A SURVEY OF COMMERCIAL VEHICLE WEIGHTS IN SAUDI ARABIA

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الخلاصـة :

أجري مسح لأحمال الشاحنات مدته أربع سنوات باستعمال بيانات الشاحنات التي جُمعت من محطات الوزن الجانبية المنشأة على جوانب الطرق المختلفة بهدف تحديد تركيبة الشاحنات وفحص مشكلة الأوزان الزّائدة السائدة في المملكة العربية السعودية تحت التّنظيم المفروض، لقد حدد حجم العينة بناء على اختيار عشوائي تجاوز مليون شاحنة ، كما عملت استطلاعات حقل في مواقع مختارة للحصول على بيانات ومعلومات اضافية. وتعرض هذه الورقة نتائج هذه الدّراسة التي تكشف أن مشكلة زيادة الوزن ما زالت موجوده بشكل مزعج لا يمكن أن يغفل أثره الضار على الطّرق والجسور، ظهر من تحليل البيانات التّشابه الكبير بين المناطق الأربع، المنطقة الشمالية والمنطقة الوسطى والمنطقة الغربية والمنطقة الشرقية. فيما يتعلق بتركيبة الشاحنات ومدى ومقدار زيادة الوزن.

ABSTRACT

With the aim of characterizing the commercial vehicle composition and in order to examine the overweight problem prevailing in Saudi Arabia under the imposed regulatory controls, a four-year truck load survey was carried out using truck data collected from the wayside weigh stations installed at various traffic corridors. The sample size, built on a random selection, exceeded over one million trucks. Additional field surveys were also conducted at selected locations to obtain supplementary data and information. In this paper, the findings of this study are presented drawing attention to the revelation that overweight problem still exists at an uncomfortable level, whose damaging impact on roads and bridges cannot be ignored. Data analysis also shows that the four provinces, Eastern, Western, Northern, and Central Province, bear an astonishing degree of similarity with regard to truck composition and the extent and magnitude of overweight.

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INTRODUCTION

The rapid development of the highway network in Saudi Arabia in the early 1980s was accompanied by an expansion of the road freight industry which relied on the operation of heavy vehicles of different shapes and sizes. Earlier design of highways and bridges experienced difficulty, as information on truck loads, axle loads, and vehicle characteristics was scanty and unclear then. The unabated flow of heavy trucks caused widespread damage to pavements and bridges [1, 2] and in the absence of a regulatory control to curb overweights, commercial vehicle operators continued to engage larger, heavier trucks with increased axle loads, further worsening the situation.

Earlier efforts [1–4] to reveal the problem of truck overweights were made by isolated, sample, field surveys of truck characteristics, gross weights, and axle loads. These studies starkly revealed the presence of a large number of extremely heavy vehicles which were blamed for damage to roadway infrastructures. In recognition of this problem, the Ministry of Communications (MOC) in 1985 adopted a regulatory plan to combat and control the overweight problem by introducing a weighing policy for all commercial vehicles. Under this policy, all loaded trucks are required to pass through wayside weigh stations installed at various traffic corridors for a verification of their gross weight. A violation of the specified legal weight limits automatically draws a monetary penalty, which is indexed to the amount of overweight above the legal limit. The enforcement of this policy led to a sharp drop in the flow of heavy trucks and to a reduction in road accidents caused by them. Furthermore, the amount of overweight above the legal limit was also seen to decline sharply [5]. The effectiveness of truck weight enforcement in Saudi Arabia has been reviewed recently (reference [6]), which asserts the need for more rigorous enforcement to curb violations.

Even in countries where vehicle characteristics are well known and weights are regulated, structural damage to pavements and bridges continue to occur unpredictably [7, 8]. This is due to the increasing push exerted by the truck operators for larger and heavier vehicles with higher axle loads to seek superior returns from trades. In Saudi Arabia, even today, the overweight problem has not been eliminated despite weight controls exercised through the weigh stations which are strategically located at various corridors of traffic flow [6].

As part of a study [9], an extensive amount of truck data was retrieved from MOC's databank in Riyadh to examine the truck composition and to review the current overweight situation. This study was further supplemented by sample field measurements conducted at different locations. The primary objective of this paper is to present the findings of this survey and to highlight the magnitude of the overweight problems currently in place. It has been observed that while the amount of illegal weights has declined appreciably, the number of violators as a percentage of the truck population is still high.

DATA COLLECTION

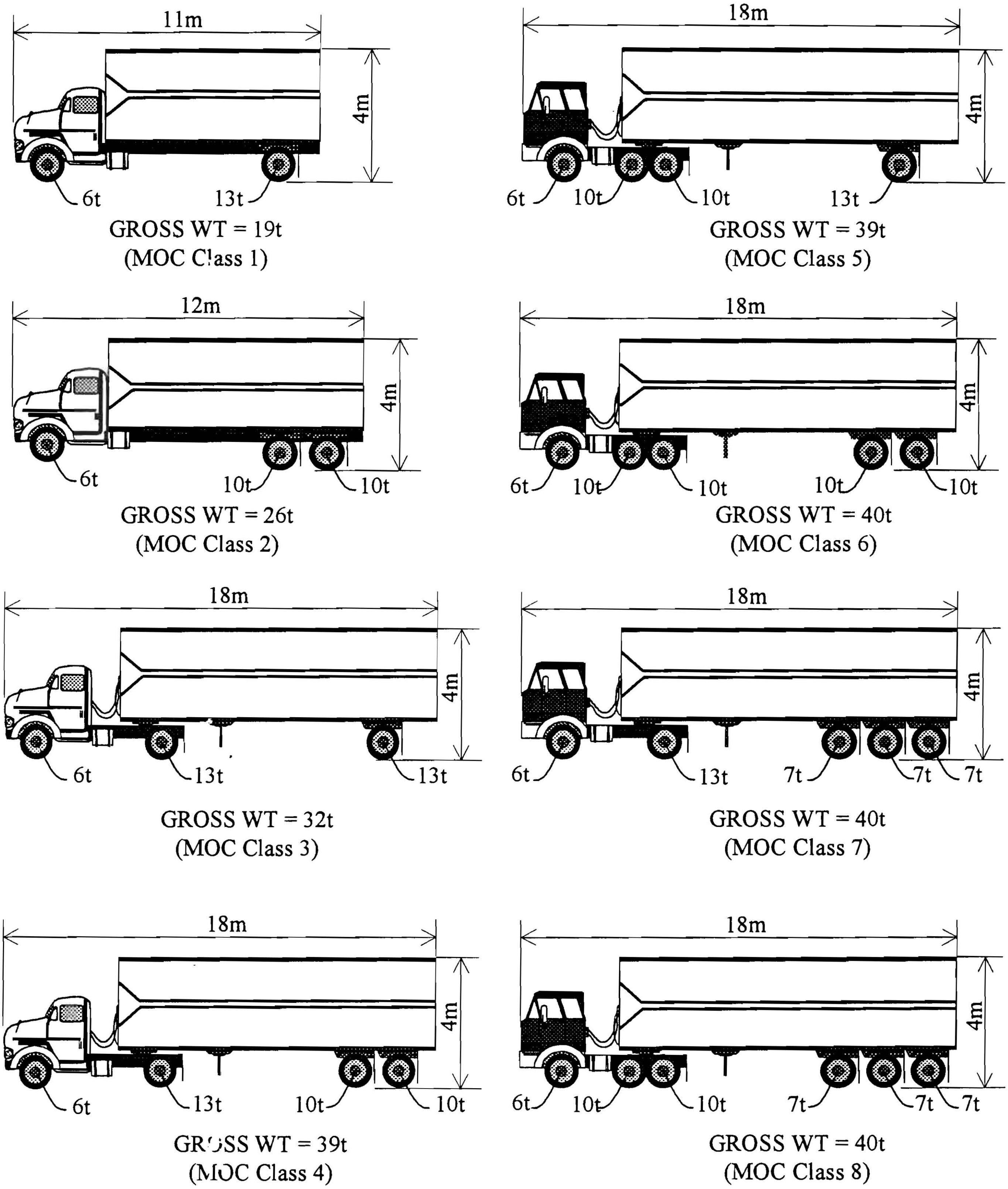
Data was collected from two sources: (1) the primary source of MOC's data bank in Riyadh and (2) the secondary source, comprising sample load surveys conducted at several strategic locations. The first source provided the bulk of the data, as truck data received from all weigh stations are accumulated and archived in Riyadh.

Truck Classification

As the bulk of commodities are transported inland by commercial vehicles, different shapes and sizes of vehicles, varying from simple two-axled rigid trucks to six-axled articulated ones, are seen on the roads. For enforcement of weight control on trucks, MOC has classified trucks into 8 basic classes (Table 1). The legal weight of each class and its general configuration with number of axles are shown in Table 1 and in Figure 1. The maximum legal weight of a truck has been limited to 40 t (~400 kN) and the maximum axle load is restricted to 13 t. Figure 1 shows the permissible limits of axle loads for different classes of trucks.

Data from MOC

Although there are 28 weigh stations currently operating in the Kingdom (Figure 2) only 19 of them are equipped with computerized data storage facilities. The list of 19 stations from which data was obtained is shown in Table 2. For identification, each station has an area code and station code number, as indicated in Table 2. Both medium speed and low speed scale systems are utilized at high traffic volume stations.



Information on this chart based on traffic regulations of 1391 H.

Figure 1. Legal truck loads and axle loads.

Truck data from a weighing station is sent to Riyadh on computer diskettes, using ASCII format, on a monthly basis for storage. The stored data provides information on truck weights, axle weights, truck type, and the overweight, if any, above the legal limits along with the registration number, day/time and the amount of imposed fine. Through MOC's cooperation, the stored data was retrieved and reformatted for analysis.

Truck data was collected at random for four consecutive years from 1413 to 1416 H (Hijira years) totaling over one million trucks, a number considered to be sufficient for a reliable statistical analysis. Table 3 contains the number of trucks sampled for each year for all provinces.

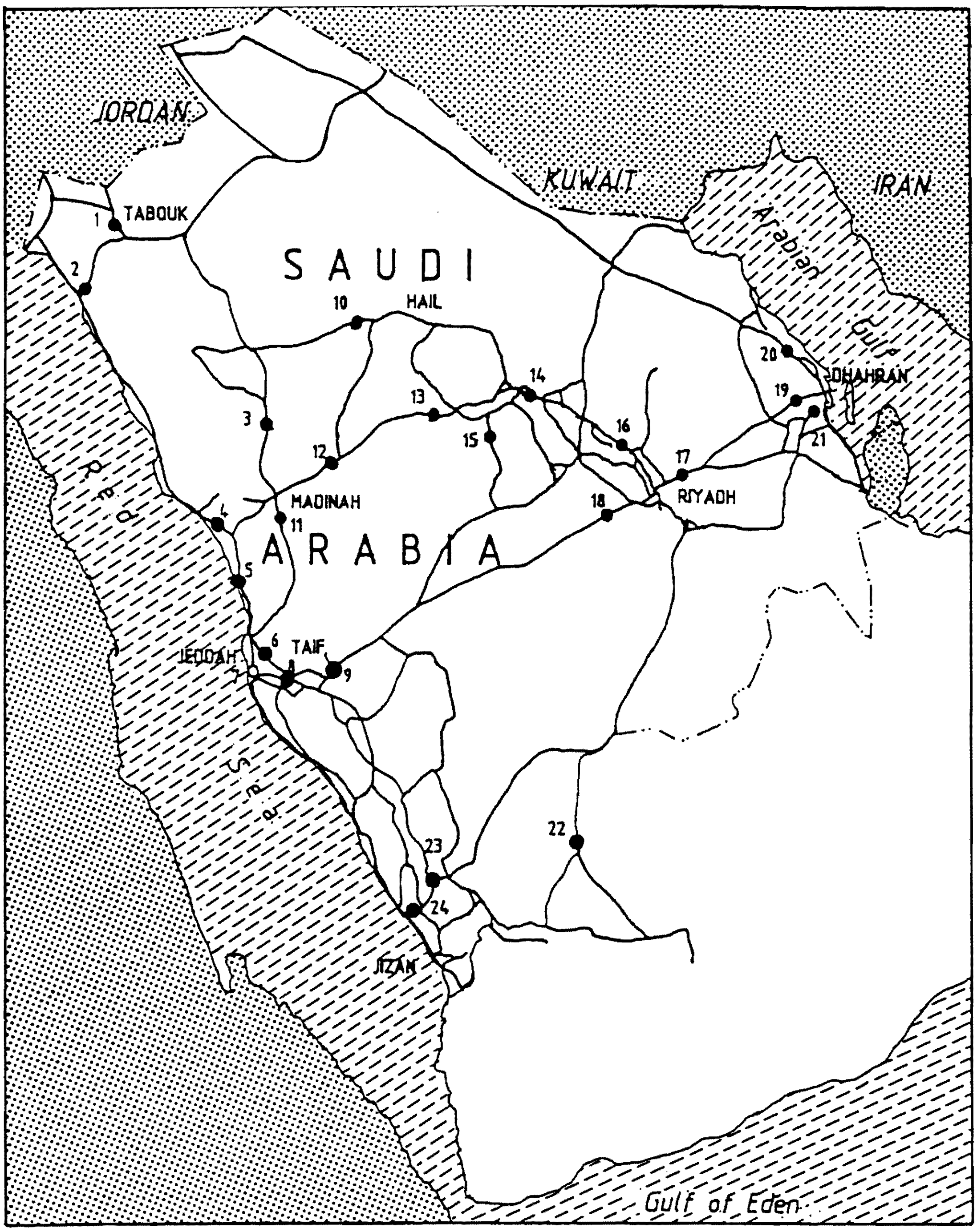


Figure 2. Weigh stations in Saudi Arabia.

Data from Sample Surveys

Sample truck load surveys were conducted at selected locations in three provinces namely: Western, Central, and Eastern Province. In the Western Province, three sites were chosen: (*i*) old Jeddah–Mecca road, (*ii*) Jeddah–Asfan road, and (*iii*) New Jeddah–Mecca road. The surveys were conducted using a portable, computerized weighing scale manufactured by Intercomp in USA (model PT 300). The following procedure was followed: At a weighing station, the pair of weighing scale was placed at about 2.4m centers. Sloping ramps were provided on two longitudinal sides of the scale to provide a gentle slope. The pair of scales, known as a master scale and a slave scale, were connected to a laptop computer using proper port connections. For the record of axle weights, the drivers were asked to slowly place one axle on the scale (Figure 3) and then move on to the next axle, once the static load of the in-place axle was recorded. The axle spacings were measured manually by using a hand-held, distance measuring rolling wheel which measures the distance as the wheel is

Table 1. Truck Classification and Legal Weights.

MOC Classification	Configuration	Number of Axles	Legal Weight (t)	Maxm. Axle Load (t)
Class 1	Rigid	2	19	13
Class 2	Rigid	3	26	10
Class 3	Trailer type	3	32	13
Class 4	Trailer type	4	39	13
Class 5	Trailer type	4	39	13
Class 6	Long Trailer type	5	40	10
Class 7	Long Trailer type	5	40	13
Class 8	Long Trailer type	6	40	10
Unclassified	Special	>6	40	13

Table 2. List of Weighing Stations Supplying the Data.

Province	Corridor Location	Area Code	Station Code
Eastern	Dammam – Riyadh	3	1
	Dammam – Abu Hadriyah	3	2
Central	Riyadh – Dammam	1	1
	Riyadh – Taif	1	2
	Riyadh – Qasim	1	3
	Taif – Riyadh	6	1
	Qasim – Madinah	13	1
	Ras Dukhna – Bajadiah	13	2
	Qasim – Riyadh	13	3
	Sulayl – Najran	18	1
Northern	Tabuk – Halat Ammar	7	1
	Hail – Alula	20	1
Western	Jeddah – Rabigh	2	1
	Jeddah – Asfan	2	2
	Jeddah – Makkah (Old)	2	3
	Madinah – Makkah	4	1
	Madinah – Qasim	4	2
	Yanbu – Madinah	9	1
	Khayber – Madinah	25	1

rolled from one axle to the other. The operating temperature for the weighing scale, recommended by the manufacturer, ranges from –28°C to 65°C and the accuracy of the measured weight is ± 1%

In total 3155 trucks were weighed. In the Central Province, measurements were undertaken at two locations, one on the Riyadh–Taif road, the other on the Riyadh–Qasim road, sampling a total number of 508 trucks. In the Eastern Province, locations on the Dammam–Riyadh highway and on the Dammam–Abu Hadriya highway yielded a sample of 1415 trucks. Almost half of the measurements on trucks measured in the Eastern Province were deliberately carried out on the side of the divided highway, where there is no weigh station, so as to see the degree of overweight violations on roads having no control.

DATA ANALYSIS

The truck data collected from MOC's data bank is presented and analyzed using collective data for four years and four provinces in unison. The truck data included information on truck types, gross weights, and the maximum axle loads.

Table 3. Provincewise Breakdown of Truck Samples.

Year	Truck Sample Size for Provinces				Total No. for the Year
	Eastern	Western	Northern	Central	
1413	54 378	57 188	11 507	89 960	213 033
1414	62 675	62 223	21 519	92 747	239 164
1415	102 849	84 116	31 619	89 183	307 767
1416	108 170	125 421	33 896	134 500	401 987
Total	328 072	328 948	98 541	406 390	1 161 951

Figure 3. Axle load measurement in field survey.

Truck Composition and Gross Weights

The truck composition was first examined by breaking down the collected truck data into different MOC classes. The composition (shown in Table 4) reveals that a vast majority of trucks, about 80% of the sample size of 1 161 951 trucks, falls into Class 4 & 5, which are four-axled trucks with a legal weight of 39 t. The next highest percentage belongs to Class 6 and 7 with five axles. Thus, close to about 90% of all truck types fall into the 4 and 5 axled categories. It appears that, among the eight classes of trucks, Class 3 type trucks (three-axled trailer type) are used by truck operators sparingly, as their percentage is relatively very small. A lower number of long trailer type trucks with 7 and 8 axles (one in one thousand approximately) are also observed as part of the total truck samples. It can be concluded that the country's truck population is dominated by an overwhelming presence of four-axled trucks belonging to MOC Class 4 & 5.

Table 4 also shows the number of overweight trucks in each class whose weight exceeded the legally permitted limit in that class and their percentages. The worst violators are clearly the high density four-axled trucks (Class 4 & 5), as a high percentage, close to 47%, exceeded the legal limit. Table 4 also shows that an uncomfortably high percentage of trucks in all other classes (with exception of Class 3) are also overweight. The surprising low number of weight violations in Class 3 is indicative of the possibility that this type of truck may be often used in carrying lightweight goods. The finding reveals a disturbing picture of the overweight problem: almost 45% of the loaded trucks sampled at random are overweight by some magnitude. Thus, close to four out of nine loaded trucks on highways can be expected to exceed their legal limits.

Data presented in Table 4 shows only the number or percentages of the overweight vehicles, but does not reveal the magnitude of overweights, which is needed to examine the severity of the problem. For the purpose of quantification, overweight trucks are grouped into ten different ranges of overweight, stepwise incremented from 5% to over 100%, and the percentages of overweight trucks falling into each range of overweight classification are then calculated. The results are shown in Table 5 for all MOC classes. Using data in Table 5, Figure 4 is plotted to graphically show the overweight distribution for MOC Class 4 & 5 and Class 6 & 7, which are the most predominate types of commercial vehicles. Table 5 and the selected plots in Figure 4 clearly reveal an encouraging observation of the overweight problem: the percentage of overweight trucks exceeding 50% of the legal limits is very low. For high density vehicles of Class 4 & 5 and Class 6 & 7, only an insignificant number exceeds the legal weight limit by 50% or more. For a better picture of the overweight distribution, Table 6 is prepared from data in Table 5 to show the cumulative relative frequency of the overweight ranges. The observation that a high percentage of the overweight vehicles in MOC Class 1 to 8 (well over 95% for Class 4 & 5 and 6 & 7) exceeds the maximum limit by less than 15% is indeed a pleasant one.

The remarkably higher relative frequencies of the widely populated four and five axled trucks which are overweight by no more than 20% (over 99% for Class 4 & 5 and for 98% over Class 6 & 7) is an indication of the far more compliant attitude of the truckers towards the control of weight. As the amount of overweight in most cases is not excessively high, it is comforting to see the beneficial impact of the regulatory control, which has led to a significant drop in the amount of overweight.

Table 4. Breakdown of Truck Composition and Percentage of Overweight Trucks.

MOC Class	No. of Axles	Number of Trucks	Percentage of Total Sample	No. of Overweight Trucks	Percentage of Overweight Trucks in Each Class
1	2	86 623	7.45	23 015	26.57
2	3	36 977	3.18	13 758	37.21
3	3	1 259	0.11	21	1.67
4 & 5	4	927 603	79.83	439 868	47.42
6 & 7	5	103 231	8.88	42 438	41.11
8	6	4 929	0.42	1 604	32.54
Other	7	943	0.08	190	20.15
Other	8	386	0.03	113	29.27
		1 161 951		521 007	

On the negative side, however, the survey reveals that the number of overweight trucks is still considerably high (over 45%) and that the number of trucks weighing more than 50% of the legal weights is not statistically insignificant for those in Class 8 and others. Records have shown that trucks having more than 100% legal weight are also encountered once in a while. Although the volume of heavier trucks (overweight by 50% or more) is significantly low, the fact that they are prevalent is an ominous sign in the sense that their damaging impact and cumulative damage to roads and highways cannot be underrated or ignored.

In Table 7, the highest truck weight recorded in this survey is shown along with the average weight and the legal weight for each class. A histogram plot of these weights is shown in Figure 5 for clarity. The average weight of trucks in a class is calculated by simply dividing the cumulative weight of all trucks in that class by the number of trucks in the class. Data in Table 7 and in Figure 5 show that the maximum recorded weight of a truck exceeds the legal weight by more than 100%, except for Class 1 and 3, indicating the presence of abnormally heavy trucks. Although extremely heavier trucks like these are rarely seen as their number is very low, the fact that they appear once in a while is indeed a problematic source of damage to roads and bridges. It is interesting to note that the computed average truck weight in each class is less than the legal weight limit. This implies that a substantial number of trucks in each class carry goods well below their maximum permitted limits, as only the loaded trucks are required to be weighed at a weighing station. A second reason attributable to this lower average weight is that the majority of overweight trucks falls within the 5–20% overweight range, as noted from Tables 5 and 6.

It is also interesting to note that the calculated average weight of trucks in all classes are close to the legal limits, with the exception of Class 3 for which the average truck load of 17.80 t is much lower than the legal limit of 32.0 t. It would appear that this type of 3-axled trailer type truck (Figure 1) which is infrequently used by truckers, are often loaded below their legal limit, tacitly implying that they may be used more often to carry voluminous, low density merchandise. The values of standard deviations for the sample in each class are also indicated in Table 7; the higher values indicate the higher spread of the truck weights.

Truck data for each province was also analyzed in a similar fashion to see if there are any notable differences within the provinces with regard to truck composition and overweight problem. While a detailed presentation is given in references [9, 10], for the sake of brevity without losing any generality, results are briefly presented here. In Table 8, the breakdown of trucks into different classes and the percentages of overweight trucks are shown for all four provinces. The bulk of trucks operating in each province belong to Class 4 & 5, as this constitutes about 75% of the sample size. The most striking observation is that the composition of the truck volume is astonishingly identical for all four provinces. This may be attributed to frequent cross border movements of trucks and the operation of similar fleet of trucks by the truck operators in each province.

Table 5. Breakdown of Overweight Trucks into Range of Overweights: Cumulative.

MOC Class	No. of Axles	No. of Overweight Trucks	Percentage of overweight trucks under the specified range of overweight percentage									
			Overweight by ≤ 5%	> 5 to ≤ 10	> 10 to ≤ 15	> 15 to ≤ 20	> 20 to ≤ 25	> 25 to ≤ 30	> 30 to ≤ 50	> 50 to ≤ 80	> 80 to ≤ 100	>100%
1	2	23 015	33.30	34.00	26.77	4.07	0.94	0.40	0.45	0.07	0	0
2	3	13 758	29.59	34.90	29.08	3.37	1.13	0.90	0.68	0.32	0.02	0.01
3	3	21	52.40	23.80	9.52	0	9.52	0	4.76	0	0	0
4 & 5	4	439 868	38.68	43.30	16.89	0.74	0.16	0.07	0.10	0.05	0.01	0
6 & 7	5	42 438	40.27	42.32	14.40	1.65	0.42	0.42	0.26	0.23	0.02	0.01
8	6	1 604	30.74	31.80	14.96	3.67	2.62	2.62	6.92	6.05	0.44	0.18
Other	7	190	23.16	23.16	12.10	5.27	5.27	5.80	10.53	11.58	2.63	0.50
Other	8	113	38.05	36.28	15.93	1.77	0	0.89	3.54	0	0.89	2.65

Table 8 also shows the percentages of the overweight trucks in each class. Again, the general trend is similar for all provinces. It appears that Eastern Province holds the highest percentage of overweight trucks in Class 4 & 5 and 6 & 7 which are the densely populated categories. Figure 6 is plotted to show the distribution of overweight ranges for Class 4 & 5 and 6 & 7. While the pattern of overweight ranges for the four provinces shows divergence for all other classes [9], the patterns for Class 4 & 5 and 6 & 7 as shown in Figure 6 bear a remarkable similarity in the distribution of overweights for all provinces. Thus, a similar composition of trucks and a similar weight distribution as observed in all four provinces, reaffirm the opinion that truck operators maintain a similar attitude on policy towards overloading and that the interprovincial flow of trucks exists at a high level.

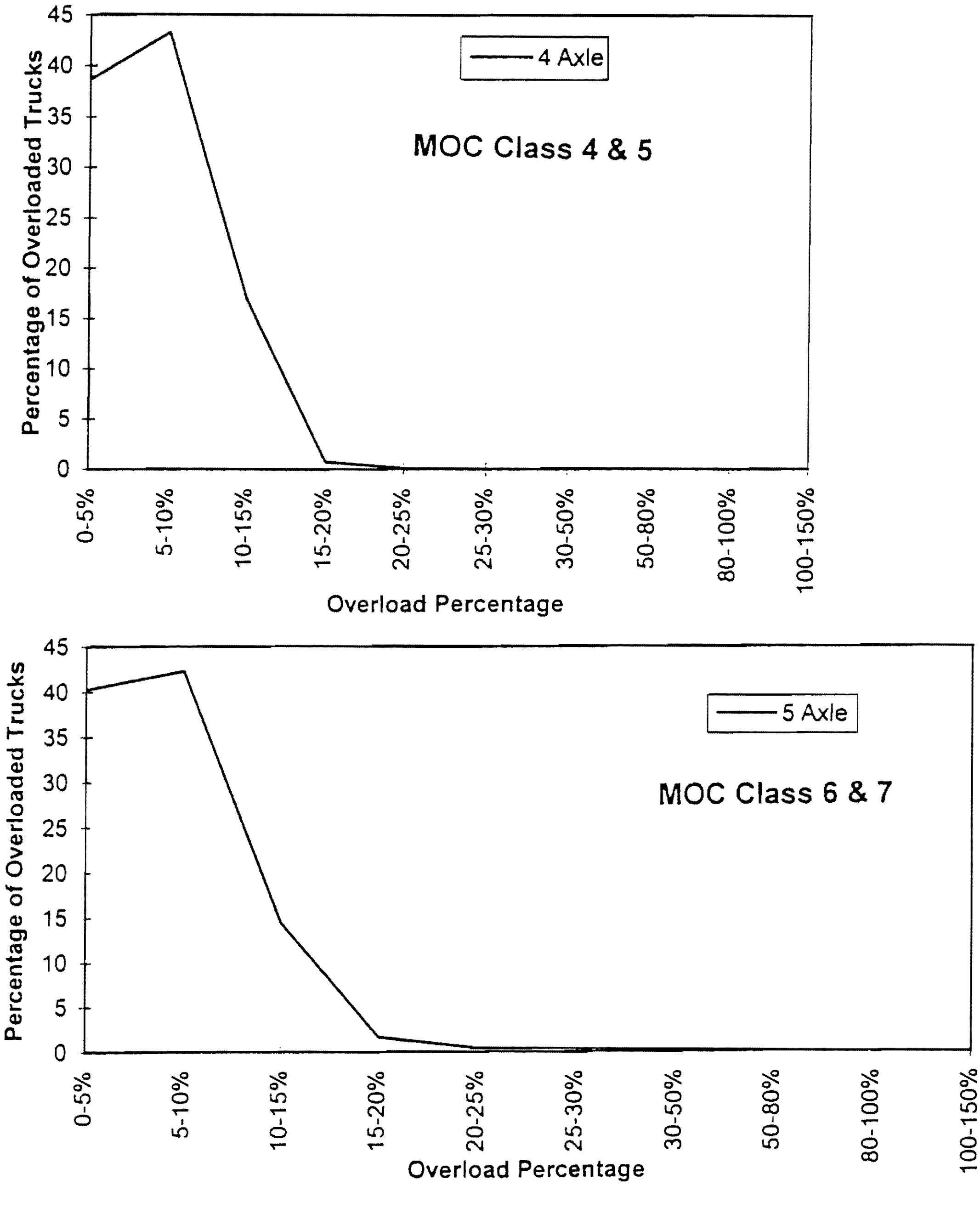


Figure 4. Distribution of overweights for collective data.

Axle Loads

To highlight the existing problem with the axle loads, only overweight trucks which were fined at a weighing station were considered at random without linking them to any class. A total of 8100 overweight trucks were sampled for this specific purpose and the maximum axle loads for each vehicle was recorded, producing a sample size of 8100 axle loads. For the presentation of data, the axle loads are grouped into subsets in which the axle load is incremented by 5 t and the number of occurrences of each subset is counted. Figure 6 shows the frequency histogram of the axle loads. A subset includes all axle loads which are less than the upper limit and higher than the lower limit of the specified range.

Table 6. Cumulative Relative Frequency of Overweight Trucks.

MOC Class	No. of Axles	Cumulative Relative Frequency in Percentage			
		Overweight by ≤ 5%	Overweight by ≤ 10%	Overweight by ≤ 15%	Overweight by ≤ 20%
1	2	33.30	67.30	94.07	98.14
2	3	29.59	64.49	93.57	96.94
3	3	52.40	76.20	85.72	85.72
4 & 5	4	38.68	81.98	98.96	99.70
6 & 7	5	40.27	82.59	96.99	98.64
8	6	30.74	62.54	77.50	81.17
Other	7	23.16	46.32	58.42	63.69
Other	8	38.05	74.33	90.26	92.03

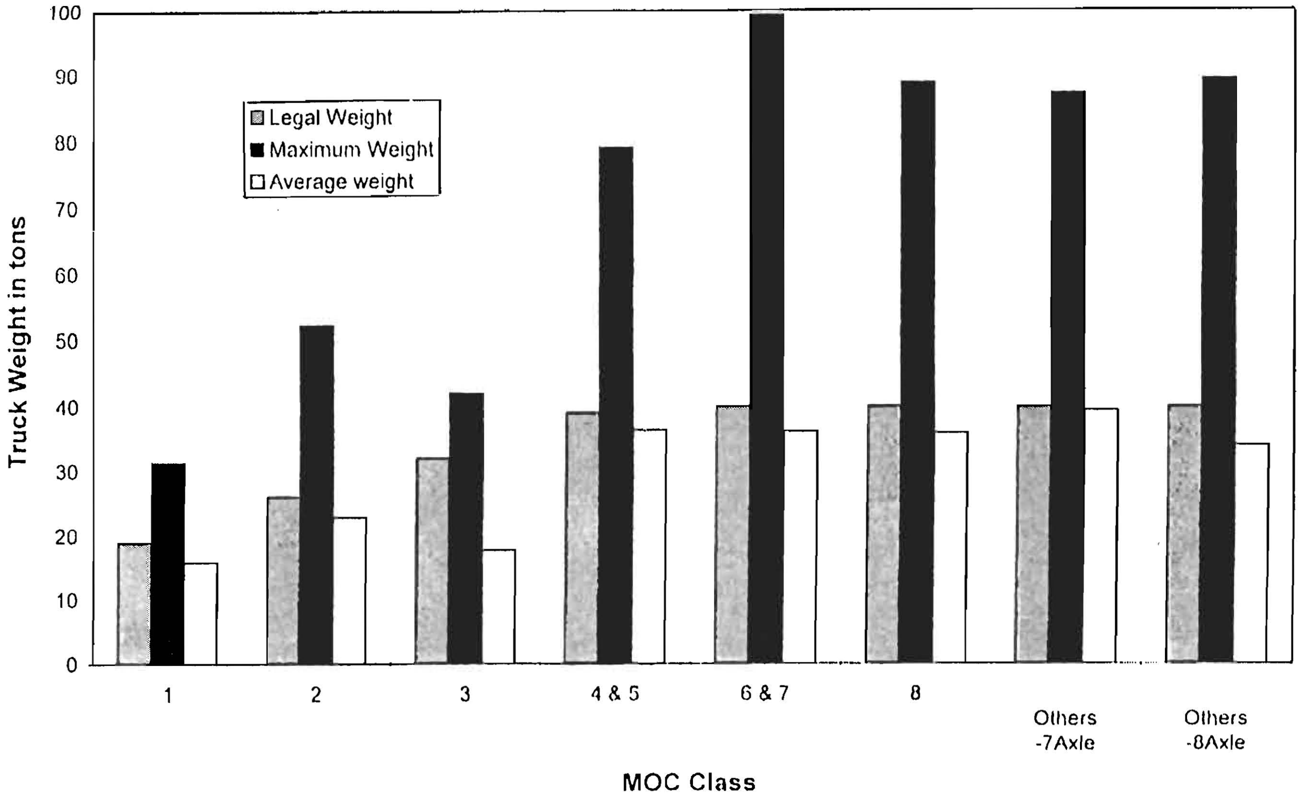


Figure 5. Histograms of legal weight, maximum weight, and average weight.

Table 7. Comparison of Legal Weight, Maximum Weight, and Average Weight for Each Class.

MOC Class	No. of Axles	Legal Weight (tons)	Maximum Weight (tons)	Maximum Overweight by Percentage	Average Weight (tons)	Standard Deviation
1	2	19.0	31.32	64.84	15.90	5.23
2	3	26.0	52.22	100.85	22.85	6.25
3	3	32.0	42.00	31.25	17.80	4.73
4 & 5	4	39.0	79.22	103.10	36.37	6.27
6 & 7	5	40.0	99.19	148.00	36.22	7.46
8	6	40.0	88.96	122.24	35.92	7.86
Other	7	40.0	87.40	118.50	39.40	8.81
Other	8	40.0	89.61	124.00	34.01	9.86

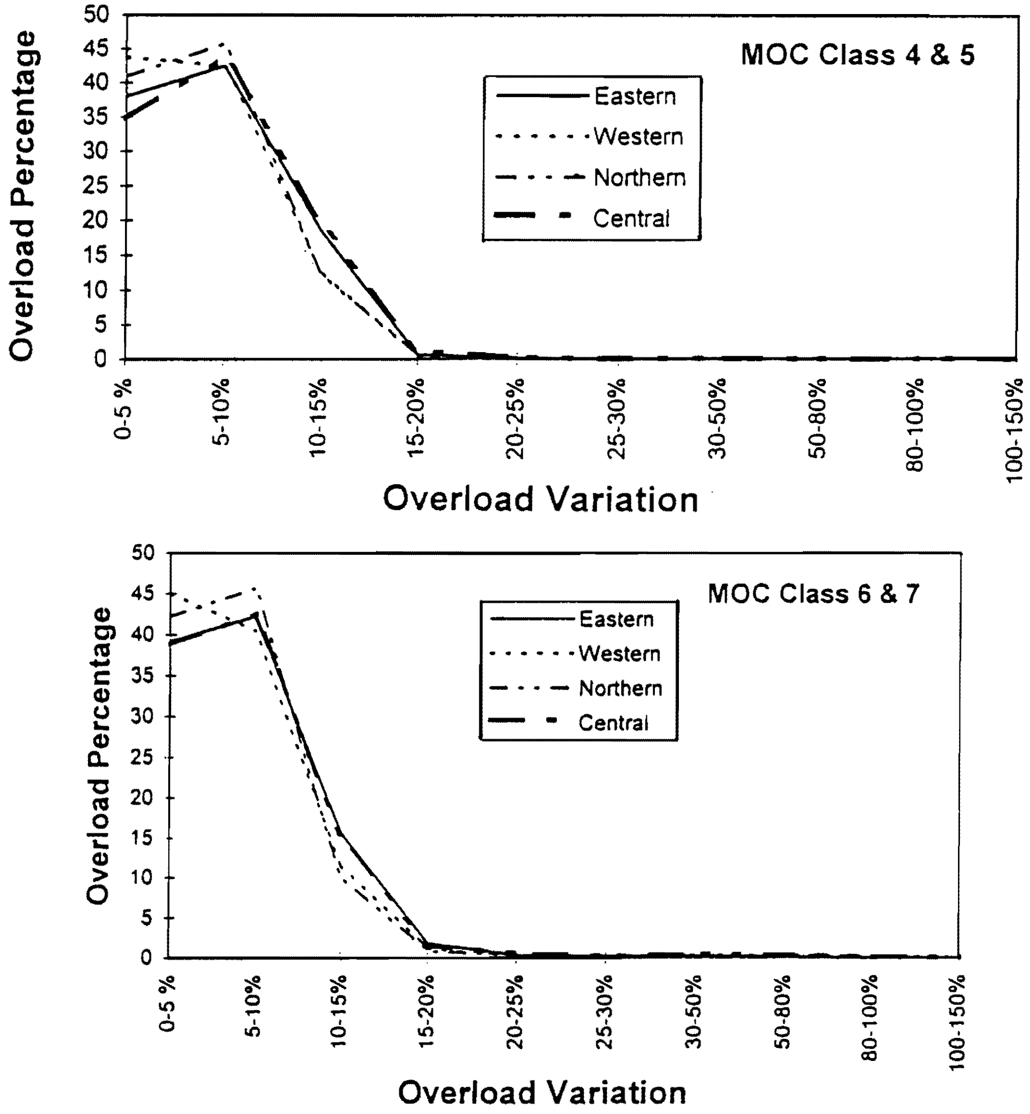


Figure 6. Distribution of overweights in four provinces.

The sampled axle data indicates a large spread of the axle weight, varying from a low of 9.5 t to a maximum of 30.4 t, as the weight is dependent upon the truck configuration and the amount of weight being carried. From Figure 7, it is readily recognized that the axle loads in the range of 15–20 t and 20–25 t are more frequently encountered in overweight vehicles, their combined relative frequency is close to 0.8 or 80%. The commonly encountered range of the axle load is 15–20 t, occurring at a relative frequency of about 0.55, *i.e.* one out of two overweight trucks is likely to have the maximum axle weight in the range of 15–20 t.

As the maximum legal axle load in Saudi Arabia is 13 t, this limit, as observed, is frequently violated, causing a serious problem for maintenance of pavements and roadway infrastructures. The recurring problem of rutting, potholes, and settlements in pavements is attributable to the excessive axle loads. It has been pointed out earlier that about four out of nine trucks sampled are overweight by some magnitude. Statistically, it would then appear that almost two out of nine trucks are likely to have heaviest axle weighing more than 15 t, *i.e.* being overweight by more than 15%.

Table 8. Provincewise Breakdown of Truck Composition and Percentage of Overweight Trucks.

		Eastern Province		Western Province		Northern Province		Central Province	
MOC Class	No. of Axles	Percentage of Total	Percentage of Overweight Trucks	Percentage of Total	Percentage of Overweight Trucks	Percentage of Total	Percentage of Overweight Trucks	Percentage of Total	Percentage of Overweight Trucks
1	2	5.20	23.17	8.25	24.93	7.85	43.58	8.54	25.72
2	3	2.12	38.57	3.76	30.10	2.90	44.65	3.64	41.05
3	3	0.10	2.20	0.13	0.67	0.10	0.10	0.10	2.52
4 & 5	4	80.12	49.83	79.73	44.14	82.35	48.97	79.08	47.73
6 & 7	5	11.52	49.08	7.76	29.53	6.52	47.98	8.24	39.60
8	6	0.69	32.95	0.31	29.60	0.25	28.86	0.34	34.67
Other	7	0.20	9.25	0.04	30.82	0.02	40.90	0.03	57.55
Other	8	0.05	25.26	0.02	25.80	0.00	66.67	0.03	35.55

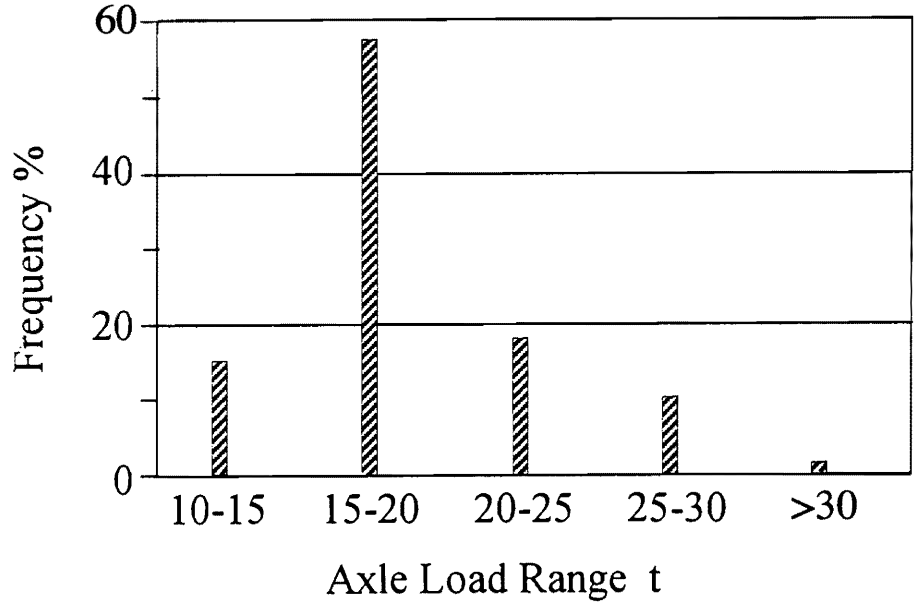


Figure 7. Frequency histograms of axle loads.

The frequency of heavier axle loads, exceeding 30 t, is comparatively very low (relative frequency less than 0.4%). These extremely heavy axle loads are more than twice the legal limit of 13 t and their occurrence once in a while is a challenging problem that should be dealt with to control damages in roads and bridges.

Observation from Sample Surveys

The purpose of the limited field survey was two-fold: (*i*) to provide additional data which can be used to check in general the trend observed from the analysis of truck data from the weigh stations, and (*ii*) specifically, to measure the spacing of axles, which was lacking in MOC's data base, so as to obtain an idea of the range of the usual axle spacing for different truck types. An analysis of the limited survey data from field measurements has been presented in detail in reference [9], the findings of which conform in general to those observed from the weigh stations.

Record of the axle spacings for different types of trucks revealed that, although the spacings vary considerably in some cases, the variation is generally small in the majority of the commonly used truck types. Table 9 shows the range of spacings of axles for different classes of trucks as observed, together with the usual range covered by at least 60% of the trucks in that class.

The survey also revealed the following informative observations:

(*i*) Trucks of GCC (Gulf Cooperative Council) countries are not required to pass through the weighing scales. Military vehicles of all types are also exempt from weighing. These exemptions may affect the overweight observation.

(*ii*) Heavy earth moving trucks with hoisted flags, indicating permission for overload, are normally exempted from fines. However, it has been observed that some of these trucks are too heavy, fully exploiting the generosity of the exemption.

(*iii*) Truck operators find clever and manipulative ways to avoid fines. Drivers often use alternative routes to bypass the weigh stations. A practice which is also known to exist involves the use of several legal weight vehicles and then once they cross a weighing station, truckers reduce the number of vehicles going to the destination to reduce the travel cost, by transferring the goods from the other trucks. The empty trucks return to the base, while the overweight trucks continue their journey unchecked, as there is no other weighing station enroute.

(*iv*) Weight violations are expected to be more severe on major highways not monitored by weigh stations. This inference draws its support from the field observation made at the Dammam–Abu Hadriya divided highway in the Eastern Province. Relatively much heavier trucks are seen on the roadway towards Dammam which has no weigh station compared with the trucks traveling on the roadway to Abu Hadriya which is equipped with a weigh station.

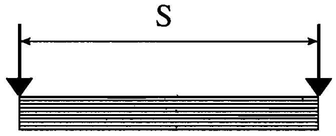
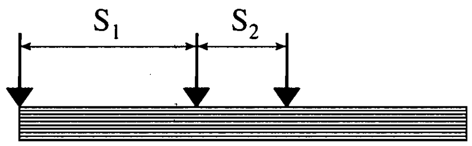
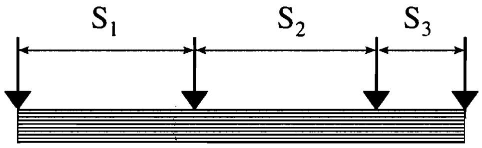
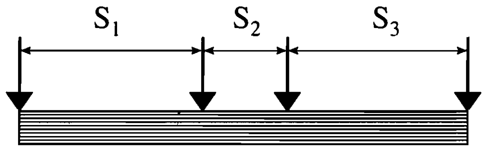
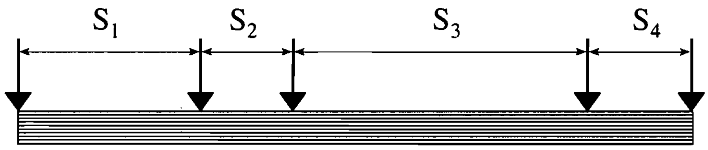
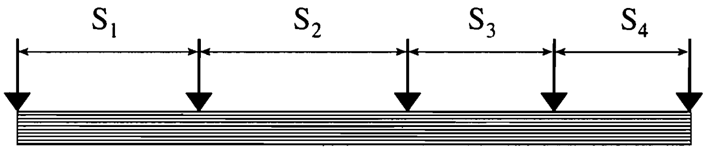
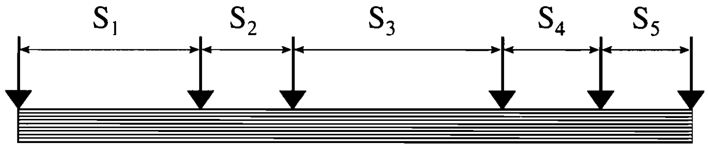
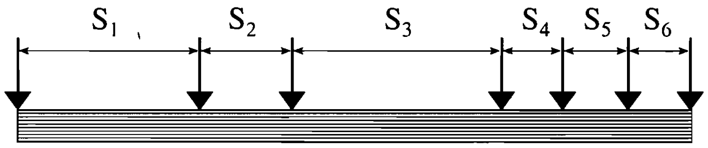
OVERWEIGHT PROBLEM IN PERSPECTIVE

Data presentation and the analysis unambiguously reveal that the truck overweight problem is still a major issue to be dealt with, despite enforcements of controls through the weigh stations. In order to visualize the trend in overweights, Figure 8 is plotted for trucks in Class 4 & 5 and in Class 6 & 7, using the yearly data. It is apparent that there is a progressive downward trend in the number of weight violations. Although the overload problems still persist in all provinces at an uncomfortable level, the percentage of overloaded trucks with greater than 15% overload seems to have a slow declining trend.

This encouraging trend perhaps is attributable to the beneficial effect of the enforcement policy and the more compliant attitude of the truck operators. A disturbing factor, which may also contribute to this observed declining trend of overweight percentages, is that the truckers use, whenever possible, detours, alternative roads with no weigh stations and other innovative ways to avoid the penalty. The unknown magnitude and impact of this clandestine operation can upset any statistical observation.

In essence, the overweight problems have not been eradicated to a level where they are no longer a potential threat to roads and bridges. Although the frequency of heavy trucks have reduced considerably, the cumulative damage to roads and bridges inflicted by them is still a concern. A host of exemptions which escape enforcement also adversely adds to the implication of overweight problem.

Table 9. Spacing of Axles from Sample Truck Survey.

Category	No. of Axles	MOC Class	Spacing of Axles
	2	Class 1	s = 5.0 – 5.5 m (mostly in 5.2 and 5.4 m)
	3	Class 2 & 3	s_1 = 3.8 – 5.5 m (mostly in 5.0 – 5.5 m) s_2 = 1.2 – 1.4 m (mostly in 1.2 m)
	4	Class 4	s_1 = 3.3 – 4.0 m (mostly in 3.5 – 3.7 m) s_2 = 6.2 – 7.9 m (mostly in 6.5 – 7.5 m) s_3 = 1.2 – 1.7 m (mostly in 1.2 – 1.4 m)
	4	Class 5	s_1 = 3.3 – 3.8 m (mostly in 3.3 – 3.4 m) s_2 = 1.4 – 1.6 m s_3 = 3.8 – 5.5 m (mostly in 4.5 – 4.8 m)
	5	Class 6	s_1 = 3.4 – 3.7 m s_2 = 1.3 – 1.5 m s_3 = 6.0 – 7.5 m (mostly in 6.5 – 7.5 m) s_4 = 1.4 – 1.9 m (majority in 1.6 m)
	5	Class 7	s_1 = 3.8 – 4.0 m s_2 = 6.4 – 6.5 m s_3 = 1.2 – 1.4 m s_4 = 1.2 – 1.4 m
	6	Class 8	s_1 = 3.6 – 4.0 m s_2 = 1.2 – 1.6 m (mostly in 1.4 m) s_3 = 9.0 – 9.6 m s_4 = 1.2 – 1.4 m s_5 = 1.2 – 1.4 m
	7	Other	s_1 = 3.4 m, s_2 = 1.4 m s_3 = 6.7 m, s_4 = 1.2 m s_5 = 1.2 m, s_6 = 1.2 m (only 1 truck found)

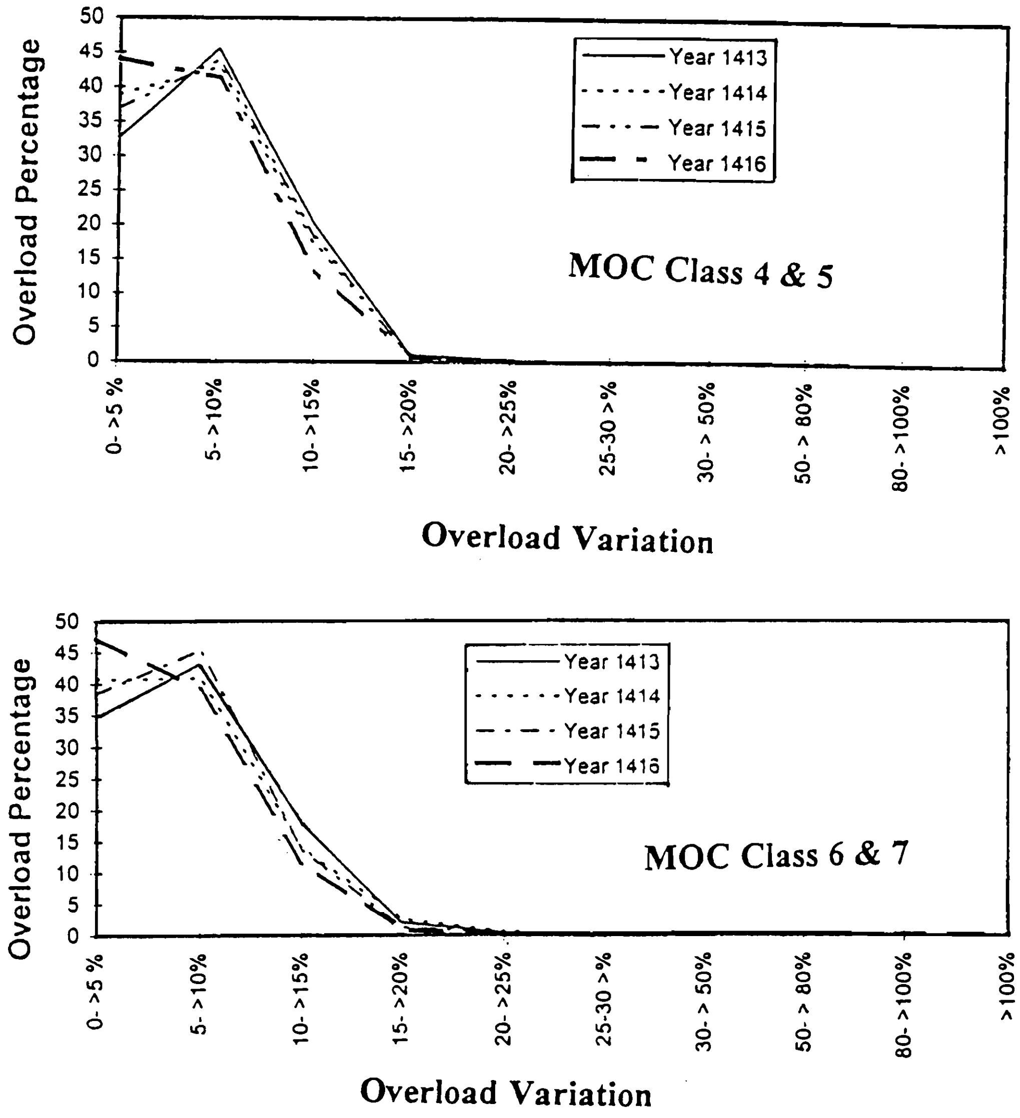


Figure 8. Yearly distribution of overweights.

SUMMARY AND CONCLUSIONS

A four-year truck load survey was conducted using truck data collected from weigh stations, installed at various traffic corridors to characterize the composition of trucks and to examine the current overweight situation. The sample size, built on a random selection, exceeded over one million trucks. Supplementary in-situ truck load surveys were also carried out to gather informative data.

Based on this study, the following conclusion are drawn:

1. The breakdown of the truck samples for years 1413–1416 H into MOC classes show that four-axled trucks belonging to MOC Class 4 & 5 constitute the bulk of the truck volume, representing almost 80% of the volume. Three-axled trailer type trucks (MOC Class 3) are seldomly used by the truck operators compared with the other seven classes. Long trailer type trucks with seven or more axles are also witnessed infrequently.

2. A larger number of trucks (close to 47% in Class 4 & 5 and 40% in Class 6 & 7) violate the legal weight limit; the amount of overweight varying from a small percentage to a very high percentage (about 100%). An encouraging finding attributable to the beneficial impact of weigh stations is that a high percentage of violations (almost 99% in Class 4 & 5 and 97% in Class 6 & 7) exceeds the legal weight by only about 5–15%.

3. With regard to axle loads, it has been observed that the maximum axle weight in the range of 15–20 t is frequently encountered in overweight commercial vehicles, whose relative frequency is of the order of 0.55. Almost two out of nine trucks carrying goods on highways are likely to have heaviest axle weights in excess of 15 t, thus being overweight by more than 15% above the legal limit of 13 t. Axle loads close to 30 t, which are more than twice the permitted limit of 13 t, are also encountered once in a while.
4. The overweight problem still exists at an uncomfortable level. The problem is very much the same in all four provinces in terms of the degree of severity and the frequency of violations. This may imply that the truck operators in all provinces maintain similar attitude and practices towards the use of overloaded vehicles and the penalty for weight violations.
5. As it is known that truck operators cleverly find ways to avoid penalty and the regulatory controls, the full extent and impact of this illegal practice is unknown and consequently the statistical data presented may not fully reflect the actual scenario.

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