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ANALYSIS OF COST OF ROAD INFRASTRUCTURE MAINTENANCE CAUSED BY OVERWEIGHT GOODS TRANSPORTATION IN PRIMARY ARTERIAL ROADS

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1. INTRODUCTION

Transport system technology contributes to increased capacity and speed of transport, which has an impact on increasing the volume of people and goods transported. Road freight transport vehicles significantly increase their carrying capacity, while the carrying capacity of the road does not increase as fast as the vehicle's carrying capacity increases. The road network in Indonesia so far has the highest classification as a road with the heaviest Axis Load (MST) carrying capacity of 10 tons. Only a small portion of roads in Indonesia have a classification with carrying capacity of 10 tons of MST, especially primary arterial roads. According to Law No. 22 of 2009 concerning Road Traffic and Transportation Article 19. arterial roads and primary collectors must have MST carrying capacity of 10 tons. If all arterial roads in Java already have classifications as class I roads (MST carrying capacity of 10 tons), overloading as a result of increased demand can be accommodated. This is a form of infrastructure support to encourage national economic growth.

Straus and Semmens (2006), calculate the cost of damage due to overload based on the amount of costs required to carry out the Supervision Program with portable weighing devices. Saleh et al. (2008) stated that the cost of road damage due to overloading can be calculated equal to the cost of adding road pavement, proportional to the overload that must be supported. The cost of damage is certainly not fair enough to be charged equally to road users. While the purpose of analyzing the cost of maintaining road infrastructure due to overloading is to:

1. Determine the cost variables in determining the level of damage to the road
2. Determine the cost of road maintenance due to the overload of goods transportation

2. LITERATURE REVIEW

2.1. Overloading and Road Damage

Damage to road pavement due to the overload of vehicles is indicated by a decrease in the value of the road structure and a decrease in the functional value of the road. Factors of vehicles that affect the level of road damage are vehicle weight, vehicle dimensions, speed, wind pressure, vehicle axis configuration, vehicle axle type, speed, and vehicle track frequency in crossing trips. Calculation of geometry and road pavement thickness are affected by:

1. Vehicle axle load (Standard Axxle Load / SAL).
2. Vehicle dimensions (Passenger Car Unit / SMP).

3. STANDART AXLE LOAD (SAL)

Road pavement construction is planned with vehicle repetition loads in the Standard Axle Load (SAL) of 18000 lbs or 8.16 tons of single axle wheels (Single Axle Dual Wheel). In accordance with the provisions of the 2012 Ministry of Public Works Minister Decree according to figure 1.

Source: Ministry of Public Works, 2012

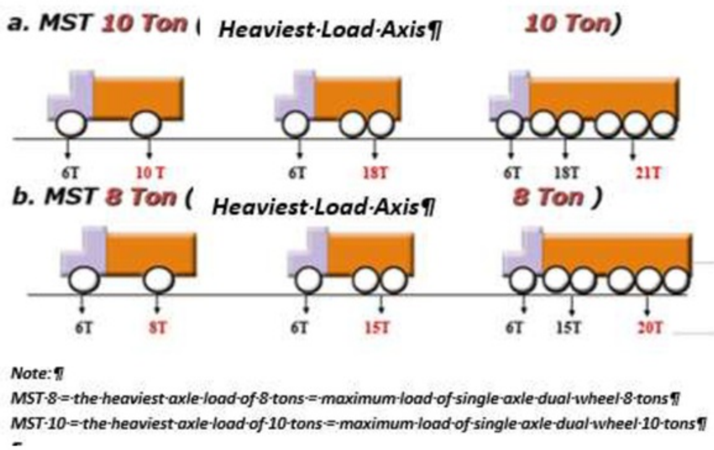

Figure 1. Vehicle Standard according to MST Classification

3.1. Impact of Overloading on Road Pavement Damage

Rahim (2000) defines the heaviest axis load is the charge axis where the destructive power (damage factor) of the pavement structure is close to or equal to one. Traffic load deviations occur if heavy vehicles carry cargo exceeding the heaviest Axis Load (MTS) that determines the amount of weight allowed (JBI). One of the impacts arising from the deviation of the load is the occurrence of a very significant destructive force. Road damage caused by the weight and trajectory of the vehicle is expressed as an equivalent number or Equivalent Single Axle Load (ESAL), which states the number of single axis trajectories weighing 8.160 kg (18,000 lbs) which will cause the same degree of damage when the axle loads one time (Department of Public Works, 1987).

3.2. Reality in the Field

1. The vehicle axle wheels vary with various vehicle shapes.
2. Various forms of axes are transformed to standard "Equivalent" single axle loads of 18,000 lbs (AASHTO, 1998).

Measuring the level of flatness of the road surface has not been widely carried out in Indonesia given the constraints of limited equipment so that evenness requirements in monitoring and evaluating existing road construction cannot be carried out properly according to national road standards. Measuring the level of road surface evenness can be measured using various methods / methods that have been recommended by DGH or AASHTO. The road surface flatness measurement method known in general is the NAASRA method (SNI 03-3426-1994). Other methods that can be used for measurement and analysis of pavement flatness are Rolling Straight Edge, Slope Profilometer (AASHO Road Test), CHLOE Profilometer, and Roughometer (Yoder and Witczak, 1975). Criteria for Assessing Road Conditions Based on IRI and SDI Values are listed in table 1.

Table 1 Criteria for Assessing Road Conditions Based on IRI and SDI (Ministry of Public Works, 2011)

IRI (m/km)	SDI			
	< 50	**50 -100**	**100 - 150**	**>150**
<4	Good	Moderate	Light damage	Severely damaged
4 - 8	Moderate	Moderate	Light damage	Severely damaged
8 - 12	Light damage	Light damage	Light damage	Severely damaged
> 12	Severely damaged	Severely damaged	Severely damaged	Severely damaged

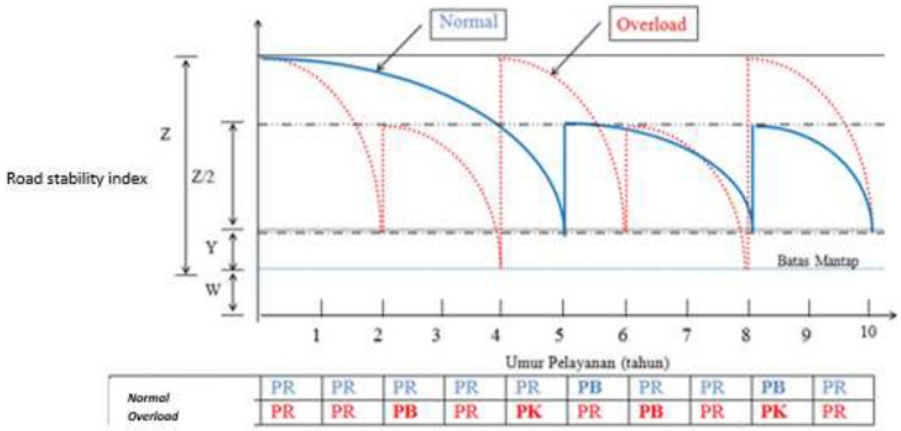

Figure 2 Concept of Decreasing Road Stability

Source: Department of Public Works, 2001

Where:

W = The lowest stability condition that must be carried out by increasing work

Y = The lowest stability condition that can still be done with periodic maintenance

Z = Stability conditions that are targeted if improvement work is carried out

Z / 2 = Amount of addition of road stability due to periodic maintenance work

PR = Routine Maintenance;

PB = Periodic Maintenance;

PK = Improved Work

The budget allocation for road handling is generally done to handle a road in such a way that the age of the road plan is capable of serving traffic flows for 10 years. However, heavy vehicles with excess cargo (overloading) have resulted in the age of the road plan not being reached or the service life is smaller than the planned age target. This can result in losses if viewed from the side of road investment. To determine the amount of loss caused by overloading heavy vehicles, several criteria need to be set as follows:

1. Under normal conditions (underload), routine maintenance is carried out every year while periodic maintenance is carried out in the 6th and 9th years, when periodic maintenance is carried out automatically routine maintenance is not carried out.

2. Periodic maintenance has the effect of increasing road stability by half of road improvement work, while routine maintenance does not have an effect on road improvement.

3. Cost loss analysis due to decreasing road service life than planned (Deficit Design Life Cost or DDLC) assessed based on decreasing road service life from 10 years to 2 years (having a deficit of 8 years) (Rahim, 2000).

Based on these criteria, a scheme for decreasing road stability under normal conditions and overloading conditions such as Figure 8 decreases road stability due to overload. Cost loss due to reduction in road service life (deficit design life cost) is obtained from the cost of handling the road in overloading conditions minus the cost of handling the road under normal conditions. During the 10-year period of road planning, the cumulative loss of costs incurred by truck overloading resulted in a service life of 2 years. The total cost loss for each road segment surveyed in this study for a period of time decreased road stability for 8 years.

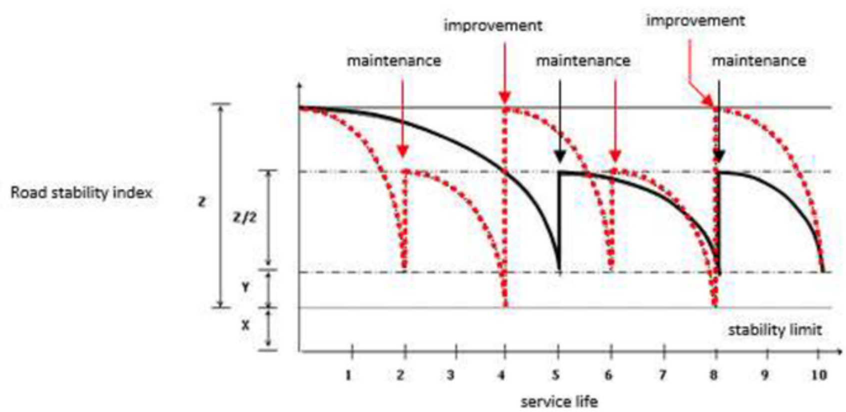

Figure 3 Decreasing Road Stability Due to Overloading

SOURCE: DEPARTMENT OF PUBLIC WORKS, 2001

Cost loss due to vehicle overloading burden charged to road users. The cost loss charged by the car user is the amount of DFC and DDLC. Accordingly, the cost of road damage is due to the overload of vehicles that are needed to know the effect of the effect of more loads. So that the officers supervising the use of roads with cargo can better know the risks that occur in the form of loss of costs and the public road users can know the actual conditions that occur in the field. The research that has been done is as follows.

A study from Helmi (1999) shows the formula for breaking the wheel of a vehicle from several countries and institutions. In the world of road pavement technology, there are many formulas for Damage to Vehicle Loads which vary both in form and results of calculations. From the Damage Power formula reviewed in particular AASHTO, Bina Marga and NAASRA for the three axes provide general results as follows:

(1) Single axle (8.0 Tons): not much different.

(2) Tandem axle (15.0 Tons): not much different.

(3) Triple axle (20.0 Tons): a lot different.

The effect of overload on the increase in damage power is far greater than the percentage increase in the load being violated, especially the Single Axle Truck.

Another study reveals for capturing the role of road user groups has the potential for participating in the implementation of roads on the Simpang Lago-Batas Road in Indragiri Hulu, Riau Province (Anas Aly & Helmi, 2002).

(1) In the era of "new Paradigms" relating to the government, one of the comparisons is the increasing role of the community and the decreasing role of the government.

(2) The contribution of funds to increase and maintain the road proportionally from investors to the overload due to the transportation of the company, has not been proportional to the damage to the road that occurred.

Analysis of the Directorate of Technical Development of the Directorate General of Highways (1995) Damage to the factor of wood transport vehicles is very large, which is an average of 10 times greater than the damage to public transport factors.

Analysis of the effect of overloading on road performance and general flexural pavement plans on the Pringsurat road, Ambarawa-Magelang (Simanjuntak, 2014) With more loads obtained a decrease in Age of Pavement Plans from the beginning of planning to 10 years to service life of 5.6 year so that if the load is left continuously then the age of service will be damaged. This caused losses in the economic terms. The calculation results follow the allowable 10-year prediction with i = 4.78% obtained by the standard axis accumulation of 49.436.988.7379 ESAL while the existing traffic reality is charged with a 10-year prediction with i = 4.78% obtained by standard axis accumulation 85.635.326. 5942 ESAL. If allowable load (JBI) is a 10-year planned additional pavement thickness of HOL = 2.932 cm and if the actual load of HOL overload is 5.584 cm.

The potential influence of overloading load on pavement on the Lubuk Pakam, North Sumatra (Dani, 2016) road results of vehicle load overload due to the highest wind pressure is 3.06 x 105 for crack criteria and 4.72 x 106 for flow criteria, the majority of load repetitions that occur are much smaller than the standard load (8.16 Ton) so that they reach faster damage and reduce the functional performance of the pavement represented by the RCI value. In the case of the most extreme overloading that occurs in the type of heavy vehicle type 6B can reduce the life of the pavement plan up to 96.78% for crack criteria and 95.85% for groove criteria.

4. RESEARCH METHODS

With a quantitative analysis method, literature studies in order to maintain the quality of services need to analyze variables from primary and secondary data sources from the field. Research requires appropriate methods, processes and data collection, collection and processing and analysis so as to produce new ideas. The problem is why more load occurs, whether the load is more common in the area, whether the cause is, whether there have been attempts to overcome, who is handling it and others. Phenomena that occur require answers through a study. Data on road conditions were obtained from the field according to the Road Pavement Survey Manual of the Ministry of Public Works. Field survey data are in accordance with Minister of Public Works Regulation No.15 / PRT / M / 2007 concerning Guidelines for Surveying Land and or Krikil Road Conditions and the condition of Detailed Paved Roads for Intercity Roads.

The cost of road damage due to overloading on eastern cross roads is a growing phenomenon at this time. Increased traffic volume of vehicle goods and technology, which is not supported by supporting road infrastructure, causes road damage to occur more quickly. As mentioned earlier, road damage, besides being caused by overloading, is also caused by several other factors, such as: vehicle volume, implementation process, drainage conditions, maintenance and strength of subgrade. The level of road damage can be measured by several indicators, such as: IRI, Surface Index. Overloading affects road damage differently according to road segments. This relates to the conditions of the road segment in question, related to vehicle volume, subgrade strength, drainage conditions, maintenance.

The cost of road damage can be calculated based on the amount of costs needed to maintain the condition of the road in a stable condition, or the difference between the cost of building a road with a normal load and with more load, according to the conditions of the road being reviewed. Road users certainly cannot be burdened with the cost of damage caused by poorly worked out pavement, or the non-functioning of drainage. The cost of this damage is expected to be calculated and charged to the users proportionally, according to the excess weight of the goods transported and the distance traveled. The greater the excess weight and the farther the hauling distance, the driver (the shipper) must pay more. Determining the cost of damage that will be charged to fair and rational road users is an important stage, so that the policy of overloading fines can be accepted by all interested parties.

In calculating overloaded fines, it is necessary to take into account the distance traveled by vehicles carrying goods. Characteristics of goods transported, overloaded, origin and destination of vehicles become important data in this study. In general, data or research variables in this study are:

1. Road conditions (level of damage, subgrade conditions, thickness of pavement, track record of road maintenance, drainage conditions).

2. The origin of the goods transport vehicle, the weight of the cargo, the type of commodity being transported.

The research data or variables mentioned above are collected directly in the field through observations, obtained from authorized institutions (Transportation Agency and Public Works Agency). Traffic data on goods and road conditions are series data, and represent all national roads and road collectors in Riau Province.

The road user population used in this study is a vehicle that has the potential to transport by means of overloading, types of freight trucks and tank trucks (oil and CPO). The amount of data obtained by the effect of its destructive power is analyzed according to the cost of the pavement structure. Sampling from

1. Weigh bridges on national roads and provincial roads.

2. Regional regulations regarding compensation for more cargo in the Province that has implemented it.

The place of research was carried out in Riau Province on National and Provincial Roads under the supervision of the Ministry of Transportation, the Ministry of Public Works and the East Sumatra Cross Road (Jalintim) in Riau Province. Controlling agency in the Riau Provincial Transportation Agency, Riau Province Public Works Agency and Riau Province Trade and Industry Office. Analysis of more vehicle loads is carried out with financial analysis so that the required variables and indicators of cost and parameters for each load are due to overload. Factors in the study meant events that affect the occurrence of overloading of vehicles that actively contribute to overloading. The parameters in the study are those that limit or base variable performance of pavement. Data in the form of:

1. Traffic volume per day from the Provincial P3JJ from the Riau Provincial Public Works Service.

2. The dimensions of the vehicle and the heaviest load weight of the vehicle from the Riau Province Transportation Agency.

3. Results of measurements of vehicle weight at weigh bridges in Riau Province.

5. RESULTS AND DISCUSSION

From the field survey data obtained from 2004 to 2014. the results of the SDI equation function of the BiPeb BiPer BiPer obtained for all national road segments on the eastern cross are shown in Table 2 as follows.

5.1. The Relationship between Damage and Costs of Road Improvement and Construction

Damage analysis and road handling costs are influenced by the following variables:

1) Surface Distress Index (SDI)

2) BiPer: Cost of Planning and Supervision / every Kilometer

3) BiPeb: Implementation Costs for Road Construction / every Kilometer

4) BiPem: Implementation Costs for Road Maintenance / each kilometer

The results after regression analysis and multiple correlation were obtained from R Square. From field surveys, data from 2004 to 2014 are found in the appendix. The results of the SDI equation function of BiPer, BiPeb, BiPem obtained for all national road segments are shown in Table 2.

Table 2 Equations generated from the SDI analysis function from BiPer, BiPeb, BiPem

NO	Segment	Road Name	Equation	R Square
1	001	Bts Sumut - Baganbatu	SDI= 31.31.1687 + 0.1615 BiPer - 0.0077BiPeb -0.0029 BiPem	0.08739
2	002	Baganbatu – Simpang. Balam	SDI= 54.03197+ 0.079076BiPer - 0.00489BiPeb -0.49912BiPem	0.45714
3	003	Simpang. Balam – Simpang. Batang	SDI= 17.8939+ 0.073461BiPer +0.002664BiPeb -0.0433BiPem	0.16091
4	004	Simpang. Batang – Bts. Dumai	SDI= 16.48791 -0.08122BiPer +0.000999BiPeb +0.00511BiPem	0.27311
5	005	Bts. Dumai – Simpang. Terminal	SDI= 13.5237+ 1.059613BiPer - 0.01242BiPeb +0.02525 BiPem	0.78400
6	006	Simpang. Batang – Simpang. Kulim	SDI= 67.68524-1.68292BiPer +0.027189BiPeb -0.04372BiPem	0.61139
7	007	Bts. Dumai – Duri	SDI= 57.32926- 0.29362BiPer - 0.005BiPeb + 0.023476BiPem	0.43116
8	008	Duri – Kandis	SDI= 25.65432- 0.61442BiPer + 0.024367BiPeb + 0.00947 BiPem	0.41478
9	009	Kandis-Bts. Kab. Bengkalis	SDI= 44.75807- 1.42248BiPer + 0.023541BiPeb + 0.007325 BiPem	0.55619
10	010	Bts. Kampar – Sikijang Mati	SDI= -6.29358 + 0.686011BiPer - 0.01122 + 0.016927BiPem	0.47415
11	011	Sikijang Mati – Simpang. Lago	SDI= 18.95744+ 0.619345BiPer - 0.01843BiPeb +0.014547BiPem	0.73198
12	012	Simpang. Lago – Sorek 1	SDI= 4.056866+ 0.642412BiPer - 0.00794BiPeb +0.009438 BiPem	0.66363

NO	Segment	Road Name	Equation	R Square
13	013	Sorek 1 – Bts. Inhu	SDI= 11.34716+ 0.481314BiPer - 0.00564BiPeb +0.023726 BiPem	0.85478
14	014	Bts. Inhu – Simpang. Japura	SDI= 13.81279+ 0.367638BiPer + 0.000467BiPeb +0.022762 BiPem	0.83754
15	015	Simpang. Japura – Pematang Reba	SDI= 17.57592+ 0.145203BiPer - 0.00031BiPeb +0.007308BiPem	0.07474
16	016	Pematang Reba – Siberida	SDI= -1.22223+ 0.456558BiPer - 0.00046BiPeb +0.004583 BiPem	0.64536
17	017	Siberida – Bts. Jambi	SDI= -101.082+ 0.504713BiPer +0.03209BiPeb +0.056836BiPem	0.93421
18	018	Jln. Subrantas – Bts. Kampar	SDI= 6.790162-0.01821BiPer + 0.002399BiPeb +0.007638 BiPem	0.57654
19	019	Bts. Kampar – Bangkinang	SDI= 13.84462-0.20428BiPer + 0.002904 BiPeb + 0.032515 BiPem	0.45589
20	020	Bangkinang – Rantau Berangin	SDI= 15.83232-0.43091BiPer + 0.040524BiPeb +0.03022 BiPem	0.46526
21	021	Rantau Berangin – Bts. Prov. Sumbar	SDI= 15.82181-0.5875BiPer + 0.015869BiPeb + 0.047068 BiPem	0.51397
22	022	Marpoyan – Bts. Kuansing	SDI= 32.47458+ 0.101786BiPer - 0.00934BiPeb +0.044872 BiPem	0.24309
23	023	Bts. Kuansing – Ma. Lembu	SDI= 8.707744+ 2.382933BiPer + 0 BiPeb - 0.0427BiPem	0.65977
24	024	Ma. Lembu – Taluk Kuantan	SDI= 20.65929+ 1.30013BiPer - 0.02455BiPeb -0.07774BiPem	0.29357
25	025	Taluk Kuantan – Bts. Sumbar	SDI= 22.21198+ 2.274538BiPer + 0 BiPeb - 0.13111BiPem	0.41767
26	026	Pematang Reba – Rengat	SDI= 40.70765-0.04396BiPer -0.00498 BiPeb -0.01584BiPem	0.38568
27	027	Rengat – Kuala Cinaku	SDI= 20.49013-0.04938BiPer - 0.00029BiPeb +0.032737 BiPebel	0.71317
28	028	Kuala Cinaku – Rumbai Jaya	SDI= 32.1289-0.04775BiPer - 0.00086BiPeb + 0.034229BiPem	0.59620
29	029	Rumbai Jaya – Bagan Jaya	SDI= -19.7578+ 1.915929BiPer + 0.01741BiPeb +0.02129 BiPem	0.85844
30	030	Bagan Jaya - Kuala Enok	SDI= -1.66288+ 0.105139BiPer - 0.00675BiPeb +0.266811 BiPem	0.62923

The equation generated from the SDI analysis function from BiPer, BiPeb, BiPem from the 30 road segments concludes R Square Significant with the highest value R Square on section 017 Siberida – Jambi Bts R Square 0.93421 and the lowest R Square value on section 001 North Sumatra Bts - Baganbatu with the value of R Square 0.08739. So the BiPer, BiPeb, BiPem maintenance variables have a significant effect on SDI on roads 005. 011. 013. 0.14. 017. 027. 0.29. 030 for other roads which are more affected than the BiPer, BiPeb, BiPem variables on the value of SDI.

5.2. The right and fair method for calculating road damage costs.

Analysis of More Content on the eastern cross at the location of the company road of Simpang Logo – Simpang Japura.

5.3. Each year the cargo as processed materials for factories needed by the Company itself with its own vehicle transportation = 3.833.629.02 m3 and the Company as a buyer = 2.656.519.58 m3

The total transported = 6.490.148.60 M³ = 6.169.342.77 Tons

5.4 Types of trucks used, composition of traffic, traffic loads.

1. Single Truck (T1.2)
2. Tandem Truck (T1-22)
3. Tow Truck (T1.22 + 1.22)

5.5 Axle load and power failure configuration

Table 3 Axle load and power failure configuration

Vehicle	Truck Type	Truck Weight	Gross Vehicle Weight	Pay Load
Public transport	T1.2(R)	4.5 Tons	7.1 Tons (3.0-4.1) Tons	2.6 Tons
	T1.22(B)	5.0 Tons	16.0 Tons (6.0-10.0) Tons	11.0 Tons
	T1.22(O)	5.0 Tons	25.0 Tons (7.0-18.0) Tons	20.0 Tons
Special Vehicles	T1.2(B)	5.0 Tons	13.0 Tons (5.0-8.0) Tons	8.0 Tons
	T1.2(O)	5.0 Tons	16.0 Tons (6.0-10.0) Tons	11.0 Tons
	T1.22(B)	5.0 Tons	24.0 Tons (6.0-18.0) Tons	19.0 Tons
	T1.22(O)	5.0 Tons	43.0 Tons (8.0-35.0) Tons	38.0 Tons
	T1.22+1.22(B)	7.5 Tons	47.0 Tons (6.0-18.0-5.0-18.0) Tons	39.5 Tons
	T1.22+1.22(B)	7.5 Tons	55.0 Tons (8.0-20.0-7.0-20.0) Tons	42.5 Tons

5.6 The damage to each type of truck with each cargo

* Public Truck Vehicles

T1.2(R)/(3.0 – 4.1) = 0.02 +0.30 = 0.10 = 960 vehicles
T1.22(B)/ (6.0 – 10.0) = 0.30 +0.194 = 0.494 = 427 vehicles
T1.22(O)/ (7.0 – 18.0) = 0.540 +2.04 = 2.58 = 76 vehicles

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* Special Vehicles

Damage Factor calculation	DF	%Truck	Pay Load
T1.2(R)/(5.0 -8.0)=0.141+0.30	0.441	12%	8.0 Tons
T1.2(O)/ (6.0 -15.0)=0.3+11.278	11.578	18%	11.0 Tons
T1.22(B)/ (6.0 -18.0)=0.3+2.04	2.34	16%	19.0 Tons
T1.22(O)/ (8.0 -35.0)=0.96+29.12	30.08	24%	38.0 Tons
T1.22+1.22(B)/ (6.0 -18.0+5.0+18.0) =0.3+2.04+0.141+2.04	4.521	12%	39.5 Tons
T1.22+1.22(O)/ (8.0 -20.0+7.0+20.0) =0.96+3.099+0.540+3.099	7.698	18%	42.5Tons

Amount of traffic of each type of Truck.

T1.2 (R) = 960 vehicles

T1.B (B) = 427 vehicles

T1.2(O) = 76 vehicles

The amount of tonnage transported per year = 6,169,342.77 tons

Amount of tuck needed: to transport to the factory location

Capacity of 100 Truks (Several types) as above comparison in total weight: = 12x8.0 + 18x11 + 16x19 + 24x38 + 12x39.5 + 18x42.5 = 2.749 Tons / 100 Trucks. Thus, the needs of trucks = 6.169.342.77 x 100 / 2.749 = 224.421 trucks / year = 224.421 / 365 Trucks / Day = 614.85 Trucks / Day (29.56%).

When compared to a public truck = 1.463 TRUCK / day (70.44%). In terms of the number of trucks for factory needs, only 29.56% of the number of trucks using the road. If the Damage Factor Damage (DF) is analyzed:

General Truck Damage Factor = 503.02 / Day

Damage factor for companies = 7,158.4 / day

Compared to Public Trucks that is only 6.6%, factory trucks amount to 93.4%, damage factor utilization per day is 93.4% which is a fantastic utilization. So that, the road as a public road is used in a special way for the company.

5.7 Fairness of responsibility for damage factors is analyzed as follows.

Total damage factor = 7,158.45 / day (93.4%)

Based on the observation of the composition of damage factors as a whole that transport goods for material needs:

* T1.2 type truck with an allowable charge R = 12%
* T1.2 type truck with overload O load = 18%
* T1.22 type truck with the allowable charge R = 16%
* T1.22 type truck with overload charge = 24%
* T1.2 + 1.22 type trucks with allowable loads R = 12%
* Trucks of type T1.2 + 1.22 with loads over Overload = 18%

So the number of vehicles that do not overload 40% & the number of vehicles that overload 60%.

Table 4 Composition of Vehicle Amounts & Damage Amount Factors between General Traffic vs. Special Traffic

Amount	General Traffic	Company Traffic
Number of Trucks/day	1.463 truck 70.44%	614 Truck 29.56%
Damage Factor Number	503.02 DF 6.6%	7,158.45 DF 93.4%

From these data 93.4% of road construction capacity is seized by companies that transport processed materials to factories. Of the 93.4% of the company's traffic transport 60% traffic overload. The contribution formula model can be considered as follows:

Notation:

X1 = EAL LL. General legal; According to MST Conditions (MST 10).

Y1 = EAL LL. General illegal; > MST Provisions; Overload

X2 = EAL LL. Illegal Entrepreneurs; In accordance with MST Conditions.

Y2 = EAL LL. Illegal Entrepreneurs; > MST Provisions; Overload

EAL TOTAL = X1 + Y1 + X2 + Y2. Does not dominate

Proportion proportion (Illustration; Example):

- $X_1 + Y_1$ → General Traffic; Government burden
- X_2 = < 50% EAL total; → 100% X_2 as a private burden.
- X_2 = > 50% EAL total; → 20 % X_2 as a private burden.
- Y_2 = < 50% EAL total; → 50 %x50% Y_2=25%Y_2 as a private burden.
- Y_2 => 50% EAL total; → 75 %x50% Y_2=37.5% Y_2 as a private burden and dominating.

An application illustration of EAL contribution Formula is as follows:

1. EAL total = 503.02 + 7.158.45 = 7.661.47 (100%)
2. EAL general total = 503.02 (6.6%)
3. EAL special total = 7.158.45 (93.4%)
4. EAL special legal (<MST) = 40% < 50% → Coach? government
5. EAL special illegal (>MST) = 60% >50%

37.5% → private;

60% -37.5% = 22.5% → coach.

Government contribution as coach = 6.1% + 40% + 22.5% = 68.6%

Company / private contributions = 100%-68.6% = 31.4%

5.8.Influence and Relationship Between Planning, Development and Maintenance Costs with Road Damage

The cost is obtained from the results of sunvey in the field carried out every work unit on a road segment. The cost of tqhe survey results required from field data is greater than the ceiling of funds provided. For this reason, a priority scale needs to be carried out such as improving priorities for the layer of road surface, road shoulder, and channel. Gradual work can also be done. The handling priority on the worst-case road conditions is indicated by the value of the level of road damage in SDI

There is a difference between funding needs and availability of funds. We make efficiency there, the roads that have been built have to bear other costs, namely road repairs that are now being carried out every year. The road repairs were carried out because the load of trucks passing through the road was often excessive. At first we should be able to fund 10 years, now every year must be injected to repair the road. It means we have to be patchy there. The government must give priority to roads that do receive heavy loads on an ongoing basis to be built with reliable structures. The limited allocation of funds and additional maintenance funds that can be saved due to better road structure will make the government still able to build new roads while still referring to priority scales based on economic principles and benefits.

Planning and supervision costs are based on road length handled on road construction and maintenance. Because the cost is relatively small for the cost of building and maintaining the road, so even though it has the effect of increasing SDI, it is not large. Cost of building a large road is better so that it reduces the value of SDI. Road Construction Costs play the most role in road damage, by increasing the cost of road construction, reducing SDI value, this is illustrated from the graph of the relationship between road construction costs and SDI Road construction costs affect road damage because road conditions that have been severely damaged and lightly damaged have decreased road construction. Increasing the cost of road construction will reduce the level of road damage getting lower so that road conditions are good.

5.9. Road Planning and Supervision Costs

Costs required for the next fiscal year work planning and the cost of supervising the implementation of work in the current year. The cost of planning and road supervision is in accordance with the effective length of the road handled on the road section and the cost of supervision of the work carried out in the current fiscal year. Costs in units of rupiah prices per kilometer of handling

5.10. Road Construction Costs

Costs needed to increase the value of road construction and road pavement widening, on the road to Critical Condition Value (NKk) and Collapse Condition Value (NKr). The cost of road construction is in accordance with the effective length of the road handled on the road section. Costs in units of rupiah prices per kilometer of handling

5.11. Road Maintenance Costs

Road maintenance costs are in accordance with the functional length of the road handled on the road section. Costs in units of rupiah prices per kilometer of handling. Maintenance costs made by the work unit on the national road section based on the results of the field survey are based on observing field conditions that are adjusted to the guidelines on the standard, then recorded and adjusted according to the specified categories in the matrix of pavement damage and road shoulder and repairs. It is important to carry out maintenance activities to determine the real situation and the damage that occurs on the national road and the level of damage, so that it can be known the handling that must be done and what stages need to be done so as to return the road to its original state.

An analysis on the eastern cross section Bts Sumut – Baganbatu, Baganbatu – Simpang Balam, Simpang Balam – Simpang Batam, Simpang Batang – Simpang Kulim, Bts. Dumai – Duri, Duri – Kandis, Kandis – Bts Kab. Bengkalis Sikijang Mati – Simpang. Lago, Simpang. Lago – Sorek 1. Sorek 1 – Bts. Inhu, Bts. Inhu – Simpang. Japura get the equation according to the following Table 5:

Table 5 The equation generated from the SDI analysis is a function of Camber, ShWidthL, ShWidthR, DiDepthL, DiDepthR, DiLin, DiUnlin, SALstd, BiPer, BiPeb, BiPem on the East Sumatra Cross Road in Riau Province

No	Segment	Name	Equation	R Square
1	001. 002. 003 006. 007. 008. 009 011. 012. 013. 014	Bts Sumut – Baganbatu, Baganbatu – Simpang Balam, Simpang Balam – Simpang Batam Simpang Batang – Simpang Kulim, Bts. Dumai – Duri, Duri – Kandis, Kandis – Bts Kab. Bengkalis Sikijang Mati – Simpang. Lago, Simpang. Lago – Sorek 1. Sorek 1 – Bts. Inhu, Bts. Inhu – Simpang. Japura	SDI = 29.7749 + 34.9556 Camber + 0.0211163 ShWidthL – 0.6612517WidthR - 0.07053 DiDepthL +0.0344732DiDepthR - 0.0002727 DiLin+ 0.021952 DiUnlin + 0.0027714SALstd+ 0.0689157BiPer - 0.0011244BiPeb +0.0011924 BiPem	0.7063

From the analysis on the eastern cross section Bts Sumut – Baganbatu, Baganbatu – Simpang Balam, Simpang Balam – Simpang Batam, Simpang Batang – Simpang Kulim, Bts. Dumai – Duri, Duri – Kandis, Kandis – Bts Kab. Bengkalis Sikijang Mati – Simpang. Lago, Simpang. Lago – Sorek 1. Sorek 1 – Bts. Inhu, Bts. Inhu – Simpang. Japura it can be seen that SDI is positively affected by +Camber +ShWidthL – ShWidthR - DiDepthL +DiDepthR - DiLin+ DiUnlin+ SALstd+ BiPer - BiPeb +BiPem significantly with R Square = 0.7063 so that the price increase of 70.63% affects SDI and 29.37% by other factors.

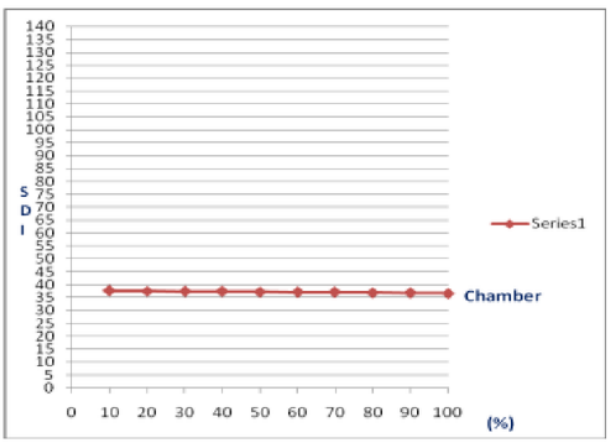


Figure 4. Graph of Chamber and SDI

Camber increases, decreases the SDI (Phase Distress Index) level of damage to the road

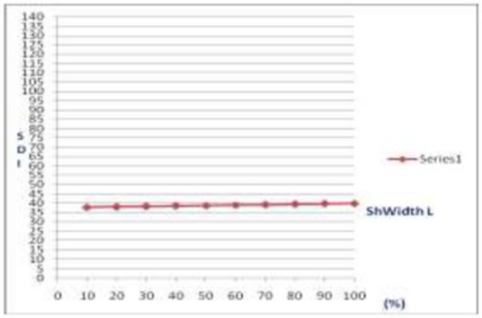


Figure 5 Graph of ShWidth L and SDI

ShWithL (the new width of the left road) rises, increasing the SDI (Surface Distress Index) value of damage to the road.

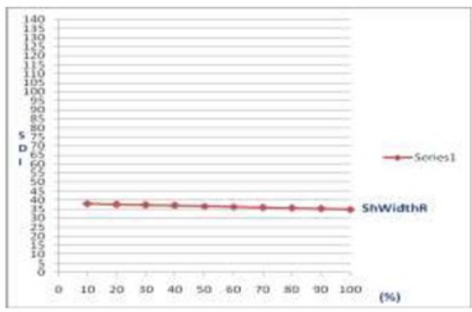


Figure 6. Graph of ShWidthR and SDI

ShWithR (the new width of the right path) rises so that the SDI (Surface Distress Index) decreases the level of damage to the road

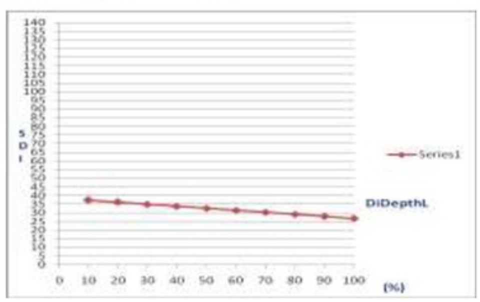


Figure 7 Graph of DiDepthL and SDI

DiDeptL (the left side channel depth) increases, reducing the SDI (Surface Distress Index) value of road damage.

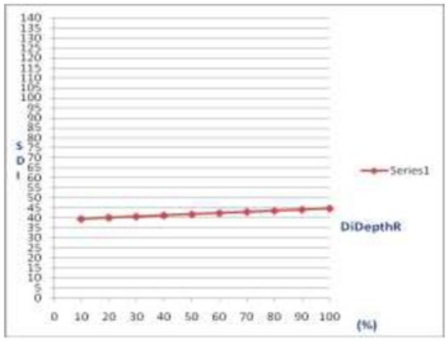


Figure 8 Graph of DiDepthR and SDI

DiDepthR (right side depth of ride) increases the SDI (Surface Distress Index) value of road damage.

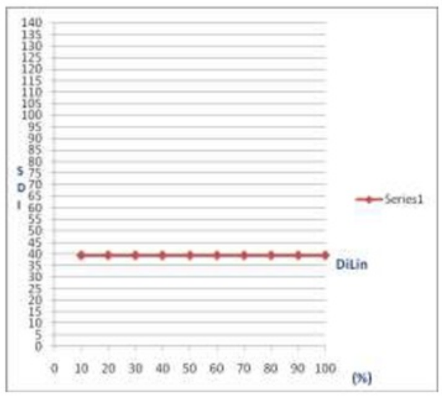


Figure 9 Graph of DiLin and SDI

Increase of DiLin (length of both sides of the channel that is hardened) increases SDI (Sufase Distress Index) level of road damage.

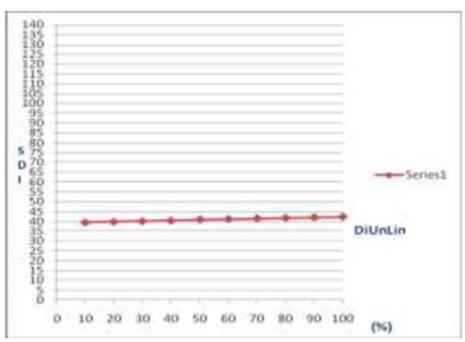


Figure 10 Graph of DiUnLin and SDI

DiUnLin will rise in line with the increase of SDI

The rise of DiUnLin (the length of both sides of the side channel is not hardened) increases SDI (Surface Distress Index) the level of damage to the road.

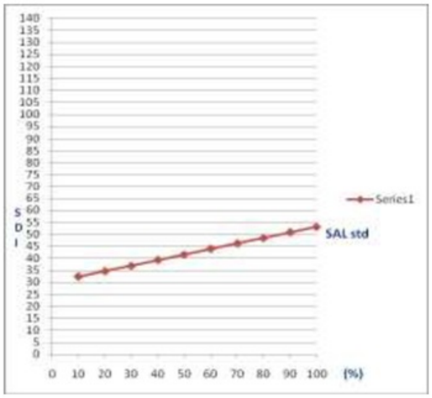


Figure 11. Grafik SAL Standard dan SDI

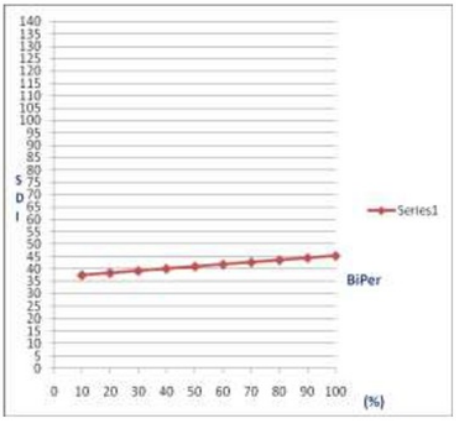


Figure 12. Graph of Maintenance Cost and SDI

The cost of planning is needed so that the road conditions are better for the SDI (Surface Distress Index) level of road damage.

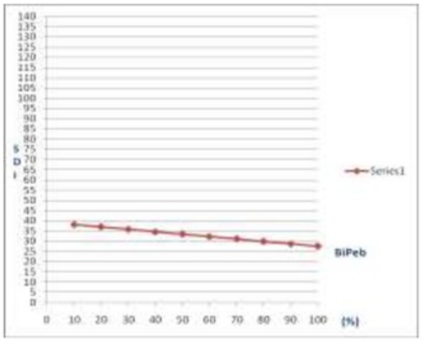


Figure 13 Graph of Road Development Costs and SDI

The increased cost of road construction (BiPem) will reduce the SDI (Surface Distress Index) value of road damage.

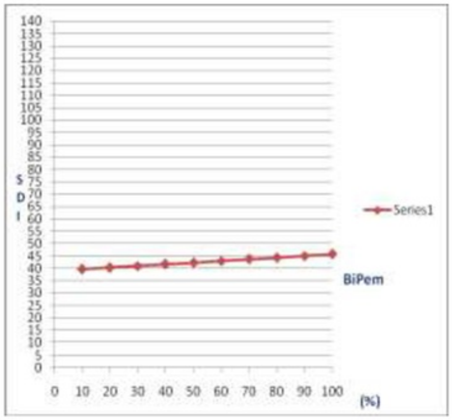


Figure 14 Graph of Road Maintenance Costs and SDI

The cost of developing maintenance will increase SDI because road conditions are not good

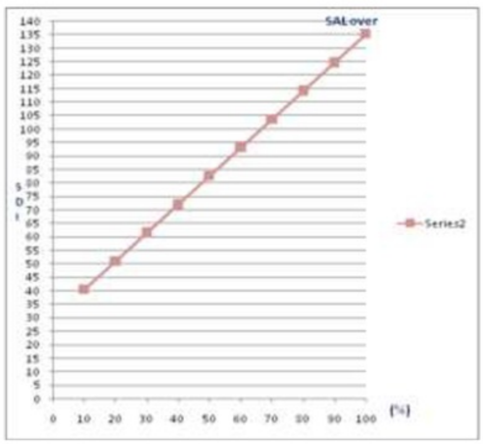
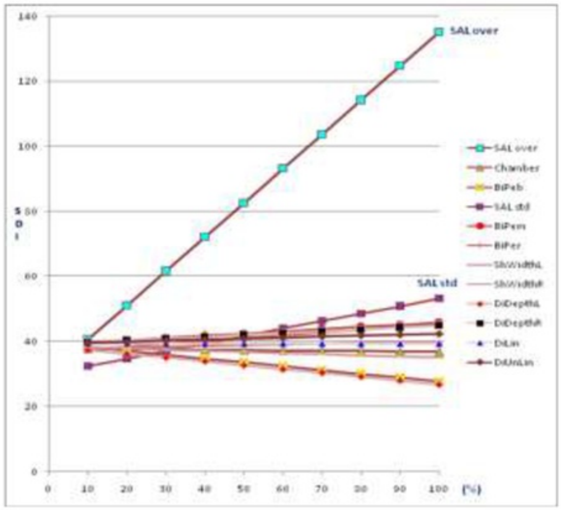


Figure 15 Graph of SAL Overload and SDI

The increase in SAL due to overload will increase SDI (Sufase Distress Index) the level of road damage will increase.

Figure 4.15. Combined Chamber Chart, Development Costs, SAL Standard, and SAL Overload and SDI



6. CONCLUSION

Based on the analysis that has been described, the results of the study suggest that the reality in the field shows that the intensity and burden of freight transport vehicles is increasing faster. The intensity can be from the amount of traffic, especially the freight truck that increases and transports the load more than the allowable freight load. This is not comparable with the government's ability to provide funds for road infrastructure. So that the funding needs for repairs in road maintenance cannot be met as needed.

Based on the results of the analysis and in accordance with the objectives of the research, conclusions can be taken as follows

1. The age of road pavement is not according to plan because the burden of vehicles passing through the road exceeds that of the allowable amount of weight. The reality in the field of trucking exceeds that of the 10 tons of the heaviest axes (MST) for the East Cross Road which are violated a lot.

2. Equation function of road conditions in SDI formula = 29.7749 + 34.956 Camber + 0.0211163 ShWidthL - 0.6612517WidthR - 0.07053 In DepthL + 0.0344732 In DepthR - 0.0002727 DiLin + 0.021952 DiUnlin + 0.0027714SALstd + 0.0689157BiPer-0.0011244BiPeb +0.0011924 BiPem

3. The government's contribution as a coach for over content is 68.6% and the contribution of the company / private sector is 31.4%

7. SUGGESTION

It is necessary to supervise the load of more vehicles to reduce the cost of maintaining a large road due to overloading of vehicles, so that the east crossing road is used according to the load in road planning so that the service road according to the age of the plan is in good condition.

ANALYSIS OF COST OF ROAD INFRASTRUCTURE MAINTENANCE CAUSED BY OVERWEIGHT GOODS TRANSPORTATION IN PRIMARY ARTERIAL ROADS

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