Article

TRR
JOURNAL OF THE TRANSPORTATION RESEARCH BOARD

Transportation Research Record
1–10

DOI: 10.1177/0361198119828283
journals.sagepub.com/home/trr
SAGE

Truck Weights on Municipal and National Roads without Weight Enforcement

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Abstract

One of the main causes of premature deterioration in pavement structures is overweight heavy vehicles. To characterize these vehicles, real loads of motor vehicles of more than four tons should be monitored, especially vehicles classified as C2 (2-axles, single units), C3 (3-axles, single units), T3-S2 (5-axles, single trailer) and T3-S3 (6-axles, single trailer) type, as they represent 99.5% of the Costa Rican truck fleet. This study includes six temporal weighing surveys on municipal roads and seven weighing surveys on national roads, comprising the weight of 525 and 554 trucks, respectively. On municipal roads, C2 vehicles with bulk and wagon body types are predominant (67% of surveyed vehicles), whereas on national routes T3-S2 vehicles predominate (42%). Likewise, it was determined that most of exceeding data correspond to vehicles transporting pit material, construction materials, and merchandise on both types of roads. Compared with municipal roads (8%), the percentage of overweight vehicles is more than twice that on national roads (18%) where weight regulations are not enforced. To estimate updated and realistic load data that can be included in pavement design manuals and guides, the same results are provided in parameters such as truck factors and load spectra.

In pavement engineering, an assertive estimation of heavy vehicle weights is essential to design pavements capable of supporting the traffic loads experienced during their lifespan. To verify the effectiveness of overweight heavy vehicles regulation mechanisms, load surveys are of great importance in pavement management. A better understanding of different variables such as truck factors and load spectra allows successful, efficient, and reliable pavement design structures.

Permanent weigh stations in Costa Rica are located on major national routes; meanwhile most national roads and municipal roads do not have weigh stations. Overweight heavy vehicles could cause premature deterioration of pavement structures on these roads. International experience has proven that the greater the enforcement in permanent weigh stations, the greater the evasion of these control points by overloaded vehicles (*1*). Studies in Idaho and Virginia revealed that transporters travel as far as 160 miles to avoid weigh stations (*2*, *3*).

The purpose of this article is to identify the weights of trucks on roads without permanent enforcement or without enforcement at all. There are factors that affect overweight vehicle circulation, such as:

- a road culture characterized by disrespect for traffic laws and regulations, and
- the presence of international roads that allow the transfer of merchandise between North and South America; this increases considerably the number of national and international heavy vehicles moving throughout the country, either from the northern border with Nicaragua to the southern border with Panama, and vice versa, and between them or to the Pacific Ocean or the Caribbean Sea.

This document summarizes the national background in load surveys, including legal regulations and a description of weighing operations to control overweight heavy vehicles in Costa Rica; subsequently, the document focuses on the analysis of field information collected through load surveys developed on municipal and national roads not regulated by permanent weighing scales. The general objective of this project is to identify

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overweight differences between controlled roads and roads without weight enforcement.

Regulation Mechanisms of Vehicular Weight

Heavy vehicles become indispensable for a country's socioeconomic development when there is no railway system dedicated to cargo transport, as all imported and exported products must be transported by road.

From the perspective of truck drivers and companies, it is reasonable to increase productivity by increasing the amount of cargo moved per trip; on the other hand, this could generate premature and accelerated deterioration of pavement structures (reflected in alterations of maintenance programs and rehabilitation plans) (*4*), especially if roads are not attended promptly (*5*). Consequently, transporters will work in an overweight condition as long as they can obtain economic benefit, either evading control points or paying minor fines that do not significantly reduce their gains (*1*).

Legal regulations and physical regulation points must be implemented to protect road infrastructure. In addition, the enforcement of these regulations ensures road safety and supports preservation of roads and bridges (*6*). Some studies indicate excess weight rates around 25% on roads with deficient regulations, whereas on highly regulated roads this decreases to 0.5% (*7*).

The Public Works and Transportation Ministry (MOPT) of Costa Rica implements *legal regulations* through special permits granted to vehicle owners that correspond to special documents, that should be presented at each *weighing site* (fixed or mobile) to verify the total tons allowed according to vehicle configuration. Both regulatory mechanisms are described below.

Legal Regulations

In 1958, the Central American Agreement on Road Traffic was signed in conjunction with Guatemala, El Salvador, Honduras, and Nicaragua, to facilitate economic integration and improve transportation conditions. However, in 1997, the agreement was updated because of significant changes in transportation technology and road infrastructure design; therefore, in 2000 the original document was modernized and accepted by Guatemala, El Salvador, and Nicaragua. Costa Rica created the Road Traffic Regulations based on Cargo Vehicles Weigh and Dimensions. The maximum weights admitted according to regulations in Costa Rica could generate 20% more damage to the pavement than the maximum weights admitted in the Central American Region (*8*).

The truck classification according to different axles combinations, and their respective maximum permitted dimensions and weights for Costa Rica, are stipulated in the legislation, which also regulates special permits for conventional cargo or hazardous materials, weighing tolerances, transshipment modes, calibration equipment scales, safety vehicle technical conditions (couplings, modifications, brakes, suspension systems), and others (*9*).

Traffic police are empowered to apply fines, and they can even compel cargo transfer to another vehicle at a fixed weighing station if a vehicle exceeds the maximum weight allowed.

Permanent Weigh Stations

In Costa Rica there are five permanent control points distributed throughout the national territory, controlling mainly land borders and seaports where the percentage of heavy vehicles is high; they are located outside the Greater Metropolitan Area of the capital region and alongside strategic national routes (as shown in Figure 1).

Currently, three control points are automated stations, intended for speeding up work and minimizing bribery possibilities. The stations present different technological devices and features, such as:

- camera systems to monitor evasion control, to register the plate and verify that the vehicle has the necessary permissions according to its vehicular configuration,
- sensors to measure vehicle length and height,
- weighing plates in the selective and precision areas, and
- a backyard parking lot to leave the vehicle while a detailed permit review is made, or to carry out the cargo transfer if necessary in the case of exceeding maximum weight.

All vehicles should enter the selective area. Only vehicles with some disagreement with the regulations in the first weighing (selective area) are required enter the precision area.

These automated stations are located in Búfalo-Limón (in both road directions), Ochomogo-Cartago, and Cañas-Guanacaste, whereas the Esparza and Río Claro stations of Puntarenas province are operated manually; all stations are expected to be automated in the future, and the national government has planned to implement more permanent weigh scales in different national road network sectors in the future.

Temporal Weighing

The temporal weighing or surveys are important to identify vehicle weights on roads without permanent weight

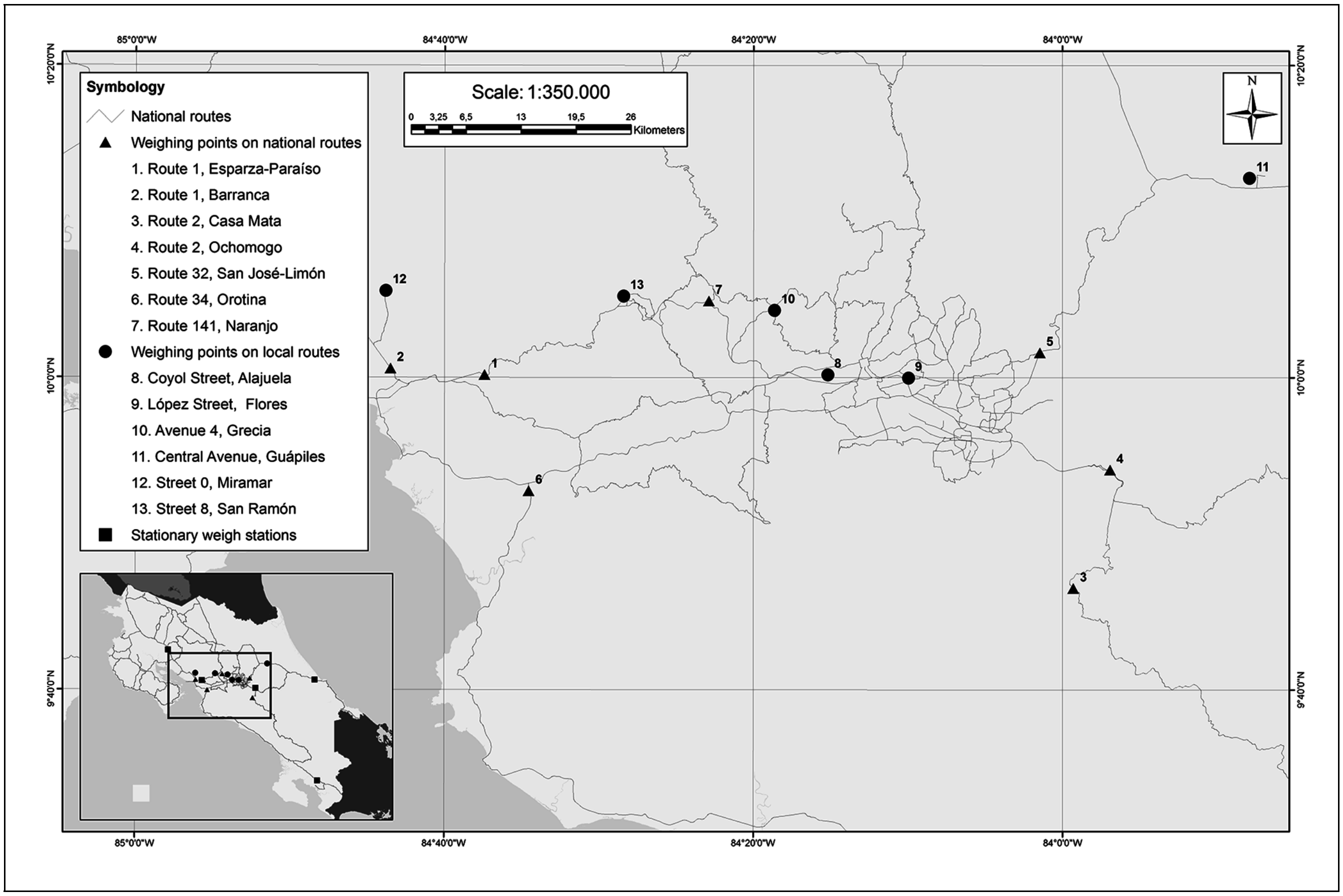

Figure 1. Location of temporal weighing.

enforcement; these roads are mainly part of the municipal road network, or serve as alternate national roads that allow evasion of weighing points even though driving conditions are less favorable, such as longer trajectories, sinuous geometry, and steep slopes, among other conditions. For example, in 1997 the Florida Department of Transportation determined that only 60% of overweight cases were identified in fixed weighing stations, the remainder being obtained by mobile weighing located in alternate roads (*1*); and a Minnesota study in 2005 discovered that 90% of overweight cases were on alternatives routes (*10*).

Weight Surveys on Alternate or Non-Regulated Roads

The accelerated and/or premature deterioration of pavement structures presents three notable points under optimal design and construction conditions: it is intensified by heavy vehicles, the deterioration curve drops sharply without timely intervention (*4*, *5*), and exaggerated deterioration increases in overweight situations (*11*). It has been proved that an increase in axle weight exponentially increases the damage level (some research assumes it as an exponent of four, even when it is a variable factor) (*12*).

In Costa Rica, previous load surveys were performed during the last decade to identify design variables that represent real loads of heavy overweight vehicles in the Costa Rican road network. These studies include a load survey on high-traffic national roads in 2007; an exclusive urban and intercity buses weighing survey in 2013; and finally, in 2016 and 2017, researchers focused efforts on roads not regulated by fixed weighing stations. As shown in Figure 1, this final study included seven weighing sites on different national roads in 2016, and measurement sites on six municipal roads in 2017.

The following section describes considerations of previous activities and during the execution of the weighing.

Methodology

Load surveys require minimum alterations on transporters' time and that the queue of trucks does not interfere with through traffic; some work phases are described below and are presented schematically in Figure 2.

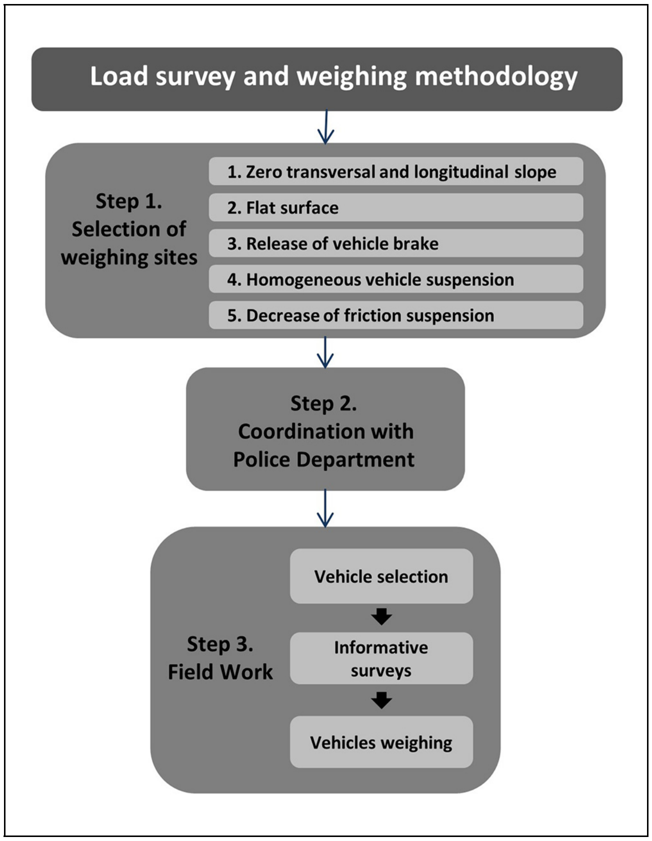

Figure 2. Load survey and weighing methodology.

1. *Equipment and work material*
   Both load surveys used two static balances with a scale precision of 50 kg. In addition, transporters were asked some questions regarding origin–destination, transported product type, and vehicular body type, among other data.
2. *Selection of weighing sites*
   The weighing site should comply with the following parameters (13):
   (a) *zero transversal and longitudinal slope* in which the axle and tire weight can be measured correctly without the influence of resultant forces,
   (b) *flat surface* without bumps or depressions that overload any axle or impede the full support of the weighing plate (a maximum of 10 mm is allowed between the ground and the balance),
   (c) *release of vehicle brake* before reading the balance, or otherwise activate the first gear and stop the engine complements,
   (d) *homogeneous vehicle suspension* in vehicles of three or more axles, because the compression of a suspension spring would translate this axle load toward others axles in a lower position,
   e) *decrease of friction suspension* in loaded vehicles with three or more axles because friction axle is opposite to circulation direction, so depending on the movement of the axle while parking, the real weight could be increased or decreased.
3. *Coordination with police*
   After locating the weighing sites, it was necessary to coordinate the availability of a traffic police officer during weighing, collaborating in traffic control and promoting road safety. In accordance with the law (14), traffic police support weigh control operatives, verifying fulfillment of obligatory requirements, and imposing authority to force transporters to stop; otherwise the disrespect toward field inspectors would make the load survey difficult to carry out.
4. *Field work*
   Once at the site, field technicians placed the scales correctly and delimitated the work zone in collaboration with the traffic officer using cones, barriers, and other safety devices; subsequently, the load survey includes the following:
   (a) *Vehicle selection*: The officer stops and divert the trucks classified as C2 (2-axles, single units), C3 (3-axles, single units), T3-S2 (5-axles, single trailer) and T3-S3 (6-axles, single trailer) type, and controls the remaining traffic flow. All vehicles with these characteristics were surveyed. During the survey no enforcement actions were taken; however, the police presence was necessary to divert the heavy vehicles.
   (b) *Informative surveys*: While drivers wait, or during weighing, they were interviewed to identify important trip details.
   (c) *Vehicle weighing*: The weight of each tire or set of tires must be recorded. Once all vehicle axles are weighed, the technicians proceed to release the vehicle and call the next truck in the queue.

Weighing Sites

The weighing sites were selected in accordance to a previous study (*15*), which established routes with the highest heavy load vehicle traffic by identification of merchandise production and delivery nodes, according to economic activities such as agriculture and construction.

Based on this report, and on the distribution of socioeconomic activities in the national territory, 13 specific sites (seven on national roads in 2016 and six in municipal roads in 2017) were selected. Each route was characterized by a high average daily traffic of heavy vehicles, and by not having permanent weigh stations. Temporal weighing was

Table 1. Number of Vehicles Sampled by Site and Truck Type

Measurement site		Vehicle type C2	C3	T3-S2	T3-S3
National routes	Route 1, Esparza-Paraíso	14	8	39	5
	Route 1, Barranca	12	16	51	27
	Route 2, Casa Mata	23	18	22	1
	Route 2, Ochomogo	21	13	35	8
Total = 554 trucks	Route 32, San José-Limón	35	18	40	12
	Route 34, Orotina	13	13	29	5
	Route 141, Naranjo	43	15	14	4
Local routes	Coyol street, Alajuela	90	25	22	2
	López street, Flores	17	12	29	8
	Avenue 4, Grecia	75	20	19	1
Total = 525 trucks	Central Avenue, Guápiles	18	3	9	2
	Street 0, Miramar	45	9	0	0
	Street 8, San Ramón	85	18	14	2

Table 2. Weight Limits According to Current Regulations in Costa Rica

Vehicle type	Axle	Maximum axle weight (kg)	Maximum truck weight (kg)
C2	Simple dual	10 000	16 000
C3	Tandem	16 500	22 500
T3-S2	Tandem 1	16 500	39 000
	Tandem 2	16 500	
T3-S3	Tandem	16 500	45 500
	Tridem	23 000	

Note: For all types of vehicles, the single axle has a maximum admissible value of 6,000 kg.

exclusively to C2 (2-axles, single units), C3 (3-axles, single units), T3-S2 (5-axles, single trailer) and T3-S3 (6-axles, single trailer) type, as they correspond to 99.5% of the heavy vehicles fleet in Costa Rica (*16*). Figure 1 presents each weighing site and the study vehicles sample per zone.

The sampling schedule was between 8:00 a.m. and 1:00 p.m., the start time varied at each site according to the availability of the traffic officer. From previous experience, 4 h is the maximum duration for each temporal weigh survey, because truck drivers communicate among themselves and evade the weighing point; thus the enforcement effectiveness of the study diminishes over time (*1*).

Analysis of Results

The following analysis uses data collected in the 13 sampling sites indicated in Figure 1, including vehicle fleet composition (Table 1). This section also describes physical characteristics and weight of the 1,079 heavy vehicles studied on the project and their influence on the deterioration of pavement structures. Their weights were compared to the current regulations (see Table 2), to determine the level of compliance.

Description of Vehicle Fleet Surveyed. As shown in Table 1, on municipal roads the C2 (2-axles, single units) trucks (67%) predominate. On national roads, there is a greater proportion of T3-S2 (5-axles, single trailer) vehicles (42%). The geometry of municipal roads presents a smaller turning radius and narrower lanes, which are better suited for short trucks; whereas on national roads, use of articulated vehicles becomes attractive, as larger trucks are able to transport more goods per trip over longer distances. T3-S3 vehicles on the municipal roads account only for 2.8% of the 525 heavy vehicles registered, and a quarter of the amount registered in national routes.

According to the total vehicles weighed on national and local routes (1,079 vehicles), the highest number of records corresponds to C2 vehicle type (45%) and T3-S2 vehicle (30%), similar to results obtained in 2014 from the fixed weighing stations analysis, in which these two vehicle types covered 84% of registered weighing (*17*).

Through informative surveys of the drivers, it was possible to describe the vehicle fleet according to the body and cargo transported type, as shown in Table 3. Regarding body type, a high frequency of vehicles with flatbed and van type was evidenced both on national and municipal roads; on the other hand, a few trucks were used as garbage trucks, cranes and concrete mixers. Some of the differences in body type observed on both types of roads correspond to the large number of enclosed box vehicles and dump vehicles on municipal roads and few of these on national roads, and the opposite condition with vehicles with tank and grain body.

Based on cargo type, the transport of retail-related freight is frequent on both road types. Similarly, agriculture and fuel load transportation vary depending on the road type—they were frequent on national roads, and rare to find on municipal roads.

Table 3. Number of Vehicles Weighed and Percentage of Overweight by Body and Cargo Type

		National roads without permanent enforcement		Municipal roads	
		Vehicles weighed	Vehicles with overweight (%)	Vehicles weighed	Vehicles with overweight (%)
Body type	Garbage trucks	5	20.0	4	50.0
	Concrete mixer	7	14.3	8	37.5
	Tank	60	28.3	17	17.6
	Container	28	10.7	6	0.0
	Flatbed	103	25.2	91	12.1
	Enclosed box (one trailer)	8	37.5	88	10.2
	Crane	5	0.0	5	0.0
	Wood	47	6.4	27	0.0
	Grain	42	33.3	2	0.0
	Other	1	0.0	1	0.0
	Dump	28	42.9	42	26.2
	Van	305	7.2	234	0.9
	Total	**639**	**16.0**	**525**	**7.8**
Cargo type	Agriculture	36	30.6	4	50.0
	Automotive	6	0.0	1	0.0
	Garbage	8	25.0	6	33.3
	Fuel	27	48.1	10	30.0
	Construction	49	44.9	53	18.9
	Aggregates (stone and sand)	24	95.8	29	37.9
	Retail related	127	15.0	313	3.5
	Empty	284	0.0	43	0.0
	Others	78	15.4	66	3.0
	Total	**639**	**16.0**	**525**	**7.8**

Table 4. Number of Trucks Classified by Compliance to Regulations

	Without overweight		With overweight		
Vehicle type	NRWE	MR	NRWE	MR	Total
C2	155	323	6	7	491
C3	80	68	21	19	188
T3-S2	192	79	38	14	323
T3-S3	28	14	34	1	77

Note: MRN = municipal road network; NRWE = national roads without enforcement.

Differences between body and cargo types on national and municipal roads are directly related to their function in the country's road network. National roads communicate land and sea borders with major cities, so transporting fuel in tank vehicles and agricultural products grown outside the capital is required; the municipal routes are used for trips between nearby towns, increasing the quantity of dump-type vehicles, usually used for municipal works and private construction in urban settlements.

Exceeding Vehicle Weight Allowed. The overweight trucks presented different configurations (vehicle and body type) and freight variety. As shown in Table 3, the number of exceedances in national roads is higher in vehicles with flatbed, tank and van-type bodies; in municipal roads, it corresponds to vehicles with flatbed, enclosed box, and dump bodies. Despite body type differences, in both road types, the highest amount of load exceedance corresponds to aggregates, construction, and retail-related freight categories. With respect to vehicle type, the most overweight vehicle type is C3 (associated mainly with body type dump), and T3-S2 (associated mainly with body type flatbed).

As shown in Table 4, the analysis of exceedances reflects that 99 of 554 vehicles surveyed on national roads (17.9%) traveled exceeding the permitted limit. In addition, vehicles T3-S2 presented the greatest overweight cases, followed by the T3-S3 configuration, which means that articulated vehicles make the biggest

Table 5. Truck Factors of Analyzed Vehicles

Vehicle type	Truck factor			
	MRN	NRWE	LSL 2007	PSD 2017
C2	0.24	0.39	0.75	0.18
C3	1.08	1.16	2.9	0.54
T3-S2	1.01	1.67	3.2	1.15
T3-S3	1.26	2.14	NA	1.56

Note: MRN = municipal road network; NRWE = national roads without enforcement; LSL = load survey 2007; PSD = permanent stations data (2017). Data obtained from (*21–24*).

contribution to pavement damage on national roads, because of overweight.

The municipal routes load survey presented 525 registers, and 41 overweight cases (8%), less than the national roads results; so proportionally, there was double the amount of overweight heavy vehicles on national roads compared with municipal routes.

The exceedance values (extra tons) on national roads are significantly higher in comparison to municipal roads. They exceed by a factor greater than nine the exceedance percentage of C2 vehicles dual single axle, doubling the exceedances in T3-S2 vehicles tandem axles, and exceed by a factor greater than seven when T3-S3 vehicles are compared.

The only axle in which similar results are observed corresponds to C3 vehicles tandem axle (17.8% vs. 17.2% in national and municipal roads, respectively).

In addition, extreme overweight cases were identified in accordance to current weight regulations. For example, in national and municipal roads, the C3 and T3-S2 vehicles exceed up to 12,500 kg and 11,000 kg of overweight, respectively, and the worst case happened with a T3-S3 vehicle on national roads that exceeded the maximum regulatory weight by up to 14,300 kg, significantly affecting the pavement lifespan. Previous studies indicate that a simple axle extra ton could increase pavement damage by up to 92%, but two extra tons could increase damage by up to 228%. According to tandem axle, an extra ton could represent 25% more damage, and two extra tons represents 55% extra damage. A tridem axle extra ton represents an additional 18% damage, whereas two tons would be 40% additional damage (*18*).

Truck Factor. Pavement design through different methodologies such as AASHTO 93 (*19*) or MEPDG (Mechanistic-Empirical Pavement Design Guide) levels 2 and 3 (*20*) requires the truck factor value, defined as an equivalent parameter to the number of simple axles of 18,000 lb per vehicle type according to its average weight. Equivalent single axle load estimations, for each vehicle type, are used to design pavement structures, and are directly related to each truck factor. Table 5 presents the average truck factors for national and municipal roads obtained with load survey data presented in this article. The table also summarizes values obtained in a load survey conducted in 2007, and other factors estimated from fixed weighing stations from information collected between 2008 and 2017.

According to results obtained in a recent load survey (MRN and NRWE columns in Table 5 correspond to 2016 and 2017 data) the highest truck factors correspond to the data from national roads without weight enforcement; vehicles circulating along these routes present factors up to 40% higher than on municipal roads for most vehicle types, which also confirms that three-axle vehicles circulate the most with overweight on municipal roads.

Comparing national roads information data from the study developed in 2007 and recent load survey, a decrease in truck factor values is important: the C2 and T3-S2 vehicles factor decreased by 48%, whereas the C3 vehicles decreased in magnitude by 60%. This information proved a decline and stabilization of the truck factors trend observed since 2007, resulting from an increase in fixed weighing stations control (*25*).

Nevertheless, fixed weighing station values compared with municipal roads results, both from 2017, demonstrate that C2 and C3 vehicles have a greater truck factor on municipal roads (the situation is opposite for articulated vehicles); in the municipal roads sample, most of the cargo is transported in vehicles of three or fewer axles. Likewise, all truck factors are greater on national roads without enforcement than on roads with fixed stations.

Load Spectra. A single average value for each heavy vehicle type is the base for methodologies based on truck factors. This may not represent the real conditions: a few overweight cases could increase the factor considerably; on the contrary, empty vehicles could reduce it. In recent years new methodologies have been developed for pavement design, based on traffic analysis from *load spectra*: a more detailed visualization of results through graphics that identify the most frequent load ranges, resulting in

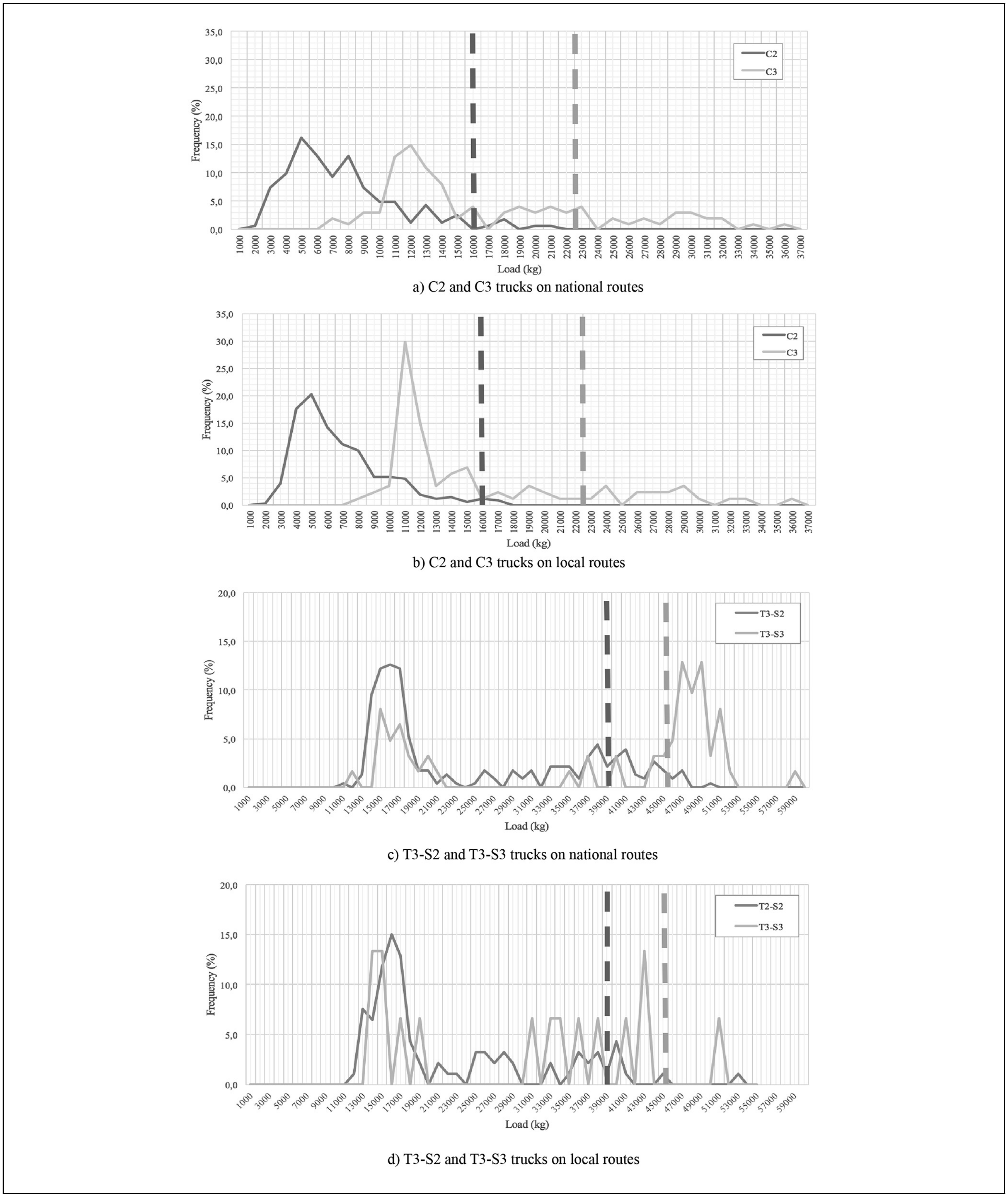

Figure 3. Relevant loading spectra on roads not regulated by weighing stations.
Note: Dashed lines indicate the maximum allowed according to vehicle type.

parameters representative of the most common traffic condition or real loads applied.

Figure 3 presents municipal and alternate national roads load spectra per vehicle type; in general most of the registers circulated according to regulation, but some overweight cases were identified in all vehicle types.

As shown in Figure 3, (*a*) and (*b*), load spectra for C2 and C3 vehicles present similar behaviors in both kind of roads; the highest part of the graph, or most frequent weight, is before the dashed lines (which represent the weight limits). However, it also presents a lot of overweight C3 vehicles, exceeding up to 35,000 kg in both cases.

Load spectra of Figure 3(*c*) describe more overweight cases in national routes alternate to fixed stations, whereas in Figure 3(*d*) (municipal roads) exceedance is very low, therefore the load spectrum is shifted to the left. Vehicles T3-S3 on national roads present a different load characterization as a result of many trucks exceeding the current regulations. Future enforcement strategies should consider this.

Future Work

There is a need to generate a more extensive load survey that covers all national territory, registering more heavy vehicles and considering weighing operations across several months, to capture temporal variations of weight and enforcement effect. It is proposed to extend weighing for a minimum period of six months, alternating across different municipal and national routes within and outside the Greater Metropolitan Area.

It is recommended to use dynamic scales in future studies to reduce queue time and to increase the number of registers, as it is intended to weigh a statistically significant number of vehicles at each sampling point. From this fieldwork it will be possible to expand databases, complementing information collected continuously in fixed weigh stations and identifying typical heavy vehicular behavior throughout the national territory.

Likewise, these comparative studies between regulated and non-regulated roads provide the information necessary to realize benefit-cost analyses concerning the investment in construction of automated stations, in contrast to premature pavement deterioration caused by vehicular overweight. A benefit-cost study is also recommended to compare road damage generated by heavy overweight vehicles, and the increase in resources needed for the installation of more fixed weighing stations and mobile weighing operatives.

Conclusions

Although there is concurrence between the cargo type present on both types of route, the vehicular fleet composition presents differences because of the purpose of the trip: national routes represent travel between borders and ports, whereas municipal routes generally correspond to shorter trips and generally lighter cargo.

Vehicles on national routes include articulated vehicles such as tanker trucks, mainly used for agricultural products and fuel transportation, whereas municipal routes evidenced a greater quantity of C2 and C3 vehicles, such as dump body trucks loaded with aggregates. However, on both routes flatbed and van trucks are common: flatbed and van trucks body type, overweight in construction materials, aggregates and retail-related merchandise.

Both route types have similar overweight vehicle proportions: C2, C3 and T3-S2 vehicles exceeded the maximum limit allowed in 3%, 20%, and 15% respectively; except for T3-S3 vehicles, which present overweight in the half of registers obtained on national routes, and only 7% on municipal routes.

Regardless the route type (national or municipal), C3, T3-S2, and T3-S3 vehicles present extreme overweight cases, exceeding limits by more than 10,000 kg.

In accordance with Cunagin et al. (*1*), sporadic weighing on alternate routes could generate a significant reduction in vehicular overweight, as it reduces the tendency of drivers not to be fined if they evade fixed control points.

A comparison between load survey results and information from fixed weighing stations shows that C2 and C3 vehicle truck factors are higher on municipal roads. The opposite occurs regarding articulated vehicles, because of the greater number of trips with this type of vehicle on national routes. According to alternate national routes and fixed stations, all truck factor values are lower on routes regulated by permanent weight enforcement, because on these roads carriers are exposed to fines and cargo transshipments resulting from overweight, which works as an incentive for respecting the established limit.

A reduction of up to 50% was observed in comparison to truck factors of all types of vehicles determined in the load survey of 2007, which implies an effective enforcement effort in controlling vehicular overweight. This conclusion agrees with previous studies that mention a decrease in the proportion of trucks that exceed the weight limits established in the legislation (*25*).

Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Ana Vargas-Sobrado, Luis Rodríguez-Solano, José Aguiar-Moya, Henry Hernández-Vega, Luis Loría-Salazar; data collection: Luis Rodríguez-Solano; analysis and interpretation of results: Ana Vargas-Sobrado, Luis Rodríguez-Solano, José Aguiar-Moya, Henry Hernández-Vega; draft manuscript preparation: Ana Vargas-Sobrado,

Luis Rodríguez-Solano, José Aguiar-Moya, Henry Hernández-Vega, Luis Loría-Salazar. All authors reviewed the results and approved the final version of the manuscript.

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The Standing Committee on Truck Size and Weight (AT055) peer-reviewed this paper (19-02691).