

## Review Article

# Forensic Engineering- A New Tool for Investigation

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### ABSTRACT

Forensic engineering is a compendium of the investigative methodologies used by engineers and scientific investigators to evaluate some of the more common types of failures and catastrophic events. In essence, it provides analyses and methods for determining how an entity was damaged and when that damage may have legal consequences. It covers common types of failures, catastrophic events, and losses that forensic engineers routinely assess. The range of topics include wind and blasting damage to structures, vehicular accidents, fires, explosions, hail damage to roofs and exteriors, lighting damage, and industrial guarding accidents. Additionally, it offers an extensive discussion of the scientific method as it applies to forensic science and provides tips on organising and writing an investigative report. The forensic engineer is yet to be used in various roles in India viz. traffic accidents, court proceedings and spot investigation. Here an effort is made to highlight the applications of the subject and to stress the importance of this field in the administration of justice in the Indian scenario.

**Keywords:** Forensic Engineering, Accident, Reconstruction

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## INTRODUCTION

Forensic engineering is the application of engineering principles and methodologies to answer questions of fact. These questions of fact are usually associated with accidents, crimes, catastrophic events, degradation of property, and various types of failures.<sup>1</sup> Forensic engineering is the science concerned with the relation between engineering and law.

Forensic engineering is the investigation of materials, products, structures or components that fail or do not operate or function as intended, causing personal injury or damage to property.<sup>2</sup> The consequences of failure are dealt with by the law of product liability. Generally, the purpose of a forensic engineering investigation is to locate cause or causes of failure with a view to improve performance or life of a component, or to assist a court in determining the facts of an accident. It can also involve investigation of intellectual property claims, especially patents.<sup>2</sup>

## EVOLUTION

With the prevalence of liability lawsuits in the late 1900s the use of forensic engineering as a means to determine culpability spread to the courts.<sup>2</sup>

Vital to the field of forensic engineering is the process of investigating and collecting data related to the materials, products, structures or components that failed. This involves inspections, collecting evidence, measurements, developing models, obtaining exemplar products, and performing experiments.

One of the first major inquiries conducted by the newly formed Railway Inspectorate was conducted by Captain Simmons of the Royal Engineers, and his report suggested that repeated flexing of the girder weakened it substantially.<sup>2</sup>

## A FORENSIC ENGINEER

Forensic civil/architectural engineers perform “autopsies” on components and materials or full-sized buildings,

## Forensic Engineering- A New Tool for Investigation

bridges, and other engineered constructed works in order to determine the cause and extent of failure. A secondary purpose is to determine methods of repair/rehabilitation/replacement.<sup>3</sup>

### Tasks performed by a forensic engineer:

- He assesses what was there before the event, and the condition it was in prior to the event.
- He assesses what is present after the event, and in what condition it is in.
- He hypothesizes plausible ways in which the pre-event conditions can become the post event conditions.
- He searches for evidence that either denies or supports the various hypotheses.
- He applies engineering knowledge and skill to relate the various facts and evidence into a cohesive scenario of how the event may have occurred.<sup>1</sup>

### PRACTICE OF FORENSIC ENGINEERING

A forensic engineer's kit should contain some or all of the following items, depending on the size and complexity of the accident:

The lens, flashlight, graph & lined paper, small blackboard w/chalk, pencils/pens, ruler and tape measure, warning signs, cassette recorder w/tape, camera and film, data collection forms, sample containers, high visibility marking tape, safety helmet, gloves, shoes, calculator. Today's forensic engineer must carry a digital camera as well as a video camera to record for later analysis. His skill set should include familiarity with computers, spreadsheets, and computer graphics.<sup>4</sup>

**The investigation should begin as soon as possible** after the accident happens, as otherwise:

1. **Operations may be disrupted.** The more serious an accident is, the more time and effort it takes to bring work back to normal. The sooner an investigation begins, the faster normal operations can resume.

2. **Memories may fade.** As time passes, what a person remembers can change. Interviewing witnesses as soon as possible after the accident helps assure a more accurate account of what happened.
3. **Employees may be put to risk.** There is a good chance a similar accident can happen again unless the causes are identified and corrected. The earlier an investigator can determine the causes, the faster corrective action can be taken to prevent a recurrence.

### SOURCES OF INFORMATION

Documents, newspaper reports, police reports and records, medial reports and records, testimony of officials and affected worker(s), photographs, videos, physical evidence at the scene, statements of witnesses are the various sources from where information can be gathered. To stand up in court, every bit of evidence collected from the site or other sources must be tracked and documented in detail from the beginning to the end.

Back analysis is a common technique of forensic investigation, involving the repetition of earlier computations, tests etc. with data extracted from later developments at site. Re-building of a collapsed structure may be possible in certain situations, but it may be undertaken (even when economically and practically feasible) only if there are detailed original designs and plans from which it was built the first time, and not from memory. Re-enactment of an accident is a very risky and high-profile activity, not to be undertaken lightly.

As a general rule, an accident or failure is not the result of a single cause or event. It is usually the combination of several causes or events acting in concert, that is, at the same time or in sequence, one after another in a chain.

An example of causes acting in concert might be an automobile accident.

- Both drivers simultaneously take dangerous actions. Driver A has to yield to the approaching traffic making a left turn and has waited for the light to turn yellow to do so. He also doesn't signal his turn. At

the end of the green light, he suddenly turns left assuming there will be a gap during the light change. Coming from the opposite direction, driver B enters the intersection at the tail end of the yellow light. They collide in the middle of the intersection.

- Driver A is drunk.
- Driver B's car has bad brakes, which do not operate well during hard braking. Driver B is also driving without his glasses, which he needs to see objects well at a distance.

Often, failures and accidents involve both sequential events and events acting in concert in various combinations.

Conclusions should be directly based on the facts and analysis, and not on other conclusions or hypotheses. If the facts are arranged logically and systematically, the conclusions should be almost self-evident.

Win or lose, and whether root causes for the accident can be found or not, the investigator should come up with improvements to the safety management system.

### **ROLE IN THE LEGAL SYSTEM**

There are several formats used to report the results of a forensic engineering investigation. The easiest is a simple narrative, where the engineer simply describes all his investigative endeavours in a chronological order. He starts from when he received the telephone call from the client, and continues until the last item in the investigation is complete. The report can be composed daily or piecewise when something important occurs as the investigation progresses, like a diary or journal. Insurance adjusters, fire investigators, and detectives often keep such chronological journals in their case files.

Alternately, the report could be prepared like an academic paper, replete with technical jargon, equations, graphs, and reference footnotes. While this type of report might impress colleagues or the editors of technical journals, it is usually unsatisfactory for this application. It does not readily convey the findings and assessment of the investigation to the people who need to read it to make decisions. They are usually not professional scholars.<sup>4</sup>

From time to time, a person who does this type of engineering analysis is called upon to testify in deposition or court about the specifics of his or her findings. Normally the testimony consists of answers to questions posed by an attorney for an involved party. The attorney will often be interested in the following:

- The engineer's qualifications to do this type of analysis.
- The basic facts and assumptions relied upon by the engineer.
- The reasonableness of the engineer's conclusions.
- Plausible alternative explanations for the accident or failure not considered by the engineer, which often will be his client's version of the event.

### **APPLICATIONS**

1. Most manufacturing models will have a forensic component that monitors early failures to improve quality or efficiencies.
2. Insurance companies use forensic engineers to prove liability or no liability.
3. Most engineering disasters (structural failures such as bridge and building collapses) are subject to forensic investigation by engineers experienced in forensic methods of investigation.
4. Rail crashes, aviation accidents, and some automobile accidents are investigated by forensic engineers in particular where component failure is suspected.
5. Furthermore, appliances, consumer products, medical devices, structures, industrial machinery, and even simple hand tools such as hammers or chisels can warrant investigations upon incidents causing injury or property damages.
6. The failure of medical devices is often safety-critical to the user, so reporting failures and analysing them is particularly important. The environment of the body is complex, and implants must both survive this environment, and not leach potentially toxic impurities. Problems have been reported with breast implants, heart valves, and catheters, for example.

## Forensic Engineering- A New Tool for Investigation

A forensic engineer is also known as a reconstruction expert.<sup>6</sup> Vehicular accident reconstructions are often conducted by forensic engineers, specialised units in law enforcement agencies, or private consultants. It is the scientific process of investigating, analysing, and drawing conclusions about the causes and events during a vehicle collision. Reconstructionists are employed to conduct in-depth collision analysis and reconstruction to identify the collision causation and contributing factors in different types of collisions, including the role of the driver(s), vehicle(s), roadway and the environment. The laws of physics and engineering principles such as the conservation of linear momentum, work-energy methods, and kinematics are the basis for these analyses and may make use of software to calculate useful quantities. The accident reconstruction provides rigorous analysis that an expert witness can present at trial. Accident reconstructions are done in cases involving fatalities, and often when personal injury is involved. Results from accident reconstructions are also useful in developing recommendations for making roads and highways safer, as well as improving safety aspects of motor vehicle designs.<sup>5</sup>

After the analysis is completed, forensic engineers compile report findings, diagrams, and animations to form their expert testimony and conclusions relating to the accident.

Forensic animation typically depicts all or part of an accident sequence in a video format so that non-technical parties, such as juries, can easily understand the expert's opinions regarding that event. To be physically realistic, an animation needs to be created by someone with knowledge of physics, dynamics and engineering. When animations are used in a courtroom setting, they should be carefully scrutinised. Animation software can be easily misused, because motions which are not physically possible can be displayed. A reliable animation must be based on physical evidence and calculations which embody the laws of physics, and the animation should only be used to demonstrate in a visual fashion the underlying calculations made by the expert analysing the case.

## CONCLUSION

Forensic engineering is a specialised discipline which is a relatively new and unfamiliar field to the public. Its activities are related to investigation of failures with a view to improve performance or life of a component, or to assist courts in determining the facts of an accident. Forensic engineering is practiced by nearly every consulting firm abroad.

- Some firms now specialise in forensic engineering and are growing very fast.
- Forensic engineering is an option that you may wish to consider as a career.
- Practice in areas that you are well qualified<sup>3</sup>

Though there is enough scope for forensic engineers in our legal setup, the subject and its applications is still not in limelight. It will help in the trial by providing the missing link sometimes one encounters in a medico legal case.

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