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THE PHENOMENON OF ADDITIONAL LEAF SPRINGS ON GOODS TRANSPORTATION VEHICLES (TRUCKS) REVIEWING FROM OVERLOADING AND VEHICLE SPEED FACTORS

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Abstract: **The truck is land transportation that functions as effective transportation of goods in facilitating the goods distribution to all regions in Indonesia. In addition, roads play an important role as supporting infrastructure which is very important in facilitating these transportation facilities and other land vehicles. The increase in the number of leaf springs in vehicles is currently a common phenomenon among owners of goods/truck transport vehicles. The addition of leaf springs is intended so that the vehicle can carry an excess amount of goods (overload). This study aimed to find out how much overload each additional sheet of spring on the overload factor (excess load) which can trigger road damage and slow vehicle speed which can lead to traffic jams. The results on road damage research in general are the result of deflections and cracks due to excessive axle pressure and decreased vehicle speed with overload loads which cause long queues of vehicles in certain spaces and decreased ability of overloaded vehicles to climb. Control measures need to be taken for goods vehicles that increase the number of leaf springs because the addition of leaf springs allows goods transport vehicles to be overloaded which causes excessive pressure so that it is not in accordance with government regulations.**

I. INTRODUCTION

According to the Great Indonesian Dictionary, a truck is a large car with a large tub in the back which is usually used to transport goods or also known as prahoto.

The truck is a goods transportation with four or more wheeled vehicles to transport goods. In the small form, the freight car is referred to as a "pickup", then the larger form with three axles is referred to as a tronton, and for those used for transporting containers in the form of a patch, it is referred to as a trailer truck. In addition, there are types of tank trucks that are useful for transporting liquids such as fuel and others.

The current phenomenon that often occurs in society, especially among owners of freight transport (trucks) is always adding the number of leaf springs on their vehicles for reasons of safety factors. In practice, these modified vehicles have the ability to transport goods in overload beyond the technical specifications vehicle.

While the road as a place for the traffic of people, vehicles, and goods is a supporting infrastructure for the movement of land transportation. A road is vulnerable to damage when it is not used according to its specifications. Damages often occur due to overloaded vehicles (11).

Every year, almost all Indonesian roads are damaged. Residents believed that road damage was caused by poor road quality, others believed that excessive vehicle loading caused road damage, so there was the term ODOL (Over Dimension OverLoad) truck, especially the type of freight transport vehicle.

Based on this background, this research will try to provide a discussion about the causes of road damage aimed to educate the public about aspects of road users in their contribution to the process of rapid road damage.

The phenomenon of adding leaf springs seems to have become a culture for drivers and vehicle owners. This is intended so that his vehicle can be overloaded.

Even the habit of carrying excess (overloading) has become a culture for owners of freight forwarding expeditions so the phrase appears among them "no overload, no walking, no overload, no eating".

The overloading culture is also considered a way to compete in today's global economy by reducing the cost of shipping goods so that the price of goods cargo can be cheaper.

II. LITERATURE REVIEW

Of course, this overloading culture among goods transportation business actors needs to be avoided so that the infrastructure built can be durable and in accordance with the planned life. Because road damage that is too early willcertainly harm many parties and can cause traffic jams and the economy.

Fig.1. Truck Leaf Springs that have been Added 3 Pieces, Broken Due to Overload.

To prevent violations by carrying excess goods, the role of weighbridges is needed. Enforcement against overload violations on weighbridges needs to be optimized. So, the passing vehicles can be adjusted to their capacity following government regulations as follows:

a. Class I roads, namely arterial and collector roads, can be passed by motorized vehicles with a maximum width of 2.5 (two points five) meters, a maximum length of 18 (eighteen) meters, a maximum height of 4.2 (four points two) meters, and the heaviest axle load of 10 (ten) tons;
b. Class II roads, namely arterial, collector, local, and environmental roads that can be passed by motorized vehicles with a maximum width of 2.5 (two points five) meters, a maximum length of 12 (twelve) meters, a maximum height of 4.2 (four points two) meters, and the heaviest axle load is 8 (eight) tons;
c. Class III roads, namely arterial, collector, local, and environmental roads can be passed by motorized vehicles with a maximum width of 2.1 (two points one) meters, a maximum length of 9 (nine) meters, and a maximum height of 3.5 (three points five) meters and the heaviest axle load is 8 (eight) tons; and
d. Special class roads, namely arterial roads that can passed by motorized vehicles with a maximum width of 2.5 (two points five) meters, a maximum length of 18 (eighteen) meters, a maximum height of 4.2 (four points two) meters, and the heaviest axle load is more than 10 (ten) tons.

Table-1 Road Class based on Dimensions and Heaviest Axis Load (MST) (15)

No	Road Class	MST (ton)	Vehicle Dimensions (mm)		
			Wide	Length	Height
1	Class I	10	2.550	18.000	4.200
2	Class II	8	2.550	12.000	4.200
3	Class III	8	2.200	9.000	3.500
4	Class IV	< 8	2.200	9.000	3.500

Table-2 Standard JBI Requirements and Maximum Body Dimensions for Dump Trucks

No	Axis Configu ration	JBI (kg)	Lowest Road Class	Max Empty Vehicle Weight (kg)	Maximum Body Dimension (mm)	
					Length	Height
1	1.1	Up to 8.500	III	2.300	4000	700
2	1.2	Up to 16.000	I or II	3.000	5000	850
3	1.22	Up to 24.000	I or II	5.000	6000	1.000

Table-3 Standard JBI Requirements and Maximum Tank Dimensions of Tank Vehicles

No	Axis Configu ration	JBI (kg)	Lowest Road Class	Max Empty Vehicle Weight (kg)	Maximum Tank Load (kg)
1	1.1	Up to 8.500	III	2.300	6.200
2	1.2	Up to 16.000	I or II	3.000	13.000
3	1.1.2	Up to 22.000	I or II	4.200	17.800
4	1.22	Up to 24.000	I or II	5.000	19.000

Table-4 Standard JBKI Requirements and Maximum Load Weight for Trailler Vehicles

No	Axis Configu ration	JBI (kg)	Lowest Road Class	Max Empty Vehicle Weight (kg)	Maximum Payload Weight (kg)
1	1.2+2.2	Up to 31.500	I or II	6.200	25.300
2	1.2+2	Up to 26.000	I or II	5.000	21.000
3	1.2+22	Up to 42.000	I or II	10.000	32.000
4	1.2+222	Up to 45.000	I or II	12.000	33.000

And generally the road class on provincial roads is class II and class III of course the role of the weighbridge is very important here (1).
There are many ways that drivers and vehicle owners use to modify their trucks so that their vehicles can be overloaded. This is accomplished by adjusting the dimensions of the vehicle, such as the size of the tank or tub; another method is to increase the number of leaf springs on the truck, to make the vehicle look balanced from front to rear when overloaded.
Leaf springs or commonly known as flat springs are a component of the suspension system function to absorb shocks from the road and wheel vibrations so that they are not

transmitted to the vehicle body directly, increase the ability to grip tires on uneven road surfaces and provide driving comfort.
The increase in the number of leaf springs causes the vehicle's suspension to become more rigid so that the road will receive more vibrations. The addition of leaf springs also increases the ability of the springs to withstand the stress that occurs due to vehicle loading.
To determine the stress that occurs in the leaf spring can be through the theoretical equation[12]

σ $6FL/nbh^2$ (13)
Where:
σ Max voltage
F = Gravity
L = Effective Length of Spring
n = Number of Springs
b = Spring Width
h = Thickness of Spring

The addition of the number of leaf springs on the vehicle carrying goods does not necessarily mean that all of the vehicles are overloaded. However, with the addition of leaf springs on goods vehicles, the potential for these vehicles is overloaded, and this is very dangerous.
As a result, the damage causes a loss of safety and comfort for road users. Handling of road construction repairs is always carried out, but damage often occurs with the same problem.

Fig.2. ODOL Truck Controlled Body Cutting During Department of Transportation Control(12).

Therefore, monitoring of road users needs to be carried out optimally and researched related to the causes of overloaded vehicles that can trigger road damage (10).
The performance of a freight vehicle can be seen from the value of the engine power, or the maximum speed and ability of the vehicle to carry loads. Where the relationship between engine power and vehicle speed is very influential on the ability of the vehicle to transport goods, which is formulated in the following form:

$P=m. V$
Where:
P = Engine power
m = Total mass of the vehicle
V = Maximum speed of the vehicle

The relationship between the mass of the vehicle and its speed can also be formulated in the form of the Kinetic Energy equation as follows:
$EK=1/2m.V^2$

Where:
EK = Kinetic Energy Maximum of Vehicle
m = Mass of Vehicle
V = Vehicle Speed

Every vehicle that follows the phenomenon of adding leaf springs and being able to be loaded in overload is certainly very influential on the workload of the vehicle engine because the addition of the vehicle load causes the engine to work harder.

III. RESEARCH LOCATION

The location of research was conducted in the Palembang container terminal parking lot. Sampling was done by shooting the vehicle spring so it does not interfere with loading and unloading activities.

IV. RESEARCH METHODS

The object of research is the spring component of a freight vehicle that is queuing up in the Palembang Boombaru container area.
The research is mainly for tronton-class cargo vehicles with two axles. Because, this vehicle has a large size/dimension of a truck with a small number of axles with the assumption that it will put greater pressure on the road surface compared to a goods vehicle with the same dimensions with more axles or axles.
The study began by counting the number of leaf springs installed on each truck vehicle and continued by comparing it with the number of standard leaf springs installed from the factory.
The research flow chart is shown in Figure 3.

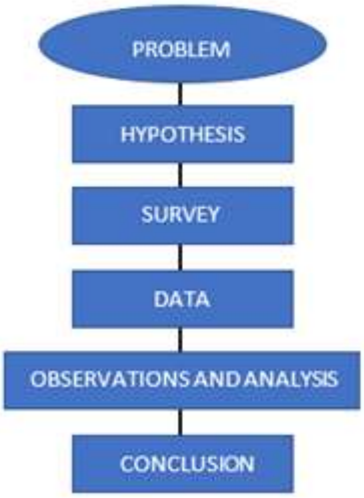

Fig. 3. Research Flowchart

V. HYPOTHESIS

With the development of the economy, vehicles as a means of transportation are also growing, which is indicated by the increasing number of types, dimensions, and engine power of goods-carrying vehicles.

This creates a phenomenon for drivers and owners of goods vehicles with the paradigm that transportation business efficiency can be achieved if the vehicle can load "large quantities" of goods in one trip. So, the drivers and owners of these vehicles change and modify their vehicles by adding dimensions and adding leaf springs to increase the ability to carry their vehicles.

With these conditions, it can be hypothesized that the addition of leaf springs for goods transporting vehicles operating on the highway can increase the road damage factor (overloading), which causes a reduction in the design life of the road, causes congestion due to reduced speed and ability of the vehicle to accelerate and decreases the ability to maneuver on the road.

VI. FIELD SURVEY

To complete the study data, it is necessary to make direct observations in the field regarding the addition of springs from each surveyed freight vehicle compared to the original configuration.

The addition of each leaf spring sheet will certainly increase the carrying capacity of goods. The addition of the spring is calculated to increase its ability to support the load loaded in the vehicle's body for each heaviest axle.

VII. DATA AND CALCULATION

The leaf spring survey data from each vehicle was presented in Appendix 1. This data is leaf spring data from a mixed survey of various vehicle brands.

The leaf spring calculation was conducted on the vehicle with the most survey results with the assumption that the largest number will be able to represent the leaf spring calculation for other vehicles using the same method. And the data from the calculation of the addition of vehicle leaf springs to be studied were presented in Appendix 2.

Fig. 4. Main Leaf Spring and Helper Spring on Hino 500 Fg260 (21)

The calculation of maximum load carrying capacity of the goods transporting vehicle is calculated through the approach of the load that can be borne by each set of leaf springs according to the number of leaf springs added, compared to the initial carrying capacity of the vehicle according to the factory design plan.

Table-5 Dimensions of Hino 500 FG 260 leaf springs Based on measurements

Spring Number	Length L (mm)	Width b (mm)	Thick h (mm)
1	1590	80	13
2	1560	80	13
3	1560	80	13
4	1100	80	13
5	950	80	13
6	750	80	13
7	730	80	13
8	520	80	13
9	400	80	13
10	230	80	13

Leaf springs are generally made based on appropriate material standards, namely alloy steel with 50 Cr: 50 Cr I V23 and 55 Si 2 Mn 90 using a quenching process at a predetermined temperature. The stresses that can be borne by the material are Ultimate Tensile Strength ranging from 168-220 (kg/mm), Tensile Yield Strength ranging from 154-189 (kg/mm), with a hardness on the Brinell scale ranging from 461-601(19).

To find out the stress that can be borne by the spring circuit, it can be calculated by the following equation:

$=6.F.L/nbh^2$ (13)

So the maximum load that can be borne by the leaf spring arrangement is:

$F= .nbh^2/6L$
Where: σ
$2L= 2L_1 – l$

Where:
L_1=Half spring length
l=Spacing of U bolt spring fastening (83mm for Hino 500FG260)
Vehicle leaf springs work in synergy between the wheels on each axle. With the heaviest load distribution located on the rear axle.
In general, the phenomenon of adding leaf springs was done by adding springs number 3 to the main spring, according to the data in Appendix 1. and also by adding springs number one to the extra leaf spring series.
From these equations and data from Appendix 1, a table of the load that can be borne by the wheel axis can be made in each set of additional springs as follows:

Table 6. Maximum load that can be borne by leaf springs according to the number of additional springs and the length of the spring.

Additional Number of Springs	Additional Spring Length (mm)	Additional Charges Generated for	
		One Wheel (Kg)	One Axis (Kg)
1	1560	512,61	1025,02
2	1560	1025,02	2050,04
3	1560	1537,61	3075,06
4	1560	2050,44	4100,02
5	1560	2563,05	5125.02
6	1560	3075,66	6150,12

While the leaf springs added to the Extra leaf springs are generally Extra leaf springs number 1 which is added into several sheets. Each sheet can bear the following loads:

Table 7. Additional Charges that can be Generated.

Additional Number of Helper Springs	Helper Spring Length (mm)	Additional Charges Generated for	
		One Wheel (Kg)	One Axis (Kg)
1	1130	662,9	1325,8
2	1130	1325,8	2651,6
3	1130	1988,7	3977,4
4	1130	2651,6	5302,4

From the literature released by the manufacturer of the Hino Hino 500 FG 260 data obtained the following data(21):

Maximum Speed (V): 108 Km/h
Maximum Power (P): 265/2,500 PS/Rpm
Maximum torque (T): 82/1,500 Kgm/Rpm
Empty Weight (m1) : 5,480 Kg
Total Vehicle Weight (m2) : 16,000 Kg

The vehicle has an engine with a constant power so that it also has a fixed maximum energy at that time and speed, according to the law of conservation of energy, it can be formulated in the following equation:
P1=P2
$m_1. V_1=m_2. V_2$
$V_2=m_1.V_1/m_2$
$=5480 .108/ m_2$ Km/Jam
So, total weight change of the vehicle due to the increase in the load causes the vehicle speed to decrease. The magnitude of the decrease in the maximum speed of each surveyed vehicle for each additional spring shown in Appendix 2

VIII. HYPOTHESIS TEST

Hypothesis testing was conducted on vehicles with the highest number of units based on survey results with the addition of leaf springs based on the few axes.
The reason for testing the hypothesis on the vehicle is based on the hypothesis that increasing the number of leaf springs will increase the carrying capacity with a small number of axes or provide an excessive compressive load on the road.

IX. OBSERVATION AND ANALYSIS

All the maximum ESA values of the freight vehicle after the addition of the leaf springs are above the preset ESA (8.16 tons) when overloaded.
Every road user should comply with road regulations, namely traffic traffic regulations or road class user regulations.
Vehicles that have been added with leaf springs have the ability to be overloaded, besides having the ability to damage the road, it will also reduce the ability of road services. Because an overloaded vehicle reduces its maximum speed and reduces its ability to maneuver on the road.
The causes of road damage are complex. However, a state administrator must provide and maintain road transport infrastructure so that it is durable following the planned age.

X. CONCLUSION

From the above discussion, especially the attached data, the following conclusions can be drawn:
1. Each addition of leaf spring sheets can increase the carrying capacity of goods transport vehicles,
2. Goods transport vehicles can loaded with Over Dimension and Over Load if the vehicle modified with

additional springs on the leaf springs, for this reason, it is necessary to regulate and supervise the authorities regarding the addition of leaf springs for goods transport vehicles, because these vehicles have the potential to be overloaded when there is no supervision from the authorities,

3. An increase in the carrying capacity of goods without an increase in engine power causes a decrease in the speed of goods transporting vehicles,
4. The higher ESA value that exceeds the standard ESA value (8.16 tons) has the potential to reduce the design life of the road,
5. If the dimensions control of the tailgate was conducted with the consideration the addition of dimensions can allow the truck to be overloaded, the addition of leaf springs must also be controlled because the addition of leaf springs to a freight vehicle also has the potential for the vehicle to be overloaded.

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Appendix 1.

Data on Leaf Springs for Goods Transport Vehicles

No.	License plate	Vehicle Brand	Number			Standard Number of Springs (Based on Factory Data)			Number of Spring Additions				
									Front		Back		
			Axle	Wheel	Tire	Front	Back	Helper	Springs No3	Springs No4	Springs No 3	Springs No 4	Springs Helper
1	BG 82.. UA	HINO 500	2	4	6	10	10	10	1	0	3	0	2
2	BG 82.. OI	HINO 500	2	4	6	10	10	10	1	0	4	0	1
3	BG 82.. EU	HINO 500	2	4	6	10	10	10	1	0	3	0	1
4	BG 83.. UV	HINO 500	2	4	6	10	10	10	1	0	3	0	2
5	BD 83.. KB	HINO 500	2	4	6	10	10	10	1	0	4	0	2
6	BG 83.. UB	HINO 500	2	4	6	10	10	10	1	0	4	0	1
7	BG 82.. AC	HINO 500	2	4	6	10	10	10	1	0	3	0	1
8	BH 82.. CU	HINO 500	2	4	6	10	10	10	1	0	3	0	2
9	BH 89.. CU	HINO 500	2	4	6	10	10	10	1	0	3	0	3
10	BH 89.. CU	HINO 500	2	4	6	10	10	10	1	0	3	0	1
11	BH 82..CU	HINO 500	2	4	6	10	10	10	1	0	4	0	2
12	BG 85.. RB	HINO 500	2	4	6	10	10	10	1	0	2	0	0
13	BG 83.. VI	HINO 500	3	6	10	10	10	10	2	0	3	0	2
14	BG 83.. VN	HINO 500	2	4	6	10	10	10	1	0	5	0	0
15	BG 86.. IB	HINO 500	3	6	10	10	10	10	1	0	2	0	3
16	BG 81.. CJ	HINO 500	2	4	6	10	10	10	1	0	3	0	0
17	BG 83.. BB	HINO 500	2	4	6	10	10	10	1	0	4	0	0
18	BG 82.. --	HINO 500	2	4	6	10	10	10	1	0	3	0	1
19	BG 83.. –	HINO 500	3	6	10	10	10	10	2	0	3	0	0

Note :

1. Survey Location: Around Palembang's Boom BaruContainer Terminal
2. The license plate number is disguised according to the agreement with thevehicle owner/driver

Appendix 2.

Calculation Results for Adding Leaf Springs

No.	License plate	Vehicle Brand	Number of Spring Additions Based on Survey Results			Max Weight which the Additional Spring can bear (Kg)			Additional Weight The Axle Can Bear (kg)		GVWR Hino 500 FG235	Maximum Total Weight That Vehicle Springs Can Bear (kg)	Max Speed Vehicle when Loaded according to Total Weight Max. Bearable (KM/H)
			Front	Back	Helper	Front (PD)	Back (PB)	Helper (PH)	Front (2PD)	Back (2PB+2PH)	(kg)	(kg)	
1	BG 82‥	HINOF	1	3	2	512,61	1537,61	1325,80	1025,02	11453,3	1600	28478,32	20.78
2	UA	G235	1	4	1	512,61	2050,44	662,90	1025,02	2	1600	27876,66	21.23
3	BG 82‥ OI	HINOF	1	3	1	512,61	1537,61	662,90	1025,02	10851,6	1600	25826,74	22.92
4	BG 82‥	G235	1	3	2	512,61	1537,61	1325,80	1025,02	4	1600	28478,32	20.78
5	EU	HINOF	1	4	2	512,61	2050,44	1325,80	1025,02	8801,72	1600	30528,26	19.39
6	BG 83‥	G235	1	4	1	512,61	2050,44	662,90	1025,02	11453,3	1600	27876,66	21.23
7	UV	HINOF	1	3	1	512,61	1537,61	662,90	1025,02	2	1600	25826,74	22.92
8	BD 83‥	G235	1	3	2	512,61	1537,61	1325,80	1025,02	13503,2	1600	28478,32	20.78
9	KB	HINOF	1	3	3	512,61	1537,61	1988,70	1025,02	4	1600	31129,94	19.01
10	BG 83‥	G235	1	3	1	512,61	1537,61	662,90	1025,02	10851,6	1600	25826,74	22.92
11	UB	HINOF	1	4	2	512,61	2050,44	1325,80	1025,02	4	1600	30528,26	19.39
12	BG 82‥	G235	1	2	0	512,61	1025,02	0	1025,02	8801,72	1600	21125,10	28.02
13	AC	HINOF	2	3	2	1025,0	1537,61	1325,80	2050,04	11453,3	1600	19193,36	30.84
14	BH 82‥	G235	1	5	0	2	2563,05	0	1025,02	2	1600	27275,04	21.70
15	CU	HINOF	1	2	3	512,61	1025,02	1988,70	1025,02	14104,9	1600	29079,90	20.35
16	BH 89‥	G235	1	3	0	512,61	1537,61	0	1025,02	2	1600	23175,14	25.54
17	CU	HINOF	1	4	0	512,61	2050,44	0	1025,02	8801,72	1600	25225,06	23.46
18	BH 89‥	G235	1	3	1	512,61	1537,61	662,90	1025,02	13503,2	1600	25826,74	22.92
19	RB BG 83‥ VI BG 83‥ VN BG 86‥ IB BG 81‥ CJ BG 83‥ BB BG 82‥ – BG 83‥ –	G235 HINOF G235 HINOF G235 HINOF G235 HINOF G235 HINOF G235 HINOF G235 HINOF G235 HINOF G235								2 10250,0 4 12054,8 8 6150,12 8200,04 8801,72 6150,12			