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Forensic Engineering Analysis of Trucking Accidents and Regulations

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Abstract

This paper discusses heavy trucking accidents, their causations, applicable state and federal regulations and the newest available technology to reconstruct those accidents. The author will explain the fundamental differences between trucking and vehicle accidents. Differences between design and performance such as braking, acceleration, and lane changing maneuvers are outlined, and their consequences are explained.

Typical trucking accidents caused by driver fatigue, defective brakes, falling cargo, lost wheels and trailers, weather and speed, U-turns, under-ride, and conspicuity are discussed.

Furthermore, specific Federal Motor Vehicle Safety Standards (FMVSS) and Federal Motor Carrier Safety Regulations (FMCSR) regarding allowed driving hours, drivers log-books, vehicle mechanical conditions and required inspections (brake requirements, cargo securement), and driving in severe weather, are discussed in correlation to accident causations.

Also, the newest technology in reconstructing accidents, such as high-definition 3D scanning and Google Earth 3D imagery is presented.

Finally, some practical recommendations for an investigating engineer will be outlined.

Keywords

Trucking accidents, Federal Regulations, FMCSR, Scanning, Point cloud, Fatigue, Cargo securement, Driving hours, Brakes.

Introduction

National statistics show that large trucks are involved in way too many serious accidents. Every year, about five thousand large trucks are involved in fatal crashes; 135 thousand large trucks are involved in non-fatal crashes. Furthermore, there are 85 thousand injuries in crashes involving large trucks (Fatality Analysis Reporting System and Motor Carrier Management Information System).

In all trucking accidents, fatigued drivers and “bad” brakes are the number one factors related to causation of trucking accidents.

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Why Semi's Are Diferent?

Semi's are different than passenger vehicles, because they are up to 75 feet long and weigh up to 80,000 lbs. when fully loaded compared to passenger vehicles that are 20 feet long and typically weigh 4,000 lbs. Heavy trucks require, when fully loaded, about 1,700 feet and 40 seconds to accelerate to 60 mph, when high-performance passenger vehicles require only 220 feet and five seconds to do the same. When it comes to braking, a semi needs at least 250 feet to stop from 60mph where high-performance passenger vehicles only need 115 feet to stop.

The trucking industry is using a mechanical, air applied braking system. The air system is pressurizing to about 100 psi and an air compressor manages that pressure at the 100 psi value. If, for whatever reason that pressure drops below 60 psi the brakes are applied automatically. One of the reasons the pressure can drop below 60 psi is a malfunction of the compressor or damage to the brake lines.

There are many advances of such design, but the most important are: they are designed to fail safely (when lacking proper pressure) and they do not contaminate an environment. If there is not enough air pressure in the system, the brakes will automatically be applied.

However, the brakes can fail not only because the air pressure drops in value, but also due to poor service, poor adjustment, or overheating by a driver "riding" the brakes.

Typical Trucking Accidents

Trucking accidents can happen for a lot of different reasons, but most typical trucking accidents are a result of:

- Driver fatigue
- Defective brakes
- Falling cargo
- Lost wheels or trailers
- Weather and speed
- U-turns
- Underride
- Conspicuity
- Fires

Of course, the above list can be extended by less common trucking accidents like roll-overs, accidents while backing up, drivers falling off the truck or trailer and more.

Important Federal Regulations

The United States Department of Transportation (USDOT or DOT) is a federal Cabinet department of the U.S. government concerned with transportation. It was established by an act of Congress on October 15, 1966, and began operation on April 1, 1967. It is governed by the United States Secretary of Transportation.

Its mission is to "Serve the United States by ensuring a fast, safe, efficient, accessible, and convenient transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future." The USDOT regulates the motor carrier industry.

The Federal Motor Carrier Safety Administration (FMCSA), established January 1, 2000, regulates the trucking industry in the United States. The primary mission of the FMCSA is improving the safety of commercial motor vehicles (CMV) and truck drivers through enactment and enforcement of safety regulations.

The trucking industry is very heavily regulated. In order to properly establish accident causation, the investigating engineer needs to be familiar with existing State and Federal regulations. There are two sets of very important Federal regulations applicable to trucking accidents. The first, Federal Motor Vehicle Safety Standard (FMVSS) and the second, Federal Motor Carrier Safety Regulations (FMCSR). They are both published in the Code of Federal Regulations (CFR).

Federal Motor Vehicle Safety Standards (FMVSS).

Federal Motor Vehicle Safety Standards (FMVSS) are published in CFR, Transportation 49, Parts 400 to 999. In Chapter V, Part 571 and there are the following standards:

- FMVSS 101 through 126
- FMVSS 207 through 222
- FMVSS 301 and 302

Out of the above 44 standards, the most commonly applied standards are:

- FMVSS 108; Lamps, reflective devices
- FMVSS 120; Tire selections and rims for motor vehicles other than passenger vehicles
- FMVSS 121; Air brake systems
- FMVSS 211; Wheel nuts, wheel discs, and hub caps

It should be noted, that FMVSS are applicable to vehicle and trailer manufacturers.

Federal Motor Carrier Safety Regulations (FMCSR).

Federal Motor Carrier Safety Regulations (FMCSR) is published in CFR, Transportation 49, Parts 200 to 399. The most commonly applied regulations are related to fatigued drivers, drivers logs, severe weather, maintenance and inspection brake requirements and cargo securement:

- FMCSR 392.3 Ill or Fatigued Operator
- FMCSR 395.3 Maximum Driving Time for Property-Caring Vehicles
- FMCSR 395.8 Driver's Record Of Duty Status
- FMCSR 392.14 Hazardous Conditions; Extreme Cautions
- FMCSR 392.2 Applicable Operating Rules
- FMCSR 396.13 Driver Inspection
- FMCSR 392.7 Equipment, Inspection and Use
- FMCSR 392.9 Inspection of Cargo, Cargo Securement Devices and Systems
- FMCSR 393.100 through 393.136 Protection Against Shifting and Falling Cargo
- FMCSR 393.47(e) Push rod adjustment limit
- Appendix G to Subchapter B of Chapter III-Minimum Periodic Inspection Standards
- North America Standard Vehicle Out-Of-Service Criteria by Commercial Vehicle Safety Alliance (CVSA)

Those FMCSR are extremely important when investigating, reconstructing and analyzing the causation of trucking accidents. FMCSR are applicable to motor carriers. However, it should be noted, that in order for motor carriers to meet some of the required regulations, motor vehicles and trailers need to be manufactured in compliance with FMCSR.

Fatigue and Driving Hours.

Federal Regulations prohibit drivers from operating a commercial vehicle when they are fatigued (392.3). Furthermore, the Federal Regulations impose specific requirements limiting drivers maximum driving time with 10, 11, 14, 60 and 70 hours regulation and also mandates the documentation of driving time (395.3).

Weather Conditions.

Federal Regulations require drivers to take extreme caution when experiencing hazardous driving conditions, such as snow, ice, sleet, fog, mist, rain, dust, or smoke. They require drivers to reduce speed and even stop driving (392.14). It also requires drivers to operate commercial vehicles in accordance with the laws of the jurisdiction in which it is being operated (392.2). Although the Federal Regulation requires drivers to only reduce speed when hazardous conditions occur, most states are more specific and they require commercial drivers to reduce speed by 1/3 in rain and by ½ in snow or icy conditions.

Vehicle Inspections.

Commercial drivers are required, before each trip, to inspect the vehicle and "be satisfied that the motor vehicle is in safe operating condition (396.13). It also prohibits driving a commercial vehicle, unless the driver is satisfied that brakes, steering system, lighting devices, tires, horn, windshield, mirrors and coupling devices are in good working order (392.7).

Brake Conditions.

Commercial vehicle brake condition is an extremely important safety feature which always needs to be considered when analyzing accident causation. Appendix G to Subchapter B of Chapter III-Minimum Periodic Inspection Standards, published by Federal Motor Carrier Safety Administration, Department of Transportation together with North America Standard Vehicle Out-Of-Service Criteria by Commercial Vehicle Safety Alliance (CVSA) outlines the criteria for vehicles which do not pass an inspection. Figure 1 is typical brake components at the wheel. Vehicles do not pass an inspection if it has one of the following defects or deficiencies:

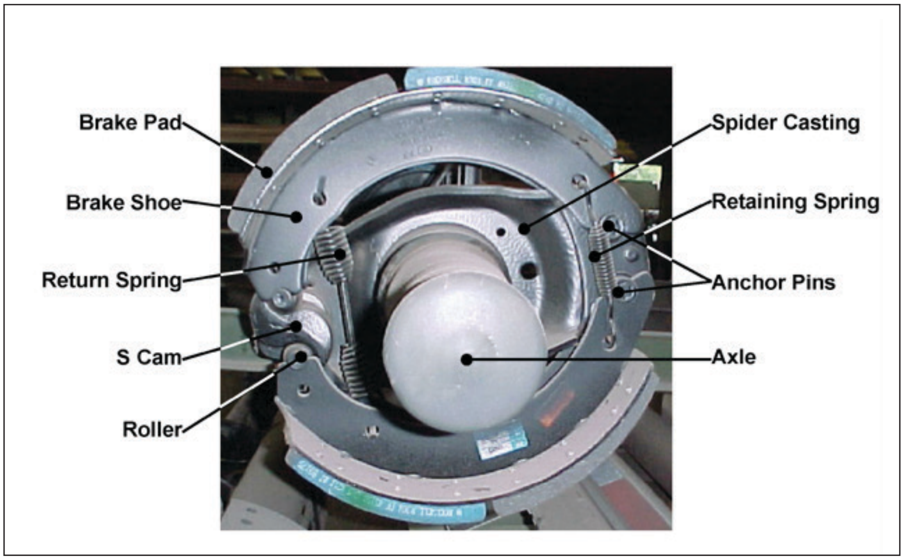

Figure 1
Drum and shoes.

- Absence of braking action on any axle required to have brakes
- Missing or broken mechanical components
- Loose brake components
- Audible leaks at brake chamber
- Push rod stroke exceeding the readjustment limit as outlined in 393.47(e)

North America Standard Vehicle Out-Of-Service Criteria by Commercial Vehicle Safety Alliance (CVSA) defines each one of the above deficiencies as *defective brakes*. Furthermore, it defines *out of service condition* for the commercial vehicle when a number of defective brakes is equal or greater than 20% of the service brakes on the vehicle or combination. It should be noted that every semi is equipped with a total of ten brakes, two brakes on each axle.

The most common brake size in the trucking industry is brake Type 30 installed on all four axles except a steering axle, which has brake Type 20 or Type 25. Brake adjustment limits for Type 30 clamp type brake chamber pushrod is 2 inches. (See Figure 2). If the pushrod travels more than 2 inches, but less than 2¼", the brakes are out of adjustment. If the pushrod travels 2¼ inches or more, the brake is defined as a defective brake. Two brakes that are out of adjustment of 2⅛ are defined as one defective brake.

Figure 2
Brake cylinder and pushrod.

Cargo Securement.

The Code of Federal Regulations (CFR) addresses the issues of proper cargo securement under the regulations set forth by the Federal Motor Carrier Safety Administration[1]. Parts 393.100 through 393.136 discuss general regulations for the proper securement of cargo as well as several commodity-specific regulations for items such as logs, boulders, and machinery.

Cargo securement is a serious issue. Improper securement of cargo can lead to devastating consequences, especially during transportation where cargo trailers are constantly traveling alongside other vehicles. On the roads, flatbed trailers are often used to transport large or unusually shaped cargo which must be tied or anchored in some way to the trailer. While it may seem easy enough to load the cargo and throw a number of chains or straps over the top, proper cargo securement is often a technically challenging issue. A proper securement method must not only take into account the attachment of the items to the trailer but also how the cargo will affect the vehicle dynamics and how the system as a whole will respond to a multitude of driving conditions. The Large Truck Crash Causation Study conducted by the Federal Motor Carrier Safety Administration and the National Highway Traffic Safety Administration reports that seven percent of serious trucking accidents nation-wide were recorded to have cargo shift or cargo securement as a factor associated with the accident[2].

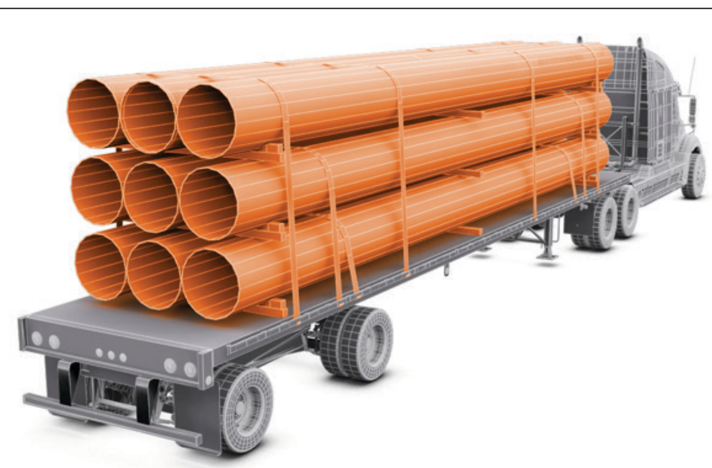

Figure 3
Large pipes secured to trailer.

In addition, part 392.9 sets forth requirements for the inspection of the cargo and cargo securement system. Under these regulations the driver must ensure that the cargo is secured properly as specified in parts 393.100 through 393.136 and must periodically check on the cargo throughout the duration of the trip. (See Figure 3). The driver must make an inspection of the load within the first 50 miles of the trip and reexamine the load every 3 hours or 150 miles, whichever comes first.

Technology In Use

There are two basic areas of forensic investigation of motor vehicle and industrial accidents, which have gone through fundamental changes in recent years:

- use of technology in *investigation and analysis*, and
- use of *visuals* in court presenting the outcome of the investigation

Investigation and Analysis.

In recent years, significant developments have occurred in the field of data recorders (EDR, DDEC, VORAD, and QUALCOM). These systems allow engineering experts and reconstructionists to download important accident-related data recorded both before and after a collision. Parameters such as speed, brake application, engine RPM, percentage of engine throttle, and turn signal usage can be downloaded and used during the analysis of the accident.

Development has also taken place in the field of digital documentation of the accident scene and involved vehicles. Not long ago, an accident reconstructionist would “walk” the accident scene with a measuring wheel and tape measure to document the accident scene geometry and vehicle crush. With today’s technology, the accident reconstructionist can utilize advanced tools such as laser total stations, photogrammetry techniques and GPS data which allow him to digitally record thousands or even hundreds of millions of data points related to vehicle damage or scene data.

Today we have the ability to quickly and effectively document vehicles and accident scenes using three dimensional, high definition laser scanners (HDS). These laser scanners are capable of quickly recording a data set made up of millions of points, accurate to a few millimeters. Scanners can scan in as little as 10 minutes, 360 degrees, reaching as far as 100 yards, capturing 45 million points. Typically, scans from multiple positions are combined to more completely document a scene or vehicle. (See Figure 4).

This data set, often referred to as a *point cloud*, can then be processed to create a 3D model, from which accurate measurements can be made allowing accident investigators to more accurately analyze evidence such as tire marks, debris and vehicle crush.

HDS technology enables the highly detailed recording and preservation of accident scene and vehicle information to be referenced and processed throughout the entire accident reconstruction process.

The HDS benefits include safety, speed, accuracy, and efficiency. Additionally, because of the speed and detail at which the data is captured, accident investigators can accurately capture an entire scene or object without having to predetermine what specific data needs to be collected.

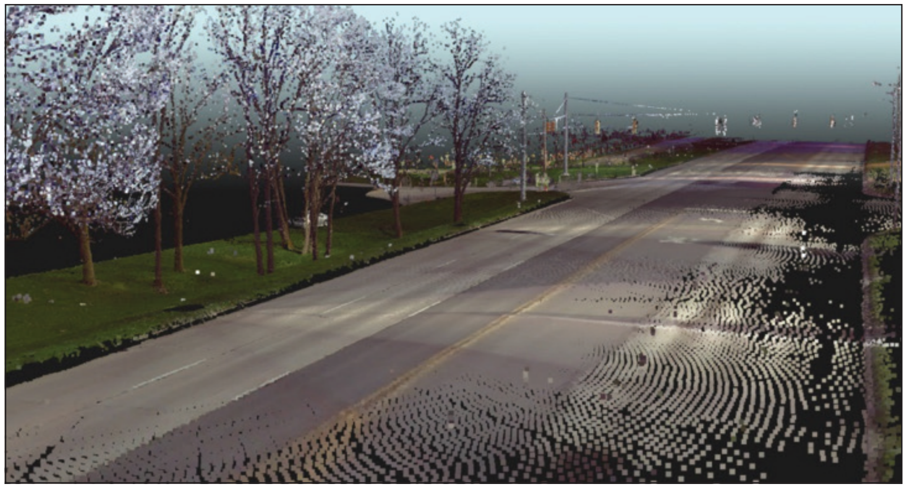

Figure 4
Three dimensional high definition laser scan, represented by 225 million point cloud.

In addition to revolutionizing the process of gathering scene and evidence data, HDS technology also helps in the process of creating photo realistic 3D environments, vehicles and other objects, which can improve the overall quality of the information presented in an animation or graphic visualization.

Visual Techniques.

The level of detail and accuracy that HDS technology provides greatly aids in establishing and defending the scientific foundation behind the accident reconstruction, an animation or graphic visualization.

Furthermore, accident reconstruction can be effectively presented to the jury in visual form by use of graphics, simulations, animations, or even interactive animation programs. With a proper foundation, these visual aids would be accepted by a court and could potentially have a strong impact on the jurors.

It should be emphasized that visual techniques must have a proper scientific foundation in order to be allowed by the courts. Such foundation includes engineering measurements and specifications, scene and vehicle surveys (Total Station and HDS), validated simulation programs such as EDCRASH, PC-CRASH, published literature related to animation techniques, proper analysis of the physical evidence, and finally an accurate "fit" of the reconstruction to the physical evidence and available witness testimony.

Figure 5
Computer generated impact between a tractor and a car.

Today, jurors are expecting to see computer generated images, CSI effects, and Hollywood quality animations. (See Figure 5). The use of aerial photographs, 3D computer modeling, photogrammetry, videogrammetry, camera matching, advanced simulation techniques, and interactive animations can significantly enhance trial presentations.

Conclusions

Reconstruction, analysis and causation studies of heavy truck accidents requires an understanding of the trucking industry, the trucks dynamics and design, and comprehension of Federal and State Regulations related to the trucking industry.

When working on trucking accidents, always remember that semi's are different than passenger vehicles, they have air brakes which have multiple requirements, download "black box" and understand its printout, and check the drivers log book.

Many times, multiple experts are required to provide comprehensive trucking accident reconstruction.

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