MAKARA, TEKNOLOGI, VOL. 16, NO. 1, APRIL 2012: 85-92

TOLERANCE LIMIT FOR TRUCKS WITH EXCESS LOAD IN TRANSPORT REGULATION IN INDONESIA

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Abstract

Reliability of a road is mandatory since damaged will impede the traffic. Destruction is caused by various factors; one of the most important factors is excess load. Overload may give the load of each axle of a vehicle exceeds the determined standard. This condition occurs in trucks exceeding the load limit. In designing the structure of a road based on the method of Directorate General of Highways Ministry of Public Works of the Republic of Indonesia, axle load calculated in equivalent-number, or known as equivalent axle load (EAL), of 8.16 tons of standard axle. Total equivalent-number over the service life is defined as cumulative equivalent standard axle load (CESA). Due to traffic volume exceeding the volume forecast or, in other words there is an excessive load of traffic, it will make CESA achieved faster than planned. This excessive load in Indonesia, however, has been considered as a factor of environmental condition, so there is a need to introduce a correction factor for EAL as high as 20-25% in the process of designing flexible and rigid pavement so as to reduce early damage.

Abstrak

Batas Toleransi untuk Truk Muatan Berlebih dalam Peraturan Angkutan di Indonesia. Keandalan jalan mutlak diperlukan karena kerusakan jalan akan menghambat arus lalu lintas. Kerusakan jalan dapat disebabkan oleh berbagai faktor, salah satu faktor terpenting adalah muatan berlebih. Muatan berlebih dapat menyebabkan beban masing-masing gandar kendaraan melebihi standar yang ditetapkan. Kondisi ini terjadi pada truk yang bebannya melebihi batas. Dalam merancang struktur jalan berdasarkan pada metode Direktorat Jenderal Bina Marga Kementerian Pekerjaan Umum Republik Indonesia, beban gandar dihitung beban ekivalen, atau dikenal sebagai ekivalen muatan sumbu (EMS), dari 8,16 ton sumbu standar . Jumlah angka ekivalen sumbu selama umur rencana didefinisikan sebagai kumulatif ekivalen muatan sumbu (KEMS). Karena volume lalu lintas melebihi volume lalu lintas perkiraan atau, dengan kata lain ada beban berlebihan pada lalu lintas, hal itu akan menyebabkan KEMS dicapai lebih cepat dari yang direncanakan. Beban berlebihan yang sulit dikendalikan ini di Indonesia, bagaimanapun, dapat dianggap sebagai faktor kondisi lingkungan, sehingga ada kebutuhan untuk memperkenalkan faktor koreksi untuk beban muatan sumbu sebesar 20-25% dalam proses merancang perkerasan lentur dan kaku sehingga dapat mengurangi kerusakan dini pada struktur jalan.

Keywords: equivalent axle, excessive load, pavement, trucks

1. Introduction

Overloading is among the most important causes of the deterioration of flexible pavements. This is especially critical in developing countries where the transportation of heavy freight on city roads and highways is increasing. Inspections indicate that this problem causes a great deal of damage to road networks and results in noticeable maintenance and repair costs [1]. Indonesia has similar problems concerning the expected damage by overloaded heavy freight.

Damage to roads not only occurs in the arterial roads, but also in the collector roads. Damage develops in the surface layer, while not excluding the possibility to occur in the layers of foundation. Roads are generally composed of several layers (Figure 1), damage caused by excessive load due to structural damage in the surface layer will result in inability of the layer to support the load incurred, and this is also the case in the foundation layer.

Minister of Transportation Decree of the Republic of Indonesia No. 74 of 1990 article 9, the load limit regulation emphasized especially for heavy trucks, regulates that the heaviest axle load (HAL) for a vehicle of single-wheel single-axle is 6 tons and a vehicle of single-axle double-wheels is 10 tons.

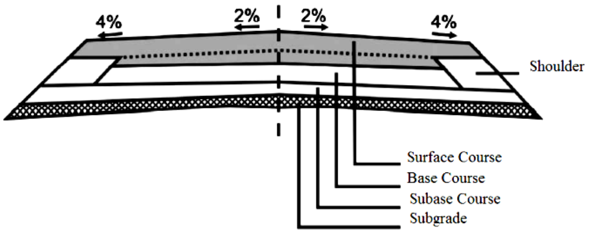

Figure 1. Cross Section of Typical Flexible Pavements

Moreover, 18 tons is allowed for double-axles double-wheels, and 20 tons for triple-axles double-wheels vehicles.

Although the load limits affecting the axle load has been established rigorously, in reality, many trucks exceeding the permitted load. This circumstance will not only disrupt the vehicle speed and safety, but also will affect the destruction of the pavement structures. Overloaded trucks give threat to road safety and the infrastructure, as they increase pavement wear, causing cracks and ruts, and thus, can contribute to premature pavement failure Heavy trucks also contribute to bridge fatigue damage. When trucks are overloaded, their aggressiveness may be significantly increased. Extreme bridge loading cases are also governed by very heavy trucks, either carrying abnormal loads (e.g. cranes) or illegal overloads. Some weak (old) bridges with reduced capacity may be severely damaged, or even destroyed, by overloaded trucks [2].

Many highway facilities experience deterioration due to high traffic volumes and the service life has been extended beyond the facility's design life. As road network deteriorates, there is a need to increase investment and rehabilitation treatments in order to restore and maintain the road condition at acceptable levels. Pavement performance is related to the pavement's response under load. In current practice, the horizontal tensile strain at the bottom of the asphalt and the vertical compressive strain at the top of the sub-grade are typically used to predict service life based on fatigue cracking and rutting, respectively [3].

In this study, evaluation of structural strength is estimated from the re-calculation of cumulative equivalent standard axle load (CESA) value due to the addition of excess cargo resulting in the increase of equivalent axle load. This method is used to evaluate the strength of a flexible pavement structure, while in concrete pavement structure re-calculation will show the ultimate strength of concrete due to excessive axle load. The difference in the CESA re-calculation of these two types of pavement structure is: for flexible pavement equivalent axle load is used, but on concrete pavement only the cargo load value of each axle is used.

2. Methods

Equivalent single axle-loads (ESALs). Factors, such as traffic, environment, materials, and design, affect pavement damage over time, with traffic loads playing a key role in deterioration. Trucks are the major user of the pavement network, applying the heaviest loads to the pavement. Truck loads are transferred to the pavements through various combinations of axle configurations depending on the truck type [4].

In the 1993 AASHTO Guide for Design of Pavement Structures, a mixed traffic stream of different axle loads and axle configurations is converted into a design traffic number by converting each expected axle load into an equivalent number of 80-kN single-axle loads, or known as equivalent single-axle loads, ESALs. Load equivalency factors, LEFs, are used to determine the number of ESALs for each axle load and axle configuration [5].

Vehicle and its load influence the road surface depending on the number and type of the vehicle's axle (Figure 2) [6]. The truck in the picture consists of a single axle at the front, two double axles in the middle and two dual axles in the rear wheel, symbolized by figures notation truck axles 5 (s.dd-dd).

Overloaded axle affects primarily the durability of a road. It reduces the pavement's life and over stresses the bridges and culvert structures. Various vehicle's axle is then converted into equivalent number of load-axis by dividing the number by 8.16 tons. There is an exponential relationship between axle loads and pavement damage (called Fourth Power Law). The fourth power law implies that pavement damage by passing axles increases exponentially with increasing load. The damage is defined as loss in pavement serviceability. Therefore, to simulate AASHTO ESALs as an exponent value of four (n=4), it is used the following formula in this study [7]:

$$E_{single} = \left(\frac{P_1}{8.16}\right)^4 \quad (1)$$

$$E_{tandem} = \alpha\left(\frac{P_2}{8.16}\right)^4 \quad (2)$$

$$E_{tridem} = \gamma\left(\frac{P_3}{8.16}\right)^4 \quad (3)$$

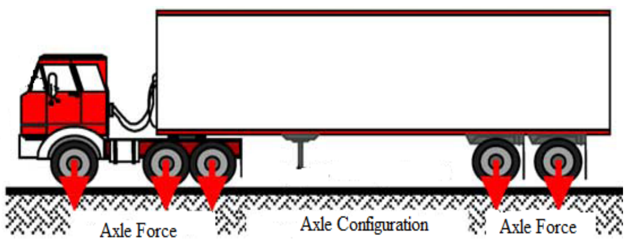

Figure 2. Axle Force and Axle Configuration

where, P_1, P_2, and P_3: Load on each group axle and α, γ is a correction factor for the Tandem and Tridem equivalent axles.

Asphalt Institute sets the value of α = 0.0773 and γ = 0.017, while the AASHTO sets the value of α = 0.133 and γ = 0.044 [8].

Guidelines for road design in Indonesia uses the Design Manual issued by the Directorate General of Highways, Ministry of Public Works of the Republic of Indonesia, in 1987, which sets the value of α = 0.086 for the Tandem equivalent axle [7]. However, the Tridem equivalent axle is not listed in the Manual, but some researchers assign a value of gamma = 0.031 [9]. More axles in each axle group will reduce the magnitude of the load on the surface of a pavement structure.

Trucks have axle configuration as shown in Figure 2. Total vehicle axle is a total equivalent number of a vehicle. This figure shows the level of damage (damage factor) generated from these types of vehicles over the service life cycle. The level of damage can be differentiated by load on the axle and the number of wheels on each axle and by the effect of the type of wheels (single or double). Damage factors generated from a single axle are greater than double axles, as well as crack or damage on the wheel rut [10].

As shown in Table 1, the type of trucks with permitted load has different axles arrangement, especially for the rear axles. Trucks type no. 9, 12, and 14 has 3 axles and the rests have one or two axles. Previous studies proved that truck with a single axle and dual axles caused cracks bigger than the triple-axles or more [11].

Total equivalent single axle load. Trucks with a variety of load limits contribute to the fatigue of pavement structures. Pavement structures are burdened by the accumulation of wheel load of vehicles through the axles during their designed life of service. In the guidelines of flexible pavement structural design in Indonesia, by using CESA, which represents the accumulated value of the vehicle's equivalent axle load obtained from the average estimates of the equivalent number of axles at the beginning and at the end of a pavement service life. Accordingly, the cumulative equivalent standard axle load (CESA) is formulated as follows [7]:

$$CESA = \frac{\beta}{20}\left\{ \begin{array}{l} \left(\sum_{j=1}^{n} AADT_J \times C_J \times E_J\right) + \\ \left[\sum_{j=1}^{n} AADT_J \times (1+i)^{\beta} \times C_J \times E_J\right] \end{array} \right\} \quad (4)$$

where β = the design period of pavement structure, AADT = traffic volume at the beginning and at the end of pavement life, i = rate of traffic growth during the designed period, C = lane distribution factor, j = type of truck. CESA is the value to determine the thickness of pavement structure by calculating other parameters.

The value of CESA at the end of design life can also be obtained when the determined traffic volume is reached before the end of design life. This is especially occurred when the traffic growth rate exceeding the prediction rate. Similarly, vehicle axle load will affect the value of CESA when the axle load exceeds the standard value.

Table 1. Axle Load for Each Type of Truck

Type of Vehicle	Axle Load (ton)						Total Load (ton)
	Axle-1	Axle-2	Axle-3	Axle-4	Axle-5	Axle-6	
Passenger Cars (s.s)	1	1					2
Small Bus (s.s)	3	6					9
Bus (s.d)	6	10					16
Truck 2-axle (s.s)	6	6					12
Truck 2-axle (s.d)	6	10					16
Truck 3-axle (ss.d)	5	6	10				21
Truck 3-axle (s.dd)	6	9	9				24
Truck 4-axle (s.s.dd)	6	6	9	9			30
Truck 4-axle (s.ddd)	6	7	7	7			27
Truck 4-axle (s.d - dd)	6	10	9	9			34
Truck 4-axle (s.d + d.d)	6	9	9	9			33
Truck 5-axle (s.s.ddd)	6	6	7	7	7		33
Truck 5-axle (s.dd - dd)	6	9	9	9	9		42
Truck 6-axle (s.dd - ddd)	6	9	9	7	7	7	45

Source: Circular Letter of Directorate General of Land Transportation No.SE.02/AJ.108/DRJD/2008 concerning the Maximum Limits for Calculated Permitted Load Amount *(Jumlah Berat yang Diizinkan, JBI*) and Permitted Combination Load Amount (*Jumlah Berat Kombinasi yang Diizinkan, JBKI*) for pickup trucks, special vehicles, road tractors including the trailers.

3. Results and Discussion

Average daily traffic truck (ADTT) and CESA. Traffic data is acquired from a survey conducted in Bogor-Cibinong Road (Table 2). This road consists of various types of trucks even though the traffic dominated by sedan and other passenger vehicles. By observing the vehicles on the road, it is estimated that passenger cars have dominated the vehicles passing by this Bogor-Cibinong road, but for the calculation of pavement structure more considerations is put on the number of vehicle's load that are distributed from each wheel to the road surface.

In Table 2 can be seen the results of calculations for the CESA initial design life of 4,162.10 ESAL. By using the equation 4 where pavement design life for 10 years, CESA obtained at 6.175 ESAL. CESA value is then used as a reference in calculating the reduction in pavement life gained from attaining higher CESA period due to the addition of the load on the pavement structure.

Vehicle and its cargo provide load to the road surface depending on the amount and type of axle of the vehicle. The more axles the vehicle has, the lesser the load on the road pavement structure. Forty percent of vehicles on the road in this case study is of sedan type vehicles. In terms of total load axis, however, a sedan type vehicle is only 0.14%.

Similarly, bus type vehicle give 40.42% of the total equivalent number of load on this road. Therefore, the bus and truck types of vehicles are very influential in the calculation of road pavement structures as they contribute to dominant load.

To see the impact of heavy vehicles on the road surface caused by the difference in the axis, the total weight of the vehicle is the multiplication of the weight of each type of vehicle with the traffic volume. While the total equivalent number of axle load is equivalent-axle number multiplication with the traffic volume.

Bus load do not exceed the limits as occurred in trucks. Therefore, in this study, observations are preferred on the truck type of vehicles. Two-axle trucks with a total weight of 16 tons (Table 3) have the largest number (25.60%) among other types of heavy trucks. While other two-axle trucks have a total weight of 12 tons (17.62%), because this type of trucks have rear axle with a single wheel which result in smaller load capacity. Therefore, the total percentage of the equivalent number of axle load for two-axle trucks is 43.22% of the total load on this road. However, the total load is only 33.21% of the total weight of all vehicles on the road. In other words, the weight of the vehicle is different from the equivalent axle load. Furthermore, for a discussion of these overload problems, the parameter used will be equivalent to the axle load.

Axle load distribution characteristics. The load of a vehicle is distributed on the structure of road pavement through each axle. As detailed in Table 4, each type of vehicle has a payload capacity and different number of axles. Therefore, the load on each axle is different. Each axle has an equivalent number of vehicle assigned with the notation E. Based on the different number of axles and axle position from different configurations, different E values are generated.

Two-axle trucks consist of two types of trucks, i.e. trucks with single rear wheels and trucks with dual rear wheels. Both types of transport trucks have different maximum load, which is 12 tons for trucks with single rear wheels that provides equivalent number of axle load of 0.5846 and 16 tons for trucks with dual rear wheels that provide equivalent number of axle load of 2.5478. The real difference in these two types of trucks is at the rear axles, where the load limits for single wheels is 6 tons and 10 tons for dual wheels trucks.

Table 2. CESA of the First Year Prediction

Type of Vehicle	AADT	C	E	CESA
Car (1.1)	12,522	0.6	0.00045	3.39
Small Bus (1.1)	39	0.7	0.31058	8.48
Bus (1.2)	678	0.7	2.54779	1,209.18
Truck 2-axle (s.s)	1,172	0.7	2.54779	2,090.82
Truck 2-axle (s.d)	23	0.7	2.53948	40.00
Truck 3-axle (ss.d)	68	0.7	2.32855	110.02
Truck 3-axle (s.dd)	41	0.7	3.93739	111.63
Truck 4-axle (s.s.dd)	5	0.7	1.65212	5.20
Truck 4-axle (s.ddd)	95	0.7	4.58403	303.23
Truck 4-axle (s.d - dd)	32	0.7	4.73178	104.34
Truck 4-axle (s.d + d.d)	14	0.7	1.94443	18.37
Truck 5-axle (s.s.ddd)	14	0.7	4.36478	41.25
Truck 5-axle (s.dd - dd)	45	0.7	3.68836	116.18
Total	14,744			4,162.10

Table 3. Comparison of the Total Vehicle Weight and the Total Equivalent Number of Axle Load

Type of Vehicle	ADT (vehicle)	total vehicle weight (%)	total equivalent axle-number (%)
Passenger Cars (s.s)	10,328	40.17	0.14
Small Bus (s.s)	61	1.07	0.58
Bus (s.d)	519	16.14	40.42
Truck 2-axle (s.s)	985	22.99	17.62
Truck 2-axle (s.d)	328	10.22	25.60
Truck 3-axle (ss.d)	32	1.31	2.49
Truck 3-axle (s.dd)	29	1.37	2.09
Truck 4-axle (s.s.dd)	20	1.17	1.60
Truck 4-axle (s.ddd)	9	0.49	0.35
Truck 4-axle (s.d - dd)	33	2.20	4.67
Truck 4-axle (s.d + d.d)	12	0.77	1.74
Truck 5-axle (s.s.ddd)	7	0.43	0.31
Truck 5-axle (s.dd - dd)	12	0.98	1.60
Truck 6-axle (s.dd - ddd)	8	0.70	0.80
Total	12,384	100.00	100.00

Note : s : single wheel single axle
d : double wheel single axles
dd : double wheel double axles
ddd : double wheel triple axles

Table 4. Distribution of Equivalent Number of Vehicle Axle Load

Type of Vehicle	E						∑ E
	Axle-1	Axle-2	Axle-3	Axle-4	Axle-5	Axle-6	
Passenger Cars (s.s)	0.0002	0.0002					0.0004
Small Bus (s.s)	0.0182	0.2923					0.3106
Bus (s.d)	0.2923	2.2555					2.5478
Truck 2-axle (s.s)	0.2923	0.2923					0.5846
Truck 2-axle (s.d)	0.2923	2.2555					2.5478
Truck 3-axle (ss.d)	0.2840 *		2.2555				2.5395
Truck 3-axle (s.dd)	0.2923	2.0362*					2.3285
Truck 4-axle (s.s.dd)	0.2923	0.2923	2.0362*				2.6208
Truck 4-axle (s.ddd)	0.2923	1.3598**					1.6521
Truck 4-axle (s.d - dd)	0.2923	2.2555	2.0362*				4.5840
Truck 4-axle (s.d + d.d)	0.2923	1.4798	1.4798	1.4798			4.7318
Truck 5-axle (s.s.ddd)	0.2923	0.2923	1.3598**				1.9444
Truck 5-axle (s.dd - dd)	0.2923	2.0362*		2.0362*			4.3648
Truck 6-axle (s.dd - ddd)	0.2923	2.0362*		1.3598**			3.6883

Note : * tandem group axles, ** tridem group axles

Four tons difference of payload for equivalent axles is considered very large. From this fact, it is shown that the number of axles and composition, as well as maximum load limit of each axle, will determine a different equivalent number of axle load that will affect the results of calculations at design level.

A similar condition occurs to 4-axle truck and 5-axle truck. The second type is a trailer truck with one front axle and 3 rear axles. This truck has a total vehicle weight of 27 tons and the total of equivalent number of axle load of 1.2135. The third is a trailer truck with one front axle, one center axle, and two rear axles with total vehicle weight of 34 tons and the total equivalent number of axle load of 4.5840.

Based on these characteristics, the type of truck having an equivalent number of lesser axles, but are able to carry heavier load, is selected. This decision will provide optimum benefit in the process of transportation of goods.

Axle loads efficiency. From the previous description, it can be seen that the total equivalent number of axle load of a truck is not linear with the amount of load that can be transported. The amount and characteristics of an axle is very influential on the total equivalent number of axle load. It is this number that affects the magnitude of burden on the pavement structure. Table 4 gives an overview on the differences in vehicle weight and total value of equivalent axle loads for various types of trucks according to the condition of axle maximum load prevailing in Indonesia.

$$ALE = \text{total load}/\Sigma E \tag{6}$$

From the combination of maximum amount of cargo and equivalent number of axle load, it is obtained the efficiency value between the configuration and maximum limit of each axle. This value is called Axle Loads Efficiency (ALE). From the 11 types of trucks as listed in Table 5, 5-axle type of truck configuration with single axle at front and three axles with double wheels at rear has the biggest efficiency value of 16.97. Conversely, the lowest efficiency value is achieved by trucks with two-axle configuration with single axle at front and single axle with dual wheels at rear.

Increasing MST from 8 tons to 10 tons and from 10 tons to 12 tons. Road function and classification according to the Government Regulation no. 43 of 1993 are classified into type I, II, and III, where type I and II with HAL of 10 tons while HAL of 8 tons for type III. HAL is the maximum allowable load of each axle of a vehicle. Currently, the overload on cargo restrictions of HAL of 8 tons and 10 tons are still happening and continue to cause early damage to some roads. Load-check controllers stationed in some roads have not been able to resolve the problem completely. Indifference to the load limit has given benefits to road users (trucks) on one hand but on the other hand detrimental to the road management due to early damage.

Case study in this research is Cibinong roadway. It can be seen that to improve the quality of the pavement with HAL of 12 tons will require construction cost of Rp.3.570.336.000,00/km and maintenance costs estimated at 10% per year. Total cost of construction and maintenance for 10 years with 4% inflation rate, calculated in the present time (NPV), is Rp.6.466.198.319,00/km. Another calculation is the benefit received by the road users (trucks). By increasing the MST limit to 12 tons (maximum), the opportunities of profit gain for 10 years in the position of NPV is Rp.10.568.178.817,00/km. This value is assuming the cost of freight in 2011 amounted to Rp.1.000,00 per ton kilometer and vehicle growth rate of 5% per year. With a simple calculation, it seems that increasing HAL to12 tons give a positive value.

However, by increasing the load by 20%, that will give a positive economic value, certainly will not completely solve the problems technically because there are other impacts, such as: decreasing vehicle speed, decreasing vehicle safety, reduced service life of vehicles, and other things that need to be considered thoroughly. Moreover, an increase of 20% is likely to impact the readiness of the possibility for a bridge structure.

Table 5. Axle Loads Efficiency

Type of Vehicle	E				Σ E	Total Load (ton)	ALE
	group axle-1	group axle-2	group axle-3	group axle-4			
Passenger Cars (s.s)	0.0002	0.0002	0	0	0.0004	2	4,433.64
Small Bus (s.s)	0.0182	0.2923	0	0	0.3106	9	28.98
Bus (s.d)	0.2923	2.2555	0	0	2.5478	16	6.28
Truck 2-axle (s.s)	0.2923	0.2923	0	0	0.5846	12	20.53
Truck 2-axle (s.d)	0.2923	2.2555	0	0	2.5478	16	6.28
Truck 3-axle (ss.d)	0.2840	2.2555	0	0	2.5395	21	8.27
Truck 3-axle (s.dd)	0.2923	2.0362	0	0	2.3285	24	10.31
Truck 4-axle (s.s.dd)	0.2923	0.2923	2.0362	0	2.6208	30	11.45
Truck 4-axle (s.ddd)	0.2923	1.3598	0	0	1.6521	27	16.34
Truck 4-axle (s.d - dd)	0.2923	2.2555	2.0362	0	4.5840	34	7.42
Truck 4-axle (s.d + d.d)	0.2923	1.4798	1.4798	1.4798	4.7318	33	6.97
Truck 5-axle (s.s.ddd)	0.2923	0.2923	1.3598	0	1.9444	33	16.97
Truck 5-axle (s.dd - dd)	0.2923	2.0362	2.0362	0	4.3648	42	9.62
Truck 6-axle (s.dd - ddd)	0.2923	2.0362	1.3598	0	3.6883	45	12.20

Furthermore, due to the excessive damage caused by heavy axle loads to the road infrastructure, and the hazards caused by overloaded vehicles, many countries such as United Kingdom, Germany, Singapore, and Malaysia have set their single axle load limit from 10 to 12 tons as shown in Table 6 [15-16]. It is argued that many countries with a successful and effective transport system have boosting their economic growth by reducing the transportation and logistics cost.

Changing the type of trucks with more axles. To see the impact of changes to overload the road damage from each type of truck is done by charging for every type of truck loads on the track due to the addition of 5% to 30%. The results of these calculations led to the addition of the traffic volume of each type of truck with a normal load, as shown in Table 7. The addition of cargo volume transported on a road to increase the number of trucks with normal load is also presented.

Table 6. Axle Load Limits in Various Countries [15-16]

Country	Axle Load Limit (Tons)
Malaysia	12
Singapore	10
Japan	11
The People's Republic of China	10
UK	10.5
Hawaii	10.9
Germany	10
Switzerland	10

Table 7. The Addition Amount of Truck Traffic Due to Increased Payload on a Road

Truck Type	Normal	Increasing load					
	0%	5%	10%	15%	20%	25%	30%
Truck 2-axle (s.s)	1.172	1.265	1.459	1.780	2.271	3.008	4.114
Truck 2-axle (s.d)	23	93	241	485	860	1.421	2.264
Truck 3-axle (ss.d)	68	129	259	472	800	1.291	2.028
Truck 3-axle (s.dd)	41	85	180	335	573	931	1.467
Truck 4-axle (s.s.dd)	5	59	174	364	656	1.092	1.748
Truck 4-axle (s.ddd)	95	138	229	380	612	958	1.479
Truck 4-axle (s.d - dd)	32	76	171	326	564	922	1.458
Truck 4-axle (s.d + d.d)	14	58	153	308	546	904	1.440
Truck 5-axle (s.s.ddd)	14	49	123	245	432	713	1.134
Truck 5-axle (s.dd - dd)	45	78	147	261	436	698	1.091

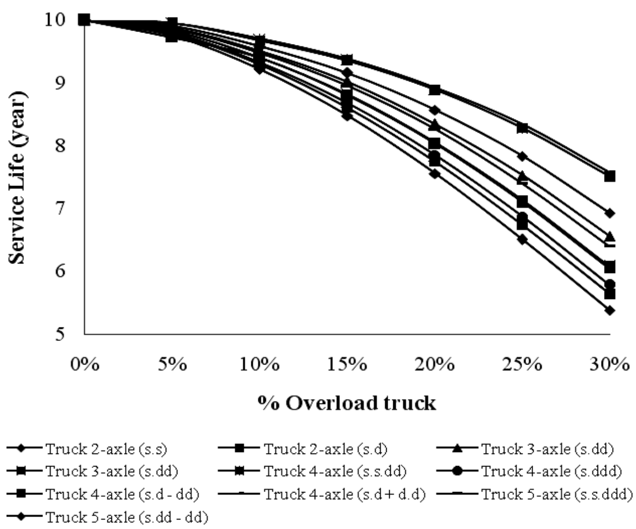

Figure 3. Chane in Service Life of Flexible Pavement Due to Overload Truck

The addition is simulated by comparing the impact of each type of truck with a normal load to increase the volume of traffic.

As explained earlier that the number of axles in trucks will deliver the load of each axle differently and more axles will cause a smaller load. In other words, the burden of every track on the road surface decreases. Figure 3 shows the burden of excessive loads from 5% to 30%. If the overloaded two-axle trucks shifted into other types of trucks that have axles more than two, the curve will show a different shape of decrease in service life of pavement structures.

Five-axis and six-axis trucks show relatively smaller decline than the two-axis, three-axis, and four-axis trucks, all curves of which show similar shape, while vehicles having two axles appears to be the type of trucks that will cause the shortest service life of pavement structures.

4. Conclusion

Excessive load tolerance policy on the basis of percentage of permitted maximum load for each type of truck is considered inappropriate due to some specific types of trucks will significantly accelerate the achievement of CESA or pavement service life. Axle configurations provide a different impact on pavement service life, because they will give a different equivalent number of axle load even for the same type of vehicle. Two-axle trucks with excessive load contribute the most to the level of road damage, especially for two-axle type of truck with rear axle load of 10 tons. To overcome the effects of overloading, the selection of trucks with more rear axles and smaller rear axle load limit than 10 tons will reduce the impact on the acceleration level of damage due to overloading. Alternative solution is to increase the axle load limit (MST) from 10 tons to 12 tons, which provides benefits economically. However, the implementation still requires several considerations, such as the strength limit of the bridge structure, the availability of trucks fulfilling such requirements, and the assurance that there will be no excess load. The fact that excess load in Indonesia has been continued to be a factor of environmental condition give rise to the need to introduce a Correction Factor for Equivalent Axle Load as high as 20-25% in the process of designing flexible pavement so as to reduce early damage to the road.

Acknowledgements

The authors acknowledge the assistance Hibah Penelitian Awal 2010 from the Direktorat Riset dan Pengabdian Masyarakat Universitas Indonesia, Contract No. DRPM/Hibah Awal/2010/I/3773.

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