Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (39) No. (2) April, 2017

COMPARISON BETWEEN DESIGN TRUCK FOR HIGHWAY BRIDGE WITH ACTUAL LOAD

Ayman Summra[1], Hazem M. R. Katamish[2], Ahmed S. El Hakim[3], And Mohamed A. El Refaeye[4]

[1] Lecturer of Structural Engineering, Faculty of Engineering, Al-Azhar University.
[2] Demonstrator, Dept. of Civil Engineering, Faculty of Engineering, Al-Azhar University
[3]Professor of Transportation Planning & Traffic Engineering, Faculty of Engineering, Al Azhar University.
[4]Assistant Professor of Highway Engineering, Faculty of Engineering, Al Azhar University

ملخص البحث

يهدف هذا البحث إلى دراسة التأثير الحقيقى لأحمال المركبات الفعلية على الكبارى ومقارنة النتائج مع الأحمال التى يتم بها تصميم الكبارى. لذلك تم تجميع بيانات عن أحجام وتصنيف المرور على أربعة طرق رئيسية فى مصر عن طريق محطات الرصد المنتشرة على هذه الطرق. كما تم تجميع بيانات عن كلا من أبعاد المركبات الموجودة فى مصر و الأحمال الفعلية لهذة المركبات. يختص هذا البحث بدراسة الأتجاة الطولى لحارة واحدة فى حالة الأزدحام المرورى بينما لم يؤخذ فى الإعتبار التأثير الديناميكى بين المركبات و الكبارى .

تم إعتبار ستة خطوط تاثير خاصة بعزوم الإنحناء للكبارى سواء كان الكوبرى المدروس يرتكز ارتكازا بسيط او كوبرى مستمر مكون من باكيتين او ثلاث باكيات بأطوال مختلفة تتراوح بين ١٠ الى ١٥٠ متر. تمت مقارنة هذه العزوم مع العزوم الناتجة عن الأحمال التصميمية المنصوص عليها فى الكود المصرى لأحمال الكبارى باستخدام أثقل شاحنات وجدت فى البيانات المجمعة ووجد أنه بزيادة طول الكوبرى فإن العزوم الناتجة عن الأحمال الفعلية تتعدى العزوم الناتجة من الأحمال التصميمية فى الكود المصرى على الرغم من أن أحمال الكود تشمل معامل التأثير الديناميكى .

ABSTRACT:

This research aims to study the real impact of the actual loads of vehicles and compare the results with the standard design load of bridges. For four main roads in Egypt, the traffic volume and traffic composition data were collected. The data of trucks' gross weights and average axle spacing was obtained. This work focuses on longitudinal direction for theoretical single lane where congested traffic conditions were considered for all spans Dynamic effects and interaction between vehicles and the structure are not considered.

Six influence lines of main girder representing the maximum bending moment at the critical sections for simply supported beam, two and three spans of a continuous beam with various spans ranging from 10 to 150 m were provided. The analysis' results using the heaviest trucks revealed that increasing the span of the bridge, moments resulting from the actual loads exceed the moments resulting from the Egyptian design load although the code loads include dynamic coefficient Effect.

Keywords: overload trucks, influence line, Highway Bridge, traffic load.

1. INTRODUCTION

Egypt currently has a road network of more than 64000 km across the country, on which more than 3000 bridges are in service [1]. Misr National Transport Study

(MiNTS) indicates that 98.6% of its domestic cargo depends on this road network [2] so that, with no doubt, the road network plays a significant role in the national economy and people's daily activities.

With regard to bridge type in Egypt, reinforced concrete bridges account for about 90%, while steel bridges accounting for only 10% [1]. However, Girder bridges are overwhelmingly common.

Considering the limited amount of money dedicated to the necessary bridge reconstruction or repair, it is important to clarify the actual traffic load effect on the bridge structure, in order to evaluate its structural capacity and determine the limits within which the existing bridge structures are safe to operate [3].

Vehicle load is a critical factor of the highway bridge live load. The continuous increase in the number of trucks and their weights led to a review of traffic data for live load. In addition, observing traffic statistics helps to realize the rate of these changes, and to draw some conclusions.

In general, trucks that are expected to move over highway bridges during the service life of the bridge are called live loads. Since future loads are not deterministic, present truck loading and its configurations are used to predict loads for designing safe and rational designs.

In the absence of updated weigh in motion (WIM) traffic measurements in Egyptian highways, the collected data included truck axle weight and spacing from platform scales at two logging industrial facilities, and one weighing station in highway.

Bridges are considered critical elements in a road network for a safe and efficient movement of people and freight. Thus, Overloaded truck traffic affects the service life of the bridge superstructure [4]. The increasing frequency of the overloaded trucks even leads to fatigue damage, therefore, the truck loads increases the damage on highway infrastructure. This will result in additional funds might be required for maintenance, repair, and rehabilitation of these bridges.

General Authority for Roads, Bridges and Land Transportation (GARBLT) specifies the limit of axle loads depending on axle configuration, despite the increase of the cost of petrol and diesel, the truck operating have a tendency to carry excess weight above the legal limits.

This paper provides a comprehensive discussion of various live load models that are used in Egypt for designing highway bridges and comparing the results with legal weight limits and actual truck data obtained from the field.

2. METHODOLOGY

In general, the process to compute site-specific bridge traffic loading consists of the following steps:

Traffic data collection: This provides the basis for the analysis. It includes traditionally traffic volume, traffic composition, truck weight and axle data, and more recent vehicle spacing, axle spacing generally sufficient for short-span bridges.

1. **Generation the influence line:** this provide the maximum bending moment at the critical sections for simple beam, two and three continuous spans.
2. **Applying the heaviest truck & standard design load:** The traffic database is passed over a bridge and the required load effects were computed and compared with the standard design load for one lane based on the results of the worst possible effect.

2.1. Traffic data collection

2.1.1. Traffic composition

It is one of the essential characteristics of traffic flow. The traffic composition consists of twelve vehicle which are listed below as per (GARBLT) classification:

1- Bikes.
2- Cars (private car, jeep and taxi).
3- 2 axle long.
4- Buses.
5- 2 Axle truck with 6 tires.
6- 3 Axle truck Single.
7- 4 Axle truck Single.
8- < 5 Axle Double.
9- 5 Axle Double.
10- >5 Axle Double.
11- < 6 Axle Multi.
12- 6 Axle Multi.
13- > 6 Axle Multi.

Traffic volume and composition data were collected for four main rural roads of the national road network in Egypt, namely, Cairo - Alexandria agricultural, Cairo – Ismailia desert, Giza – Beni Suef and Cairo – Suez Roads. The selected roads were chosen so that they represent the GARBLT road network covering all road types (agricultural/desert roads and medium/high traffic volumes).

Table (1) shows the traffic composition for the links specified by the location of the traffic counting stations. The stations are arranged to represent the traffic movement directions such as Cairo - Alexandria agricultural road (stations 10, 6, 2 and 15) with average of truck percent equal to 12.71, Cairo – Ismailia road (station 1) with ratio of truck percent equal to 5.85, Giza – Beni Suef road (station 3) with ratio of truck percent equal to 8.11, and Cairo – Suez road (station 4) with ratio of truck percent equal to 16.48.

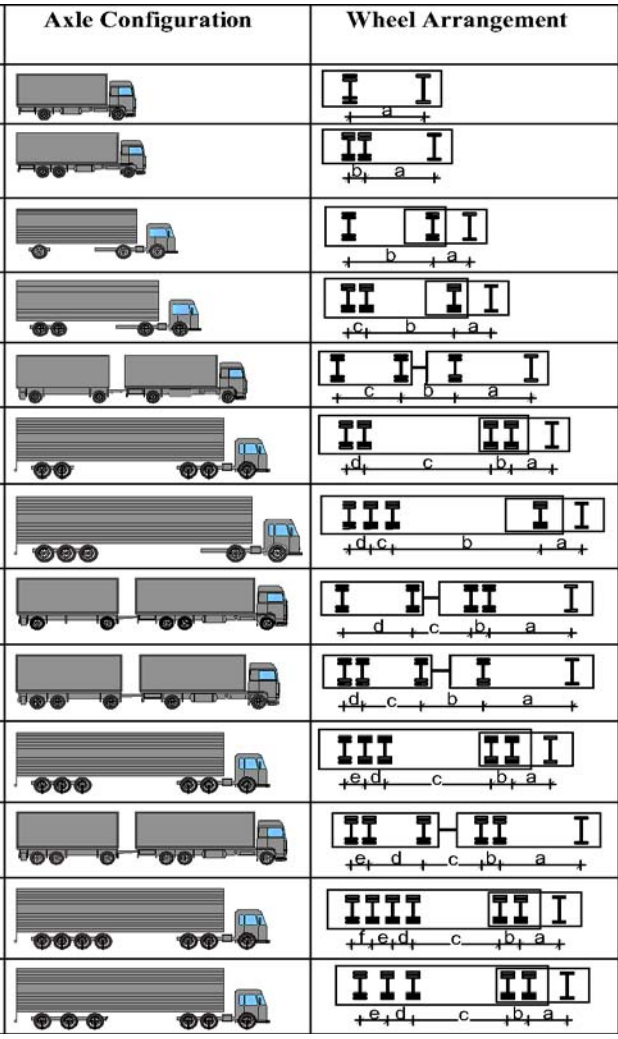
Table (1) Traffic Composition

Road Name	Station	Type of Vehicle													% of truck
		1	2	3	4	5	6	7	8	9	10	11	12	13	
Cairo - Alexandria agricultural	10	0.52	57.26	15.06	14.43	6.16	1.59	1.45	1.60	1.02	0.39	0.35	0.16	0.01	12.73
	6	0.81	61.26	13.28	10.87	8.62	1.01	0.56	1.43	0.55	0.23	1.26	0.11	0.01	13.78
	2	0.20	77.25	7.37	7.18	4.50	1.20	1.12	1.18	0.00	0.00	0.00	0.00	0.00	8.00
	15	1.24	54.01	15.64	12.77	6.50	2.70	2.01	2.19	1.57	0.74	0.45	0.16	0.02	16.34
	A.V	0.69	62.45	12.84	11.31	6.45	1.63	1.29	1.60	0.79	0.34	0.52	0.11	0.01	12.71
	S.D	0.38	8.93	3.27	2.70	1.47	0.65	0.53	0.37	0.58	0.27	0.46	0.07	0.01	4.40
Cairo – Ismailia	1	0.95	72.33	10.98	9.89	3.85	0.59	0.02	0.45	0.51	0.22	0.13	0.08	0.00	5.85
Giza – Beni Suef	3	0.71	64.52	12.32	14.34	4.57	1.39	0.06	1.92	0.15	0.01	0.00	0.01	0.00	8.11
Cairo – Suez	4	0.58	63.17	11.33	8.44	8.27	1.40	0.37	2.27	1.25	1.42	1.34	0.15	0.01	16.48

Since the categories from 5 to 15 specify the heavy traffic, the summation of these vehicle ratios have been calculated and presented in a separate column to indicate the ratio of the heavy traffic with respect to the total traffic.

GARBLT classified trucks into 9 groups based on the number of axles, regardless the type of vehicle itself. It was necessary to subdivide the truck group to distinguish between vehicle types having the same number of axles, so when consider the vehicle type the total number of truck groups equal to 13 groups as shown in table 2.which represent the average dimensions for heavy trucks collected by the authors

Table (2) Average dimension for freight vehicles in Egypt



Truck Type	Wheelbase (m)
1	a = 4.20
2	a = 3.85 b = 1.30
3	a = 4.50 b = 5.25
4	a = 3.90 b = 4.00 c = 1.30
5	a = 4.50 b = 5.35 c = 4.60
6	a = 3.55 b = 1.30 c = 6.33 d = 1.30
7	a = 4.50 b = 5.70 c = 1.30 d = 1.30
8	a = 4.50 b = 1.30 c = 5.35 d = 4.60
9	a = 4.50 b = 5.35 c = 4.60 d = 1.30
10	a = 3.55 b = 1.30 c = 6.33 d = 1.30 e = 1.30
11	a = 4.50 b = 1.30 c = 5.35 d = 4.60 e = 1.30
12	a = 4.50 b = 1.30 c = 5.85 d = 1.30 e = 1.30 f = 1.30
13	a = 4.50 b = 1.30 c = 5.85 d = 1.65 e = 1.65

2.1.2. Traffic load

Traffic load is one of the most complex variables that significantly affect the uncertainty of the bridge element assessment. Traffic load models in different national standards are very conservative and are intended primarily for the design of new structures.

Bridge live load is dynamic load which may be considered as a sum of static and dynamic forces. This study is concerned with the static portion of the load.

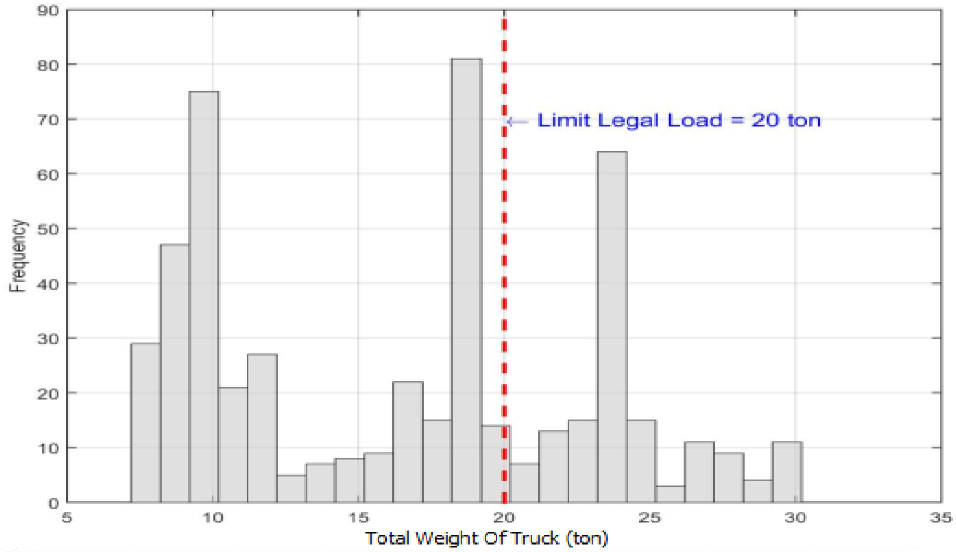
This section discusses the statistical characteristics of each truck type from the measured data to reach the reasonable truck loading for the design of bridge element and for the evaluation of safety

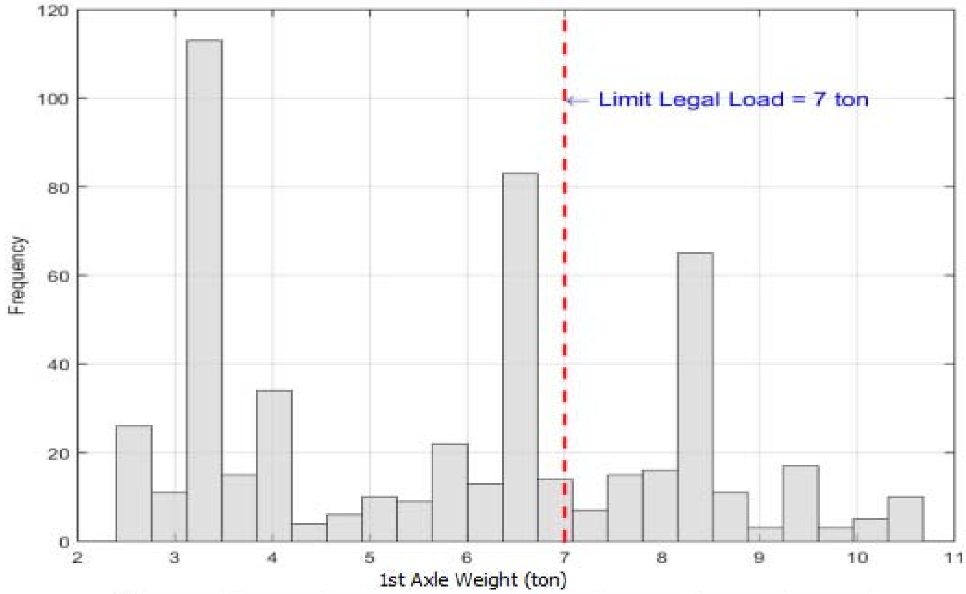
Table 3 shows the sample capacity and the statistical characteristics for each type of trucks and each axle of each truck.

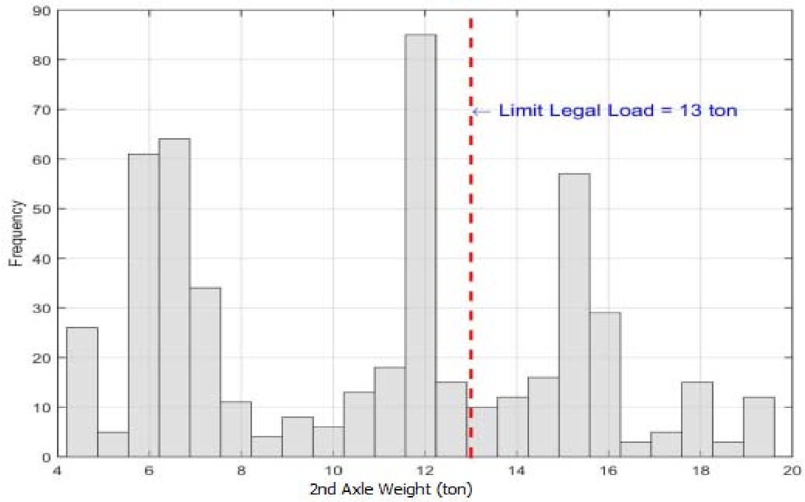
Table (3) statistical analysis for different truck types

Type		NO.of Trucks	Min. (ton)	Max. (ton)	Mean (ton)	Std. (ton)	Median (ton)	Skew (ton)
Type1	1st.axle	512	2.54	10.50	5.80	2.26	6.30	0.18
	2nd.axle		4.71	19.50	10.76	4.19	11.70	0.18
	Total		7.25	30.00	16.56	6.44	18.00	0.18
Type2	1st. axle	100	3.12	11.44	5.13	1.51	4.68	2.18
	2nd.		4.44	16.28	7.30	2.14	6.66	2.18
	3rd.		4.08	14.96	6.70	1.97	6.12	2.18
	Total		12.00	44.00	19.72	5.79	18.00	2.18
Type4	1 st axle	28	3.51	8.29	5.18	1.28	4.85	1.20
	2 nd		6.20	22.77	13.63	4.27	13.32	0.43
	3 rd		5.83	20.12	12.08	3.70	11.76	0.51
	4 th axle		2.29	7.82	4.70	1.43	4.57	4.57
	Total		18.50	59.00	35.59	10.60	34.50	0.63
Type5	1 st axle	1656	3.92	11.46	6.55	1.85	6.48	0.49
	2 nd		4.24	21.82	11.36	4.79	11.20	-0.05
	3 rd		4.45	18.11	9.75	3.57	9.30	0.12
	4 th axle		5.55	22.61	12.17	4.46	11.61	0.12
	Total		18.16	74.00	39.83	14.61	38.00	0.12
Type6	1 st axle	40	2.52	9.41	5.03	1.68	4.36	1.11
	2 nd		0.94	6.86	3.51	1.45	3.18	0.36
	3 rd		5.81	27.78	14.40	5.54	12.87	0.65
	4 th axle		4.50	22.16	11.47	4.44	10.27	0.62
	5 th axle		3.22	15.79	8.18	3.16	7.32	0.63
	Total		18.00	82.00	42.60	16.22	38.00	0.68
Type7	1 st axle	195	2.78	11.14	5.58	1.70	4.80	0.64
	2 nd		5.51	35.09	15.50	7.30	14.88	0.25
	3 rd		4.72	28.08	12.51	5.72	11.91	0.29
	4 th axle		1.63	9.90	4.40	2.03	4.20	0.28
	5 th axle		2.41	14.80	6.57	3.04	6.28	0.27
	Total		18.00	99.02	44.56	19.65	42.00	0.34
Type8	1 st axle	951	3.23	10.81	6.63	2.15	5.89	0.55
	2 nd		4.07	23.99	13.24	6.29	13.07	0.14
	3 rd		1.84	8.26	4.69	2.00	4.50	0.30
	4 th axle		3.60	20.78	11.49	5.42	11.32	0.15
	5 th axle		4.48	25.95	14.35	6.78	14.14	0.15
	Total		18.00	89.94	50.49	22.55	49.00	0.23
Type10	1 st axle	1056	3.25	9.97	5.44	1.41	5.03	0.50
	2 nd		1.04	8.27	3.83	1.87	3.73	-0.07
	3 rd		6.46	32.48	15.80	6.38	14.66	0.18
	4 th axle		5.45	28.41	13.76	5.66	12.82	0.15
	5 th axle		1.79	9.31	4.51	1.85	4.20	0.16
	6 th axle		2.14	11.28	5.45	2.25	5.09	0.15
	Total		20.80	99.72	48.80	19.23	45.00	0.22
Type11	1 st axle	207	3.74	13.17	6.64	2.45	5.77	1.18
	2 nd		4.07	28.09	12.63	6.37	10.24	0.85
	3 rd		1.84	9.73	4.52	2.06	3.55	1.04
	4 th axle		2.63	17.75	8.00	4.00	6.47	0.87
	5 th axle		3.49	23.53	10.61	5.30	8.57	0.87
	6 th axle		2.00	13.37	6.04	3.01	4.87	0.88
	Total		18.00	105.64	48.44	23.00	38.50	0.97

Through the analysis of the trucks weight data drawing the histogram for each







axle of each type as shown in fig. (1) As example for type 1

Fig. (1) Histogram of the total, 1st and 2nd axle weight for truck type 1

Every country has specified legal axle limits and maximum permissible gross load, the maximum permissible load limits for different types of trucks or Heavy Commercial Vehicles (HCV) specified in Egypt.

To study the extent of overloading, the percentage of number of trucks overloaded was studied and presented in table (4) and it can be seen that on an average 42.9 % trucks were overloaded and the maximum recorded axle overload factor was 2.7 also the overload factor was estimated and presented. Thus it is evident that overloading in Egypt and its effect on bridge need to be studied.

Table (4) Percent overloading in trucks and the overload factor in trucks

Type		NO. of Trucks	No.Trucks of Legal	No. of Overloaded Trucks	% Over load	Max. Load	Limit legal load	Over load factor
Type1	1st.axle	512	360	152	29.7	10.50	7.00	1.5
	2nd.axle		360	152	29.7	19.50	13.00	1.5
	Total		360	152	29.7	30.00	20.00	1.5
Type2	1st.axle	100	92	8	8	11.44	7.00	1.63
	2+3		92	8	8	31.24	20.00	1.562
	Total		92	8	8	44.00	27.00	1.63
Type4	1st.axle	28	24	4	14.3	8.29	7.00	1.18
	2nd.axle		12	16	57.14	22.77	13.00	1.75
	3+4		23	5	17.86	27.94	20.00	1.397
	total		22	6	21.4	59.00	40.00	1.475
Type5	1st.axle	1656	598	1058	36.11	11.46	7.00	1.64
	2nd.axle		1051	605	36.53	21.82	13.00	1.68
	3rd.axle		1279	377	22.77	18.10	13.00	1.39
	4th.axle		1041	615	37.14	22.61	13.00	1.74
	Total		1098	558	33.71	74.00	46.00	1.6
Type6	1st.axle	40	34	6	15	9.41	7.00	1.344
	2+3		29	11	27.5	34.65	20.00	1.733
	4+5		28	12	30	37.95	20.00	1.898
	total		11	29	72.5	82.00	47.00	1.745
Type7	1st.axle	195	121	74	37.95	11.14	7.00	1.59
	2nd.axle		72	123	63	35.10	13.00	2.7
	3+4+5		112	83	42.56	52.75	30.00	2.25
	Total		121	74	37.95	99.02	50.00	1.98
Type8	1st.axle	951	641	310	32.6	10.81	7.00	1.54
	2+3		599	352	37	32.24	20.00	1.61
	4th.axle		608	343	36.07	20.78	13.00	1.6
	5th.axle		453	498	52.37	25.95	13.00	2
	total		523	428	45	89.94	53.00	1.7
Type10	1st.axle	1056	891	162	15.34	9.97	7.00	1.43
	2+3		570	486	46	40.75	20.00	2.04
	4+5+6		669	387	36.65	49.00	30.00	1.63
	Total		634	422	40	99.72	57.00	1.75
Type11	1st.axle	207	144	63	30.43	13.17	7.00	1.88
	2+3		144	63	30.43	37.32	20.00	1.89
	4th.axle		148	59	28.5	17.75	13.00	1.37
	5+6		145	62	30	36.90	20.00	1.85
	Total		148	59	28.5	105.64	60.00	1.76
Average % of overload truck					42.9			
Average overload factor								1.682

Over loaded truck traffic affects the service life of the bridge superstructure. Damage typically occur in the main superstructure elements like bridge deck, girders, diaphragms, joints and bearings. With the rapid growth of highway transportation, the increasing frequency of the over loaded trucks even leads to fatigue damage [7].

The lack of enforcement of the maximum allowable axel load of trucks is one of the major problems in Egypt. Currently, GARBLT charges fines on the trucks with axel load more than the allowable using stationary weighing stations on major roads. Directing the truck to the weighing station is the responsibility of traffic police. Due to low police enforcement and traffic police officers are not available all the time, many overweight trucks pass without penalty. The exceeding axel load expedites the deterioration of the pavement resulting in higher maintenance cost in addition to its effect on increasing the stoppage distance of the truck at the time of brake application [2].

2.1.3. Vehicle spacing

As the bridge span increases, congested traffic is known to be more critical live loading scenario than the free-flowing traffic [10]. Previous studies decided to use a constant distance between two vehicle wheelbases in case of traffic jam. For Example, Nowak and Hong (1991) modelled assumed gaps of 4.57 m and 9.14 m [11]. Vrouwenvelder and Waarts (1993) use two models: for distributed lane loads a gap of 5.5 m is used, whilst for full modelling a variable gap of 4 to 10 m is used [12]. Bruls et al (1996) and Flint and Jacob (1996) use a 5 m gap between vehicles [13, 14]. Getachew (2003) used 2 m gap between two vehicles [5], Lutomirska (2009) used 7.62 m spacing between two vehicle wheelbases [15] and Hwang et al. (2012) assumed 4.5 m distance between last axle of the leading vehicle and first axle of the following [6]

For this study it was assumed that there was a 1.5 m gap between each vehicle in a train and that each vehicle had an overhang of 1 m at the front and rear. Thus there was a 3.5 m spacing between the rear axle of one vehicle and the front axle of the following vehicle. These overhangs and spacing's were believed to be typical of the vehicles at the time and typical of normal jam situations as shown in fig. 2

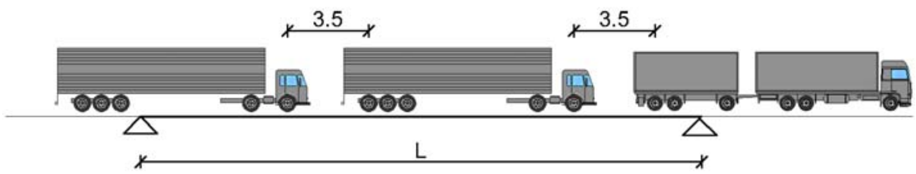


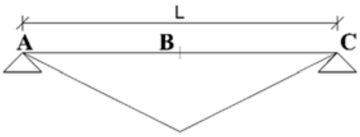
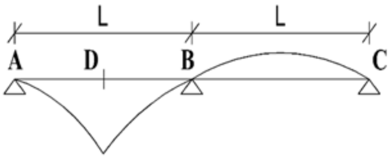
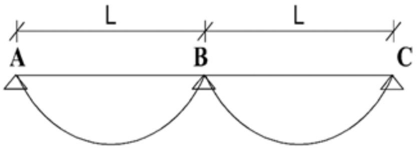
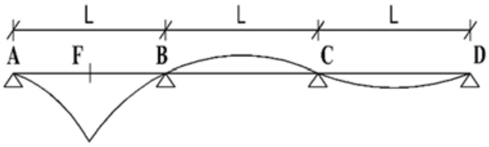
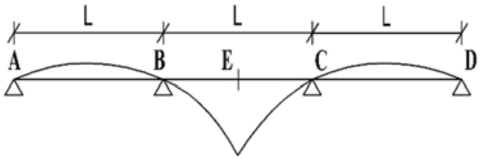
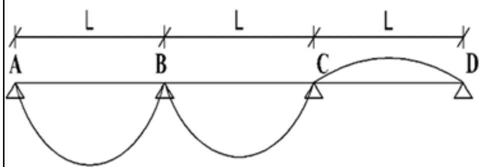
Fig. (٢) Vehicle spacing at traffic jam

The worst case scenario would occur if there are only trucks in the lane and establish the vehicle load on the bridge to obtain load bending effect in the controlled sections from the theory of the influence line.

2.2. Generation the influence line:

Six different influence lines shapes representing moments for both simply-supported and continuous spans effects under the heaviest trucks found in the collected data and to compare it with standard loading. The shapes of the influence lines are shown in Table 5. For each influence line shape were performed for several loaded lengths from 10 to 50 m.

Table 5. Theoretical Influence Line for Calculation

No.	Representation	Description of the influence line	span (m)
1		Bending moment at mid-span of a simply supported beam.	10-20-30-40-50
2		Bending moment at mid-span of the first span of the first continuous beam.	10-20-30-40-50
3		Bending moment over the central support of a two-span bridge	10-20-30-40-50
4		Bending moment at mid-span of the first span of three continuous beams.	10-20-30-40-50
5		Bending moment at mid-span of the second span of three continuous beams.	10-20-30-40-50
6		Bending moment over the internal supports of three continuous beams.	10-20-30-40-50

2.3. Applying the heaviest truck & standard design load

The traffic database is passed over a bridge and the required load effects were computed and compared with the design load for one lane based on the results of the worst possible effect. In order to simplify the calculation process, the paper does not consider the vehicle load under different lanes distribution.

2.3.1. Vehicular live load of ECP-201:2012

Defines three different load models, namely Load Model 1 (LM1), Load Model 2 (LM2), and Load Model 3 (LM3). LM1 shall be used for the design of the different elements of the substructure and superstructure, except for bridge deck slabs. LM2 shall be used only for the design of bridge deck slabs, whilst LM3 shall be used for pedestrian bridges only.

LM1 consists of a combination of concentrated loads and uniformly distributed loads. The clear roadway of the bridge is divided into a number of lanes; with a lane width of 3.0 m. the contact area of all wheels used for LM1 is 400 × 400 mm. The loads for the different lanes including the dynamic impact factor are and as shown in Fig. 3

Lane 1 double-axle concentrated loads (tandem system), 60 ton truck with four wheels (wheel load = 15 ton). In addition to the truck load, a uniformly distributed load of 0.9 ton/m2 is to be applied to the total area of lane.

Lane 2 double-axle concentrated loads (tandem system), 40 ton truck with four wheels (wheel load = 10 ton). In addition to the truck load, a uniformly distributed load of 0.25 ton/m2 is to be applied to the total area of lane.

Lane 3 double-axle concentrated loads (tandem system), 20 ton truck with four wheels (wheel load = 5 ton). In addition to the truck load, a uniformly distributed of 0.25 ton/m^2 is to be applied to the total area of lane.

The remaining width of the roadway is loaded by a uniform load of 0.25 ton/m^2

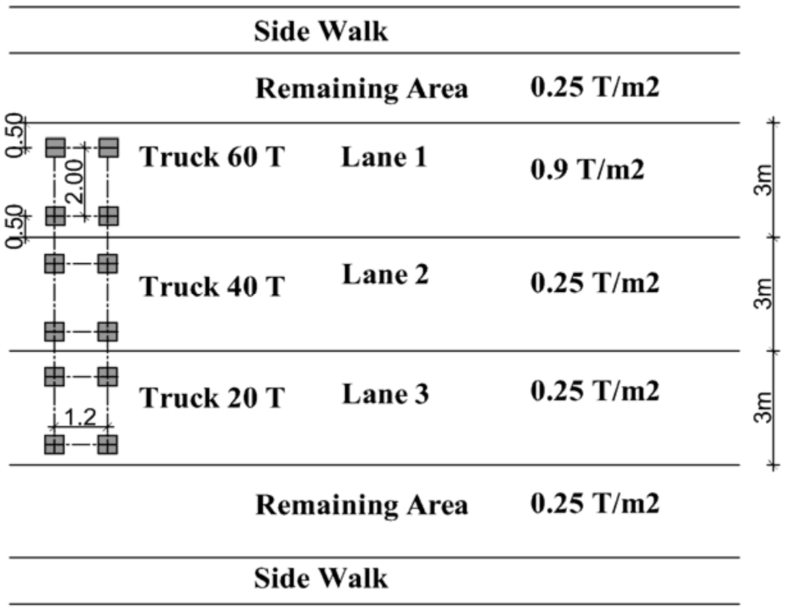


Fig. (3) Load Model 1 of vehicular live load according to ECP-201:2012

3. Results

For quantitative comparisons, the value of maximum bending for one lane were determined and summarized as shown in table (6) to table (8). The values which were greater than those of the Egyptian design load were given a **NOT PASS** value.

For simply supported beams, it should be revealed that **type 7** produced the maximum moments for spans greater than 30 m. It can be seen that the maximum responses were not necessarily caused by the heaviest trucks **type 11.**

For two span continuous beam, the maximum moments at mid-span for the first beam were produced by type 7 for spans greater than 30m and for the maximum moment over the central support (negative moment) for spans greater than 10 m.

For the three span continuous beam, the maximum moments at mid-span for the first beam were produced by type 7 for spans greater than 30 m, the maximum bending moments at the mid-span for the second span for spans greater than 40 m and the maximum negative moment at the internal support for spans greater than 15 m.

Table 6. Moments' results for simple beam with different lengths

Span (m)	Sec. (1-1)		
	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result
10	101.987	165.75	Pass
20	312.179	417	Pass
30	668.944	735.75	Pass
40	1210.253	1122	Not Pass
50	1866.085	1575.75	Not Pass

Table 7. Moments' results for 2 continuous spans with different lengths

span (m)	Section -D			Support B		
	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result
10	70.16	131.06	Pass	-64.96	-90.26	Pass
12	92.921	166.455	Pass	-121.455	-116.573	Not Pass
20	246.77	328.514	Pass	-285.83	-250	Not Pass
30	510.8	576.825	Pass	-684.29	-475.213	Not Pass
40	887.945	875.82	Not Pass	-1194.727	-770.53	Not Pass
50	1397.85	1225.472	Not Pass	-1878.769	-1131.95	Not Pass

Table 8. Moments' results for 3 continuous spans with different lengths

span (m)	Section -F			Section -F			Support B = Support C		
	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result	Moment due to truck load (t.m)	Moment due to code design load (t.m)	Result
10	74.85	133.1	Pass	47.67	108.55	Pass	-78.04	-90.775	Pass
15	145.742	224.5	Pass	107.653	185.93	Pass	-166.501	-161.335	Not Pass
20	260.59	331.622	Pass	152.65	273.65	Pass	-291.98	-248.655	Not Pass
30	540.14	586.497	Pass	402.9	479.687	Pass	-632.1	-467.19	Not Pass
40	927.65	895.441	Not Pass	667	726.334	Pass	-1119.61	-749.8	Not Pass
50	1491.63	1258.415	Not Pass	1117.6	1013.524	Not Pass	-1750.51	-1059.163	Not Pass

4. CONCLUSIONS

This paper has highlighted the effect of overloading trucks on Highway Bridge. The main conclusions may be summarized as follows:

1. 42.7% from the observed heavy trucks were overload than allowed by (GARBLT) and the maximum recorded axle overload factor was 2.7.
2. The analysis' results using the maximum observed truck weight was 99.02 ton revealed that the increase in the span of the bridge, moments resulting from the actual loads exceed the moments caused the Egyptian design load.
3. The design live load model for the Egyptian highway bridge need to be modified by considering and analyzing the actual load.
4. Therefore, this study recommends either to prevent overload trucks or change the design load of bridges.

REFERENCES

1. Arab Republic of Egypt the Project for Improvement of the Bridge Management Capacity, (2015), Final Report, Egypt.
2. Misr National Transport Study, The Comprehensive Study on The Master Plan For National wide Transport System In The Arab Republic Of Egypt, (2012), Final Report, Egypt.
3. Paeglitis, A., & Paeglitis, A. Traffic load models for short span road bridges in Latvia.
4. Aggarwal, V., & Parameswaran, L. (2015). Effect of Overweight Trucks on Fatigue Damage of a Bridge. In Advances in Structural Engineering (pp. 2483-2491). Springer India.

5. Getachew, A. 2003. Traffic Load Effects on Bridges. Statistical Analysis of Collected and Monte Carlo Simulated Vehicle Data: PhD thesis. Stockholm: Royal Institute of Technology. 50–55.
6. Hwang, E. S.; Lee, K. T.; Kim, D. Y. 2012. Modelling of Truck Traffic for Long Span Bridges. Stresa, Lake Maggiore; Italy, Taylor & Francis Group, 1100–1107.
7. Wang, T. L., & Liu, C. (2000). Influence of heavy trucks on highway bridges (No. FL/DOT/RMC/6672-379,).
8. ECP No. 201. Egyptian Code of Practice for Calculation of Loads and Forces in Structural and Masonry Works. Housing and Building National Research of Egypt, Giza, Egypt, 2012.
9. Caprani, C. C. (2012). Calibration of a congestion load model for highway bridges using traffic microsimulation. Structural Engineering International, 22(3), 342-348.
10. Caprani, C. C., Carey, C., & Enright, B. (2010). A new congested traffic load model for highway bridges.
11. Nowak, A. S., & Hong, Y. K. (1991). Bridge live-load models. *Journal of Structural Engineering*, *117*(9), 2757-2767
12. Vrouwenvelder, A. C. W. M., & Waarts, P. H. (1993). Traffic loads on bridges. *Structural Engineering International*, *3*(3), 169-177.
13. Bruls, A., Croce, P., Sanpaolesi, L., & Sedlacek, G. (1996). ENV 1991-Part 3: Traffic loads on bridges Calibration of road load models for road bridges. *IABSE REPORTS*, 439-454.
14. Flint, A. R., & Jacob, B. (1996). Extreme traffic loads on road bridges and target values of their effects for code calibration. *IABSE REPORTS*, 469-478.
15. Lutomirska, M. (2009). Live load models for long span bridges.