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The Relationship between Overloading and Over Dimension of Freight Vehicle

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***Abstract*— The freight vehicle, as the primary mode of goods distribution, has a relatively small carrying capacity. However, it is forced to be able to meet the demand. As a result, many business actors overload their freight vehicles to reduce transportation costs. In organizing the transportation of goods, the indications are such violations in vehicle dimensions (over dimensions) in line with the business actors' vehicle overload. This study aims to determine the effect of over-size on an overload of the freight vehicle. This study's research method is a quantitative method that used a survey technique to collect the data and used the statistical method of regression and correlation as the analysis method. The study results reveal that the level of overloading at Widang weighbridge reached an average of 44.72% per day. In comparison, the level of overloading at the Losarang weighbridge reached 87.85% per day. The vehicle dimension measurement survey results showed that from 159 vehicle samples, there were 107 over-dimension vehicles in the form of length, width, and height, and there were 32 vehicles, which increased their tire size. The statistical analysis of regression and correlation tests showed that only the addition of the maximum vehicle dimensions, which had a significant effect on the overweight.**

***Keywords*— Freight vehicle; over-dimension; overloading; road safety.**

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I. INTRODUCTION

Over dimension and overload (ODOL) in the goods transportation system have become a significant issue in various countries, including Indonesia, that rely on trucks to transport goods [1]. Various handling efforts have been carried out, such as strict law enforcement, the imposition of excess overload permits, and high penalty fines for perpetrators who overload their freight vehicles. Still, these efforts do not seem to provide positive results. Overloading is one of the main problems of road freight transportation. Over-dimension and overloading occur almost every day [2], [3].

These problems increasingly alarm. Panturapost.com reported two traffic accidents on the flyover of Kretek Bumiayu Brebes [4]. The first accident was a truck beating up houses and motorbikes that caused six dead and five injured, 500 m away from the flyover gate's northern side (20/3/2018). The second accident was a truck hit houses, cars, and motorcycles (05/20/2018) with 12 fatalities victims. Those last two accidents were caused by brake failure due to overloading and high speeding when descending a flyover [5],[6]. The objectives of this study are as follows:

- Identify the type of vehicle that often overload and over dimensions
- Know the types of modification that commonly done by vehicle owners
- Analyze whether there is a relationship between overloading and over-dimension vehicles.

II. MATERIAL AND METHOD

A. Freight Vehicles

Law No. 22 of 2009 on Traffic and Road Transportation states that Motorized Vehicles' transportation of goods must use freight cars [7],[8]. Freight cars refer to Motorized Vehicles, which are designed to transport goods in part or whole. In general, freight vehicles have several types; they are [9]:

- Pick Up
- Light Truck 2 Axes
- Large Trucks

B. Vehicles Roadworthiness

According to the Decree of the Minister of Transportation No. 63 of 1993, roadworthiness is a minimum condition for a vehicle that must fulfill the safety and prevent air pollution

and environmental noise when operated on the road [10],[11]. Refer to Law No. 22 of 2009 on Road Traffic and Transport and rules No. 55 of 2012 on Vehicles, vehicles are stated to be roadworthy based on the minimal performance of Motorized Vehicles which at least includes [12]:

- exhaust gas emissions
- noise
- the efficiency of the primary brake system
- the effectiveness of the parking brake system
- front wheel blades
- the sound of the horn
- transmit the power and direction of the main light beam
- turning radius
- accuracy of speed indicators
- suitability of wheel performance and tire conditions
- the relevance of the driving machine power to the weight of the vehicle

C. Freight Vehicles Loading Violation

1) Overload: By definition, overload is a condition of axle load over a predetermined haul based on the amount of weight allowed. Axle load is determined by vehicle ability and road capacity based on its class [13],[14]. Based on Law No. 22 of 2009 on Traffic and Road Transportation, the limit of the most massive axle load according to the class of road can be seen in the following Table [7]:

TABLE I
STREET CLASS

Road Class	The Strongest Axle Load
Road Class1	≤ 10 Tons
Road Class2	≤ 8 Tons
Road Class3	≤ 8 Tons
Special Road Classes	≥ 10 Tons

2) Over Dimension: Over dimension is any changes in length, width, and height in the primary dimension of vehicles and exceeding the size determined based on applicable regulations. Government Regulation No. 55/2012 states that the applicable dimension restrictions are [12]:

- The maximum length of a vehicle is limited by road class and axis distance.
  Maximum length formula based on axis distance

$$P\ max = FOH + WB + ROH \quad (1)$$

  where

$$FOH = 47.5\% \times WB \quad (2)$$

$$ROH = 62.5\% \times WB \quad (3)$$

  Where P is the vehicle length, WB is the distance of axis, FOH is the front overhang, and ROH is the rear overhang
- The Axis Distance (WB) may not be resized
- The maximum width of a single axis freight vehicle is 100 mm from the width of the cabin; it must be ≤ 2,500 mm
- The maximum width of double axles freight vehicle is 100 mm from the distance of the outer right and left wheels of the double-axis; it must be ≤ 2,500 mm
- The maximum height of a motorized vehicle is 1.7 x wide and ≤ 2,500 mm

D. Research Location

The study was conducted at 2 Weighbridges; they were Widang Weighbridge and Losarang Weighbridge. The Unit of Vehicle Weighing Scale (Indonesian: Unit Pelaksanaan Penimbangan Kendaraan Bermotor/UPPKB) is a part of the nine weighing implementing units under the Directorate General of Land Transportation, which has begun to be re-operated.

1) Widang Weighbridge: It is located on Jl. Raya Widang Pandan, Minohorejo Widang, Tuban Regency, East Java. The Widang Weighbridge functions to monitor freight vehicles' weight that passes the northern coast road when entering or leaving East Java Province.

2) Losarang Weighbridge: It is located on Km 76 Jl. Raya Losarang, Muntur, Losarang, Indramayu Regency, West Java. Losarang Weighbridge functions to monitor freight vehicles' weight that passes the northern coast road when entering or leaving West Java Province.

E. Data Collection Techniques

The data used in this study include primary data and secondary data. To collect the primary data, the writer uses:

1) The weighing sample survey: It is a survey method using a sample of vehicles that carry out the average daily weighing in the Field Vehicle Weighing Implementation Unit. Determination of the sample using the Slovin formula, a formula to calculate the minimum number of samples if a population's behavior is unknown with certainty. Sample calculation with an error tolerance limit of 5%.

Slovin formula:

$$n = \frac{N}{1 + Ne^2} \quad (4)$$

Where n is the number of samples, N is the total population, and e is the error tolerance limit.

The sampling technique uses systematic sampling; that is, the sample's determination is systematically regulated in this case based on the vehicle that was acted upon by weighbridge officers for violating the form of overload.

2) Interview Survey: An interview survey is a survey method that asks informants to find information and facts that occur in the field. To simplify the interview survey, the surveyor can use the written stationery and interview form.

There are two types of data obtained from Pantura Road Network and Vehicle Weighing Results for the secondary data. Pantura road network data illustrates the status, functions, and services of roads along the Northern Coast of Java. They were obtained from the Ministry for Public Works and Human Settlements. At the same time, Vehicle Weighing Results data illustrates the number of vehicles that conduct the weighing process and vehicles that violate the load weighing, such as overload, type of goods, the weight of goods, and the origin of goods.

F. Method of Analysis

From the data collection process, the data analysis process is then carried out with the following techniques:

1) Analysis of Data on Weighing Results: In this stage, the writers process the primary data (the weighing survey results) and the secondary data (the weighing results during the weighbridge reactivated) [15]. Data analysis is intended to get a picture related to the freight vehicles on the weighbridge, such as:

- Percentage of load violations on freight vehicles
- The magnitude of the average excess vehicle that violates
- The type of vehicle that often breaks the load
- The type of modification that vehicle owners usually do

2) Analysis of the relationship between overloading and over dimensions: In analyzing the relationship between overloading and over dimensions, the writers use statistical methods of regression and correlation [16]. Regression and correlation are used to measure associations or relationships between two or more quantitative variables. The idea of the calculation is set by Bergland & Andreas [17] states that the regression equation is a mathematical equation that allows forecasting the value of an independent variable (dependent variable) of the importance of an independent variable (independent variable).

III. Results and Discussion

A. Overload Analysis

From the weighing data at the weighbridge, overload analysis can be done by the analysis based on the number of load violations, the analysis based on the percentage of overload, the analysis of load violations based on vehicle type, the analysis of load violations based on goods commodity, and the analysis of Pantura (northern coast) road load performance [18]. Based on the observations at two weighbridges, the results of the load violation data analysis are as follows:

1) The number of load violations: The observation at Widang weighbridge is carried out during 4 (four) days; the number of overload violations can be seen in the Table below.

TABLE II
Load Violations at Widang Weighbridge

No.	Date	Number of vehicles	Number of Load Violations	%
1.	27	292	116	39,73
2.	28	285	140	49,12
3.	29	321	151	47,04
4.	30	296	127	42,91
Total		1194	534	44,72

TABLE III
Load Violations at Losarang Weighbridge

No.	Date	Number of vehicles	Number of Load Violations	%
1.	13	142	123	86,62
2.	14	132	123	93,18
3.	15	121	101	83,47
Total		395	347	87,85

2) Percentage of overload: The Table shows the percentage of load violations in Widang weighbridge is higher than Losarang weighbridge in the field of 5-25, 76-100, and >100. While in the range of 26-50 and 51-75, the load violations at Widang weighbridge is lower than the Losarang weighbridge.

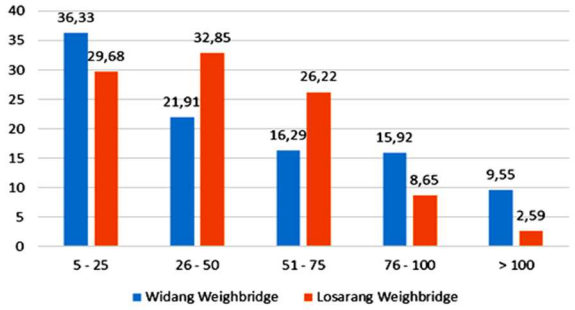

Fig. 1 Comparison of violations

3) Transportation type: The Figure below shows that the percentage of vehicle types violation of Pick Up, Large Trucks, and Collected Trucks in Widang weighbridge is higher than the Losarang weighbridge. Simultaneously, the vehicle type violation of Light Truck at Widang is lower than Losarang weighbridge [19], [20]. Based on the type of vehicle, the Outboard Truck has not measured yet so that in the Widang weighbridge and the Losarang weighbridge, there is no data on it.

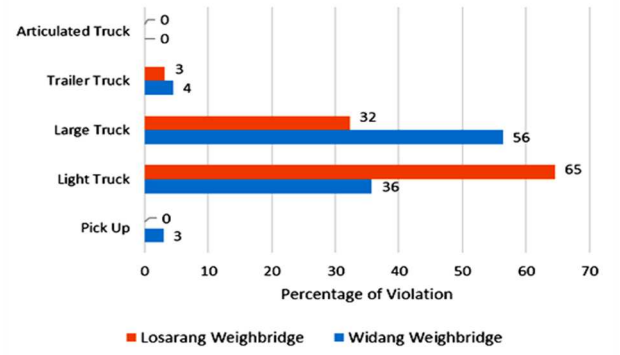

Fig. 2 Vehicle type violations

4) Load commodities: From Figure 3 below, it can be seen that the mixed freight commits the highest position of load violations based on the types of goods. The term mixed freight refers to freight, which consists of two or more different kinds of goods. The load violations by mixed freight take 63% of all the types of freight at Widang Weighbridge. The second position is placed by dry/grain freight, which takes 25%. Reefer freight takes 9% and places the third position of the load violators while liquid takes 2% and places the fourth position. The smallest percentage of load violation at Widang Weighbridge is taken by gas, only 1%, and it makes gas freight places the lowest position of the load violators.

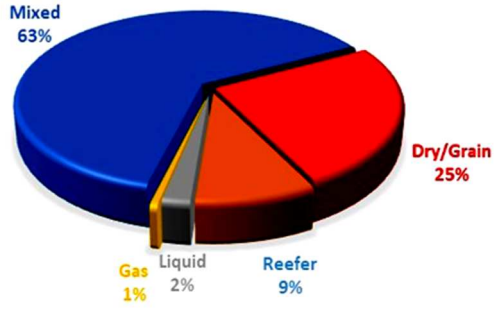

Fig. 3 Violations of Load Commodity at Widang Weighbridge

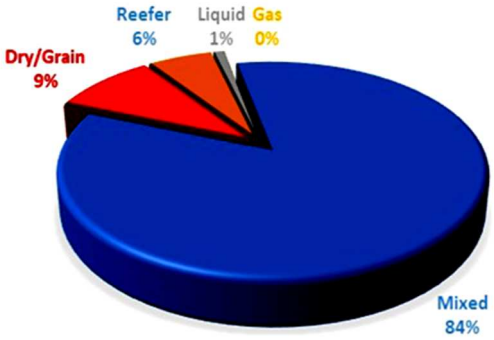

Fig. 4 Violations of Load Commodity at Losarang Weighbridge

Figure 4 above shows that the mixed freight also commits the highest position of load violations based on the types of goods. It takes 84% of all the types of freight that violates the load standard at Losarang Weighbridge. Similar to what happened at Widang Weighbridge, the lowest position of load violations is also placed by the gas freight. It takes only 0% or zeroes violation at Losarang Weighbridge, which they do.

5) The Load performance of Pantura road: From the graph of Figure 5 below, it is explained that the highest load performance of Pantura road is in the cities which have weighbridges, such as Indramayu (according to data from Losarang Weighbridge) and Tuban (according to data from Widang Weighbridge).

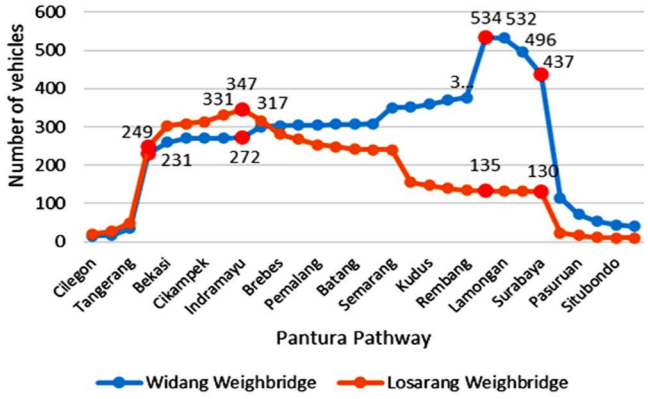

Fig. 5 The burden on the performance of Pantura Road

Based on the data from Losarang Weighbridge, Indramayu is a short cut area. It can be seen from the small gap between the lane of Subang - Indramayu – Cirebon, which indicates a slight movement of vehicles that starts from Indramayu. Whereas for Tuban, it is classified as a central area [21], [22]. Based on Figure 5, there is a high gap between Tuban and Rembang where the number of vehicles has increased by 71%. The average number of vehicles originating from Tuban has a reasonably short route. Still, they have a high percentage of load violations according to their types of load commodities, which include construction materials such as concrete, cement, and sand. Based on the explanation above, the northern coast road with the highest load performance is Tuban - Surabaya route.

B. Analysis of Dimension Violations (Over Dimensions)

The analysis of dimension violations is devided into two parts: violation survey results at Widang Weighbridge (see Table 4) and violation survey result at Losarang Weighbridge (see Table 5).

TABLE IV
VIOLATION SURVEY RESULTS AT WIDANG WEIGHBRIDGE

No.	Date	Sample	Type of Violation		
			Cargo	Dimension	
				Primary Dimension	Tire Size
1	27	22	20	15	9
2	28	20	19	11	4
3	29	24	24	16	10
4	30	18	15	15	3
Total		84	78	57	26

TABLE V
VIOLATION SURVEY RESULT AT LOSARANG WEIGHBRIDGE

No.	Date	Sample	Type of Violation		
			Cargo	Dimension	
				Primary Dimension	Tire Size
1	13	27	27	21	2
2	14	31	31	18	2
3	15	17	17	11	2
Total		75	75	50	6

C. Statistical Test Analysis

The statistical test analysis uses a 95% confidence level, and the significance value is 0.05. There are three variables used, they are the main dimensions (X1) and tire size (X2) as the independent variables, and the vehicle load as the dependent variable (Y). The data on Load and Dimension Violation Samples from Widang Weighbridge and Losarang Weighbridge are shown in Table 6.

TABLE VI
DATA SAMPLE OF LOAD AND DIMENSION VIOLATIONS

No.	Load (Y)	Main Dimension (X1)	Tire Size (X2)
1	20	15	9
2	19	11	4
3	24	16	10
4	15	15	3
5	27	21	2
6	31	18	2
7	17	11	2

TABLE VII
NORMALITY TEST RESULTS

One-Sample Kolmogrov-Smirnov Test			
	Dimension (X1)	Tire Size (X2)	Vehicle Load (Y)
Kolmogorov-Smirnov Z	.598	.741	.525
Asym. Sig. (2-tailed)	.867	.643	.945

Based on the results of the Kolmogorov-Smirnov One-Sample normality test, the significance value of the variable X1 (0.867> 0.05); variable X2 (0.63> 0.05); and Y variables (0.945> 0.05), the variables X1, X2, and Y are normally distributed so that the regression test can proceed.

1) Analysis of multiple regression test: Regression analysis is a method or technique for analyzing research hypotheses to test whether there is influence between one

variable and another variable expressed in the form of a mathematical equation (regression). While the Multiple Regression Test is to find the impact of two or more independent variables (X) towards the dependent variable (Y).

The hypothesis Formulations with a 95% confidence level are as follows:

H1: There is an effect of violation of the main dimension (X1) towards the load violation (Y)

H2: There is an effect of violation of tire size (X2) towards load violation (Y)

H3: There is no influence of the primary dimension (X1) and tire size (X2) violation towards load violation (Y)

- t-test analysis

The primary consideration on the t-test is; if the sig value <0.05, or t arithmetic >t table, there is the influence of the leading dimension and, or of the tire size violation towards the load violation. Meanwhile, if the value of sig >0.05, or t arithmetic <t table, there is no influence of a dimensional violation towards the load violations. The t-test curve shows that if the t <t table's value, then the hypothesis is rejected, which means that the variable x is not related to the variable y. Meanwhile, if the value of t arithmetic >t table, then the hypothesis is accepted, it means that the variable x is not related to the variable y. A positive sign shows directly proportional, while a negative sign indicates inversely proportional.

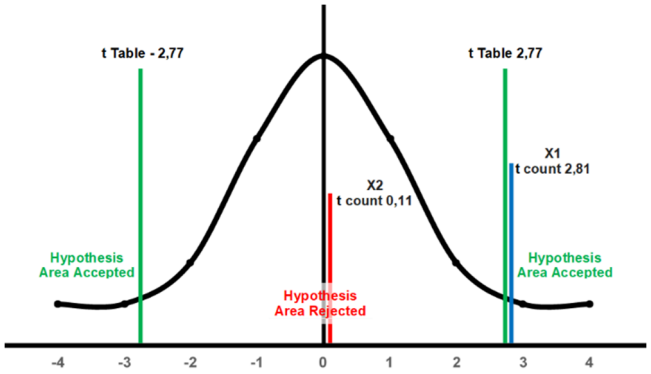

Fig. 6 Test Curve t

TABLE VIII
TEST RESULTS

Coefficients[a]		
Model	**t**	**Sig.**
1.(Constan)	.609	.576
Main Dimension	2.877	.045
Tire Size	.114	.915

T table value:
t table
= t (α / 2; n-k-1)
= t (0.025: 4)
= 2.77645

- F-test analysis

The basis for Test Analysis F is, if the sig value <0.05, or F arithmetic> F table, there is a combined effect of the violation of the main dimensions and breach of the tire size to the load violation.

TABLE IX
TEST RESULTS F

ANOVA[b]					
Model	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	133.038	2	66.519	4.1691	105[a]

Table F Value:
F table
= F (k; n-k)
= F (2; 5)
= 5.79

From the data above, it can be concluded that hypothesis with a 95% confidence level as follows:

H1: The significance value for the influence of variable X1 on the variable Y is 0.045 <0.05, and the value of t count 2.87> t table 2.77. It can be concluded that H1 is accepted, which means there is an influence of the main dimension violation of the load violation.

H2: The significance value for the influence of variable X1 on the variable Y is 0.956> 0.05, and the value of t count 0.11 <t table 2.77. It can be concluded that H2 is rejected, which means there is no effect of violation of the tire size against the load violation.

H3: The significance value for variable X1 and variable X2 towards the variable Y is 0.105> 0.05. The calculated F value is 4.165 <F table 5.79. It can be concluded that H3 is rejected, which means there is no influence of the main dimension and tire size violations towards the load violations.

2) Correlation test: The writer performed the Correlation test after completing the Multiple Regression Test analysis. It is a statistic that measures the linear correlation between two variables X and Y. This study's independent variables are the vehicle's main dimension (X1) and the vehicle's tire size (X2). The dependent variable used in this study is the vehicle load. The results of this test can be seen in the following Table.

TABLE X
CORRELATION TEST RESULTS

		Dimension (X1)	**Tire Size (X2)**	**Vehicle Load (Y)**
Main Dimension (X1)	**Pearson Correlation**	1	-.125	.821
	Sig. (2-tailed)		.789	.023
	N	7	7	7
Tire Size (X2)	**Pearson Correlation**	-.125	1	-.071
	Sig. (2-tailed)	.789		.880
	N	7	7	7
Vehicle Load (Y)	**Pearson Correlation**	.821	-.071	1
	Sig. (2-tailed)	.023	.880	
	N	7	7	7

Based on the analysis results above, it can be concluded:

The significance of test results X1 to Y 0.023 <0.05 indicates a significant relationship between the main dimensions and the load violations. The significance of test results X2 to Y 0.88> 0.05, meaning there is no significant relationship between the main dimension violations and the load violations. The value of the correlation coefficient (r) is 0.821, so the violation of the main dimensions with the load

violation has a very strong and direct correlation level. The coefficient of determination (R) X1 towards Y for 67.4%, means that the main dimensions violation has the effect of 67.4% against the load violation.

The criteria of the correlation coefficient test are, Ho can be accepted if: -1.96 <Zo<1.96. It means that the sample is not related to the population. Ho is rejected if Zo>1.96 or Zo<-1.96, which means that the sample is related to the population.

Z Test Value Calculation

$$\mathbf{Zo} = \frac{0{,}821}{\sqrt{1/7 - 1}} \tag{5}$$

Zo value of 2.04> 1.96 means that the sample is related to the population.

3) Analysis of interview results: The survey at Widang Weighbridge takes 84 drivers as the sample. The result of the study is presented in the following Figure.

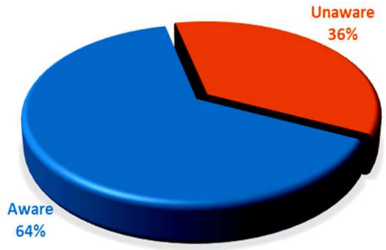

Fig. 7 Results of the ODOL Violation Survey at Widang Weighbridge

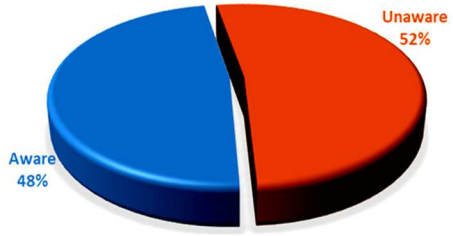

Fig. 8 Results of the ODOL Violation Survey at the Losarang Weighbridge

The results of an interview survey at the Losarang Weighbridge, with a sample of 75 drivers, 48 of them knew that their vehicles had violated the load standard and/or dimension violation. The rest 52 drivers answered that they did not understand it.

IV. Conclusion

Based on the result above, it can be concluded that the type of vehicle which has the highest level of load violation at Widang Weighbridge is a Large Truck, while at Losarang weighbridge is Light Truck. The violations are in the form of changes in the main dimensions and tire size addition. However, the most frequently violated dimensions are changes in the main dimensions, such as the addition of length, width, and/or height of the vehicle. The statistical analysis of regression and correlation shows a significant relationship between vehicle dimension violation in the form of the main dimension addition (over-dimension) with load violations (overloading).

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