SECTION 5

Safety Analysis

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Hook Engineering • Dr. George Hearn

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Task 5 - Safety Impacts

This area of the study will address two separate but related safety issues. The first issue is the dynamic performance of the tractor-trailer loaded with more than one precast concrete wall panel. This subsection will discuss the overall safety of the weight of a nondivisible load that balances the A-frame along the longitudinal axis. Diagrams of trailers with pre-stressed concrete panels loaded onto A-frames are shown in Appendix 3-A. The second issue will discuss the effects of heavier loads on the highway system, with reduced vehicle miles traveled (VMT) as a result of the non-divisible load regulation.

Load Safety

Some of the main rational behind the TEA21 legislation was the improvement of safety by the trailers carrying a more balanced load. Clearly, a heavy load that rides relatively high, and is asymmetrically loaded will be more prone to tipping, rollovers, and shifting loads when traveling. Additionally, the ability to negotiate turns and maneuver in traffic, and the ability to successfully maneuver when confronted with a potential crash threat are other factors affected by heavier loads. Policies regarding divisible and non-divisible loads can affect design properties and configurations of tractor-trailer combinations operators choose to use. The following is a list of tractor-trailer properties that affects the vehicle dynamics and are typically modified as a result of differing weight allowances:

- Overall vehicle length;
- Vehicle wheelbase and track width;
- Overall vehicle weight;
- Individual axle weights;
- Number of axles on vehicle;
- Number and type of tires;
- Suspension properties; and,
- Brake system properties.

Numerous vehicle performance tests and engineering analyses have highlighted significant differences in the stability and control properties of different sizes and configurations of tractor-trailers. Some larger and heavier trucks are more prone to rollovers than other, smaller trucks; some are less capable of successfully avoiding an obstacle when traveling at highway speeds; some negotiate tight turns and exit ramps better than others; and some trucks can be stopped in shorter distances than others and maneuver better in traffic. The effects of these differences on the safety and the likelihood of being involved in a traffic crash are subtle, but can become more evident as traffic increases and road conditions deteriorate.

The measure of a vehicle's performance with respect to its rollover tendencies is static roll stability (SRS). SRS can be described as the minimum amount of lateral acceleration needed to cause the wheels to lift off the ground, when rollovers occur. The higher the SRS value, the better a vehicle's performance with respect to rollover. Typical tractor-trailer vehicles loaded to the 80,000-pound weight limits generally have SRS thresholds of 0.30 to 0.33 g's. For comparison, automobiles generally will not roll over until its lateral acceleration exceeds 0.8 to 1.0 g's. Larger, heavier vehicles do not necessarily perform worse with respect to SRS than do smaller, lighter vehicles. Increasing the center of gravity, travel speed, and turning radius all affect the vehicle's tendency to rollover. It is not practical or feasible to test tractor-trailers with precast concrete panels loaded onto A-frames to determine vehicle stability.

If forced to carry only one panel on an A-frame, the drivers will be under extreme pressure to make extra safe turning movements. Colorado has acknowledged this very early, and as a result has been permitting these types of loads for several years. Because of this permitting, there is no known accident data that can verify this safety claim.

Industry practice, recognized performance and safety criteria, and anecdotal operator experiences all confirm this claim. A discussion with one hauler further reinforces this. At times, the hauler would carry his payload on one side of an A-frame trailer, then carry two half weight panels as dead loads on the other side of the A-frame. On the return trip,

one half of the dead load was hauled back on each side of the A-frame to continue to maintain a balanced load.

Colorado is also unique in its use of precast wall panels. We appear to be leading the nation in implementation of this technology. As a result, the team was unable to find any similar problems in surrounding states. The team believes this is more a result of the uniqueness of this technology in Colorado, then other areas dealing with the problem differently.

Truck Safety and Weight

Truck safety at a national level is a major concern. The regulations governing truck weight are intended to balance the costs that large trucks can impose on the exposure to crash risk, and the costs of shipping. In the US, private fleet carriers account for 50% of truck movement and about 60 percent of truckload volume. In this study, the private fleet would be Rocky Mountain Prestresses (RMP) internal trucking fleet. The other portion of the industry is considered for-hire carriers. In this study, CAST, a sole contractor for RMP would be classified in this category. The for-hire category is again divided into two types, truckload, or less than truckload. CAST is considered truckload type carrier.

The total vehicle miles traveled by freight vehicles in 1996 were 182.8 billion miles. VMT for all trucks has increased by over 20 percent between 1990 and 1996. The majority of truck operations, on a nationwide basis, are considered short-haul. Short-haul is considered 200 miles or less from the point of origin to point of destination. All trips studied and in our sample fall within this category. Typically, trucks and truck combinations operating local, short haul operations tend to have lower annual VMT than those in long-haul.

Transportation related crashes are now the seventh leading cause of death in the US. In 1998, 41,471 people died on the nation's roads. The USDOT has set specific 10 year safety goals for the early part of the 21st century. The goal is to reduce crashes involving big trucks by 50 percent and reduce roadway deaths by 20 percent.

At this time, there is no available database or accident record system that tracks overweight or permitted accident rates. Additionally, truck weight as a whole is not tracked in any accident records system. All we can do is look at the vehicle characteristics compared to operating weights. The average overweight load studied was 90,000 lbs. This is not significantly higher than legal or non-permitted loads. These loads also fall well under other states grand fathered TSW regulations. Nothing indicates that measurable safety performance will be affected by nondivisible loads.

This leads to looking at the next indicator, Vehicle Miles Traveled. By allowing the non-divisible loads to occur, Colorado has reduced the VMT by roughly half. This has decreased the overall statistical chance of being involved in a crash. The carriers studied have outstanding safety records. By all accounts, the trucking industry in Colorado exceeds national standards by a wide margin. There are several data sources available for study.

- The Fatality Analysis Reporting System (FARS) is maintained by the National Highway Traffic Safety Administration (NHTSA). The FARS is a census of crashes involving any motor vehicle traveling on a public trafficway.

- General Estimates System(GES) is also maintained by NHTSA. The GES is a probability based, nationally-representative sample of all police-reported fatal, injury, and property-damage only crashes.

- Motor Carrier Management Information System (MCMIS) is maintained by the Federal Motor Carrier Safety Administration (FMCSA).

The appendices show several accident trends in Colorado vs. the national averages. The data was taken from MCMIS.

On a nation wide basis, from 1975 to 1998 fatal crashes per 100 million VMT has decreased from 4.9 to 2.5. From 1988 to 1997, Injury crash involvement rates have decreased from 68 to 51 per 100 million VMT of all classifications of trucks.

Examining the bulk of the data has several interesting points. With fatalities, the bulk of the evidence from the crashes was obtained from the truck driver. They had an incredibly higher survival rate then the passenger car involved in the same accident.

It can be expected, that this regulation will have a positive impact of traffic safety, but with the VMT's involved, it will be statistically insignificant. This may save one injury crash per 100 years due to the relatively low VMT's involved.

Large Trucks Involved in Crashes by Vehicle Configuration - 1998 Colorado

Vehicle Configuration	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference	Non-Fatal USA Total	Non-Fatal USA Percent	Non-Fatal State Total	State Percent Non-Fatal	State-USA Percent Difference
Single Unit Truck, 2-axle	533	10.80%	6	11.50%	6.50%	11193	12.00%	190	11.70%	-2.50%
Single Unit Truck, 3+axle	473	9.60%	5	9.60%	0.00%	9255	9.90%	197	12.20%	23.20%
Truck/Trailers	186	3.80%	4	7.70%	102.60%	10180	10.90%	300	18.50%	69.70%
Truck/Tractor (bobtail)	102	2.10%	1	1.90%	-9.50%	2942	3.20%	39	2.40%	-25.00%
Tractor/Semi-trailer	3185	64.50%	30	57.70%	-10.50%	48991	52.50%	797	49.20%	-6.30%
Tractor/Double	136	2.80%	4	7.70%	175.00%	2677	2.90%	54	3.30%	13.80%
Tractor/Triple	8	0.20%	1	1.90%	850.00%	132	0.10%	3	0.20%	100.00%
Other	8	0.20%								
Unknown	304	6.20%	1	1.90%	-69.40%	2585	2.80%			
Missing						5353	5.70%	39	2.40%	-57.90%
Totals	**4935**		**52**			**93308**		**1619**		

Large Trucks Involved in Crashes by Cargo Body Type - 1998 Colorado

Cargo Body	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference	Non-Fatal USA Total	Non-Fatal USA Percent	Non-Fatal State Total	State Percent Non-Fatal	State-USA Percent Difference
Van/Enclosed Box	2135	43.30%	20	38.50%	-11.10%	34071	36.50%	764	47.20%	29.30%
Cargo Tank	388	7.90%	10	19.20%	143.00%	4770	5.10%	118	7.30%	43.10%
Flatbed	678	13.70%	6	11.50%	-16.10%	12039	12.90%	246	15.20%	17.80%
Dump	551	11.20%	7	13.50%	20.50%	8586	9.20%	237	14.60%	58.70%
Concrete Mixer	40	0.80%	2	3.80%	375.00%	1472	1.60%	35	2.20%	37.50%
Auto Transporter	37	0.70%				920	1.00%	7	0.40%	-60.00%
Garbage/Refuse	120	2.40%	1	1.90%	-20.80%	2258	2.40%	55	3.40%	41.70%
Other	498	10.10%	1	1.90%	-81.20%	19483	20.90%	90	5.60%	-73.20%
Unknown	488	9.90%	5	9.60%	-3.00%					
Missing						9709	10.40%	67	4.10%	-60.60%
Totals	**4935**		**52**			**93308**		**1619**		

Large Trucks Involved in Crashes by Gross Vehicle Weight Rating - 1998 Colorado

Gross Vehicle Weight Rating	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference	Non-Fatal USA Total	Non-Fatal USA Percent	Non-Fatal State Total	State Percent Non-Fatal	State-USA Percent Difference
Under 10,001 lbs.	15	0.30%				1484	1.60%	4	0.20%	-87.50%
10,001 - 26,000 lbs.	417	8.40%	2	3.80%	-54.80%	8143	8.70%	196	12.10%	39.10%
Over 26,000 lbs.	4094	83.00%	44	84.60%	1.90%	66725	71.50%	1362	84.10%	17.60%
Unknown	341	6.90%	5	9.60%	39.10%					
Missing	68	1.40%	1	1.90%	35.70%	16956	18.20%	57	3.50%	-80.80%
Totals	**4935**		**52**			**93308**		**1619**		

Large Trucks Involved in Crashes by Domicile vs. Non-Domicile Carriers - 1998 Colorado

Domicile vs. Non-Domicile	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference	Non-Fatal USA Total	Non-Fatal USA Percent	Non-Fatal State Total	State Percent Non-Fatal	State-USA Percent Difference
Non-Domiciled Carrier	1526	40.50%	20	45.50%	12.30%	40227	43.10%	716	44.20%	2.60%
Domiciled Carrier	2235	59.30%	24	54.50%	-8.10%	52781	56.60%	902	55.70%	-1.60%
Other/Unknown	11	0.30%				300	0.30%	1	0.10%	-66.70%
Totals	**3772**		**44**			**93308**		**1619**		

Large Trucks Involved in Crashes by Urban vs. Rural

Urban vs. Rural Location	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference
Rural	3313	67.10%	33	63.50%	-5.40%
Urban	1601	32.40%	19	36.50%	12.70%
Unknown	21	0.40%			
Totals	**4935**		**52**		

Large Trucks Involved in Crashes by Type of Trafficway - 1998 Colorado

Trafficway	Fatal USA Total	Fatal USA Percent	Fatal State Total	Fatal State Percent	Fatal State-USA Percent Difference	Non-Fatal USA Total	Non-Fatal USA Percent	Non-Fatal State Total	State Percent Non-Fatal	State-USA Percent Difference
Not Physically Divided	2756	55.80%	22	42.30%	-24.20%	32547	34.90%	533	32.90%	-5.70%
Divided Highway - Without	1541	31.20%	21	40.40%	29.50%	21470	23.00%			
Divided Highway - With Bar	578	11.70%	9	17.30%	47.90%	15954	17.10%	1035	63.90%	273.70%
One-Way Trafficway	30	0.60%				3245	3.50%	2	0.10%	-97.10%
Unknown	30	0.60%								
Missing						20092	21.50%	49	3.00%	-86.00%
Totals	**4935**		**52**			**93308**		**1619**		