is well known to the general public because of the publicity that these crashes create. What is not well known is that accidents involving automobiles, home appliances, etc. are also the subject of engineering investigations.

Simply because of the large number of vehicles in use (about 220 million registered cars, trucks, and buses in the United States in 2000), and the inherent risks of high-speed transportation, unless one has some unrelated specialty, he should expect that the bulk of the work may be derived from automobile accidents. This work will come in two forms, automobile accident investigation and automotive defect investigation. Accident investigation involves applying principles of dynamics, perception, and general physics to the movements of vehicles before, during, and after the collision to determine speeds, positions, and driver responses or possible responses during the sequence of events that took place. Defect investigation involves the mechanical failure of critical components such as brakes, steering, and suspension that lead to an accident. As more occupant protection systems (air bags, automatic seat belts) are added to vehicles, these also become the subject of litigation. One can even have investigations that involve several aspects.

While as much as 80 percent of the work will come from automotive sources, the remainder will come from a wide range of home appliances and equipment. Many engineers find themselves specializing in one group of products. Just to give an idea of what a forensic engineer might become involved in, a list of some of the items that the authors have investigated follows.

1. Glass coffeepots
2. Chairs
3. Ladders
4. Dishwashers
5. Falling pictures
6. Plumber's snakes
7. Toilets
8. Floor designs and materials
9. Water heaters
10. Roofing materials
11. Power tools
12. Air compressors
13. Machinery fires
14. Plumbing systems
15. Cranes
16. Machine tools
17. Presses
18. Construction machinery
19. Agricultural machinery
20. Industrial machinery

21. Elevators
22. Conveyors
23. Medical devices

The above list will provide a general idea. The real point is that almost any household appliance or tool can cause injury and might be worthy of investigation, or of equal importance, could be wrongly accused of causing an injury. While these products may seem highly divergent, a fact opposing counsel will dwell upon, the engineering principles and methods are remarkably similar.

One other area of investigation that involves forensic engineering is called slip and fall or trip and fall. These accidents occur when a person falls as a result of losing traction or balance while walking. These investigations involve principles of friction and floor design. That is what places them within engineering rather than physiology. This subject is discussed in detail in Chapter 17.

Industrial accidents constitute another area of interest. Accidents involving large industrial equipment or machinery are common. Here the investigation may be directed toward mechanical failures, mechanical design, maintenance, or misapplication. This subject will also be discussed in a later section. Many of these cases involve very expensive property damage rather than personal injury.

One final word on the terms "expert witness" and "forensic engineer." No matter what one calls himself, attorneys will probably refer to him simply as an "expert." Sometimes the use of this term raises eyebrows. It is a legal term which means that the expert has sufficient practical experience, knowledge, and education to do the investigation, and more important, to render opinions. In court, if the judge agrees that the witness is sufficiently qualified, he will allow him to testify as an expert. This is usually not a problem in defect analysis so long as the witness has appropriate experience. Accident reconstruction is another matter. A judge will probably insist that the expert have had some training and experience specifically in accident reconstruction before he will be allowed to testify.

The legal definition of expert (and many other common terms) is different than the common definition. A legal expert possesses knowledge exceeding that of a layman. It does not mean that he can cite endless facts and figures. In many cases, the only expertise the authors have offered is expertise in engineering research and analysis. It often turns out that the forensic engineer is the first engineer to have ever analyzed the product.

Although adverse attorneys will often create a great deal of bluster if the expert has no experience with the exact product or industry involved, it is usually irrelevant. As long as the engineer has a good background in appropriate fundamentals, it doesn't matter that he got them in a different environment. For example:

1. An engineer with extensive design experience in mechanisms, hydraulics and multi-speed industrial gear drives can testify about automatic transmissions, shock absorbers, and brakes if he has done his homework.

2. An engineer with extensive experience in rocket engine design, sophisticated instrumentation, and vehicle design can testify about a gas barbecue, an air dryer explosion, and a defective hospital gurney if he has the data available.

Attorneys have even successfully used an engineer just to present the opinion of an unbiased learned professional.

Chapter 2

WHY ARE FORENSIC ENGINEERING INVESTIGATIONS MADE?

Now that the readers have some idea about what forensic engineering is, they can develop some insights into the reasons and rationale that precede the investigation request. First of all, it should be patently obvious that all accidents do not lead to investigations. Sometimes there is no doubt of liability. Another obvious reason is that all accidents do not result in injuries. Now, this doesn't mean that all investigations involve injuries; it is just that most of them do. Typically, if an auto accident is just a "fender bender" where no one was injured, it is virtually certain that no one will be called to do an investigation. Moreover, the injuries that lead to investigations are usually very serious, the kind of accidents where someone loses fingers, toes, arms, legs, eyesight, hearing, or life itself. These are the kinds that the forensic engineer will investigate; also cases where a large property loss is involved may be investigated. For example, an overheated wheel might come off of a truck and start a forest fire. In such a case, the truck company is responsible for the fire losses, and the insurance company that insured the truck might call upon an expert.

Another factor that can increase dollar losses is "downtime." Owners of businesses invest large amounts of money in equipment. The idea, of course, is that this investment, like any other, will pay dividends. In this case, the customer is charged for the use of the equipment as well as the labor charge for an operator. If the equipment is "down" because of a failure, the owner loses accordingly, because he still carries the cost of the equipment but at the time it isn't producing income. For this reason, "downtime" is a legitimate charge in addition to real property loss. The downtime may even involve other equip-