ISBN: 978-602-5649-417

THE INFLUENCE OF VEHICLE AXLE CONFIGURATION AGAINST BACK AND MAXIMUM DEFLECTION DUE TO EXCESSIVE LOAD WITH BENKELMAN BEAM TOOLS

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Abstract

The cause of early damage to road sections in Indonesia is still a matter of debate among expert and road expert. But it was pointed out that many parties that these early damages were likely caused by the age of the road plan that had been passed, the puddle of water on the road surface that could not flow due to poor drainage, excessive overloaded traffic loads which caused more road life short of planning. The research was carried out on the local road which was assumed to represent the condition of the thickness of the flexible pavement layer, with one hope that it could be known the reverse deflection and maximum deflection on the road section. The research was conducted by looking at the back deflection and the maximum deflection that occurred due to variations in loading and variations in commercial vehicle axle configuration. Vehicle axle configurations used in this research is Single Axle Dual Wheel (SADW), Single Axle Single Wheel (SASW) and Dual Axle Tandem Wheel (TADW). SADW and SASW are represented by Truck 1.2 H, TADW is represented by Truk 1.22. The results of the research, data analysis and calculation process obtained the maximum deflection magnitude right on the vehicle axle (Δ_{mc}) can be determined by making a deflection ratio, $\frac{\Delta_{m30}}{\Delta_{r30}} = \frac{\Delta_{mc}}{\Delta_{rc}}$, so that it is obtained $\Delta_{mc} = \frac{\Delta_{m30} \times \Delta_{rc}}{\Delta_{r30}}$, because of the magnitude ($\Delta_{m30} = p \times \Delta_{r30}$) and magnitude ($\Delta_{rc} = q \times \Delta_{r30}$), then the magnitude $\Delta_{mc} = \frac{(p \times \Delta_{r30})(q \times \Delta_{r30})}{\Delta_{r30}} = p \times q \times \Delta_{r30}$. For reverse deflection value, SADW with vehicle load 14.24 tons and Δ_{rc} 1,05mm, and TADW with vehicle load 16.73 tons and Δ_{rc} 0,48mm , for maximum deflection value SADW 14.24 tons Δ_{mc} 1,18 mm, TADW 16,73 ton Δ_{mc} 0,58 mm and maximum deflection for PSADW Single Axle Single Wheel (SASW) P_{SADW} 14,24 ton P_{SASW} 4,62 ton $\Delta_{ms-sasw} = \Delta_{mc-sadw} \times \frac{P_{sasw}}{P_{sadw}}$ = 0,27 mm

Keywords : ***Flexible Pavement, Reverse Deflection, Maximum Deflection***

Introduction

Each layer in every street pavement has a time range in term of age. Hence, its condition will decrease along with the increase of volume in vehicles running above it. These days, there's a massive increase in number and burden of capacity of vehicles, causing detrimental damage in street surface and its pavement structure.

The cause of this early damage in many street sides is still a matter of debate among experts. But, many have argued that these early damages were probably caused by the age of the road plan that had been passed, the puddle of water on the road surface that could not flow due to poor drainage, excessive traffic load overloaded which caused more road life short of planning.

Burden of the vehicle axe is the total burden of the vehicle distributed to each of its respective axle, and fully supported by the respective tires of the vehicle. Bina Marga (1987), in "Petunjuk Perencanaan Perkerasan Lentur Jalan Raya Dengan Metode Analisa Komponen", SKBI-2.3.26.1987, mentioned thata composition for a vehicle axle must be : (1) MP 1.1 (2 ton) with burden distribution of 1 ton + 1 ton, (2) Bus 1.2 (8 ton) with burden distribution of 3 ton + 5 ton, (3) Truck 1.2 L (13 ton) with burden distribution of 5 ton + 8 ton, (4) truck 1.22 (20 ton) with burden distribution of 6 ton + 14 ton, and (5) truck 1.22 + 2.2 (30 ton) with burden distribution of 6 ton + 14 ton + 5 ton + 5 ton.

Meanwhile, Irmawan dan Mochtar (1990), explained that the composition for vehicle axle loads consists of three variations: single axle tandem axle, and tridem axle. On the next research, Mochtar (1999), categorized the composition for tandem axle into single axle single tire/SAST, single axle dual tire/SADT, tandem axle dual tire/TADT, and triple axle dual tire/TRDT).

Mochtar (1998), stated that there are seven misconceptions and the drawback in the planning method of the street pavement: 1) Overload in burdens of commercial vehicles in Indonesia, (2). A limit of Marshall stability for heavy traffic in Indonesia, (3).Categorization in street classification according to Muatan Sumbu Terpusat (MST), 8 ton and 10 ton, (4). Traffic survey method in order to determine total amount for Equivalent Axle Load (EAL), along the planning, (5). Correlation on vehicle axle load to EAL unit, (6). Method on deciding thickness of the pavement; and, (7). The ageing process of the asphalt that happens too fast tropical area which will be the foundation for establishing British Standard method in Indonesia.

In an effort to treat street pavement, constant checking and repairing are direly needed. One of the quality checking method for the street pavement is surveying the deflection analysis using bengkelmen beam method..

Research Methods

This section describes the experimental design, tools, data collection methods, and types of controls. If research is carried out in nature, the author describes the research area, location, and also explains the work done. The general rule to keep in mind is that this section should be detailed and clear so that the reader has the basic knowledge and techniques to develop.

Research Results and Discussion

This research is conducted in the layer of pavement in local street (Ruas Jl. Widang-Plumpang, Kec. Widang, Tuban) which will be loaded by variations of burdens and configuration of vehicle axle *Single Axle Dual Wheel* (SADW), *Tandem Axle Dual Wheel* (TADW) dan *Tridem (Triple) Axle Dual Wheel* (TrADW), Within that state, exclusive for the vehicles with *Single Axle Dual Wheel* (SADW) there must be a variation of load below 8,16 ton, precisely at 8,16 ton and the one exceeding 8,16 ton. The choosing of ruas jalan arteri, is expected to show the thickness of layer in flexible pavement towards the subgrade support.

In this research we used a vechicle with variations of loads below the standard, precisely at the standard (8,16 tons), and exceeding the standard load. For the vehicle with *Single Axle* we used 1.2 H truck, and the vehicle with *Tandem Axle* used 1.22 truck, and the vehicle with *Tridem Axle* used semi trailer.

The measurement of maximum reverse deflection was conducted by testing the vehicle forward from point +0,00; +0,30 m; +2,70 m an +6,0 m. Meanwhile the test for maximum deflection and reverse deflection survey ranging from 30 cm – 50 cm, the tested vehicle ran forward from point - 6,0 m; - 2,7 m; - 0,3 m; 0,0 m; +0,3 m; + 2,7 m; and + 6,0 m from the tested vehicle axle. Point 0,0 m was straight at the tip of *Benkelman Beam* tools, precisely at the shoulder part that was used as a definite pointer for deflection at pavement layer.

The measurement of the maximum deflection precisely at the vehicle' (Δ_{mc}) can be determined by making a deflection ration, $\frac{\Delta_{m30}}{\Delta_{r30}} = \frac{\Delta_{mc}}{\Delta_{rc}}$, hence it is obtained that $\Delta_{mc} = \frac{\Delta_{m30} \times \Delta_{rc}}{\Delta_{r30}}$, because the result of (Δ_{m30} = p x Δ_{r30}) and the result of (Δ_{rc} = q x Δ_{r30}), results in $\Delta_{mc} = \frac{(p \times \Delta_{r30})(q \times \Delta_{r30})}{\Delta_{r30}} = p \times q \times \Delta_{r30}$. Δ_{mc} is a prediction on maximum deflection in a tirem and, Δ_{rc} is the reverse deflection precisely in the tire axle and Δ_{m30} and Δ_{r30} respectively is maximum deflection and reverse deflection 30 cm from the outer part later of the tire..

Research Results and Discussion

Reverse deflection

The measurement for reverse deflection and its calculation analysis for its respective load variatoon and axle configuration can be seen in Table 4.1 to Table 4.4

Table 4.1: Calculation on Reverse deflection for *Single Axle Dual Wheel (SADW)* Configuration

Axle Load Variation (ton)	Dial Read		Dial Scale (mm)	Reverse deflection (Δ_{rc}) (mm)
	d $_{(+6,0)}$	d $_{(0,0)}$		
Local Street Side (Ruas Jl. Widang-Plumpang, Kec. Widang, Tuban)				
6,87	22	0	0,01	0,22

7,68	29	0	0,01	0,29
8,16	42	0	0,01	0,32
11,88	72	0	0,01	0,72
14,24	105	0	0,01	1,05
Source : Result of Calculation and Analysis, Processed				

Tabel 4.2 : Calculation on Reverse deflection for *Tandem Axle Dual Wheel (TADW)* Configuration.

Axle Load Variation (ton)	Dial Read		Dial Scare (mm)	Reverse deflection (Δ_{rc}) (mm)
	d (+6,0)	d (0,0)		
Ruas Jalan Lokal (Ruas Jl. Widang-Plumpang, Kec. Widang, Lamongan)				
7,02	21	0	0,01	0,21
8,16	25	0	0,01	0,25
16,73	48	0	0,01	0,48
Source : Result for Calculation and Analysis, Processed				

Table 4.3 : Calculation of Reverse deflection for *Tridem (Triple) Axle Dual Wheel (TrADW)* Configuration

Axle Burden Variation (ton)	Dial Read		Dial Scale (mm)	Reverse deflection (Δ_{rc}) (mm)
	d (+6,0)	d (0,0)		
Local Street Side (Ruas Jl. Widang-Plumpang, Kec. Widang, Lamongan)				
16,18	18	0	0,01	0,18
21,52	42	0	0,01	0,42
25,63	58	0	0,01	0,58
Source : Result of Calculation and Analysis, Processed				

Maximum Deflection

Table 4.4: The amount of Maximum Deflection Right On Wheels Center (Δ_{mc})To ConfigureAxle *Single Axle DualWheel (SADW)*

Imposition Variation Axle (tonnes)	Δ_{R30} (mm)	Price $p_{Average}$	price $q_{average}$	$\Delta_{mc} = p \times q \times \Delta_{r30}$
A. Local Roads (Section Widang-Plumpang Street, Widang District, Lamongan)				
6,87	0,19	1,12	1,15	0,25
7,68	0,25			0,32
8,16	0,28			0,36
11,88	0,63			0,81
14,24	0,92			1,18

Source: Result of Calculation & Analysis, Processed

The amount of maximum deflection precisely at the vehicle axle (Δ_{mc}) can be determined by making a ratio, , $\frac{\Delta_{m30}}{\Delta_{r30}} = \frac{\Delta_{mc}}{\Delta_{rc}}$ so as to obtain $\Delta_{mc} = \frac{\Delta_{m30} \times \Delta_{rc}}{\Delta_{r30}}$, because the result of (Δ_{m30} = p x Δ_{r30}) and the result of (Δ_{rc} = q x Δ_{r30}), hence $\Delta_{mc} = \frac{(p \times \Delta_{r30})(q \times \Delta_{r30})}{\Delta_{r30}} = p \times q \times \Delta_{r30}$. Calculation on the maximum deflection precisely at the tested vehicle's axle (Δ_{mc}) can next be seen in Table 4.4 to Table 4. 6 as shown below.

Tabel 4.5 : Calculation on Maximum Deflection Precisely at the Core of the Tire (Δ_{mc}) for *Tandem Axle Dual Wheel (TADW)* Configuration

Axle Load variation (ton)	Δ_{r30} (mm)	Price Average p	Price Average q	$\Delta_{mc} = p \times q \times \Delta_{r30}$
A. Local Street Side (Ruas Jl. Widang-Plumpang, Kec. Widang, Lamongan)				
7,02	0,11	1,18	1,86	0,23
8,16	0,14			0,31
16,73	0,26			0,58

Sumber : Hasil Perhitungan & Analisis, Diolah.

Approach by using SADW axle for reference is exclusively used to determine the maximum deflection precisely at the core of the tire. Maximum deflection for SASW is predicted to be about . For the complete result, see Table 4.6.

Table 4.6 : Maximum Deflection for Single Axle Single Wheel (SASW)

P SADW (ton)	P SASW (ton)	$\Delta_{mc-sadw}$ (mm)	$\Delta_{ms-sasw} = \Delta_{mc-sadw} \times \frac{P_{sasw}}{P_{sadw}}$ (mm)
Local Street Side (Ruas Jl. Widang-Plumpang, Kec. Widang, Lamongan)			
6,87	3,19	0,22	0,07
7,68	3,42	0,31	0,08
8,16	3,68	0,36	0,10
11,88	4,57	1,00	0,20
14,24	4,62	1,64	0,27

Source : Result of Calculation and Analysis, Processed

Conclusions and recommendations

From the research and explanation we can conclude that:

Vehicle axle configuration used in this research is *Single Axle Dual Wheel (SADW), Single Axle Single Wheel (SASW)* and *Tandem Axle Dual Wheel (TADW).* SADW and SASW represented by Truck 1.2 H, TADW represented by Truck 1.22 . Research result, data analysis, and calculation process obtained the maximum deflection precisely at the core of the tire (Δ_{mc}) can be concluded by making a ratio, $\frac{\Delta_{m30}}{\Delta_{r30}} = \frac{\Delta_{mc}}{\Delta_{rc}}$, so as to obtain that $\Delta_{mc} = \frac{\Delta_{m30} \times \Delta_{rc}}{\Delta_{r30}}$, because the result of (Δ_{m30} = p x Δ_{r30}) and the result of (Δ_{rc} = q x Δ_{r30}), hence the result of $\Delta_{mc} = \frac{(p \times \Delta_{r30})(q \times \Delta_{r30})}{\Delta_{r30}} = p \times q \times \Delta_{r30}$. for value of reverse deflection obtained by SADW with total loads of 14,24 tons and result Δ_{rc} 1,05mm, and TADW with vehicle loads of 16,73 tons and result Δ_{rc} 0,48mm , for maximum deflection obtained SADW 14,24 ton Δ_{mc} 1,18 mm, TADW 16,73 ton Δ_{mc} 0,58 mm and maximum deflection for *Single Axle Single Wheel (SASW)* P_{SADW} 14,24 tons P_{SASW} 4,62 ton $\Delta_{ms-sasw} = \Delta_{mc-sadw} \times \frac{P_{sasw}}{P_{sadw}}$ = 0,27 mm

From the research, data analysis, and conclusion of the study so as to find a better result, there are some suggestions we can offer:

1. On variation of load in the tested vehicle axle, some further tests are needed for a case in which axle load is exceeding maximum axle that can be achieved in this research.

2. It is better to use portable axle balance that can be used to measure loads in axle directly in the field for all variations of commercial rides in the street surface.

Thank-you note

In the preparation of this research can not be separated from the support of various parties. The author specifically thanked Kemenristek Dikti for providing financial support so that the preparation of this research could run smoothly

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