1st International Conference on Multidisciplinary Engineering (ICoMdEn)
Advancing Engineering for Human Prosperity and Environment Sustainability
October 23-24, 2018, Lhokseumwe - Aceh, Indonesia.

e-ISSN 2656-7520

EFFECT OF LOADING VEHICLE ON STRAIN VALUE AND LOAD REPETITION USING MECHANISTIC METHOD

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ABSTRACT

The main component in the road's construction is its pavement. The pavement is used to protect subgrade soil as well as prevent it from the overload of the strain due to a big number of loading repetitions. It also used to lengthen the durability of the roads, therefor it minimizes the need of renovations. In this research, we use mechanistic approach namely KENPAVE program that analyze the response of the structure of each pavement layers. The objective of this program is to response to the result of pavement's structure which is horizontal and vertical tensile of strain, under both surface layer and upper subgrade layer. The following step is the calculation of loading repetition's value in the failure, in doing so, rutting damages are taken into account. Parameter study in this research is to vary vehicle's loading capacity, which is one of the mechanistic method parameter. Splitting variation of the vehicle's loading capacity into five variations from standard variation 265,5 KPa to 365,5 KPa, 465,5 KPa, 565,5 KPa, and 665,5 KPa. Next, the research will be inputting values to the KENPAVE program to collect strain's values and calculate loading repetition's values. The result found from through the research is that the more loading variations, the higher strain into the road pavement's structure, and the less loading variation, the lower strain take place. Strain values are also influenced by loading repetitions' values inversely proportional. The higher strain's value, the fewer sums of the loading repetitions.

KEY WORDS: *Pavement, Load Vehicle, Repetition, Mechanistic*

INTRODUCTION

The main component of the road's construction is its pavement which is used to protect subgrade soil as well as to build pavement layers. Pavement is used to protect strain and stress from overloading due to a big number of traffic repetitions.

Strain and stress in the pavement's structure of the road occur due to the cross of loading repetitions. The more sums of loading that cross pavement's structure, the longer durability of the roads, hence, it minimizes the needs of renovations.

Cracks and deformations are examples of road failures caused by the inability of pavement's structure to load maximum capacity. Cracks are overloading of pavement's material due to splits along the horizontal direction.

While deformation failures are caused by land degradations across the vertical direction. To retrieve the structure of the pavement's responses, few parameters of each pavement layer are compulsory to be taken into account. One of parameters is modulus elasticity and another one is Poisson's ratio. Both of them are derived from laboratories experiment.

In this research, we used KENPAVE program for analysis which is developed by Dr. Yang H. Huang P.E Professor Emeritus of Civil Engineering University of Kentucky. KENPAVE is a loading pavement capacity program which uses mechanistic method.

METHOD

Existing secondary data which is indirectly derived from the field is available in this research. The data collected by previuos research Citra Kharisma Putri (2014) for a case study in Arteri Selatan Road. Type of data is load traffic, loading vehicle characteristic, type and axis-configuration of the vehicle.

Pavement thickness design parameter step:

1. Multi-Layer Elastic System Analysis

In this step, there are two result is derived, calculation in manual analysis and calculation in KANPAVE program. Both of those result then validated for cross-checking that if calculation is in the correct way.

2. Parameter Study

In this step, inputing the loading variation to KANPAVE program in order to collect strain and stress responsity. This results then will use for loading repetition analysis.

RESULTS AND DISCUSSIONS

Programm Validation

Validation means an action to prove that method that achieve consistent result based on a particular specification and well documented. A program can be useful if it has a basic or manual calculation. A KENPAVE program is work on layers' system. So that the variation observation could be done by comparison

e-ISSN 2656-7520

with manual calculation and KENPAVE calculation

Table 1. Results Calculation of the KENPAVE Manual and Program

Strain - Voltage Value			Manual Calculate	Program KENPAVE	Manual Program (%)
	Strain	Vertical	14.6076000	14.60800	0.00137
6.00	(Kpa)	Radial	-222.3060000	-222.309	0.00000
(in)	Voltage	Vertical	0.0005923	0.00059	0.00135
		Radial	-0.0002961	-0.0002961	0.00709
	Strain	Vertical	7.1256000	7.12600	0.00281
12.00	(Kpa)	Radial	-3.9960000	-3.995	0.00000
(in)	Voltage	Vertical	0.0005561	0.00056	0.00719
		Radial	-0.0002780	-0.00028	0.00719

Parameter Study

Parameter's study that has been done is the parameter of vehicle's loading variations therefrom influences of additional vehicle's loading on the strain of horizontal direction tensile on the surficial layer and also the strain of the one layer of subgrade will be analyzed especially which relate to the number of loading repetitions based on the analysis of fatigue crack and rutting as well.

Table 2. Data Input

Pavement Layer	Modulus Elasticity (Mpa)	Thickness (cm)	Poison Ratio
Surface	1100	10	0,4
Base Course	1200	15	0,4
Sub Base Course	1600	45	0,4
Sub Grade	60	∞	0,45

Mechanistic evaluation to standard loading vehicle capacity will raise the loading itself, from 265,5 KPa to 100 KPa, 200 KPa, 300 KPa, 400 KPa, and from 500 KPa to 365,5 KPa, 465,5 KPa, 565,5 KPa, 665,5 KPa. effect of Vehicle Load on Strain Value

Tabel 1. Strain Value Analysis

Structural Response	Load Variation				
	265.65 (kPa)	365.65 (kPa)	465.65 (kPa)	565.65 (kPa)	665.65 (kPa)
Horizonal Pull Strain	0.004053	0.005579	0.007105	0.008631	0.01016
Vertical Press Strain	0.01921	0.02645	0.03368	0.04091	0.04815

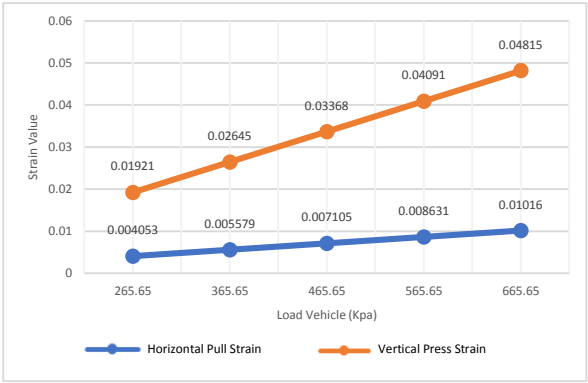

Fig 1. Graph of the relationship between variations in vehicle and strain values

The addition loading capacity contributes the influence to the strain value. The more loading capacity, the higher strain value in the pavement layer structure. Figure 1. shows the strain value is significant changed between tensile strength and tension strength, in horizontal and vertical direction respectively. Modulus elasticity value also allows to the influence of the strain value. Modulus elasticity value in the surface layer is higher than subgrade or base soil. So that, the higher value of modulus elasticity, the lower strain value in surface layer.

Table 4. Fatigue crack analysis

Load Variation (kPa)	Fatique Crack Analysis Asphalt Institute Model	
	Horizontal Pull Strain (εt)	Fatique Crack Analysis (Nf)
265,65	0.000004053	307164422386.96
365,65	0.000005579	107311614585.46
465,65	0.000007105	48424630982.41
565,65	0.000008631	25526224227.56
665,65	0.00001016	1.999293351

e-ISSN 2656-7520

1. Fatique Crack Analysis

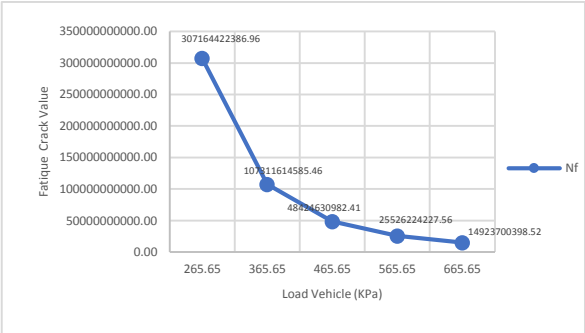

Fig. 2 The relationship of variations in vehicle load to the value of fatigue crack

From the Fig. 2, it is shown differences between changes of the loading repetition's values over the fatique failure values. The more variated loading value the less loading repetitions over fatigue crack and the vice versa, the less loading variations given the bigger the number of loading repetitions over the elastic pavement..

2. Rutting Crack Analysis

Table 5. Rutting Crack Analysis Data

Load Variation (kPa)	Fatique Crack Analysis Asphalt Institute Model	
	Vertical Press Strain (εv)	Rutting Demage Analysis (Nd)
265,65	0.00001921	1781478719500.55
365,65	0.00002645	425532660083.93
465,65	0.00003368	144240705050.76
565,65	0.00004091	60390979227.51
665,65	0.00004815	29117162787.42

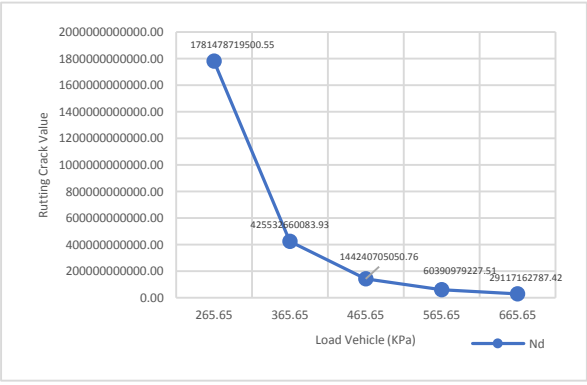

Fig 3. The Relation of variations in vehicle load to Rutting crack value

From the Fig. 3, it is shown differences between changes of the loading repetition's values over the rutting failure values. the more variated loading value the less loading repetitions over rutting crack and the vice versa, the less loading variations given the bigger the number of loading repetitions over the elastic pavement.

The Influence of Loading Vehicle

Flexible pavement has an elastic or ductile pavement means that the pavement can return back to basic form after loading. However, due to traffic service or loading repetition will effect strain and stress in the pavement structure.

Response to vehicle loading in the flexible pavement defines as horizontal strain (Єh) in the surface layer and vertical strain (Єv) in the basic or base soil layer.

The mechanistic method is one of technique that we approach in this research which is analyzing and describing synthon of material physically such as pressure, deflection, strain and other physic that can cause in the pavement structure.

The relationship between physic that can cause in pavement structure is described in a mathematical model such as many layer system analysis.

Together with the mechanistic approach, empiric elements are compulsory to determine the factors and type of failure in the pavement structure. Then, repetition loading calculation is describing by equations such as The Asphalt Institute (1982). With this approach, time served in a pavement structure is acknowledgeable.

How far the influence of pavement structure caused by variation of loading vehicle and the relationship of road failure, then a research and analysis was conducted with the mechanistic approach. The result is described in Graph shows that structure response is slightly different which is the value of strain tensile in horizontal direction and value of strain pressure in a vertical direction.

The higher variation of given loading onto pavement layer, the higher strain response value that occurs in the pavement structure.

This statement together with Robert Hooke research on the relationship between each force that conducts in a spring or other elastic thing in order to that thing can come back to basic position and do not out of a particular threshold

CONCLUSIONS

Based on the research problems and data analysis, we conclude that:

1) Vehicle's loading capacity variations significantly influence the strain of roads directly in proportional way. The heavier loads, the higher strain of the pavement of the road's structure exists.
2) The amount of the emerging strain's results due to loading capacity variations of vehicles on a particular structure of a pavement will influence times of loading's results, as the heavier loads given to the pavement's structure causing big response to the strain result fewer loading's repetitions. Inversely, the lighter loads given to the pavement's structure, the more loading repetitions take place.

e-ISSN 2656-7520

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