ANALYSIS OF CARGO-SECUREMENT RELATED ROAD ACCIDENTS IN MÉXICO

José A. Romero[1] **and Alejandro Lozano**[2]

[1]Querétaro Autonomous University, Río Moctezuma 249, San Cayetano, San Juan del Río, México 76800.
[2] CONCYTEQ, Luis Pasteur Sur No. 35, Centro Querétaro, Qro. México 76000

Presenter

Dr. José Antonio Romero
Querétaro Autonomous University
Rio Moctezuma 249, San Cayetano
San Juan del Rio, Queretaro
Mexico 76807
Phone: 011-52-427-2741244
Email: jaromero@uaq.mx

ABSTRACT

During the last decade, important efforts were directed towards understanding of cargo-vehicle interaction, aiming to establish sound cargo-securement standards. However, the accident reports now in use generally do not include any consideration of cargo restraint effectiveness, thus making it difficult to compare road accident statistics before and after the recently promulgated compulsory standards. In this paper an analysis is carried out of a sample of road accidents involving the failure of cargo-securement in Mexico. The classification of accidents is based on the type of freight, road geometry and overall consequence of the accident. The cargo-securement effect is characterized in terms of cargo-securement performance as a critical event, a critical reason, or an associated factor. From a sample of 1790 road accidents, it was found that cargo-securement effectiveness represented a critical event in 8 cases; a critical reason in 8 cases; and an associated factor in another 13 cases. While a critical event was described by the falling of the cargo, the critical reason consisted of the cargo shifting, leading to vehicle rollover, while the spilling of the cargo was recognized as an associated factor. While it was not possible to establish the under- or over- representation of the type of payload involved in road accidents, the data clearly indicated the greater probability for the accident to occur in curved sections of the road. Analysis suggests the urgent need for a Mexican regulation concerning cargo-securement.

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1 INTRODUCTION

Road accidents attributed to failure of the load restraining elements have been recognized in the literature (Gillespie, 1987; Rakheja *et al*., 1988; Hildebran and Wilson, 1997; FR, 2000). Consequently, a consistent series of research studies were performed in the 90´s, aiming to improve the knowledge of the load restraint mechanics (Billing and Couture, 1996; Billing, 1998, Rakheja *et al.*, 1997). As a result of such an effort a North American Load Securement Standard now exists, specifying requirements for load restraint as a function of the type and dimensional and weight characteristics of the cargo (CCMTA, 2005; FMCSA, 2003; FMCSA, 2005). The proposed standard requires the following (FMCSA, 2003): "*Cargo must be contained, immobilized or secured so that it may not, leak, spill, blow, fall from, fall through or otherwise become dislodged from the vehicle; or shift upon or within the vehicle to such an extent that the vehicle's stability or maneuverability is adversely affected*". While the research work has led to the publication of such standard, road accident statistics still lack specific information about the cargo restraint failure (FMCSA, 2004; SCT, 2004). Such information is necessary to further evaluate the impact of the proposed standard on road safety.

In Mexico in 2004, about 14000 people were killed in road accidents, with 28400 people suffering incapacitation injuries. The material and medical costs of the accidents were 63 billions of Mexican Pesos (6 billions of USD)(SH, 2005). In order to decrease such big numbers, an in-depth analysis should be carried out examining the causation of road accidents.

In this paper, an assessment is made of the contribution of cargo-securement failure to road accidents that occurred in a Mexican State during 2002.

2 METHODOLOGY

The Mexican road accident system was developed by the Mexican Institute of Transport (SCT, 2004). It is called "System for accident data acquisition and administration", and represents a comprehensive Police Accident Report (PAR). Table 1 describes the information contents of the system. It includes the cargo type but no specific fields regarding the cargo restraint methods or the occurrence of cargo spill. To find out about the relationship of cargo-securement and the accident it was thus necessary to analyze the information under the field "ultimate cause of the accident".

Table 1. Fields in the Mexican Road Accident Report (SCT, 2004).

Accident location
Road/highway
Road segment identification
Administration
Severity and victims
Fatalities
Pedestrian
Injuries
Emergency service
Cause of the accident
Ultimate cause of the accident
Remarks about the accidents
Driver
License (Type, expiring date)
Nationality
Vehicle owner data
Name
Address
Cargo information
Type of cargo
Damage to the cargo (monetary and percentage of loss)
Federal jurisdiction
Drawing of the accident scene

3 DATA ANAYLIS

Veracruz State road accident database was selected to assess the influence of cargo securement performance on accident severity and causation. The database included 1790 PAR´s (SCT, 2004).

The discussion is based on a mixed approach in which, on one hand, a fault tree could be developed throughout the analysis of the failure of the inherent safeguards linked to regulation, design and operational concepts (Ale *et al*, 2005). On the other hand, the present approach also considers a causation analysis to establish the role of the load restraint as a precursor of a mishap, in such a way that the cargo restraint failure could be identified as a critical event, a critical reason or an associated factor (Blower, 2002).

The analysis of load restraint related accidents should consider both the environment under which the accident occurred as well as the series of actions that took place before the accident. It is important to note that within the narrative description of the accident (abstract in Table 2), the police officer identifies as an ultimate cause of the accident a “poorly secured” cargo, suggesting his/her awareness of poor load restraint methods, in spite that there is no domestic standard for cargo restraint methods.

Table 2 illustrates some characteristics of the load-securement related accidents within the selected database, in which the following abbreviations are used:

Road segment characteristics

Ascending tight left turn (ATLT)
Ascending tight right turn (ATRT)
Ascending wide left turn (AWLT)
Descending Straight (DS)
Descending tight left turn (DTLT)
Descending tight right turn (DTRT)
Descending wide left turn (DWLT)
Level tight right turn (LTRT)
Level wide left turn (LWLT)
Straight Level (SL)

Severity of injuries

Not seriously injured (NSI)
Seriously injured (SI)

Vehicle type

Straight truck (ST)
Tractor-semitrailer (TS)
Tractor-semitrailer-trailer (TST)

In this table, a "tight turn" is considered as one involving a short-radius curve (around 100 m radius). "Lanes" refers to the number of lanes for each traveling direction. "Spill" column indicates the occurrence or not of cargo spill. The "cargo" column represents the type of payload, while the "abstract" narrates the sequence of events leading to the accident, according to the "ultimate cause of the accident" described in the PAR.

For the 29 accidents listed in Table 2, Fig. 1 illustrates the type of cargo statistics, which suggest that metallic rolls is the most common cargo involved in cargo-securement related accidents in this data sample. However, there is no way to objectively verify the over-representation of such type of cargo since information of traffic composition in that region is not available at the present moment.

The consequences of the accidents listed in Table 2, as far as people fatally or non-fatally injured, indicates that there were no fatalities in these accidents while three persons were injured (two not seriously; one seriously). As far as the vehicle type is concerned, these data show that 17% were straight trucks, 79% tractor-semitrailer, and 4% tractor-semitrailer-trailer combinations.

About the relationship between road geometry and load-securement accidents, Fig. 2 reveals a balance in the representation of ascending tight left turn (ATLT) and descending tight right turn (DTRT), with 5 events each, while ascending wide left turn (AWLT) and straight level (SL) exhibit 4 occurrences each. The lower representation relates to ascending tight left turn (ATRT), descending wide left turn (DWLT), level straight (LS) and level wide left turn (LWLT). So, a tight turn appears as a common element in the most frequent accident situations, and in one out of four in the less frequent situations. Left turn appears in three out of four of the most frequent road accident geometries, and in three out of four of the less frequent road accident geometries. This output suggests a randomness of the cargo-securement related accidents concerning the side towards which the turn is performed, while reveals a higher probability for such a type of accident when the vehicle negotiates a tight turn.

Abstract description in Table 2 provides the basis for developing fault-trees. However, for many of the accidents described, the failure of the regulation safeguards would cover the top of the complete set of potential fault-trees. On the other hand, assuming that each driver obeys his/her own "common-sense" safety standards, failure of operational safeguards would be involved in some of the accidents (e.g. case 29).

Failure of technical safeguards (equipment) is clearly identified in cases 11, 16, 19, 21, 22 and 29, although it could be attributed to failures regarding design-selection of the cargo-securing methods.

Case 29, in which a truck was crashed during a technical stop to check the load restraint, evidences the need for proper road infrastructure, which should provide parking areas to check the condition of load restraint elements.

3.1 Cargo securement as a critical event, critical reason or an associated factor

Figure 3 classifies the role of cargo securement in the road accidents listed in Table 2, as a critical event/cause or as an associated factor. Failure of the cargo restraint elements leading to cargo fall is identified as a critical event; vehicle rollover due to cargo shifting is qualified as a critical reason; and the spill of the cargo due to non-related vehicle rollover is considered as an associated factor. Cargo shifting as a critical reason derives from a poor selection of the restraint elements or a deficient supervision during the trip. According to these concepts, 8 out of the 29 accidents analyzed (27%) imply cargo-securement as the critical event; the same amount corresponds to cargo-securement as the critical reason; and the remaining 46% of the accidents imply cargo-securement as an associated factor. That is, about 50% of the cargo-securement related accidents were directly caused by the failure of the cargo-securement elements.

The accidents (16) in which cargo-securement was a critical event/cause represent around 0.8 % of the 1790 accidents reviewed. Furthermore, around 30% of these 16 accidents involved the transportation of metal coils (sheet or wire), which suggests the need for an effective regulation and enforcement regarding this type of cargo.

4 DISCUSION

It is believed that most of the accidents in Table 2 could have been prevented through good regulations and dependable practices. Additionally, another deficiency of the Mexican commercial transport system seems to be the lack of enough and capable safety managers within the transportation companies (managerial safeguards). Furthermore, from the operational safeguards perspective, statistics suggest that it is necessary to better enforce the rules for continuous training of truck drivers.

Table 2. Cargo-related accidents.

Case	*Cargo*	*Vehicle type*	*Road*	*Spill*	*Abstract*	*Lanes*	*Injuries*
1	Wood in sheets	TS	ATLT	Y	Cargo fall onto the incoming traffic-no other vehicle involved	1	No
2	Paper rolls	ST	DTLT	Y	Flat tire causing vehicle rollover and cargo spill	2	No
3	Fruit in bulk	ST	SL	Y	Cargo spill as a result of vehicle rollover	2	No
4	Sugar cane	TS	AWLT	N	Solid cargo shift causing vehicle rollover while negotiating a turn	2	No
5	Flour in bags	TS	ATLT	N	Vehicle rollover due to overloading and high c.g. position	1	No
6	Pipes	TS	SL	Y	Offtracking on and cargo spilling	NA*	No
7	Pipes	TS	LTRT	Y	Detaching of semitrailer, rollover and cargo spill	1	No
8	Pipes	TS	DS	Y	Cargo spill due to vehicle rollover	1	1-NSI
9	Metallic wire mesh	TS	LWLT	Y	Cargo shift causing vehicle rollover	1	No
10	Paper rolls	ST	DTRT	Y	Cargo fall due to cargo-securement failure	1	No
11	Fruit in bulk	TS	AWLT	NA*	Solid cargo shift causing vehicle rollover	2	No
12	Container	TST	DTLT	NA*	Offtracking on uneven right of way, rollover and cargo spill	1	1-NSI
13	Container	TS	AWLT	Y	King ping failure due to cargo shift; rollover	1	No
14	Machine	TS	DTRT	Y	Rollover due to speeding; cargo spill	1	No
15	Pipes	TS	SL	Y	Cargo fall during passing maneuver due to webbing tiedowns failure	2	No

*Not available

Table 2. Cargo-related accidents (Cont.)

Case	***Cargo***	***Vehicle type***	***Road***	***Spill***	***Abstract***	***Lanes***	***Injuries***
16	Paperboard bundles	TS	DWLT	Y	Rollover due to speeding	1	No
17	Wire coils	TS	ATLT	Y	Cargo fall due to overspeeding – no other effect	2	No
18	Metal coils	TS	DTRT	Y	Cargo fall due to failure of load securing elements	2	No
19	Container	TS	SL	Y	Pothole causing loss of control; crashing on central barrier	2	NA*
20	Metal coils	TS	ATLT	Y	Failure of chains securing the cargo - no other effect	1	No
21	Container	TS	AWLT	Y	Cargo shift/fall due to failure of cargo securing elements	NA*	No
22	Pipes	TS	LTRT	Y	King ping failure due to over-speeding; cargo spill	1	No
23	Metal coils	TS	DTRT	Y	Rollover due to over-speeding; spill onto the incoming traffic	1	1-SI
24	Wire coils	TS	DS	Y	Cargo shift due to poor restraint and road unevenness; trailer detaching; rollover	1	No
25	Fruit in bulk	ST	ATRT	Y	Semitrailer rollover due to off-tracking on depressed edge	1	No
26	Paper items	TS	LS	Y	Cargo spill due to impact against bridge under work	2	No
27	Paper rolls	TS	ATLT	Y	Shift of high c.g. cargo causing semitrailer rollover	1	No
28	Poles	ST	NA*	Y	Cargo fall due to failure of cargo securing elements	1	No
29	Live chicken in crates	TS	DTRT	N	Crash due to tractor-trailer parked to check load restraint	1	No

*Not available

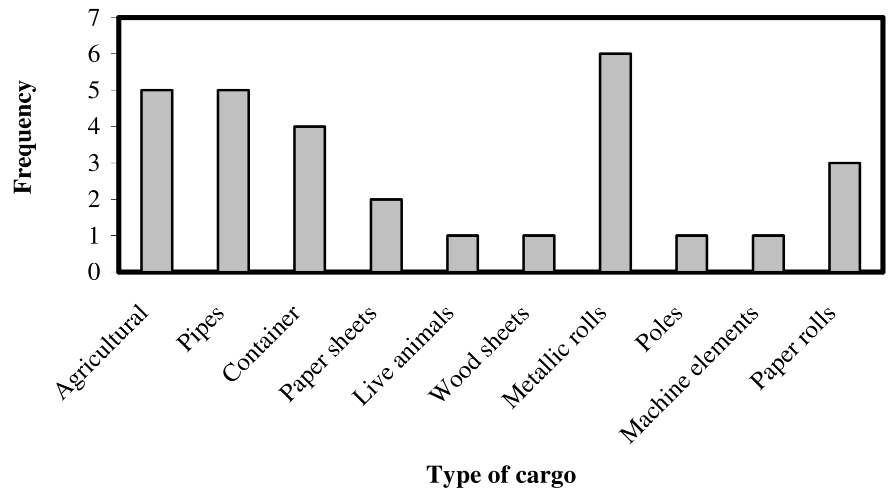

Figure 1. Effect of the type of cargo.

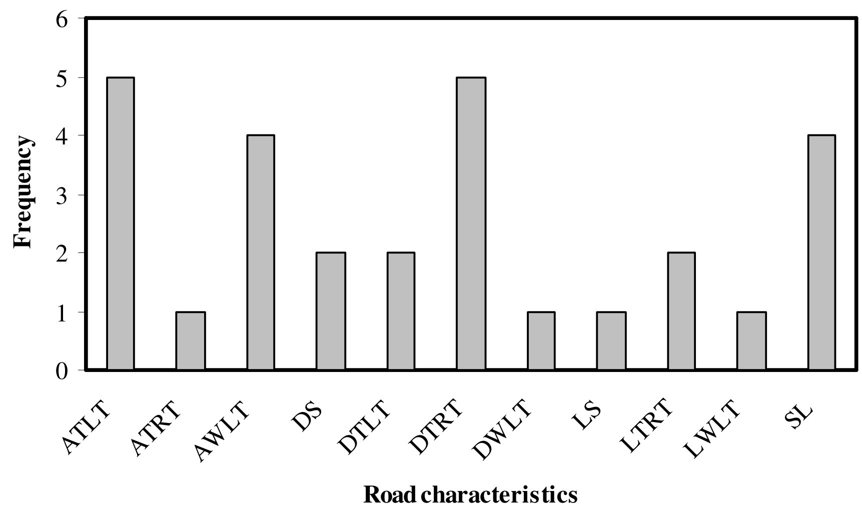

Figure 2. Effect of road geometric characteristics (Case 28: N.A.).

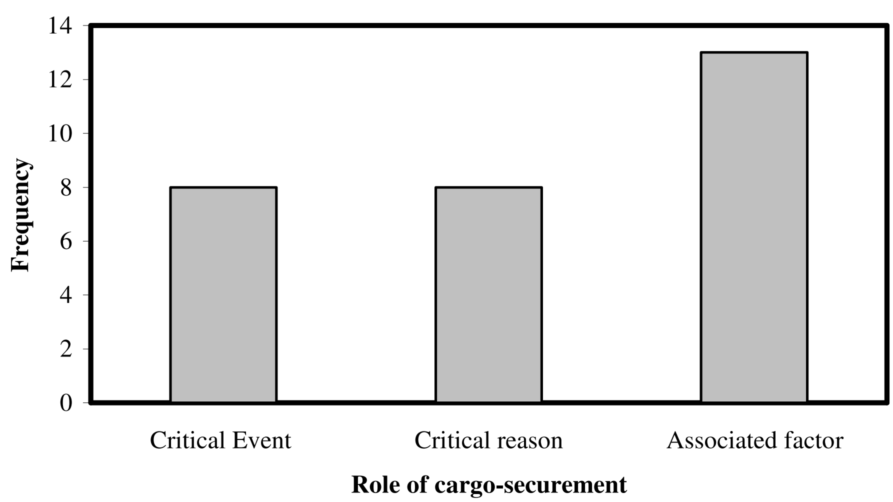

Figure 3. Role of cargo-securement failure on accidents in Table 2.

5 CONCLUSIONS

An analysis has been presented concerning the influence of cargo-securement effectiveness on road accidents within a sample of Mexican statistics. The role of cargo-securement performance on the causality of these accidents is described in terms of a critical reason, a critical event, or an associated factor.

A total of 1790 police accident reports were scanned for a potential cargo-securement accident relationship. Results indicate that the role of cargo-securement effectiveness in the selected accidents ranged from associated factors to critical events. The failure of the cargo-securement elements leading to cargo fall was identified as a critical event; the failure of such elements leading to vehicle rollover was considered as a critical reason; while the spilling of the cargo was recognized as an associated factor.

Review of these statistics revealed that 29 accidents were cargo-securement related, involving cargo-securement as critical event (8 cases); critical reason (8 cases); and associated factor (13 cases).

Due to incomplete statistics available at the present moment regarding the type of payload transported within the selected geographic region, it was not possible to establish the under- or over- representation of the type of payload involved in the reviewed road accidents,

The data clearly indicated, however, the greater probability for the accident to occur in curved sections of the road.

It is strongly recommended that the Police Accident Reports include detailed information regarding the load restraint system and its safety performance.

6 REFERENCES

Ale, B.J.M., Bellamy, L.J., Roelen, A.L.C., Cooke, R.M., Goossens, L.H.J., Hale, A.R., and Kurowicka, D. (2005) “Development of a causal model for air transport safety”, Proceedings of IMECE2005, 2005 ASME International Mechanical Engineering Congress and Exposition, November 5-11, 2005, Orlando, Florida, USA, Paper IMECE 2005-79374, 10pp.

Billing, J.R. and Couture, J. (1996) "North American load security research project", Proceedings of the Congress Truck Safety: Perceptions and Reality. Institute of Risk Research, Toronto, pp. 289-300.

Billing, J.R. (1998) "Effect of cargo movement on tension in tiedowns", Canadian Council of Motor Transport Administrators, Report # 9.

Blower, D., and Campbell K. L. (2002) “The Large Truck Crash Causation Study”, Center for National Truck Statistics, The University of Michigan Transportation Research Institute, UMTRI 2002-31.

CCMTA (2005) “National Safety Code-Standard 10-Cargo Securement - Interpretation Guide”. Canadian Council of Motor Transport Administrators, 24 pp.

FMCSA (2005) “Driver´s handbook on cargo securement. A guide to the North American Cargo Securement Standard”, Federal Motor Carrier Safety Administration.

FMCSA (2003) “North American Cargo Securement Standard, Draft Model Regulation”, Draft 5, January 2005.

FMCSA (2004) “MCMIS Crash file-2002-770162015”.

FR (2000) “Development of a North American Standard for Protection Against Shifting and Falling Cargo”, Federal Register: December 18, 2000 (Volume 65, Number 243), Federal Register Online via GPO Access [wais.access.gpo.gov].

Gillespie, T.D. (1987) "Engineering analysis of cargo restraint on commercial highway trucks", University of Michigan Transportation Research Institute, Report UMTRI-87-28.

Hildebran, E.D., and Wilson, F.R. (1997) "Development and intermediate findings of a level III heavy-truck collision study", Transportation Research Record 1595. National Research Council, pp. 39-45.

Rakheja, S., Ranganathan, R. and Sankar, S. (1988) "Load spill analysis of an articulated vehicle transporting wooden logs", Proceedings of the Ninth Symposium on Engineering Applications of Mechanics, London, Ontario, May 1988, pp 380-388.

Rakheja, S., Sauve, P., and Juras, D. (1997) "Experimental evaluation of friction coefficients of typical loads and trailer decks under vertical vibration" Load Security Research Project Report No. 2. Canadian Council of Motor Transport and Administrators.

SCT (2004) “SAADA System for accident data acquisition and administration SAADA)”, Mexican Institute of Transport. (In Spanish)

SH (2005) **“**Road accidents statistics 2005**”,** Secretary of Health, Mexican Federal Government, March 2005. (In Spanish)