



PARAMETRIC STUDY ON THE EFFECT OF INCREASE IN THE TRUCK AXLE LOAD CARRYING CAPACITY

Engineering

Agrawal, Nikhil J. Department of Civil Engineering, College of Engineering, Shivaji Nagar, Pune - 411005, Maharashtra.

Dr. Bhosale, S. S.* Department of Civil Engineering, College of Engineering, Shivaji Nagar, Pune - 411005, Maharashtra. *Corresponding Author

ABSTRACT

Mostly, trucks are overloaded than the prescribed limit of legal axle load. In India prescribed limits of Gross Vehicle Weight (GVW) and Maximum Safe Axle Weight for different types of vehicle axle configurations are notified by the Ministry of Road Transportation and Highways (MORTH). Also, MORTH is proposing to increase the truck axle load by 20-25% so as to cater the distress in existing pavement because of the overloading. The proposal of increase in truck axle load would directly affect the maximum safe axle load carrying capacity of various axle configurations. Hence, in the present study effect of increase in maximum safe axle load on the existing flexible pavement/roads is studied.

KEYWORDS

Equivalency Factor, Design Traffic, Maximum Safe Axle Weight, Vehicle Damage Factor.

Introduction

There are several possible basic vehicle wheel and axle arrangements: single wheel, dual wheel; single axle, tandem axle and Tridem axle. Now, in order to channelize the various vehicle wheel and axle arrangements, Indian Road Congress (IRC) has adopted the most commonly used vehicle wheel and axle arrangement in India. And the same had being laid down in IRC: 37 (2012). Predominantly, the vehicle wheel and axle arrangement used by IRC: 37-2012 are: Single Axle with Single Wheel on either side, Single Axle with dual Wheel on either side, Tandem Axle and Tridem Axle.

MORTH (1996) recommends a permissible axle load for a Single Axle Single Tyre on either side as 6.0 tonnes. Whereas IRC: 37 (2012) recommendations on maximum safe axle weight for Single Axle with Single Wheel on either side, Single Axle with dual Wheel on either side, Tandem Axle and Tridem Axle are 65 kN, 80 kN, 148 kN and 224 kN, respectively. With the proposal of increasing the axle load by 20-25%, IRC: 37 (2012) recommended maximum safe axle weight for Single Axle with Single Wheel on either side could be considered as 80 kN in lieu of present permissible limit of 65 kN. Similarly, maximum safe axle weight for Single Axle with dual Wheel on either side, Tandem Axle and Tridem Axle recommended by IRC: 37 (2012) can also be computed using Eq. (1) and the same had being presented in Table 1.

Maximum Safe Axle Weight (kN) =

$$\frac{[(\text{Max. GVW}) - (\text{Max. safe axle weight for single axle single wheel on either side})]}{\text{Factor for tyre inflation pressure}} \quad (1)$$

The present and proposed maximum Gross Vehicle Weight (GVW) for various axle configurations and maximum safe axle weight for single axle single wheel on either side is given Table 1. Whereas factor for tyre inflation pressure is taken as 1.25 AITD and CRR, (2004).

It is to be noted that consideration of maximum safe axle weight of 80 kN for Single Axle with Single on either side in lieu of 65 kN is only to match the percentage increase in maximum safe axle weight for various other axle configuration and for the conformity of the recommendation laid by MORTH (1996) and IRC: 37 (2012). Also, if this consideration is accepted, a further study is to be proposed to evaluate the distress in pavement because single axle with single wheel on either side will cause more deteriorating effect with increment in maximum safe axle weight. Moreover, single axle with single wheel on either side is generally configured as front axle of a vehicle, which also has to adhere with the steering torque requirement, which is out of the scope of the present study.

Table 1: Maximum Gross Vehicle Weight (GVW) And Maximum Safe Axle Weight (MORTH, 1996 And 2012)

Axle Configuration	Present		Proposed		Percentage Increase in Max. Safe Axle Weight (%)
	Max. GVW (kN)	Maximum Safe Axle Weight (kN)	Max. GVW (kN)	Maximum Safe Axle Weight (kN)	
Single Axle with Single Wheel on either side	-	65*	-	80 ^[1]	23.08
Single Axle with Dual Wheel on either side	165	80	190	88	10.00
Tandem Axle with Dual Wheel on either side	250	148	305	180	21.62
Tridem Axle with Dual Wheel on either side	345	224	420	272	21.43

* IRC 37-2012 specifies a value of 65 kN.

[1] Value extrapolated so as make the increase in proposed axle weight in line with the present axle weight increment. Also, single axle with single wheel on either side are mainly configured as front axle of a vehicle, hence it has to be checked with the vehicle manufacturer so as meet the steering torque requirement.

Design Traffic

The design traffic in terms of the cumulative number of standard axles to be carried out during the design life of road is computed using Eq. (2), which is as recommended by IRC: 37 (2012).

$$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F \quad (2)$$

Where,

N = Cumulative number of Standard axles to be catered for in the design life in terms of msa.

A = Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor

F = Vehicle Damage Factor (VDF)

n = Design life in years

r = Annual growth rate of commercial vehicles in decimal

The traffic in the year of completion is estimated using the following formula:

$$A = P(1+r)^x$$

Where,

P = Number of commercial vehicles as per last count

x = Number of years between the last count and the year of completion of construction.

In the computation of design traffic in terms of the cumulative number of standard axle, the standard axle load is taken as 80 kN IRC: 37 (2012). Hence, it is necessary to convert maximum safe axle weight of various axle configurations in terms of standard axle load of 80 kN.

Vehicle Damage Factor

Vehicle Damage Factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration into the number of repetitions of standard axle load of magnitude 80 kN. It is defined as equivalent number of standard axles per commercial vehicles. The VDF varies with the vehicle axle configuration and axle loading.

Eq. (3.1), Eq. (3.2), Eq. (3.3) and Eq. (3.4) are recommended by IRC: 37 (2012) for computing the equivalency factor for Single Axle Single Wheel on either side, Single Axle dual Wheel on either side, Tandem Axle and Tridem Axle, respectively.

$$\text{Single Axle Single Wheel on either side} = \left(\frac{\text{axle load in kN}}{65}\right)^4 \quad (3.1)$$

$$\text{Single Axle Dual Wheel on either side} = \left(\frac{\text{axle load in kN}}{80}\right)^4 \quad (3.2)$$

$$\text{Tandem Axle Dual Wheel on either side} = \left(\frac{\text{axle load in kN}}{148}\right)^4 \quad (3.3)$$

$$\text{Tridem Axle Dual Wheel on either side} = \left(\frac{\text{axle load in kN}}{224}\right)^4 \quad (3.4)$$

It is noted that Eq. (3.1), Eq. (3.2), Eq. (3.3) and Eq. (3.4) are the function of axle load and the maximum safe axle load. Whereas, axle loads for the various axle configuration can be measured from the axle load survey and maximum safe axle loads are prescribed by MORTH (1996) which is as represented in Table 1 for the above axle configuration. Also, the equivalency factor for the various axle loads is computed for the present and proposed maximum safe axle load, which is as given in Table 2. Parametric Analysis is subheading

Table 2: Equivalency Factor

Axle Load (kN)	Present				Proposed			
	Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle	Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle
10	0.0006	0.0002	-	-	0.0002	0.0002	-	-
20	0.0090	0.0039	-	-	0.0039	0.0027	-	-
30	0.0454	0.0198	-	-	0.0198	0.0135	-	-
40	0.1434	0.0625	-	-	0.0625	0.0427	-	-
50	0.3501	0.1526	-	-	0.1526	0.1042	-	-
60	0.7260	0.3164	-	-	0.3164	0.2161	-	-
70	1.3451	0.5862	-	-	0.5862	0.4004	-	-
80	2.2946	1.0000	0.0854	0.0163	1.0000	0.6830	0.0390	0.0075
90	3.6755	1.6018	0.1367	0.0261	1.6018	1.0941	0.0625	0.0120
100	5.6020	2.4414	0.2084	0.0397	2.4414	1.6675	0.0953	0.0183
110	8.2020	3.5745	0.3052	0.0582	3.5745	2.4414	0.1395	0.0267
120	11.6164	5.0625	0.4322	0.0824	5.0625	3.4578	0.1975	0.0379
130	16.0000	6.9729	0.5953	0.1134	6.9729	4.7626	0.2721	0.0522
140	21.5208	9.3789	0.8007	0.1526	9.3789	6.4059	0.3660	0.0702
148	26.8778	11.7135	1.0000	0.1906	11.7135	8.0005	0.4570	0.0877
150	28.3604	12.3596	1.0552	0.2011	12.3596	8.4418	0.4823	0.0925
160	36.7136	16.0000	1.3659	0.2603	16.0000	10.9282	0.6243	0.1197
170	46.7888	20.3909	1.7408	0.3317	20.3909	13.9272	0.7956	0.1526
180	58.8080	25.6289	2.1880	0.4170	25.6289	17.5049	1.0000	0.1918
190	73.0064	31.8167	2.7162	0.5176	31.8167	21.7312	1.2414	0.2381
200	89.6327	39.0625	3.3348	0.6355	39.0625	26.6802	1.5242	0.2923
210	108.9491	47.4807	4.0535	0.7725	47.4807	32.4300	1.8526	0.3553
220	131.2313	57.1914	4.8825	0.9305	57.1914	39.0625	2.2315	0.4280
224	141.0388	61.4656	5.2474	1.0000	61.4656	41.9818	2.3983	0.4600
230	156.7682	68.3206	5.8326	1.1115	68.3206	46.6639	2.6658	0.5113
240	185.8624	81.0000	6.9151	1.3178	81.0000	55.3241	3.1605	0.6061
250	218.8299	95.3674	8.1417	1.5516	95.3674	65.1372	3.7211	0.7136
260	256.0000	111.5664	9.5246	1.8151	111.5664	76.2014	4.3531	0.8349
270	297.7156	129.7463	11.0766	2.1109	129.7463	88.6185	5.0625	0.9709
280	344.3330	150.0625	12.8111	2.4414	150.0625	102.4947	5.8552	1.1229
290	396.2220	172.6760	14.7416	2.8093	172.6760	117.9400	6.7375	1.2922
300	453.7656	197.7539	16.8826	3.2173	197.7539	135.0686	7.7160	1.4798
310	517.3606	225.4690	19.2486	3.6682	225.4690	153.9984	8.7974	1.6872
320	587.4170	256.0000	21.8551	4.1649	256.0000	174.8514	9.9887	1.9157
330	664.3583	289.5315	24.7177	4.7105	289.5315	197.7539	11.2971	2.1666
340	748.6214	326.2539	27.8528	5.3079	326.2539	222.8358	12.7299	2.4414
350	840.6568	366.3635	31.2770	5.9605	366.3635	250.2312	14.2949	2.7416

In order to study the effect of increase in maximum safe axle load on existing pavement, a parametric analysis is carried out for axle load survey data available from literature. Kumar et. al. (2014) conducted an axle load survey for a 62 km long Outer ring road which runs around the perimeter of Bangalore, Karnataka. Based on the three days axle load survey data, vehicle damage factor was computed as per the guideline laid down by IRC: 37 (2012). The axle load survey data comprises the number of axles on each vehicle, total number of vehicles and the axle load for the axle configuration as proposed by IRC: 37 (2012). The computation of equivalent factor was carried out for present maximum safe axle load of 65 kN, 80 kN, 148 kN and 224 kN for single axle single wheel on either side, single axle with dual wheel on either side, tandem axle and Tridem axle, respectively. Based on the axle load survey data it is observed that around 25% of the vehicles are overloaded than the prescribed limit of legal axle load. The

overloading is mainly observed in the Heavy and Very Heavy Trucks. The range of overloading varies from 30 to 40% than the prescribed limits. The vehicle damage factor computed for the stretch of survey conducted is 2.49.

Similarly, in the present parametric study the vehicle damage factor is computed for the proposed maximum safe axle load of 80 kN, 88 kN, 180 kN and 272 kN for single axle single wheel on either side, single axle with dual wheel on either side, tandem axle and Tridem axle, respectively. The equivalent load factor for the various axle configurations proposed by IRC: 37 (2012) and for the measured axle load can also be determined from Table 2. The variation in the present and proposed maximum safe axle load is in the range of 20 to 25%. The vehicle damage factor computed for the proposed maximum safe axle load and the axle load survey data from the literature is 1.31.

Table 3 and Table 4 presents the computation of vehicle damage factor from the axle load survey data for the present and proposed maximum safe axle load, respectively.

Table 3: Vehicle Damage Factor (VDF) based on present Maximum Safe Axle Load

Sr. No.	Vehicle Category	No. of axles	Total No. of vehicles	Axial Load (kN)				Equivalent Factor per Axle				Total Equivalent Factor	No. of Vehicle EF	Avg. Equivalent Factor
				Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle	Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle			
1	Buses	2	12	60.8	64.8	-	0	0.766	0.430	-	0	1.196	14.35	2.49
2	Medium Truck	2	2879	59.5	62.5	-	0	0.702	0.373	-	0	1.075	3093.93	
3	Heavy Truck	3	619	78.5	104.5	206.7	0	2.127	2.911	3.805	0	8.843	5474.04	
4	Very Heavy Truck	4/5	128	73.7	79.4	155.8	0	1.653	0.970	1.228	0	3.851	492.95	

Table 4: Vehicle Damage Factor (VDF) based on proposed Maximum Safe Axle Load

Sr. No.	Vehicle Category	No. of Axles	Total No. of vehicles	Axial Load (kN)				Equivalent Factor per Axle				Total Equivalent Factor	No. of Vehicle EF	Avg. Equivalent Factor
				Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle	Single Axle with single wheel on either side	Single Axle with dual wheel on either side	Tandem Axle	Tridem Axle			
1	Buses	2	12	60.8	64.8	-	0	0.334	0.294	-	0	0.628	7.53	1.31
2	Medium Truck	2	2879	59.5	62.5	-	0	0.306	0.254	-	0	0.560	1613.49	
3	Heavy Truck	3	619	78.5	104.5	206.7	0	0.927	1.989	1.739	0	4.655	2881.14	
4	Very Heavy Truck	4/5	128	73.7	79.4	155.8	0	0.720	0.663	0.561	0	1.944	248.87	

Conclusion

With increase in the maximum safe axle load of around 20%, the vehicle damage factor is reduced by around 45%. Theoretically, as vehicle damage factor is used in the computation of design traffic, indicates that there is significant increase in the life of pavement with the increase in maximum safe axle load. But, as the mechanistic design of flexible pavement is more preferred, it would be unrealistic to predict the performance of the flexible pavement with increased maximum safe axle load, without the computation of permissible stresses and strains at the critical location. Also, the existing pavement is being design based on the present maximum safe axle load. At last, based on the parametric analysis, it can be concluded that even with increase in the maximum safe axle load, the practice of overloading the vehicle than the prescribed legal axle load should be avoided so as reduce the detrimental effect to pavement structure.

References

1. AITD and CRRRI (2004), Technical Note on Optimum Axle Load of Commercial Vehicle for Indian Roads, New Delhi.
2. Huang, Y. H. (2004), Pavement Analysis and Design.
3. IRC: 37 (2001), Guidelines for the Design of Flexible Pavements, Indian Road Congress, New Delhi.
4. Kumar, P. Praveen, Kumar, Kiran BV, Manjunatha, S, and Kumar, Sunil R, (2014), Analysis of Axle Loadings and Determination of Vehicle Damage Factor and Design of Overlay on Outer Ring Road in Bangalore, Karnataka, International Journal for Scientific Research & Development Vol. 2, Issue 09, 2014.