Influence of road traffic vehicle volume with damage and road safety

I Farida¹, H D Awliya, I Purnamasari, N Nanang and G J Johari
Department of Civil Engineering, Sekolah Tinggi Teknologi Garut, Jalan Mayor Syamsu 1, Garut 44151, Indonesia

¹idafarida@sttgarut.ac.id

Abstract. Increasing population and vehicles on the road will be accompanied by increased transportation needs so that the traffic density cannot be avoided. Generally, happens on a national road route, which is a connecting road between the provincial capital and a national strategic highway. The traffic density is potentially a bottleneck, road damage, and traffic accidents. The research aims to determine the influence of vehicle volume against the damage and safety of roads in one of the national roads in West Java. The Data sourced from road planning and supervision, the police sector, and field Survey Board. The methods used Bina Marga method to determine the number of road damage, RCI, and IRI methods to assess the value of road conditions, and to determine the influence of inter-variable, road safety inspection refers to the test of the roadway to evaluate roadworthiness of road functions. The results of the study gained that the impact of vehicle volume on road traffic damage and categorized accidents was insignificant. The dominant factor in the traffic accident that occurs caused by carelessness and unordered driving. These roads in the road category are still eligible and recommended for routine maintenance.

1. Introduction
Roads, additional buildings, and equipment provided for the above-ground traffic passed by vehicles [1,2]. The increasing number of vehicles resulted in higher transportation needs that could potentially cause congestion, road damage, and traffic accidents [3-5]. In general, road surface damage is flexible or rigid due to high vehicle volume, overload, weather, environment, and lack of maintenance, which could have an impact on road traffic accidents [6-8].

One of the strategic roads is the national road, which is a border road between cities/districts that has substantial traffic characteristics [2,9,10]. National roads bypassed by all types, namely light vehicles (LV), Medium weight vehicles (MHV), large buses (LB), large trucks (LT), motorcycles (MC), or non-motorized vehicles (UM) [11,12].

The volume density of vehicles passing through the road contributed to the damage [13,14]. Vehicles that crossroads sometimes do not follow the maximum load capacity and allowable payload [15]. Overloads received by road surfaces can directly affect the plan life and road damage. Surface damage related to road safety [16]. This type of damage includes damage to exceptional cracking conditions, crocodile skin cracks, edge cracks, cracks in the shoulder joints, crack road connections, longitudinal cracks, transversal cracks, random cracks [17,18]. Distortion with the type of damage in the form of
grooves, curling, collapsing, surface defects in the holes, fillings, exfoliation surfaces, wear, and reduction of utility marks [19].

Discomfort for road users, including road traffic safety, is significant and strategic because it involves the human psyche [20,21]. Based on the existing problems, researchers analyzed the level of damage and feasibility of road function and how to influence vehicle volume to damage and road safety levels.

2. Methodology

The research was conducted on Jalan Limbangan in Garut Regency, bordering Sumedang Regency, and Bandung Regency with a length of 2.830 km. The Road is a national road, using secondary data from the national road Planning and Supervision Unit (P2JN) of West Java province, the police sector of the basin, and the primary field survey data. The research flowchart can see in Figure 1.

Regression analysis performed to obtain a functional relationship between two or more variables or to obtain an independent variable effect against the dependent variable or to predict the impact of an independent variable against the dependent variable [22]. Determining the value of road conditions according to the Directorate General of Bina Marga, by taking an average of each number and value for each state of damage. The order of priority (UP) of road conditions is a function of the LHR class and the road condition value, using the equation [23,24]: UP = 17 - (LHR class Class + Road condition value).

Stages of road damage to determine road damage level, road condition value of the total number of road damage figures, priority proposed road-handling value. It proposed a priority for road handling programs [25]. The measurement of the International Roughness Index (IRI) based on a comparison of the accumulated standard vehicle suspension movement with vehicle mileage during measurement. Determined by the criteria for road conditions based on the IRI value on the road surface. In Indonesia, using a value between IRI and RCI [26,27]. The second Parameter like this stated: RCI = 10 x EXP (1) -0.094 x IRI. Determination of the road Condition Index (RCI) value using the rating at envy [28].

The relationship between the RCI value and IRI of the average daily traffic (LHR) used in determining the condition of the TService with the determination of the handling activities, as in Table 1.

| Condition          | Handling Program                      |
|--------------------|---------------------------------------|
| Good (B)           | Maintenance                           |
| Routine (PR)       | Periodic Maintenance (PM) or Rehabilitation |
| Medium (S)         | Periodic Maintenance (PM) or Rehabilitation |
| Heavy Damage (RR)  | Enhancement (PK) or Development       |

Figure 1. Flow chart.
3. Results
The Volume of the vehicle in 5 years (2014-2018) on the road Limbangan and class values based on average daily traffic volume (SMP/day) is 7th grade, as in Table 2.

| Year | MC  | LV  | MHV | LB  | LT  | Vehicle smp/day | Class |
|------|-----|-----|-----|-----|-----|-----------------|-------|
| 2018 | 41292 | 11851 | 3564 | 351 | 1936 | 58994 | 40680 | 7 |
| 2017 | 16496 | 9883 | 3677 | 493 | 407 | 30956 | 25517 | 7 |
| 2016 | 21631 | 11430 | 824 | 230 | 378 | 34493 | 32619 | 7 |
| 2015 | 9406 | 13019 | 2538 | 660 | 272 | 28027 | 25612 | 7 |
| 2014 | 1555 | 20961 | 4321 | 660 | 272 | 27769 | 28361 | 7 |

Roads divided into 28 segments. The highest road damage occurred in section 22, with a percentage of 13.02% of the total area of 770 m2. The sector contains a surface consisting of an 83.2 m2 grain release. Based on the total amount of damage across the segment, the most road damage in section 11 obtained, the entire data can see in Table 3.

| Segment | Damage (%) | Total Segment | Damage (%) | Total Segment | Damage (%) | Total Segment | Damage (%) | Total |
|---------|------------|---------------|------------|---------------|------------|---------------|------------|-------|
| 1       | 2.99       | 3.00          | 8          | 1.92          | 11.00      | 15            | 12.10      | 8.00  | 22 | 13.02 | 12.00 |
| 2       | 1.28       | 12.00         | 9          | 1.28          | 14.00      | 16            | 7.94       | 12.00 | 23 | 2.88  | 12.00 |
| 3       | 1.53       | 15.00         | 10         | 5.00          | 12.00      | 17            | 3.99       | 16.00 | 24 | 0.70  | 8.00  |
| 4       | 2.69       | 14.00         | 11         | 10.61         | 22.00      | 18            | 1.05       | 13.00 | 25 | 1.03  | 13.00 |
| 5       | 8.39       | 11.00         | 12         | 1.64          | 13.00      | 19            | 7.16       | 16.00 | 26 | 0.32  | 13.00 |
| 6       | 0.35       | 17.00         | 13         | 1.63          | 16.00      | 20            | 5.84       | 1.00  | 27 | 2.75  | 5.00  |
| 7       | 4.17       | 13.00         | 14         | 1.29          | 8.00       | 21            | 9.06       | 4.00  | 28 | 0.47  | 11.00 |

The average result of the priority order for handling 28 segments is 5.75. Therefore, the handling that can do is with routine maintenance programs. According to the IRI method and RCI [26] [27], the Road with a periodic maintenance program is a moderate road condition. Results obtained according to the established by the Bina Marga method that on the road of the Limbagan must be carried out routine maintenance.

The road test focused on the aspect of the road structure. The number of LHR from 2014 to 2018 is still appropriate, was on the main road class I if served > 20,000 vehicles. Based on the kind of road dreary in the state of decent function. Assessment of the appropriate service based on the conditions of the road's roadway using the Envy method and RCI to LHR is determined by a moderate road condition so that the road condition set in decent condition. Data on road and road conditions can see in Table 4.

| Year | LHR | IRI | RCI | Road Conditions | Feasibility |
|------|-----|-----|-----|-----------------|-------------|
| 2018 | 40680 | 5.8 | 5.80 | Medium | Worthy condition |
| 2017 | 25517 | 5.7 | 5.88 | Medium | Worthy condition |
| 2016 | 32619 | 4.2 | 6.72 | Medium | Worthy condition |
| 2015 | 25612 | 4.9 | 6.31 | Medium | Worthy condition |
| 2014 | 28361 | 5.0 | 6.28 | Medium | Worthy condition |

Regression analysis performed on variable x as vehicle volume (LHR) and variable y as the road damage value of RCI. Based on the calculation result, the correlation in the second variable is not significant, with an amount of 7.95%. Based on the T-test and F test, the x variable for Y is not substantial, as can be seen in Table 5.
Table 5. Results of regression analysis of 2 variables.

| Equation     | Information                           |
|--------------|---------------------------------------|
| \( y = a + bx \) | \( 6.62 + (-0.000014) x \)          |
| Correlation  | \( r = -0.282 \)                      |
|              | \( r \) table: 0.8783                 |
| Koef. determination | \( r^2 = 0.0795 \)   |
| F test       | \( F = 0.25 \)                        |
|              | \( F \) table: 10.13                  |
| T test       | \( T = -0.5 \)                        |
|              | \( T \) table: 2.77                   |

Although this road deserves to be enabled, there are still high enough traffic accidents happening every year. Based on the five-year accident data, that the leading cause caused by the carelessness and disruption of vehicle users, can be seen in Figure 2.

![Figure 2](image)

Information: A (careless), B (tired), C (sleepy), D (sick), E (disorderly), F (Psychological pressure), G (drug effect), H (alcohol effect), I (speed limit)

Figure 2. Number and factors causing road traffic accidents.

Table 6. Data on road damage, LHR, road traffic accidents.

| Year | Road Damage (x₁) | LHR (x₂) | Accident (y) |
|------|------------------|----------|--------------|
| 2018 | 5.80             | 40680    | 56           |
| 2017 | 5.88             | 25517    | 38           |
| 2016 | 6.72             | 32619    | 73           |
| 2015 | 6.31             | 25612    | 45           |
| 2014 | 6.28             | 28361    | 66           |

Acquired equations form of a regression coefficient upward. The correlation in all three variables has a significant effect of 81%. Based on the T-test, the three variables have a considerable influence, but based on the F test is not significant. The regression analysis results are as in Table 7.

Table 7. Results of regression analysis 3 variables.

| Equation     | Information                           |
|--------------|---------------------------------------|
| \( y = b_1 x_1 + b_2 x_2 \) | \( (-197.52) + 34.41 x_1 + 0.0013 x_2 \) |
| Correlation  | \( r = 0.9 \)                        |
|              | \( r \) table: 0.8783                 |
| Koef. determination | \( r^2 = 0.81 \)   |
| F test       | \( F = 4.26 \)                        |
|              | \( F \) table: 19                    |
| T test       | \( T = 3.7 \)                         |
|              | \( T \) table: 3.18                  |
4. Conclusion
The results concluded that:

- The highest road damage in segment 22, found in Sta. 2 + 100-2 + 200 with a percentage of 13.02% because in the section, there is a dominant surface defect of the release of 83.7 m².
- Based on the methods of Bina Marga, RCI, and IRI methods, determined that road conditions are in moderate condition with periodic road maintenance recommendations.
- There is no significant influence between the vehicle volume relationship to road damage and traffic volume with traffic accidents.
- Structurally, Jalan Limbangan is still in a state of function, so that the road can even assure road safety for vehicles, but the majority of accidents that occur resulting from human factors.

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