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Forensic Engineering Analysis In The Collision of Two Tractor-Trailer Trucks

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Abstract

After a fatal accident involving two tractor-trailer trucks, one of which (vehicle #1) overturned and dumped its load in front of an oncoming tractor-trailer (vehicle #2), it was discovered that two of the leaf springs of the overturned trailer were broken. Forensic Engineering metallurgical examination of the fracture surfaces of the broken springs and other axle evidence, in conjunction with accident reconstruction results, played a key role in determining the overall sequence of events in the accident.

Keywords

Forensic Engineering, Tractor-Trailer, Suspension Leaf Spring, Flat-Bed Trailer, Trailer Suspension

Introduction

This paper concerns the collision of two tractor-trailer rigs on a rural highway in Texas. **Vehicle #1** was an eastbound, 2004 white International tractor pulling a 48 foot flat bed trailer hauling 1400 sheets of 8' x 20' wire reinforcing mesh. The wire mesh was placed on the trailer in two stacks. Each stack was approximately 7 ft. tall. The load weight was 48,000 lbs. **Vehicle #2** was a westbound, 1999 blue Freightliner tractor pulling a 53 ft. box van hauling empty auto parts crates. The location of the accident and road details are as follows:

- The accident happened on December 17, 2006 at approximately 6:50 pm on Texas highway 315 east of the town of Henderson, Texas. It was dark, and there were no unusual weather conditions;
- At the accident location the road was one lane in each direction with a double yellow center line. The lanes were 12 ft. wide and shoulders were 8 ft. wide;
- The posted speed was 65 mph;
- At the accident location, the road crested and went into an S-curve to the south. The accident occurred just east of the crest in the road as Vehicle #1 was descending the crest.

The Accident

When deposed, Driver #1 testified that he saw Vehicle #2 “almost over in the center part of my lane.” As a result, he jerked to the right to avoid Vehicle #2. At that point, Vehicle #1’s tractor and trailer with the load of wire mesh overturned to the left, dumping the wire mesh into the west-bound lane, and in front of on-coming Vehicle #2. Vehicle #2 collided with the wire mesh, greatly decelerating the rig.

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Under the deceleration, the 5th wheel adjustment pad of Vehicle #2 stripped and the van trailer impacted into the cab of the tractor, fatally crushing Driver #2. (The 5th wheel pad is the flat metal plate that is attached to the chassis of the tractor, between the 2nd and 3rd axles, and which accepts a swivel pin that is mounted to the front of a semi-trailer. It slides forward and rearward in a toothed channel so that clearances and load distribution can be adjusted.) The vehicle #1 tractor and trailer came to rest *up-righted* approximately 330 ft. from the overturn location, and facing northeast. Driver #1 was uninjured.

The Forensic Engineer was retained on behalf of the distributor of the vehicle #1 trailer and asked to metallurgically examine the accident evidence. Others were retained to address accident reconstruction and trucking issues.

After-Incident Evidence

In examination of the evidence after the incident, the Forensic Engineer determined the following metallurgically relevant facts:

- The Vehicle #1 tractor showed abrasion marks and damage on the driver's side all the way up to the tip of the exhaust stack. Front-wheel lug nut abrasion markings were found on the road surface. The flat bed trailer showed abrasion marks and yellow paint scrapes on its left edge. The Forensic Engineer determined that this was evidence that both the tractor cab and trailer had indeed overturned to the left and had contacted the road.
- The Vehicle #1 flat bed trailer had single-leaf suspension springs on both the fourth and fifth axles. (Tractor-trailer axles are numbered sequentially from the front of the tractor to the rear of the trailer.) The trailer's fifth axle left leaf spring was fractured and parted at the aft edge of its top plate. The mating piece of the spring was found by the investigating officers approximately 10 to 20 feet from the final resting place of the #1 rig, approximately 300 feet east of the overturn point. See **Figure 1a and 1b.**

Figure 1a
Vehicle #1 Fifth Axle Left. Shown is the spring fracture location. Forward is to the right.

Figure 1b
Vehicle #1 Fifth axle.
Fourth axle is at the top of the figure.

Figure 2
Vehicle #1 Fourth Axle Left Leaf Spring.
Deformed downward and touching the radius rod.

Figure 3
Vehicle #1 Fourth Axle Right Leaf Spring.
Fractured and separated.

- Vehicle #1 fourth axle left leaf spring was permanently deformed downward. See **Figure 2.**
- Vehicle #1 fourth axle right leaf spring was fractured underneath its top plate and was separated. Abrasive polishing was found on the top plate, which showed that the spring had been fractured and separated prior to the incident. See **Figures 3 and 7.**

Figure 4
Vehicle #1 Fifth Axle Right Leaf Spring.
Intact and not deformed.

Figure 5
Vehicle #1 Fifth Axle Radius Rods.

- Vehicle #1 fifth axle right leaf spring was intact and not deformed. See **Figure 4.**
- The adjustable radius rods of both the fourth and fifth axles of the vehicle #1 trailer were deformed laterally in a direction that showed that the axles were laterally loaded toward the left (driver side of the trailer). See **Figure 5.**

- Vehicle #2 fifth wheel assembly showed that both the right-side and left-side channel retaining lips on the pad had deformed, thus allowing the fifth wheel to disengage from and channel and override the adjusting teeth. In addition, the right-side channel lip had fractured. See **Figure 6**

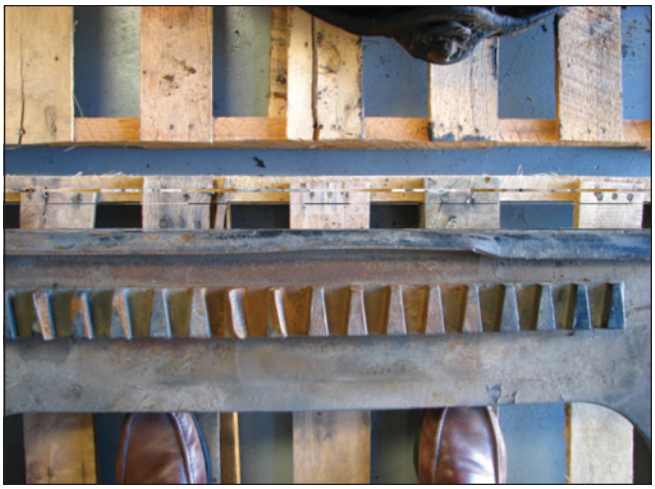

Figure 6
Vehicle #2 Fifth Wheel Toothed Adjustment Pad.
Note the forward deformation of the teeth (to the left) and the deformation of the channel lip.

Police Investigation

The Highway Patrol's investigation report concluded that the most probable cause of the accident was the fracture of the #5 left spring, which caused the trailer to overturn to the left and lose its load. This was based on the investigation team's observation of the salient evidence of the broken left spring on the vehicle #1 trailer. The fact that the mating piece of the spring was found ~300 feet east of the overturn site, and the fact that the fourth axle right leaf spring was also broken were not taken into account.

Litigation

Based on information at the time, The Estate of Driver #2 (Plaintiff) sued the following:

- Vehicle #1 transport company,
- Vehicle #2 fifth wheel manufacturer,
- Vehicle #1 trailer suspension manufacturer,
- And Vehicle #1 trailer sales company. The trailer manufacturer was not a named party in the suit.

The primary Defendant, as third party Plaintiff, sued the following:

- Vehicle #2 transport company,
- Vehicle #2 fifth wheel manufacturer,
- And Vehicle #1 trailer sales company.

Laboratory Analysis

The #4 and #5 axles from the Vehicle #1 trailer were removed intact and brought by the Forensic Engineer to a metallurgical laboratory for further examination. In removing the axles, the Forensic Engineer found that on this particular suspension, the leaf springs were not attached to the trailer rail by means of shackles. Rather, the ends of the springs fit loosely into pockets in suspension hangers and in a central equalizing beam. The pockets had pins (bolts), and the ends of the springs were bent downward

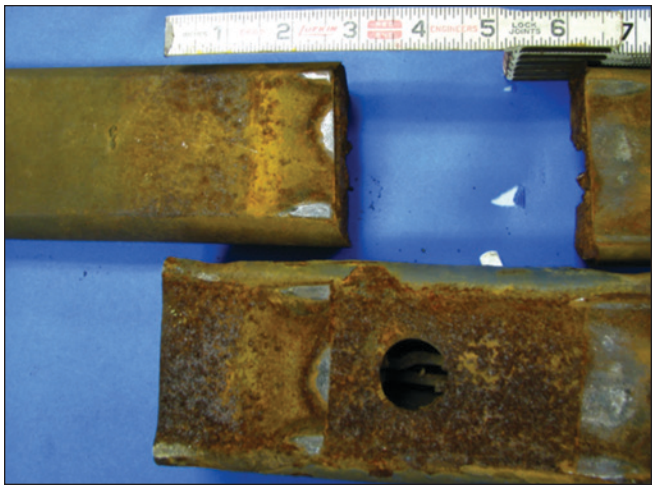

Figure 7
Vehicle #1 Fourth Axle
Right Leaf Spring (top) and
Top Plate (bottom).

so that the pins would prevent the springs from slipping axially out of the pocket. Additionally, the axles were further stabilized axially by radius rods, and the leaf springs themselves stabilized the axles laterally. There were no shock absorbers on this suspension. See **Figure 5.**

On spring #4 Right (the one that was broken under the top plate), wear markings and areas of abrasive polishing (fretting) were found at the interface between the spring top surface and the top plate bottom surface. These markings were separated the same distance as the spring. Additionally, there were wear markings on the radius rod that was under the forward portion of the spring. These witness markings showed the Forensic Engineer that this spring had been fractured for some time prior to this incident. See **Figure 7.**

Microscopic examination of the fracture surfaces of springs #4 Right and #5 Left showed the Forensic Engineer that both fractures had occurred from the *bottom* of the spring, and had progressed to the top of the spring! Both fractures were *tearing fracture* propagating from fatigue pre-cracks at the *bottom* of the spring. The tearing fracture propagated *continuously* to the top surface of the spring - there was no area at the top surface that changed from tearing to axial tensile overload. See **Figures 8 and 9.**

Figure 8
Vehicle #1 Fifth Axle Left Leaf Spring Fracture Surface.
Fatigue fracture at the bottom progressing continuously in tearing fracture to the top of the spring.

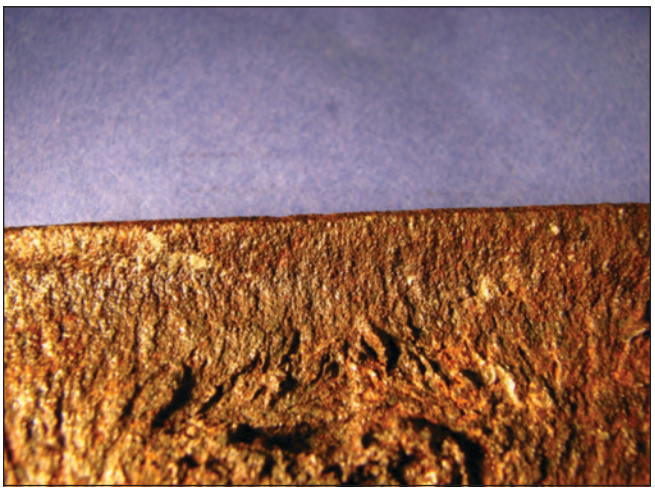

Figure 9
Same as Figure 8 showing continuous tearing fracture texture to the top of the spring.

This is contrary to the progression that the Forensic Engineer expected under excessive normal loading on the suspension, such as the trailer tilting to the left. Under normal loading, the axle is pushed *toward* the trailer bed, and tensile stresses are produced on the top of the spring. In this instance, tensile

stresses were on the bottom of the two springs. Fatigue fracture in metals is a cyclic *tensile* phenomenon. The fatigue at the bottom of the spring and the tearing toward the top of the spring showed that the two fractures were the result of the axles being pulled vertically *away from* the trailer bed. An example of such loading would be from the trailer bouncing off the road, over time, and lifting the wheels with it.

The continuous propagation of the tearing texture at the top of the two springs, and specifically in the #5 Left spring, showed the Forensic Engineer that either the #5 Left spring was fractured prior to the incident, or, more likely, fractured during the course of the incident as the trailer was sliding on its side or up-righting itself. The Forensic Engineer determined that it did not fail first, thus causing the trailer to overturn. Additionally, with no shackle to keep the broken piece of spring in place, if it had broken first, it would have been found close to the overturn location rather than approximately 300 feet from the overturn location. And, there were no abrasion marks on the loose piece of #5 Left spring to indicate it had slid on the pavement.

The Forensic Engineer performed hardness testing of all four springs and found that spring #4 Left (the one that was deformed downward) was much softer than the other three, and in fact was not even spring hardness ($\geq$ 40 on the Rockwell C scale). This explained why it was deformed downward.

At the time that the case settled, laboratory examination by the Forensic Engineer had not yet begun on the fifth wheel assembly from Vehicle #2. However, visual examination results were sufficient to show that the assembly was grossly overloaded, and was a victim of the collision.

Conclusion and Litigation Consequences

Partly as a result of the above findings, and in conjunction with other accident reconstruction findings, it was concluded by the investigation team that this accident was not caused by the fracture of the #5 Left suspension spring, but was a result of the tractor-trailer being in a right hand turn with higher than normal lateral acceleration acting upon a high center of gravity load and the driver making a sudden evasive maneuver to the right. This matter settled shortly after preliminary results were reported. Specifics of the settlement were not divulged.